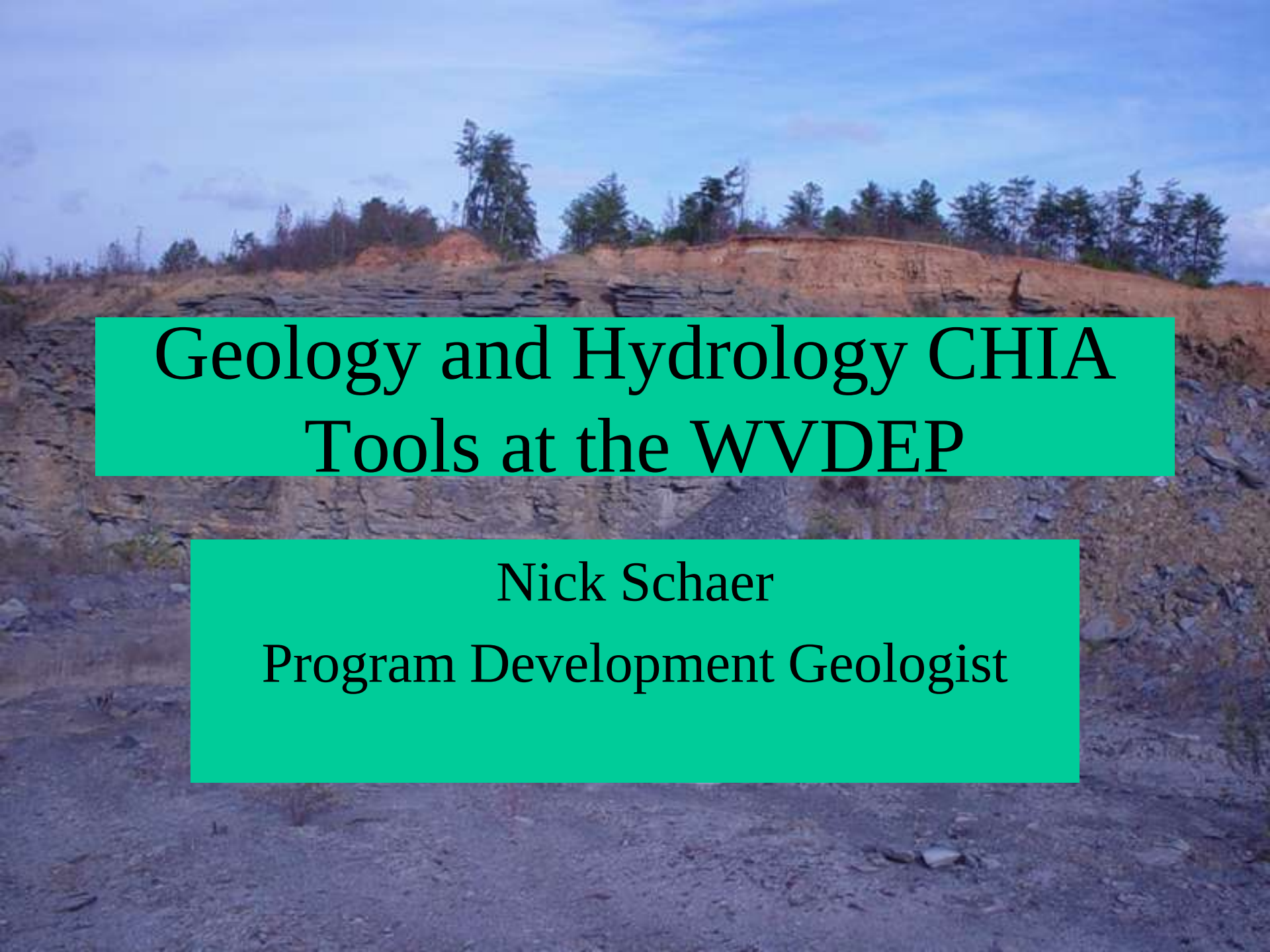


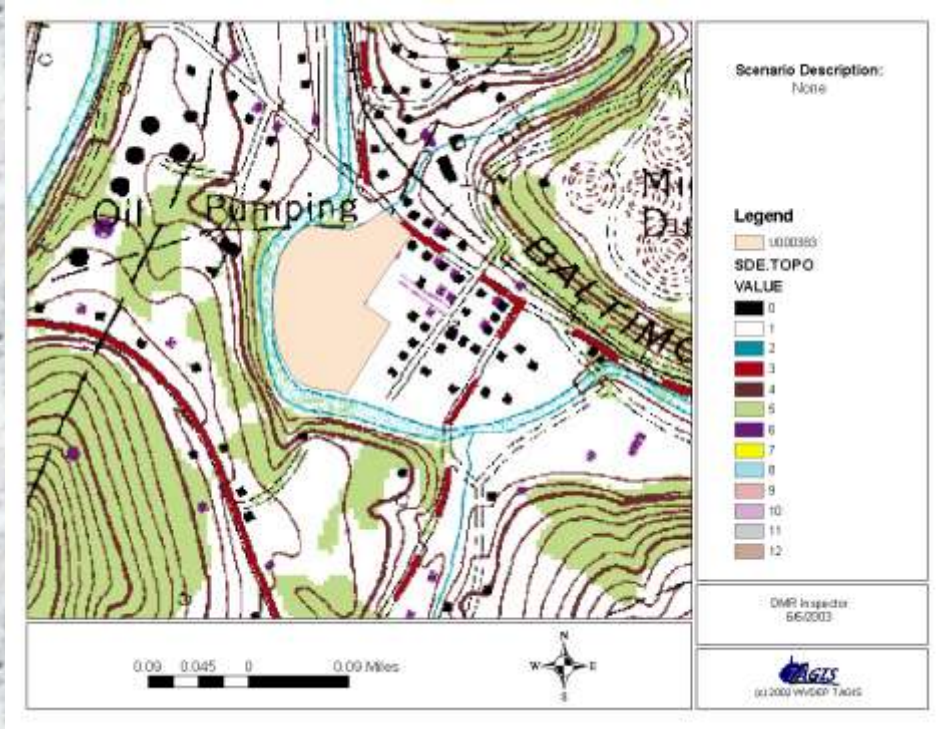
Geology and Hydrology CHIA Tools at the WVDEP

Nick Schaer

Program Development Geologist

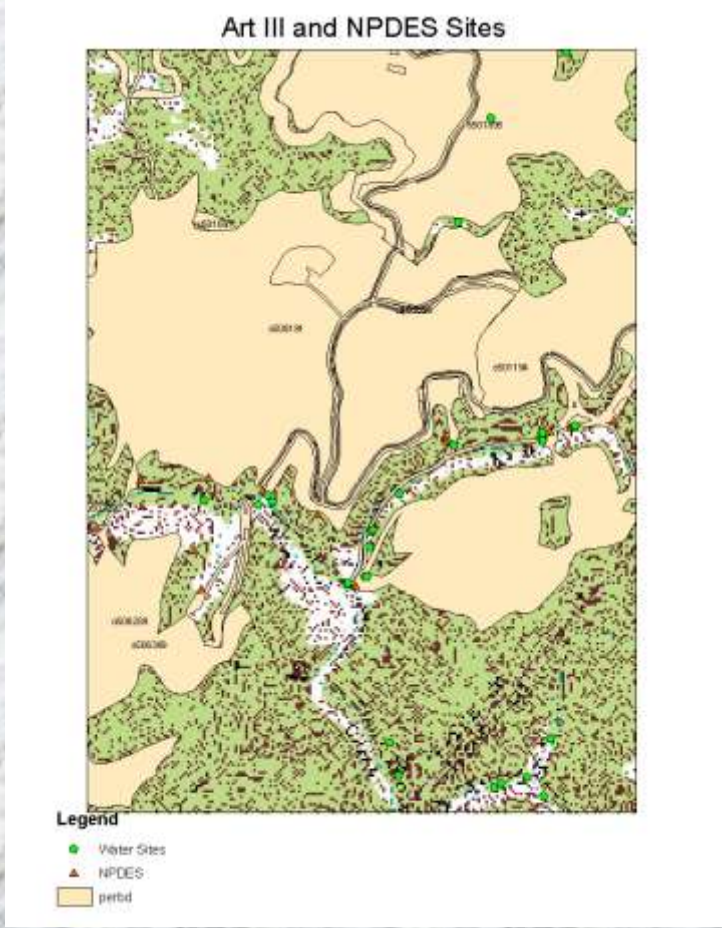
Introduction

- Many databases of GIS shape files and water quality data exist to help the CHIA writer.



GIS is key to looking at the Cumulative Hydrologic Impact”

Inter-relating Shapefiles - Databases



WVDEP/TAGIS Database

- For WDEP access (gis on '172.17.100.48')
- Internet http://gis.wvdep.org/
- UTM 1983
- DRGs and other state data.
  - State Geology
  - State Quads
  - Roads, Streams, etc.

http://gis.wvdep.org/

EP

Well Search
e Mapping
np Cleanup Projects
oto Browser

stations
e Conversion
lease Inventory
(DEP Only)
it

Division of Mining and Reclamation Data

All data have been projected to UTM zone 17, NAD83. Click on the icon to view metadata.

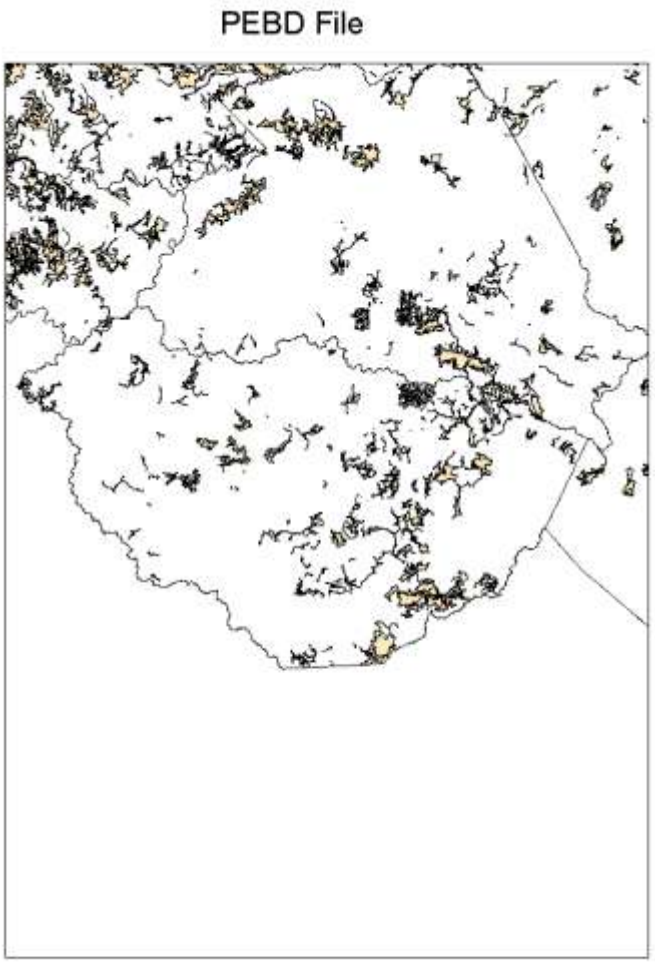
- adjacent permits
- drainage control structures
- mineral removal area
- overburden core holes
- roads
- water sample locations
- permits, point locations
- mining related impoundments, point coordinates
- auger mining
- underground mining limits
- NPDES outlets
- permit boundaries
- valley fills
- mountaintop removal area (from WVGES)

TAGIS Database

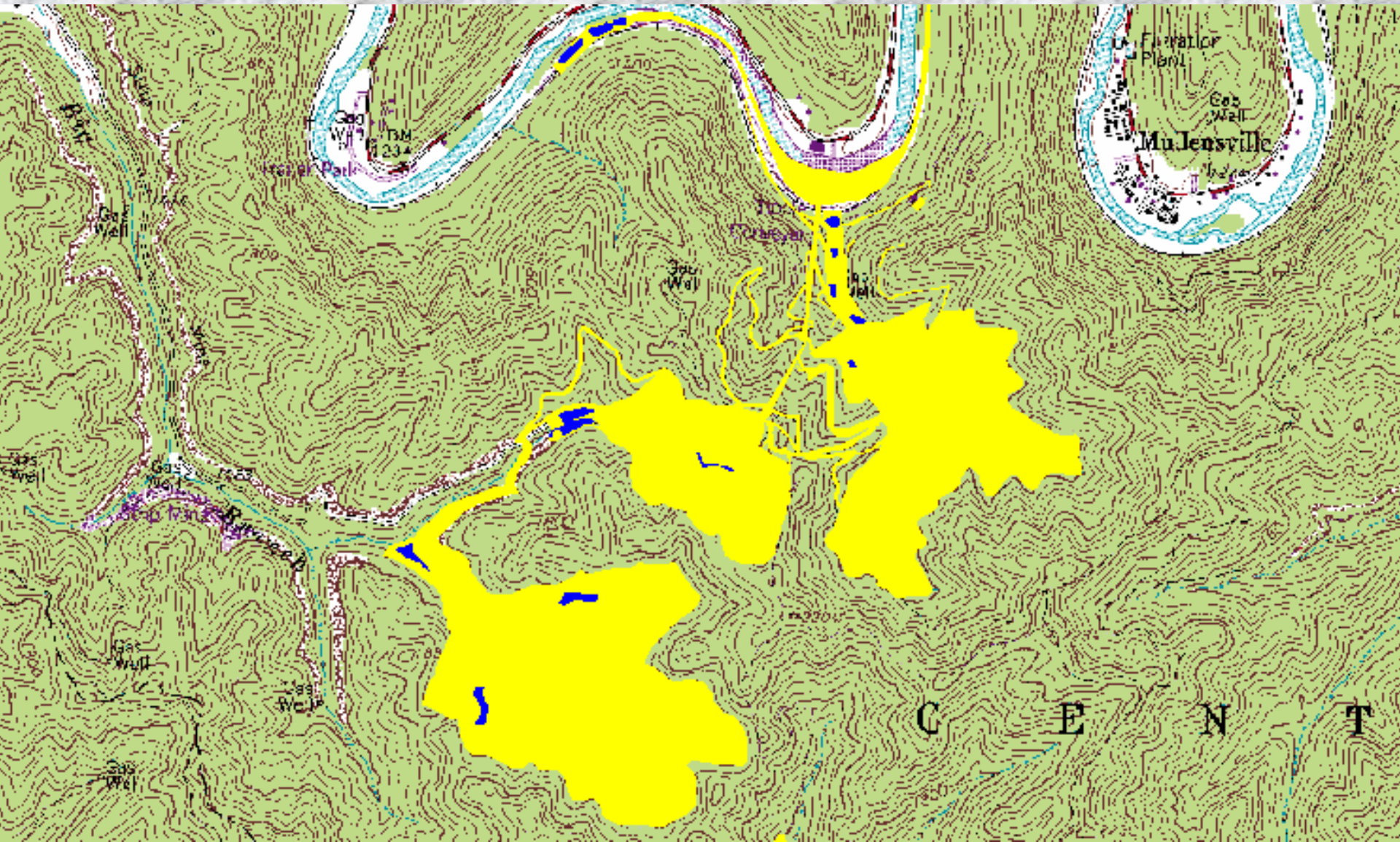
Permit Data

WCMS Scanned Maps

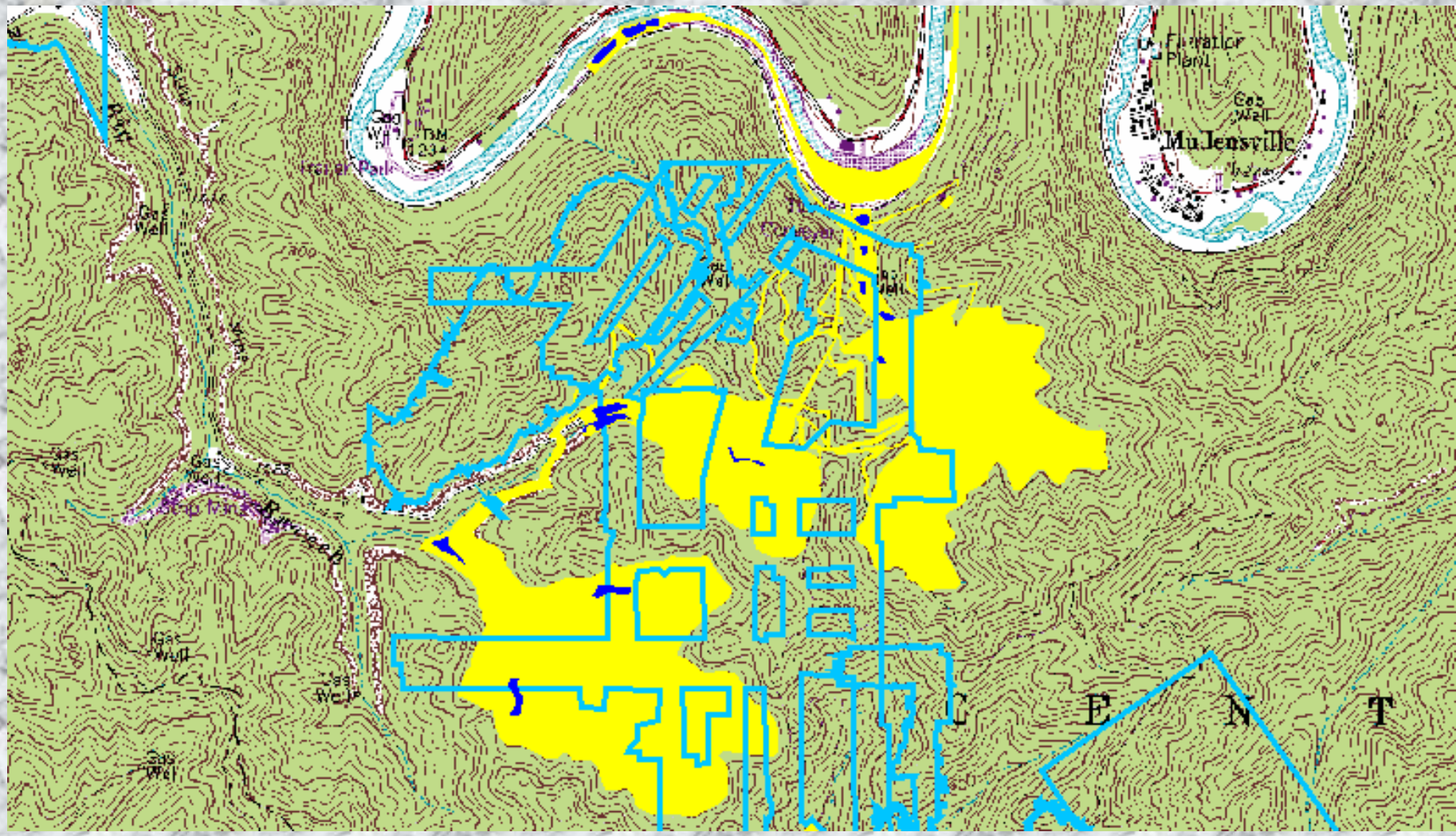
PERBD. MINLI, Etc



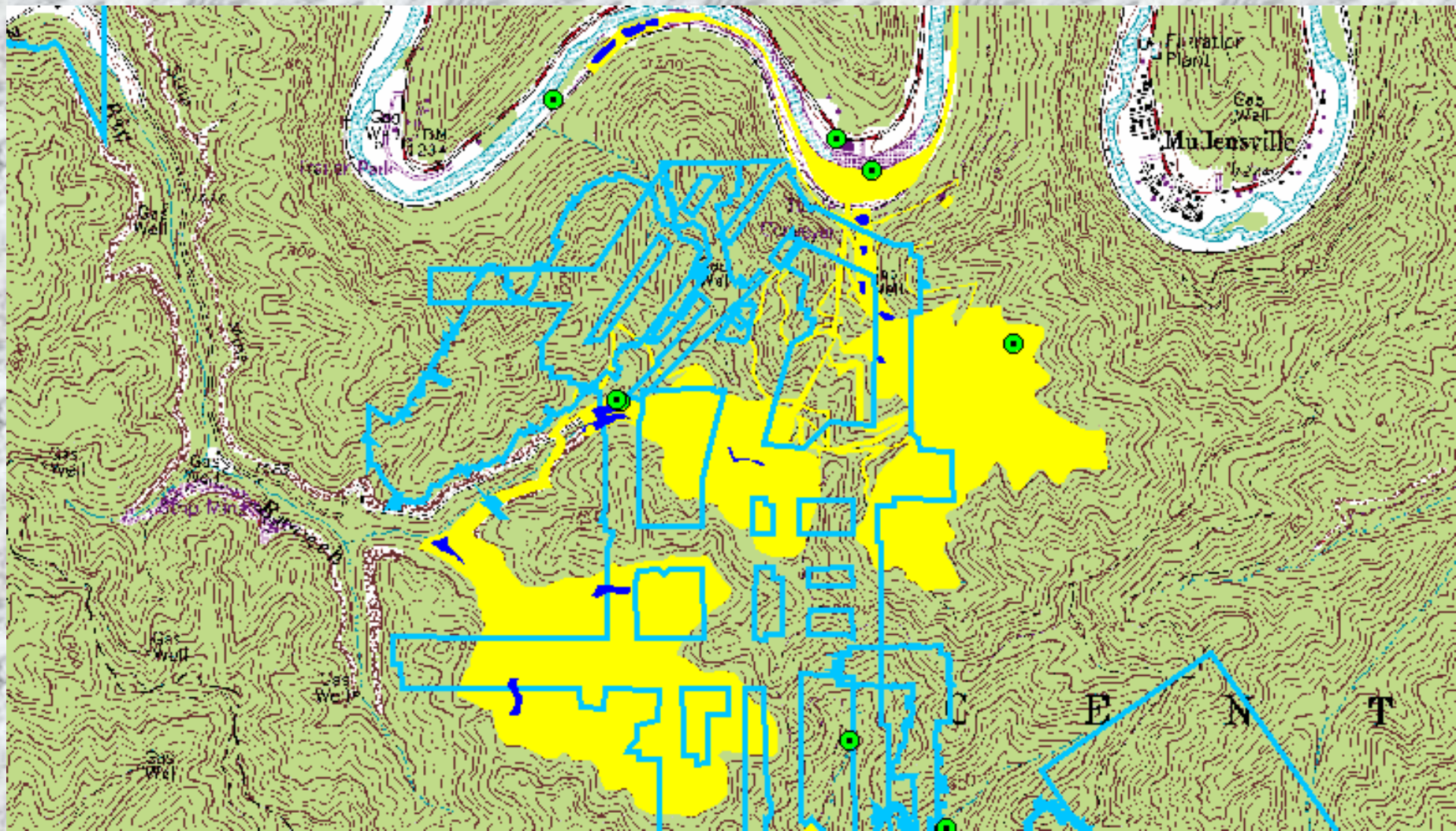
Permit Boundary



Mine Limits

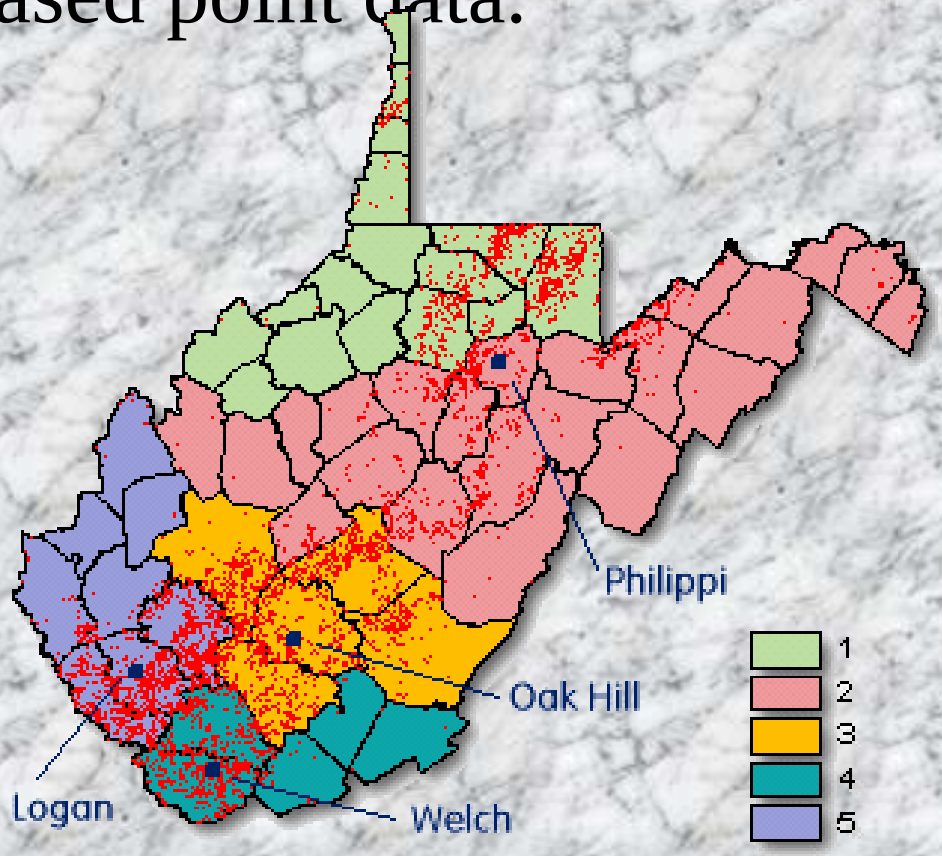


Water Sample Sites



TAGIS Database
Permit Data

- Oracle/ERIS based point data.
  - Article III
  - NPDES



TAGIS Database

- Historic Maps
  - 15 Minute Quads
  - Mine Atlas
  - Old County Geology Maps

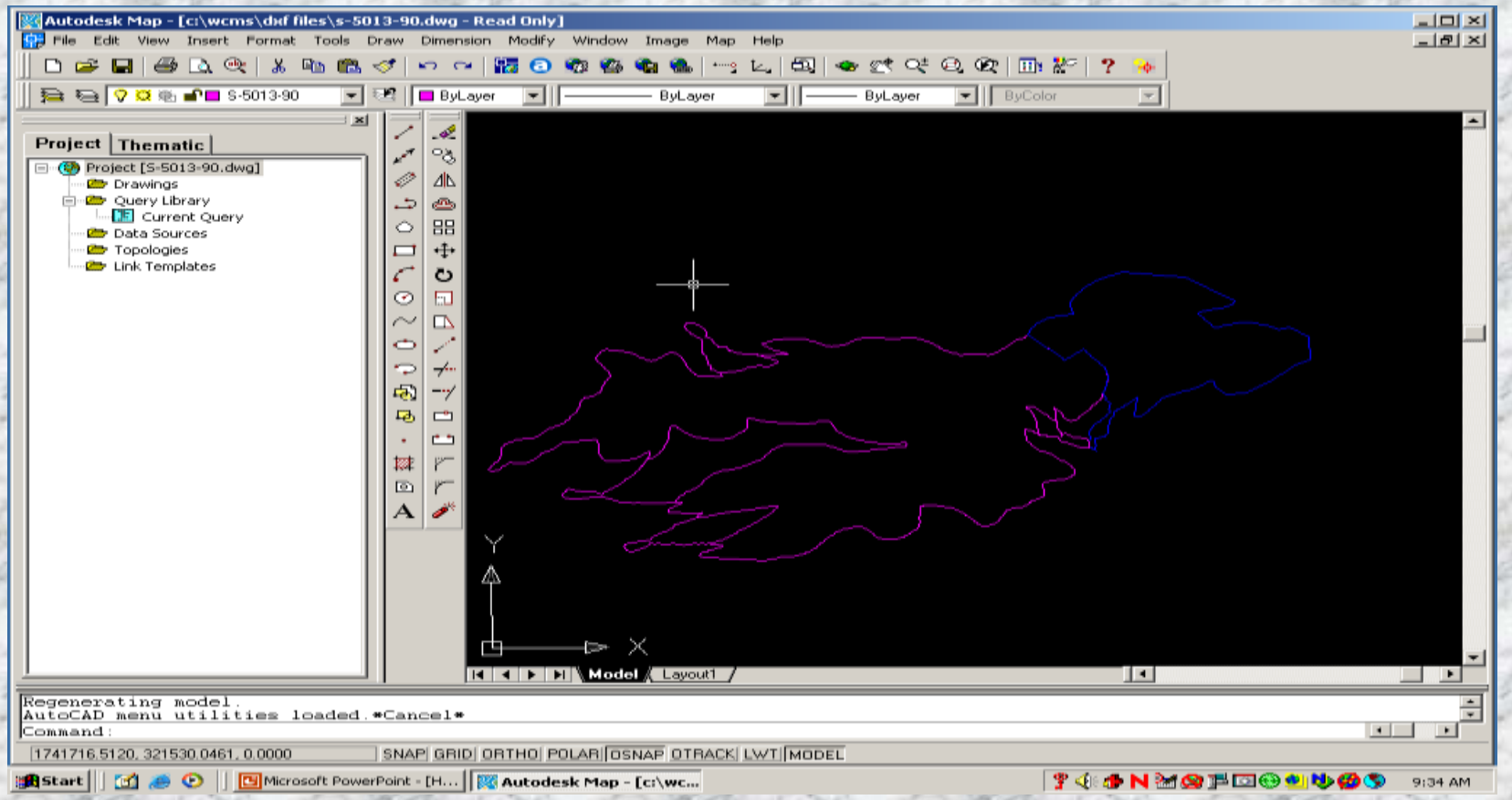
TAGIS Database

Ariel and Satellite

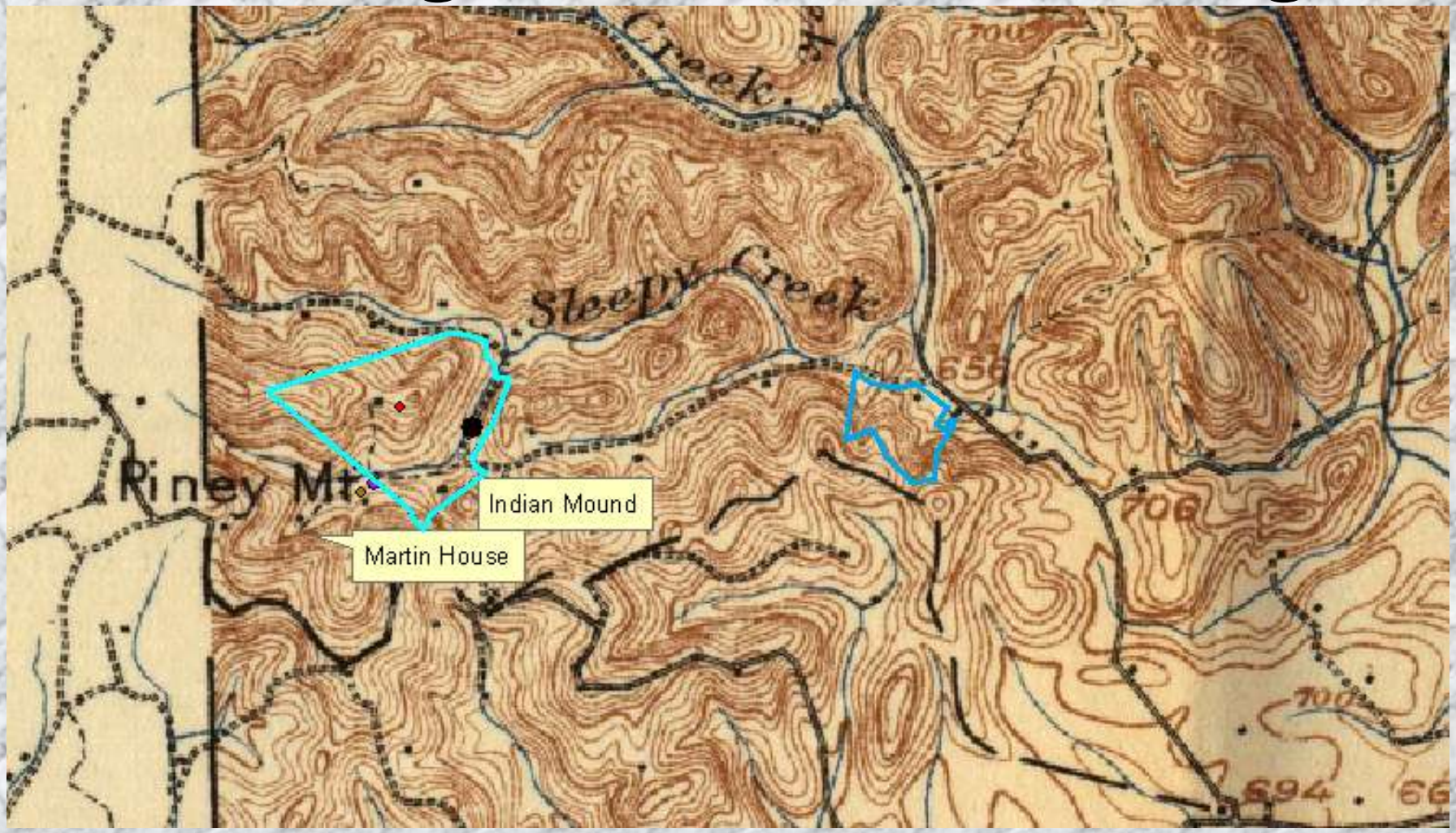
- DOQ's
- LU/LC
- Satellite

GIS Database Maintenance

CAD to ESRI conversion



Scanning and Rubber Sheeting

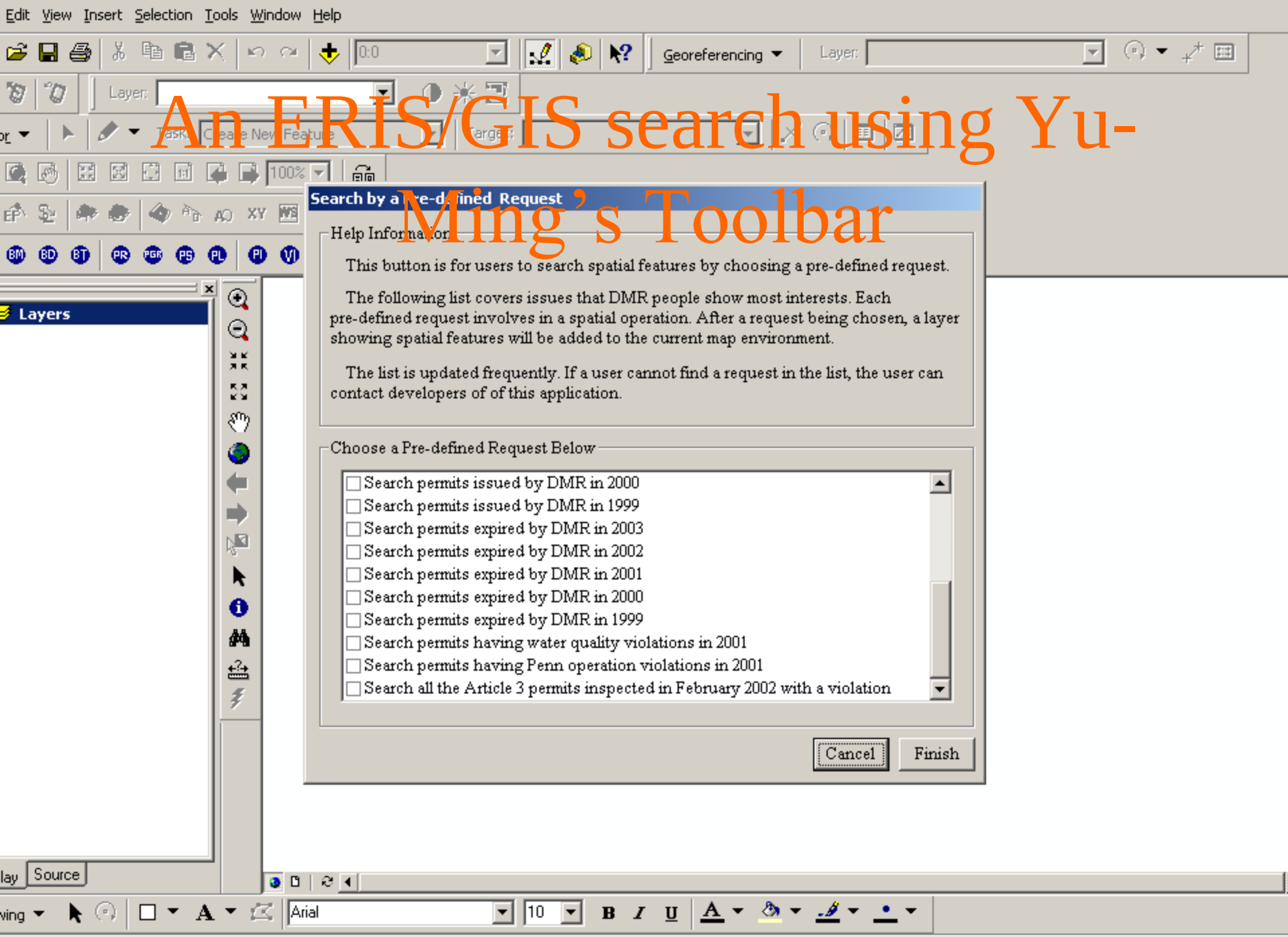


GPS Data from the field

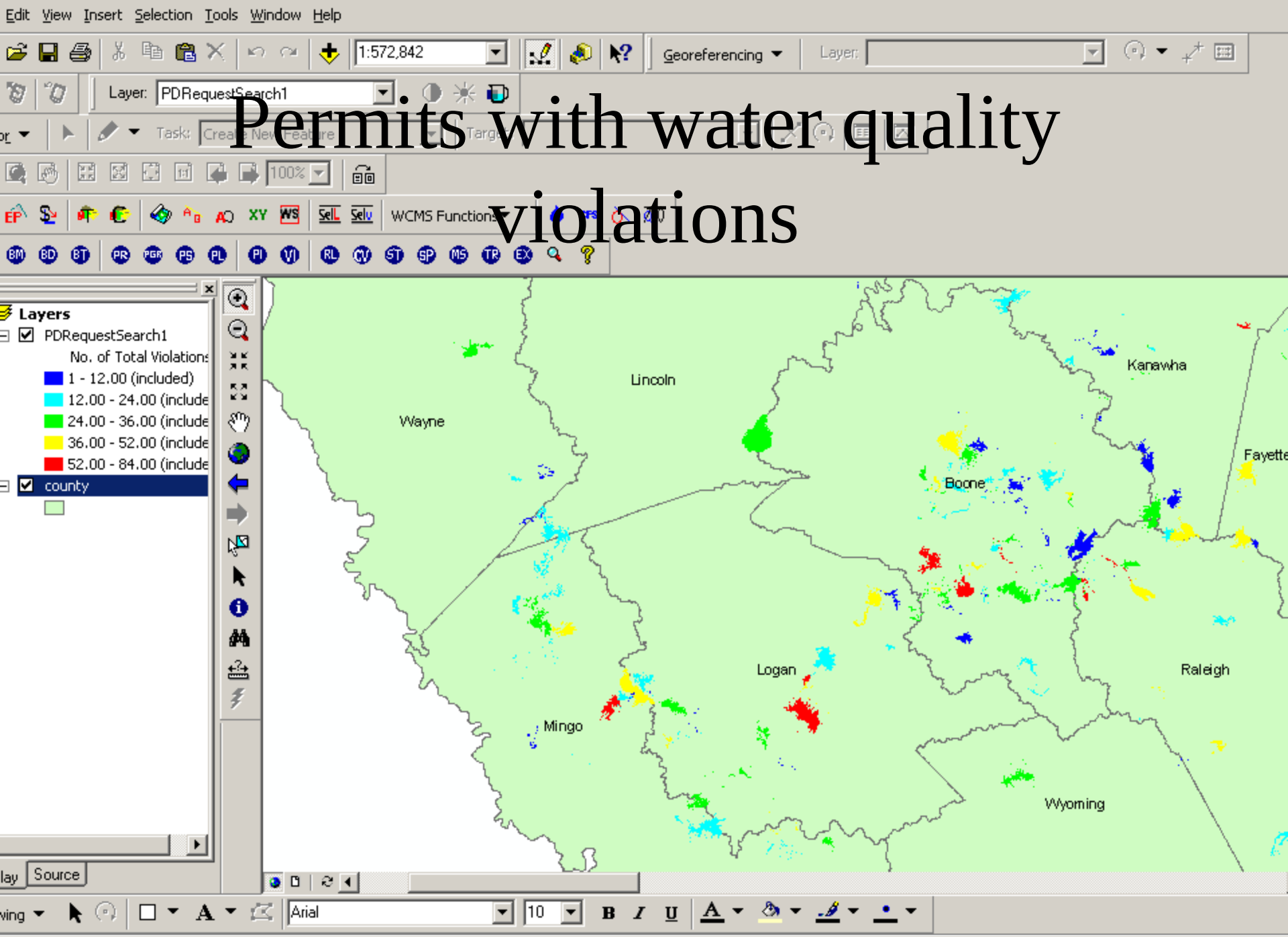
ArcGIS Toolbars

- Yu-Ming's ERIS/TAGIS Toolbar
- WCMS 8.0.3 Toolbar

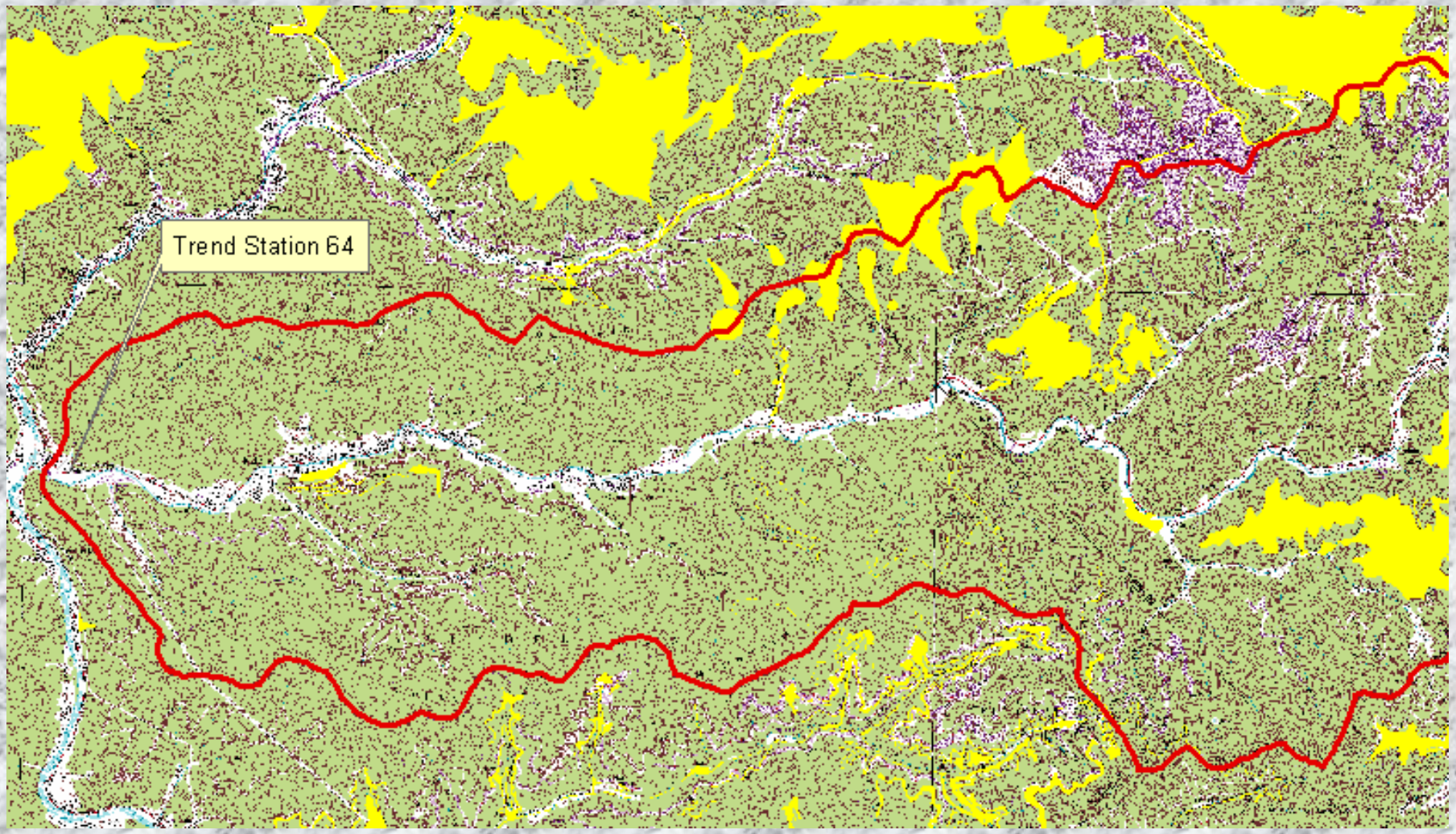
An ERIS/GIS search using Yu-Ming's Toolbar



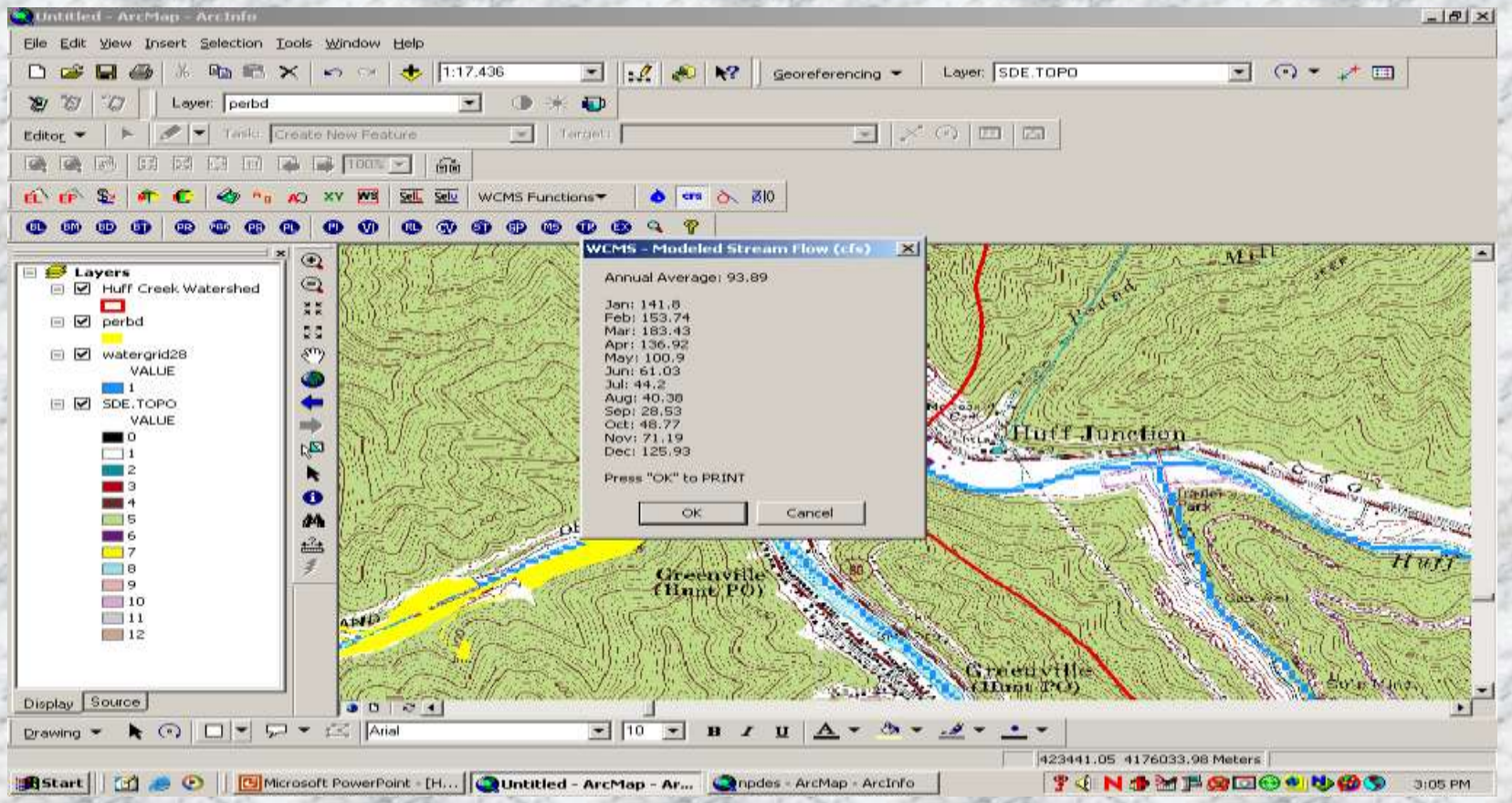
Permits with water quality violations



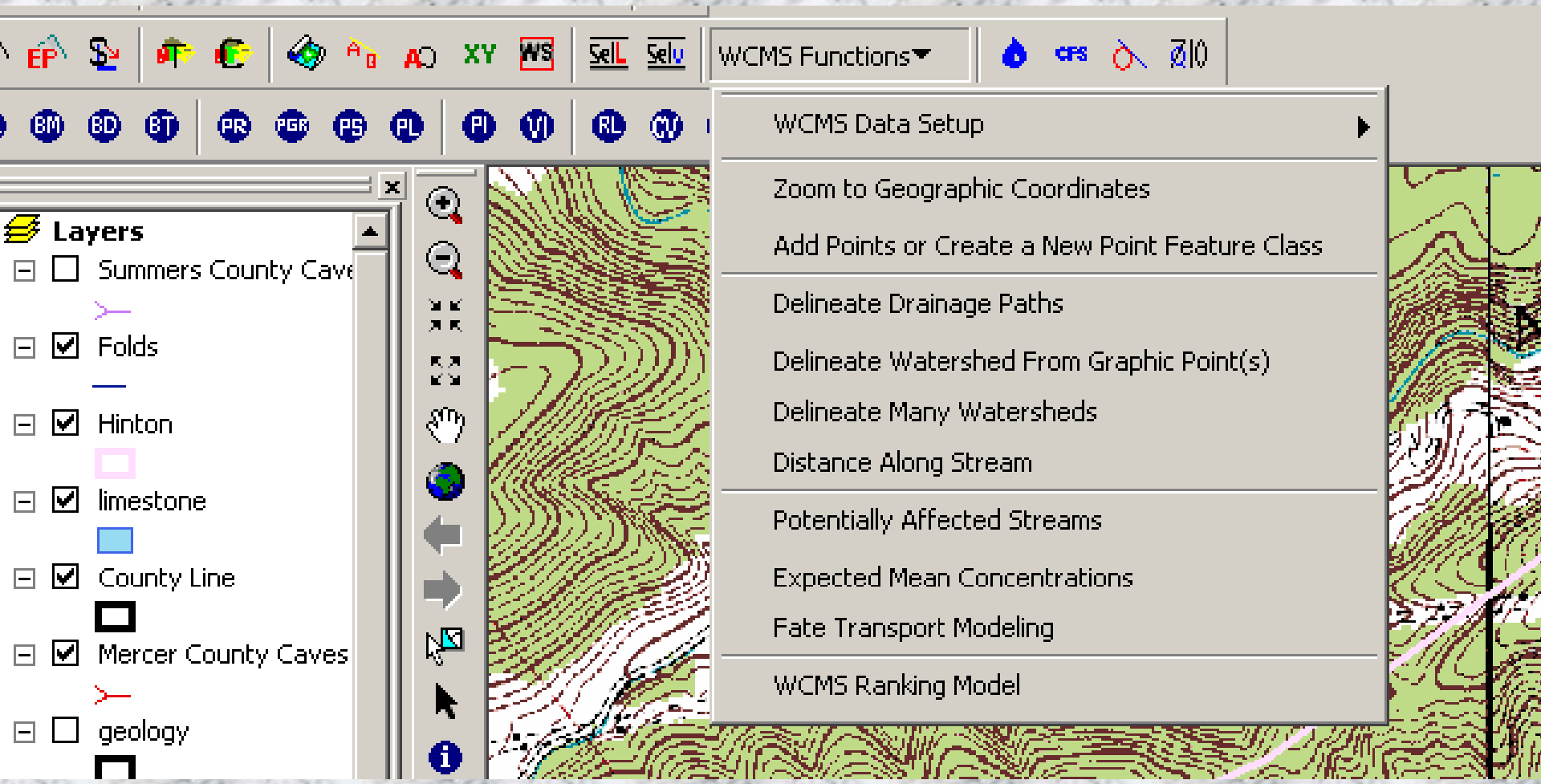
WCMS Toolbar



Hydrology Tools



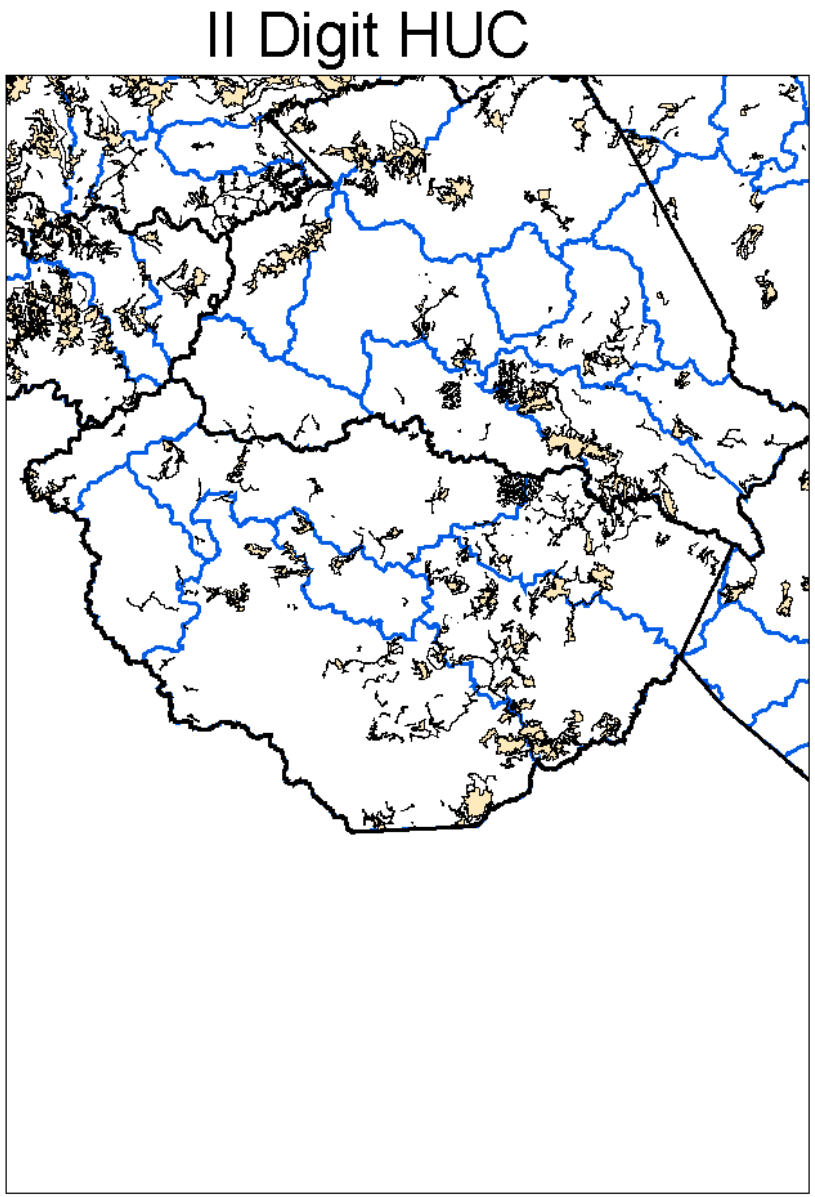
And More


WCMS Functions
WCMS Data Setup
Zoom to Geographic Coordinates
Add Points or Create a New Point Feature Class
Delineate Drainage Paths
Delineate Watershed From Graphic Point(s)
Delineate Many Watersheds
Distance Along Stream
Potentially Affected Streams
Expected Mean Concentrations
Fate Transport Modeling
WCMS Ranking Model
Layers
Summers County Cave
Folds
Hinton
limestone
County Line
Mercer County Caves
geology

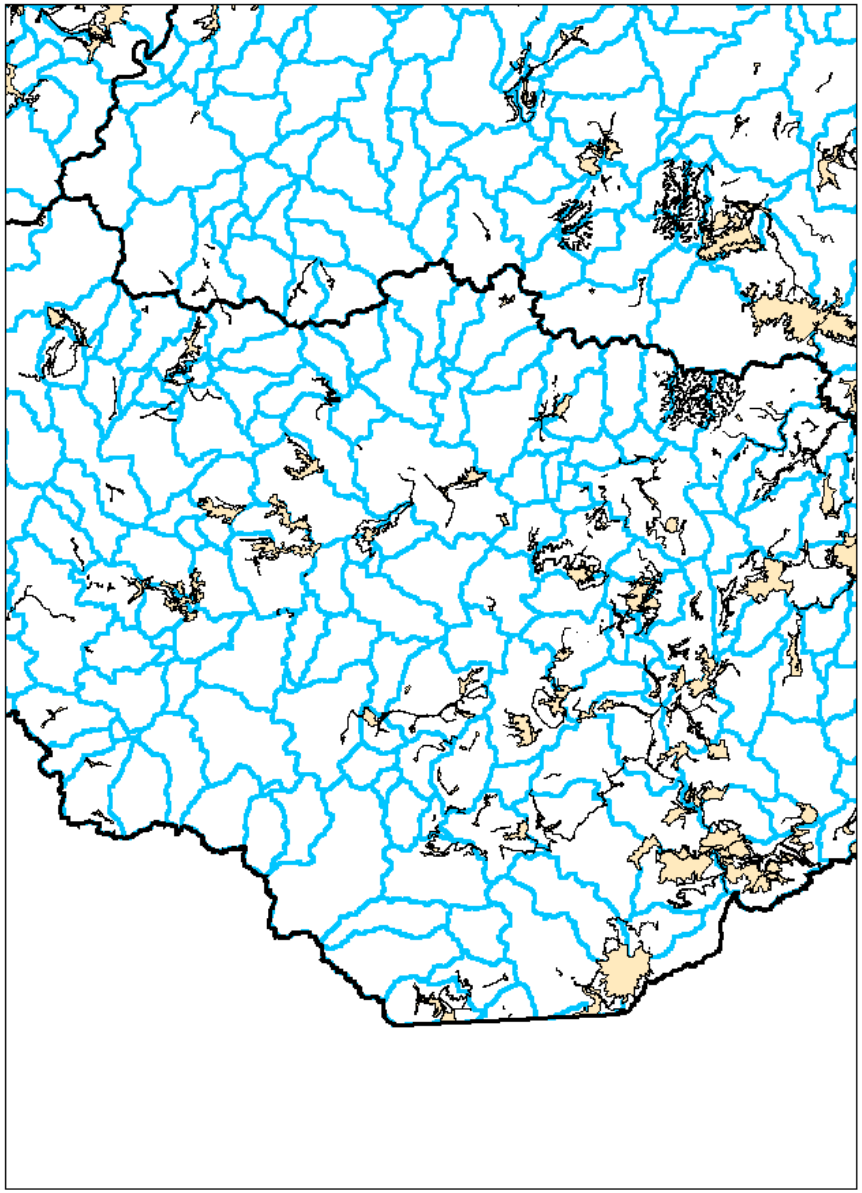
GIS Watersheds for CIA Development

- HUC Unit.
- Trend Station Watersheds.
- BWQ Reachsheds.

HUC Map

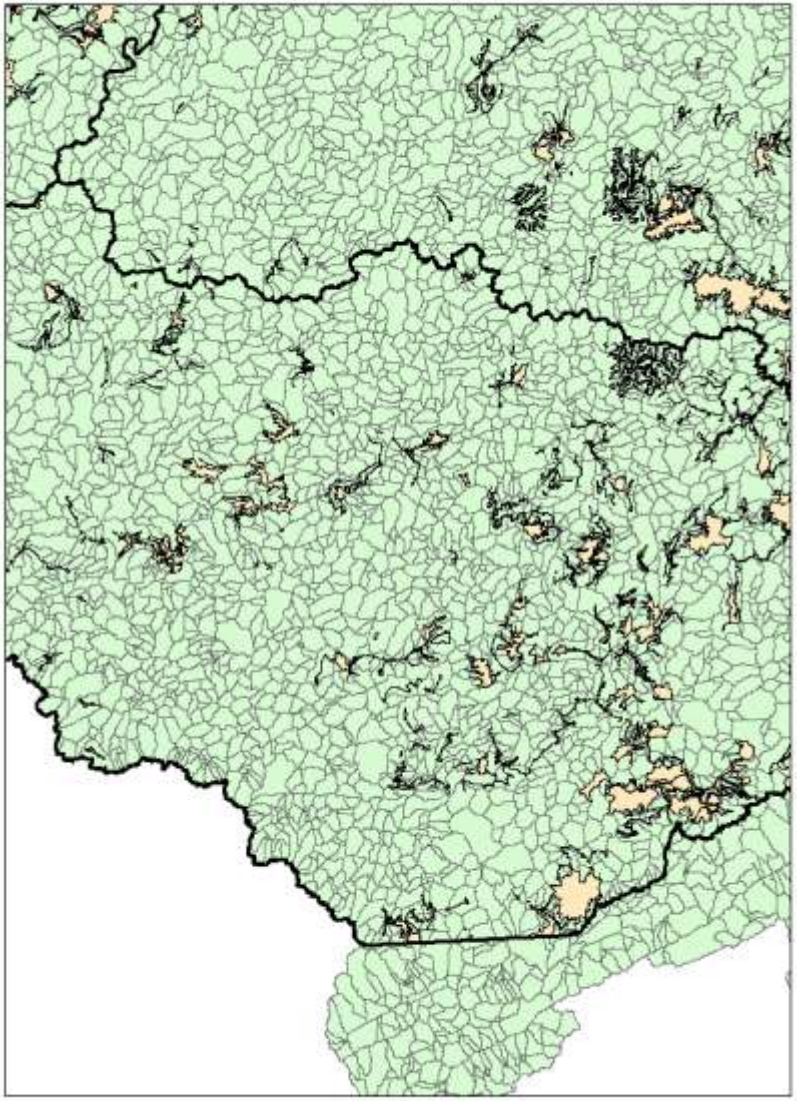


14 Digit HUC

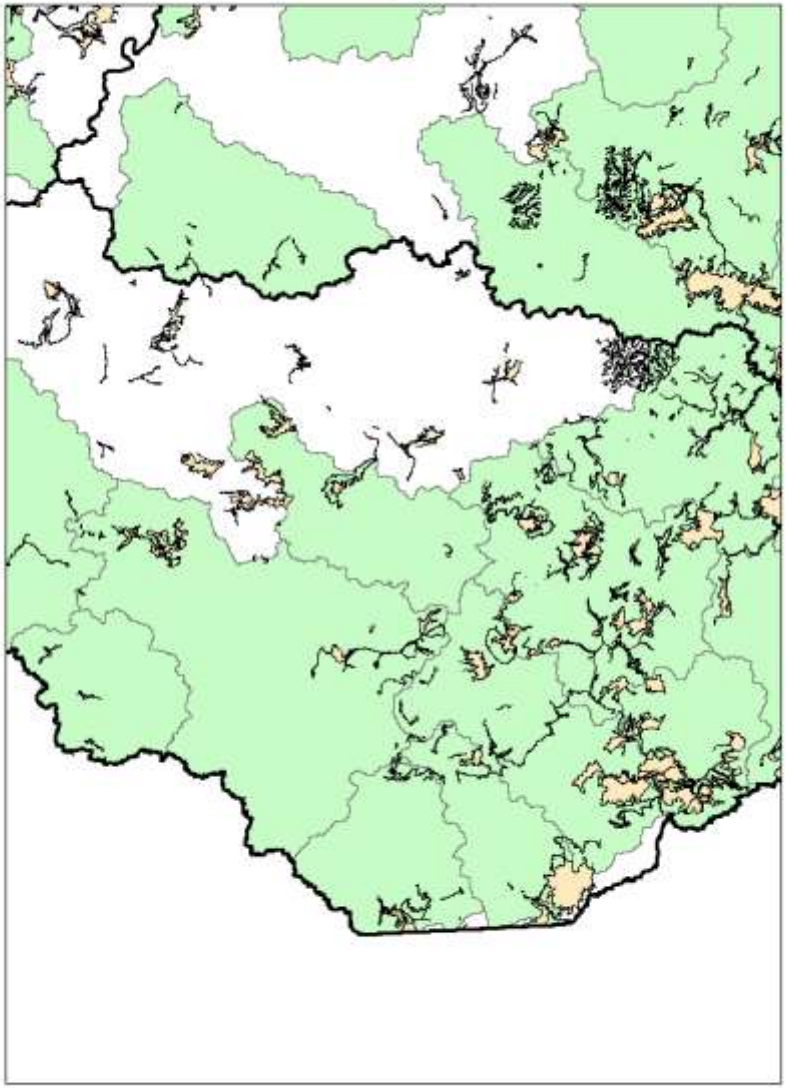


HUC Map

Reachsheds



Trend

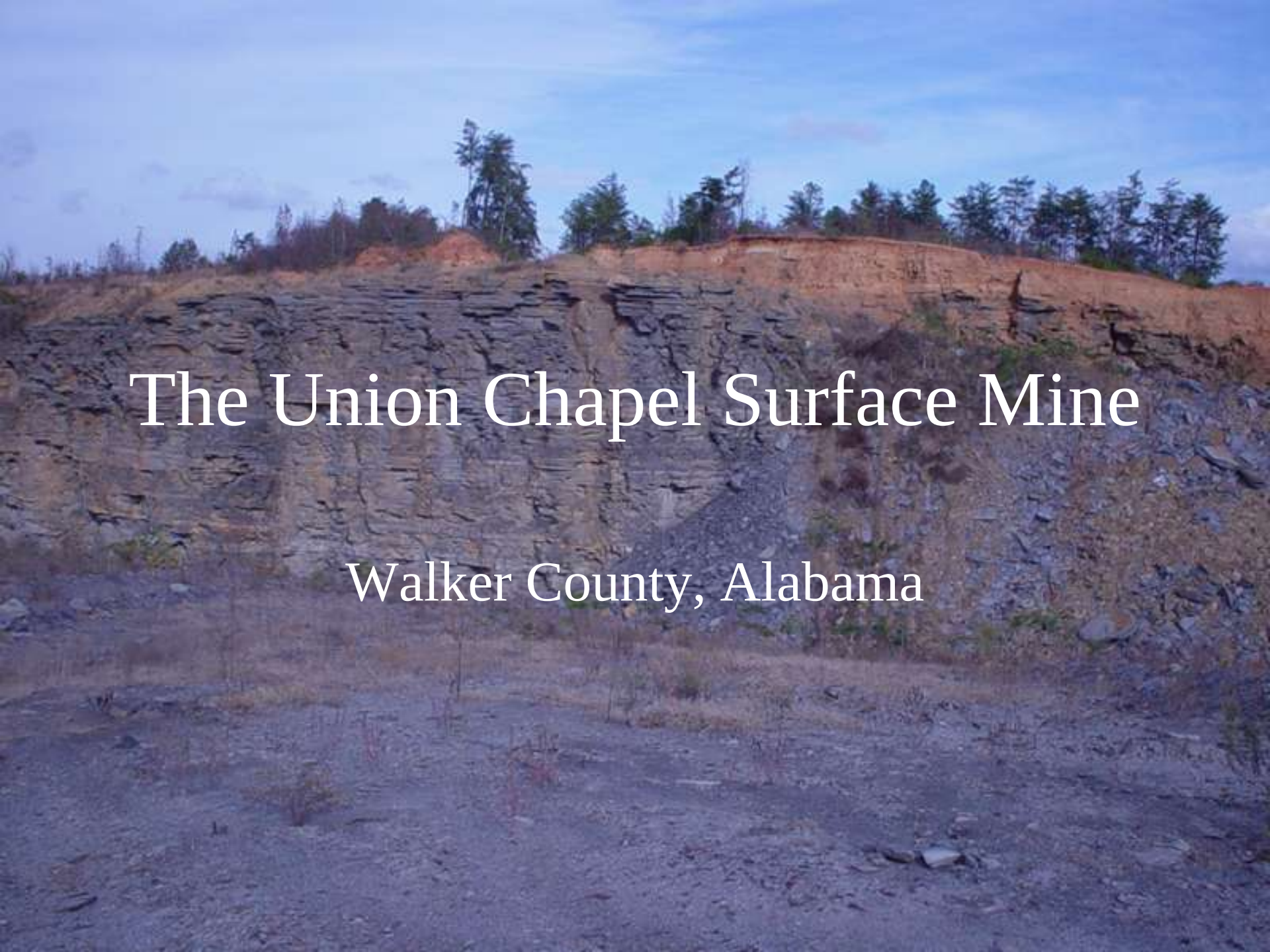


Water Data for CHIAs

- Baseline
- Trend Stations.
  - Heavy Metals
  - Baseline
  - Benthic
- BWQ.
  - Site Specific NPDES used for Anti-Deg

Future Tools

- EQUIS
- Electronic Permitting/Digitized Mine Maps.
- High Resolution DEM.
- WCMS/HSPF Flow and quality model.



The Union Chapel Surface Mine

Walker County, Alabama

Active coal mine to fossil park

Amazing fossils and trackways

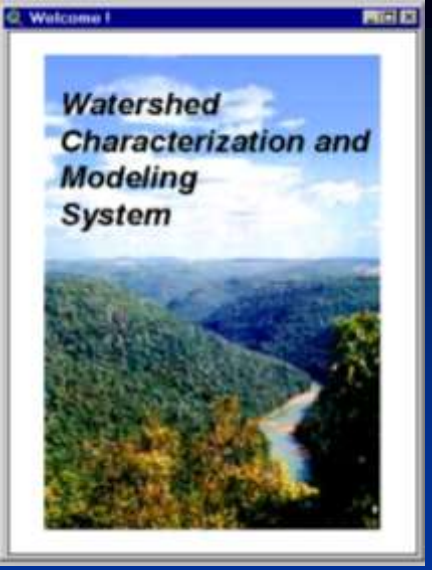
Above the Mary Lee Coal Seam

Unique preservation

- Dragonfly Wing

Frogzilla

- Over 3000 recorded tracks.



Watershed Characterization and Modeling System (WCMS)

Development, Capabilities, and Application to Large Watersheds

Historical Technical Development Team:

Qi Dai, Ph.D.
Michael P. Strager, Ph.D.
Jacquelyn M. Strager, M.S.
John B. Churchill, M.S.

A product of the

Natural Resource Analysis Center

West Virginia University

Jerald J. Fletcher, Director

Overview of the Presentation

- Background, development goals, and implications
- Summary of capabilities – What is WCMS?
- Future plans – Where are current development activities headed?

Background

- WV Department of Environmental Protection manages water quality statewide
  - Division of Mining and Reclamation
  - Division of Water and Waste Management
- Regulatory agencies need:
  - Consistent, documentable, and reliable sources of information
  - 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, discharge rates, and 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

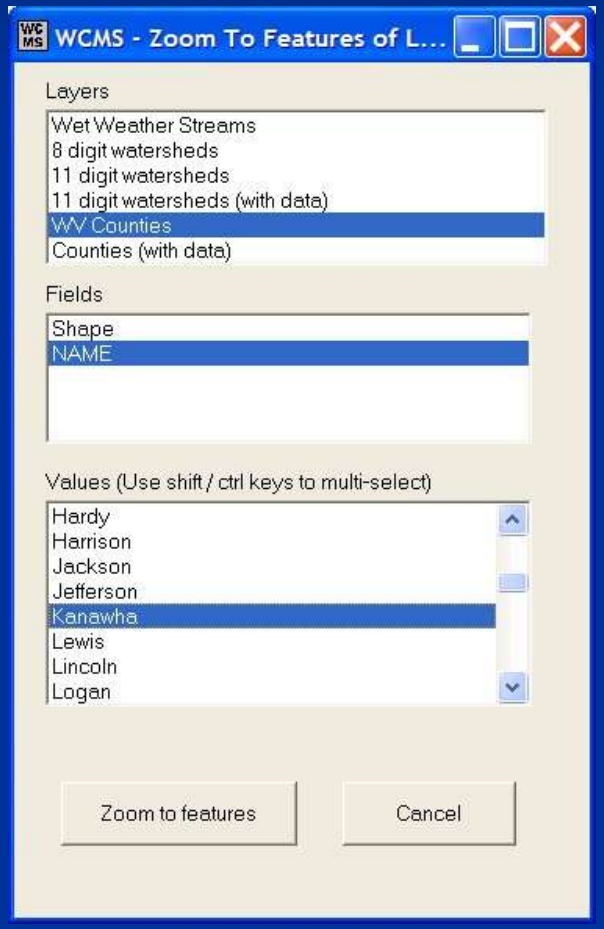
- ArcGIS and Spatial Analyst
- PC platform - Windows 2000/XP or Server 2000/2003
  - Runs in a Citrix environment at WVDEP
- Basic ArcMAP skills
- Available GIS data imported into WCMS

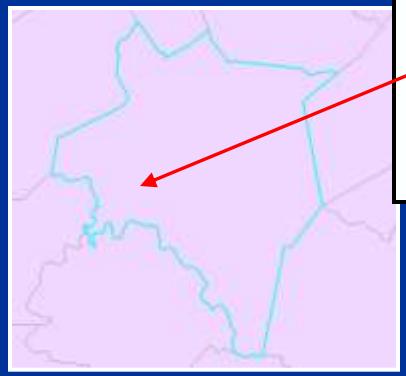
GIS Data Used by WCMS
(Provided for West Virginia)

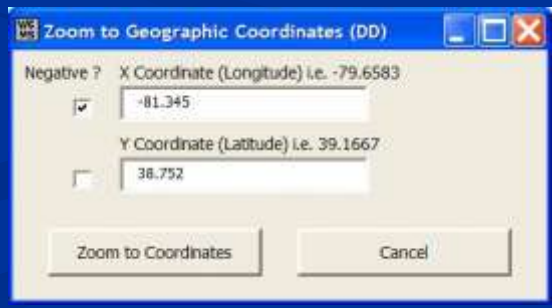
- Raster stream network
- Flow direction grid
- Flow accumulation grid
- Runoff grid
- Cumulative runoff grid
- Hydro-corrected DEM with burned in streams
- 30m DEM (the standard DEM that is not hydro-corrected
- Landcover from the WV GAP analysis project
- Landcover made from MRLC data
- Table of expected 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

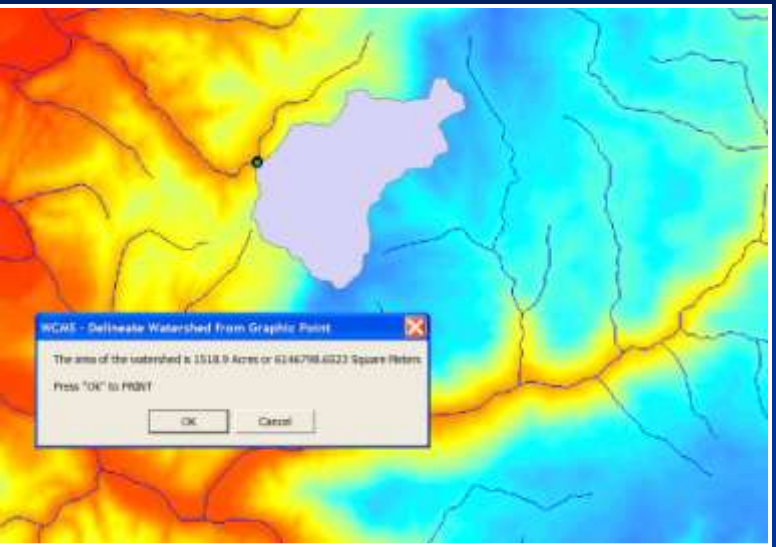
- Trace the path of a raindrop across the landscape (flow direction)
- Find the 30 yr-average annual and monthly streamflow
- Report the drainage area for a stream reach
- Find the 7Q10 flow for a stream locations

WCMS Watershed Delineation

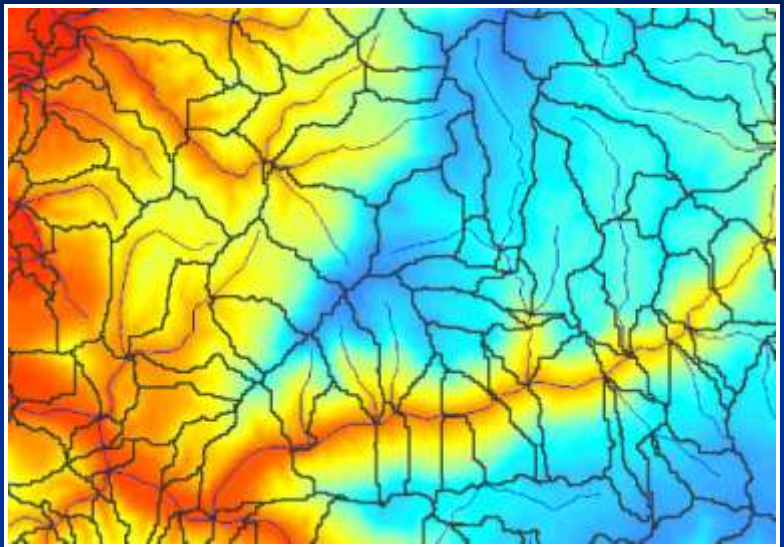
- Delineation watersheds from graphic point(s)
  - Choose a spot on the raster stream
  - Choose any point in the watershed
  - Area of a polygon may be delineated
    - Watershed, mine site polygons
- Delineate drainage paths
- Delineate many watersheds
- Calculate the distance between two points in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

Watershed Delineation

Point



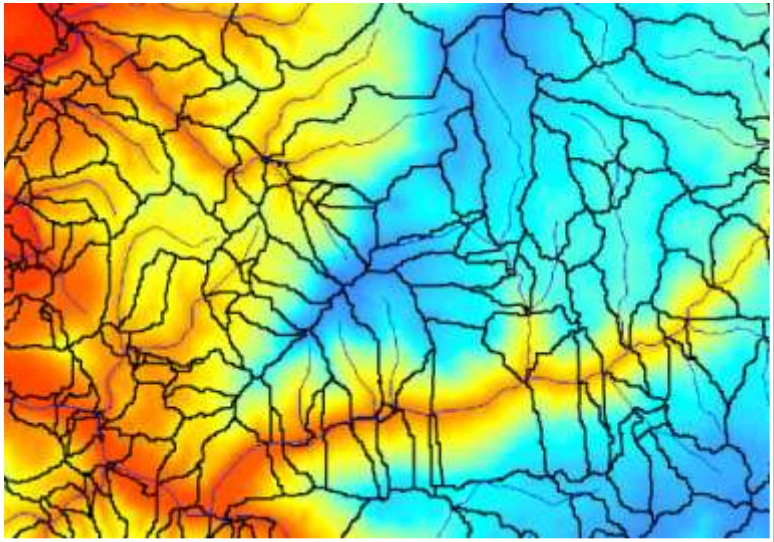
Area Threshold



Segment

Level

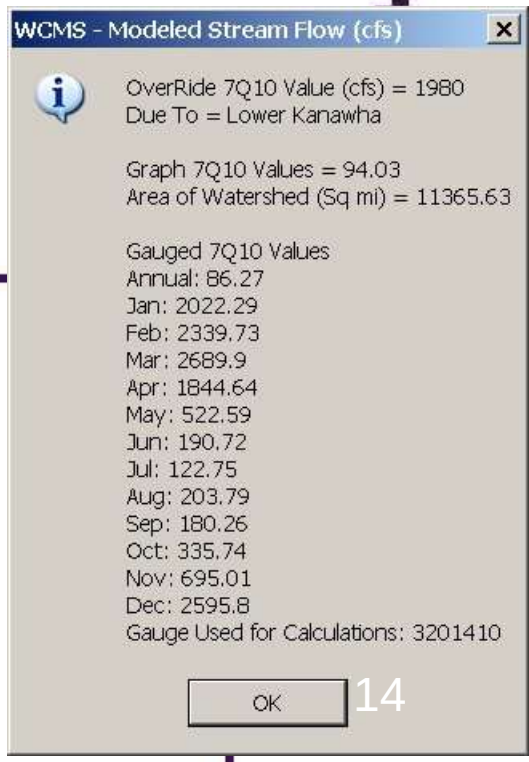
Watersheds



Watershed Tools

Drainage area and flow

ck Point on Stream

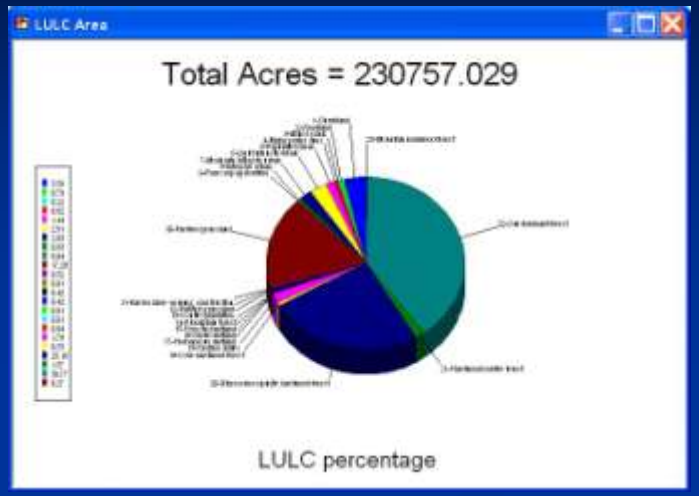


Tabulate Landuse Statistics

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

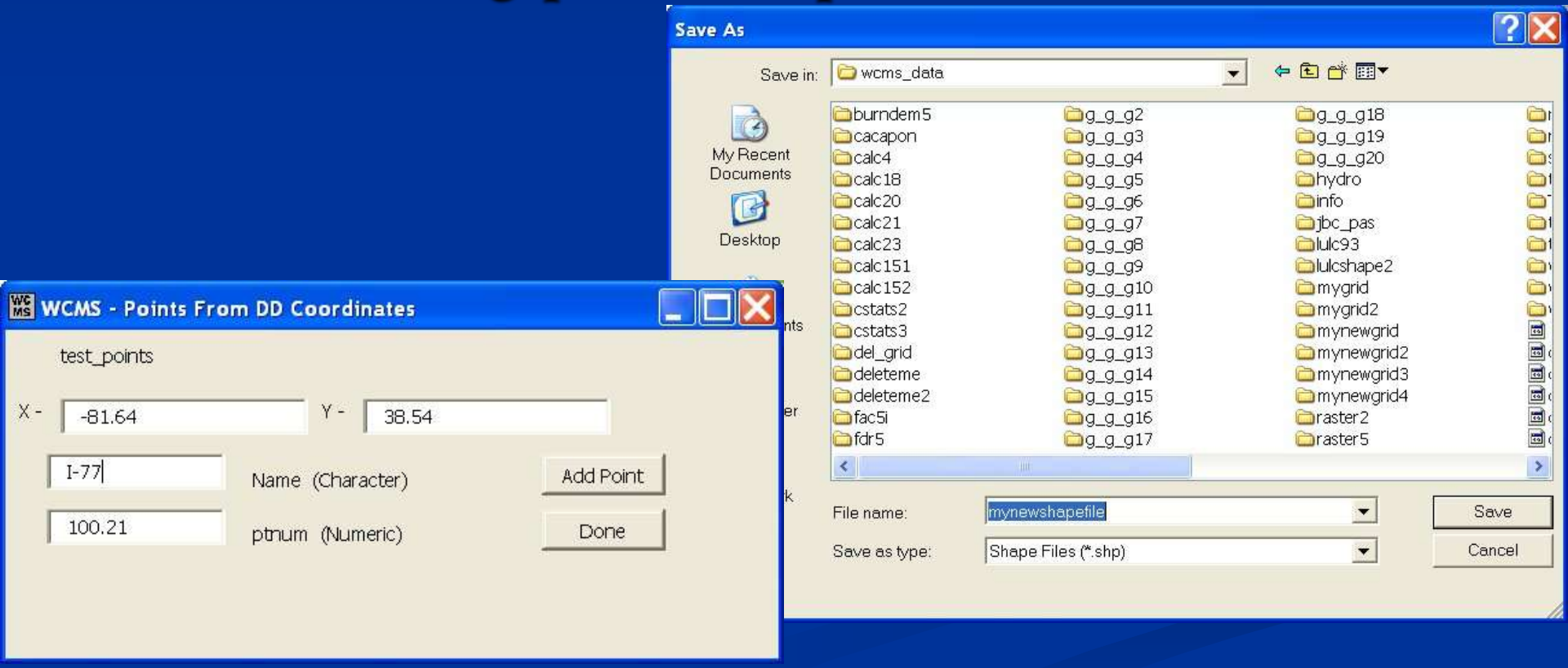


Update/Change Landuse

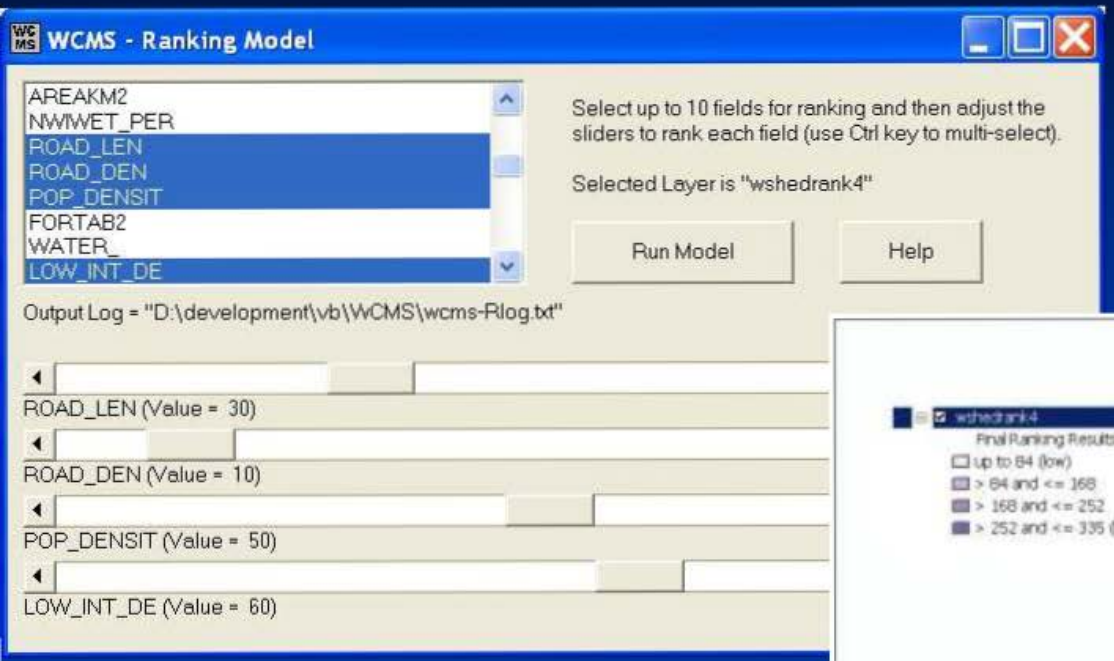
Original Digitize new Update grid

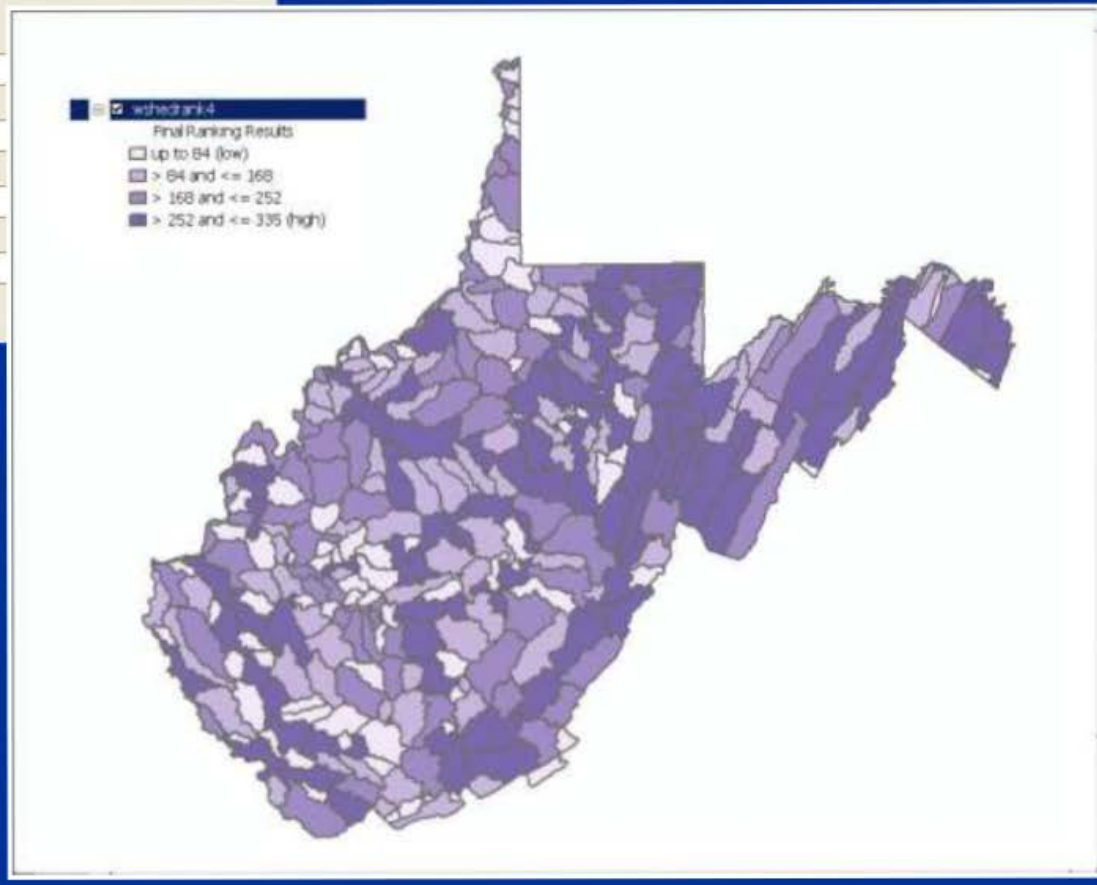
Adding Points

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



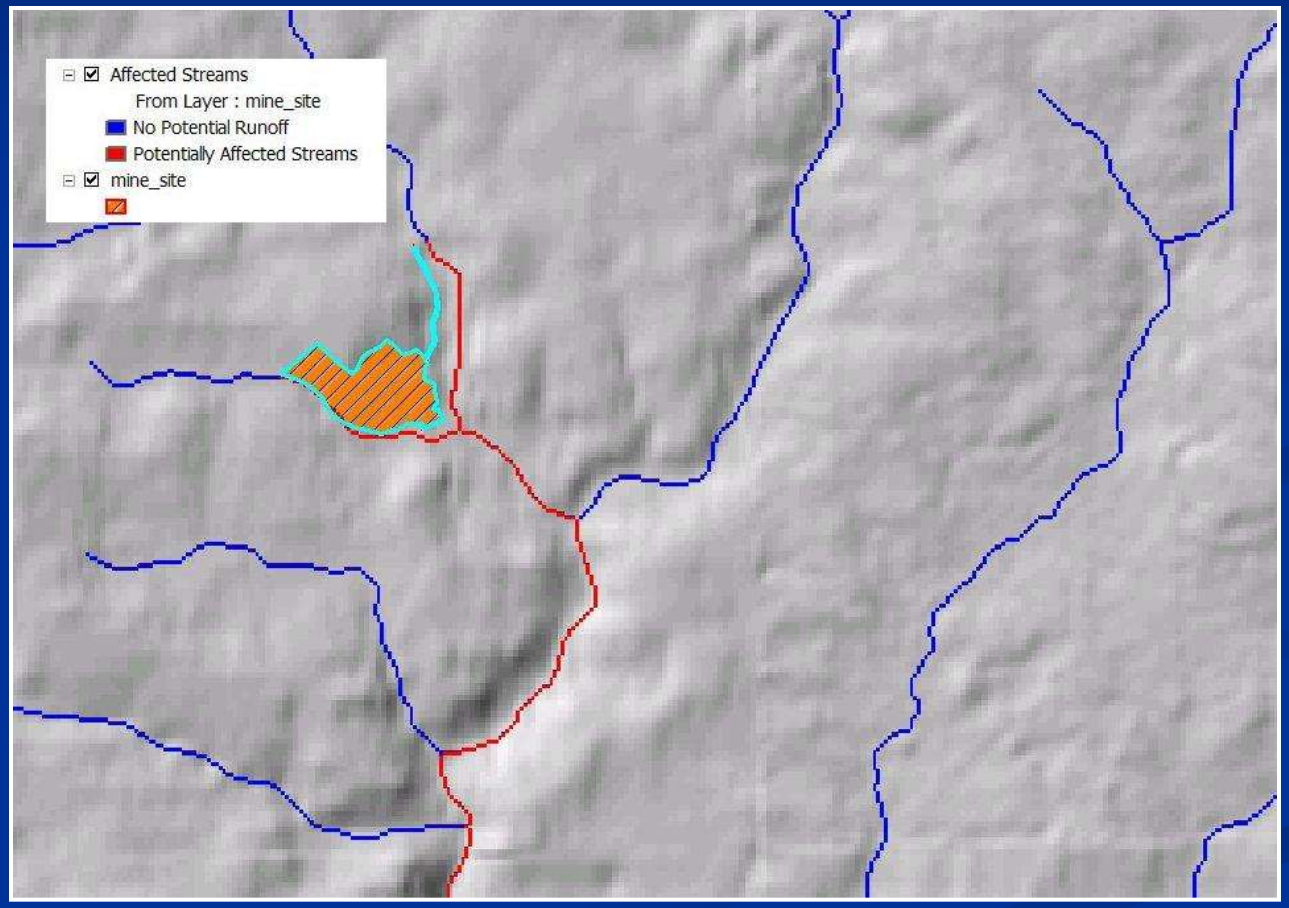
Ranking Model (Multiple Criteria)



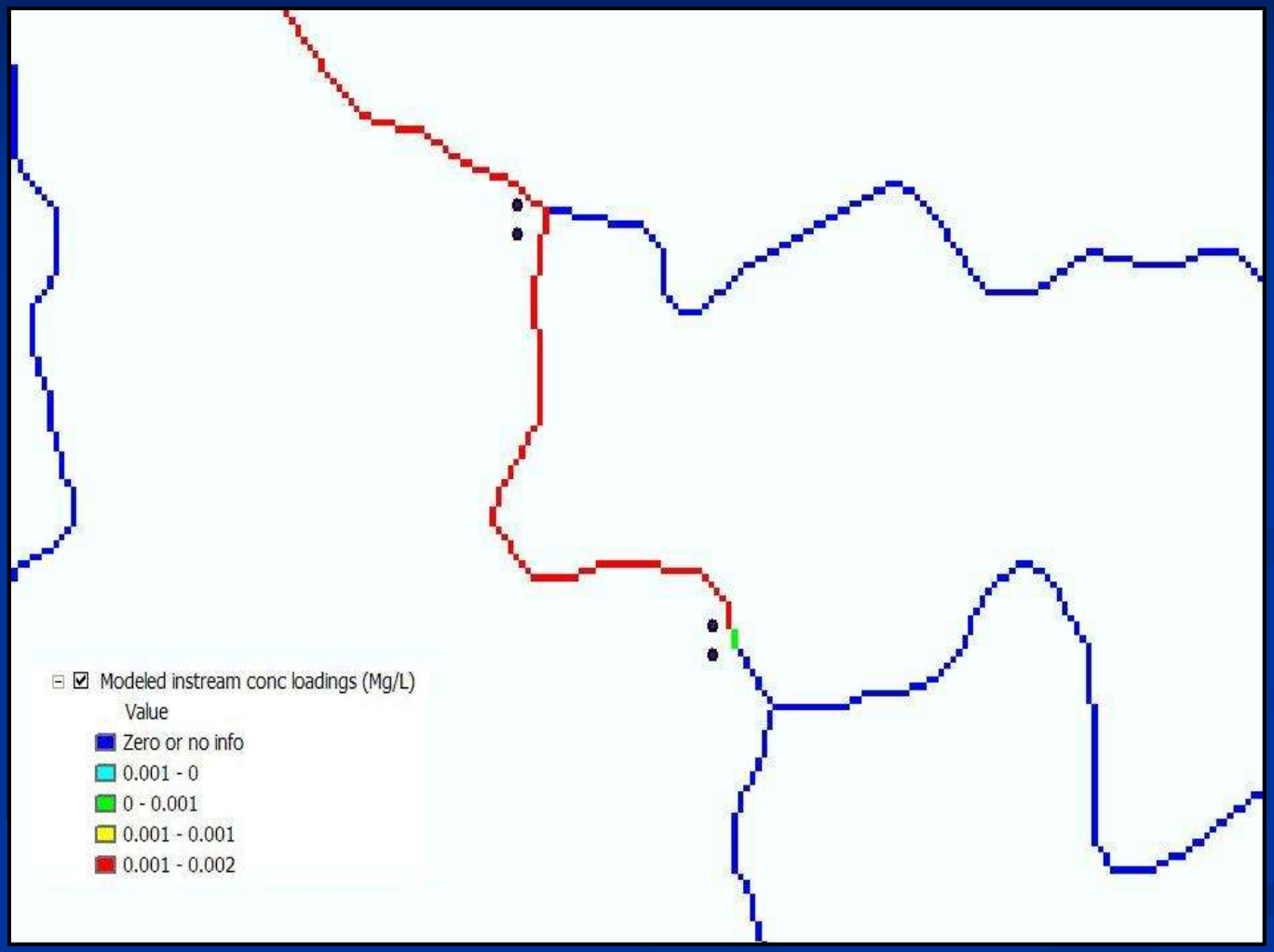


Water Quality Prediction

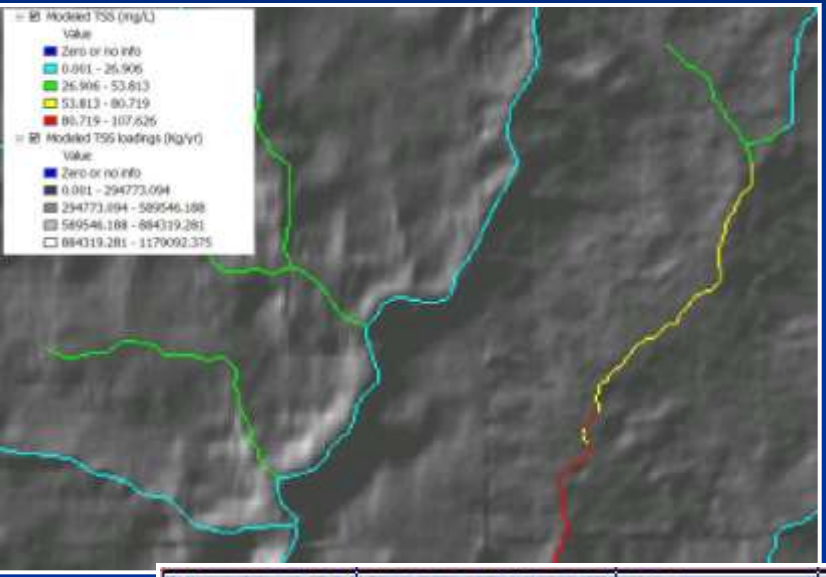
Potentially Affected Streams Results



Water Quality-Average Concentrations

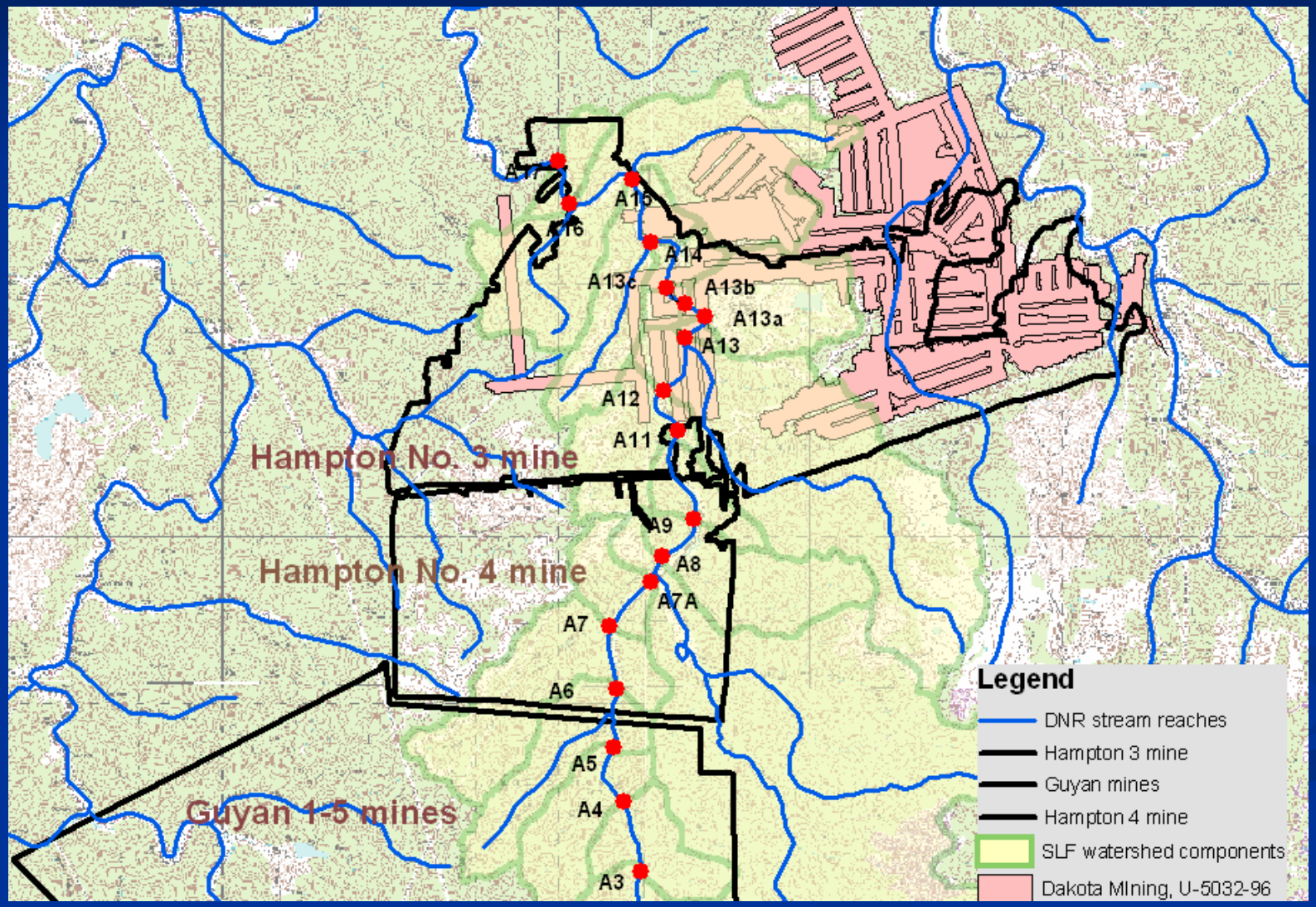


Water Quality – Expected Mean Concentrations from Landuse and Soils



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

- Development of WCMS within NRAC has been supported by numerous activities
- 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
  - Precip data - from ZedX – hourly estimates, 1949-2002, 5 km grid for all of WV (20 GB SAS Dataset)
- Coordinated effort of NRAC, WVU Dept of Civil and Environmental Engineering, and the USGS/Water Resource Division in West Virginia
- Objective – develop appropriate models of flow for streams in the WV mining region

Summary

- WCMS remains a work in progress – capabilities continue to expand
- ArcView version continues to be used by most permit writers in WVDEP
- ArcGIS version now being used by advanced WVDEP users with broad adoption scheduled for Summer, 2004 (currently ongoing change)
- 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

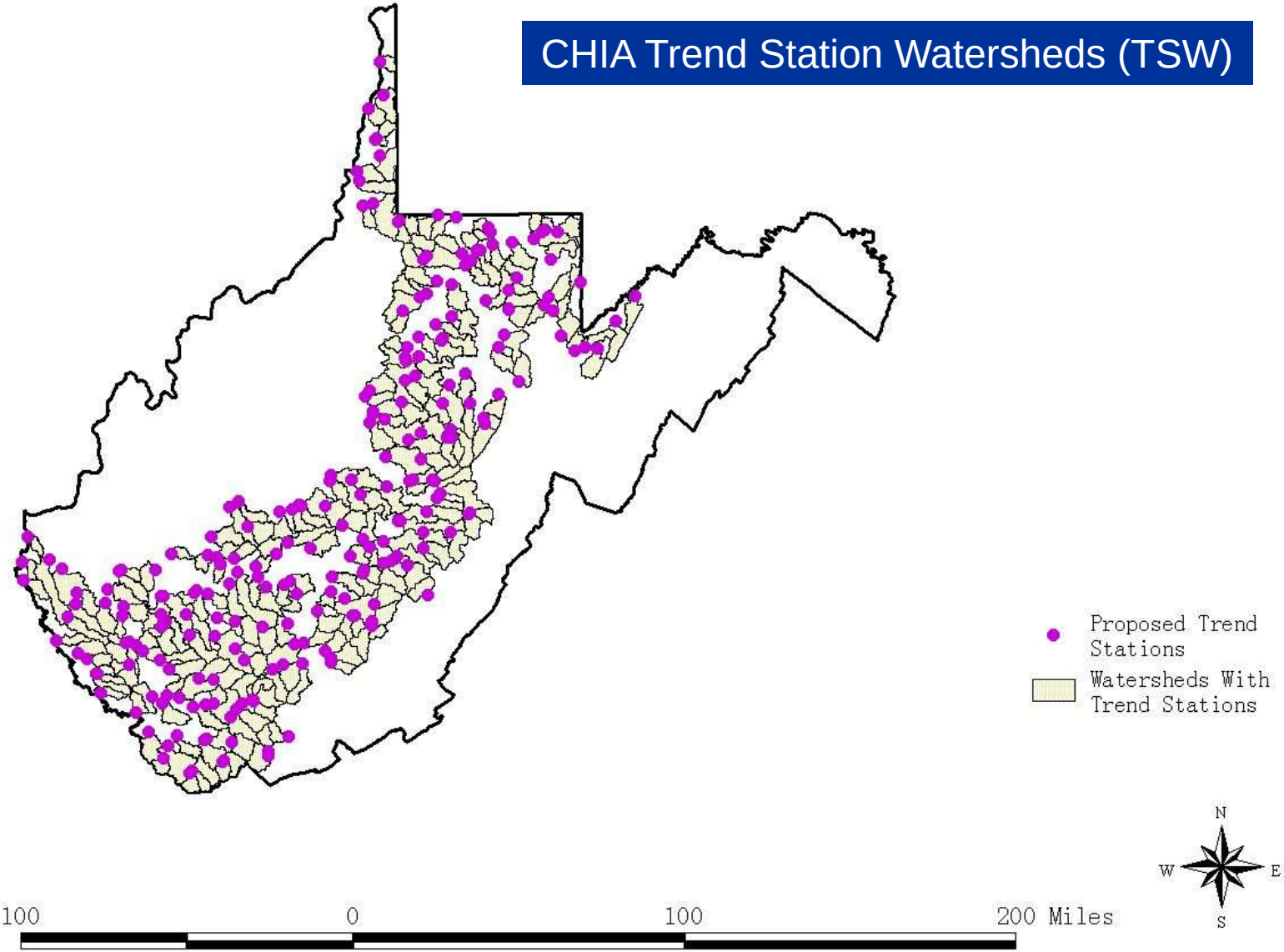
HSPF Model Description

- It is a continuous watershed simulation model
- It can be applied to natural and developed watersheds
- Model components simulate both the surface and subsurface hydrology and water quality processes.
- HSPF utility programs provide time series data management , statistical analysis tools, and graphic display of results.
- Both stream and lake hydraulics, and water quality processes, can be simulated.
- Development and maintenance of HSPF related software is sponsored by EPA and USGS.

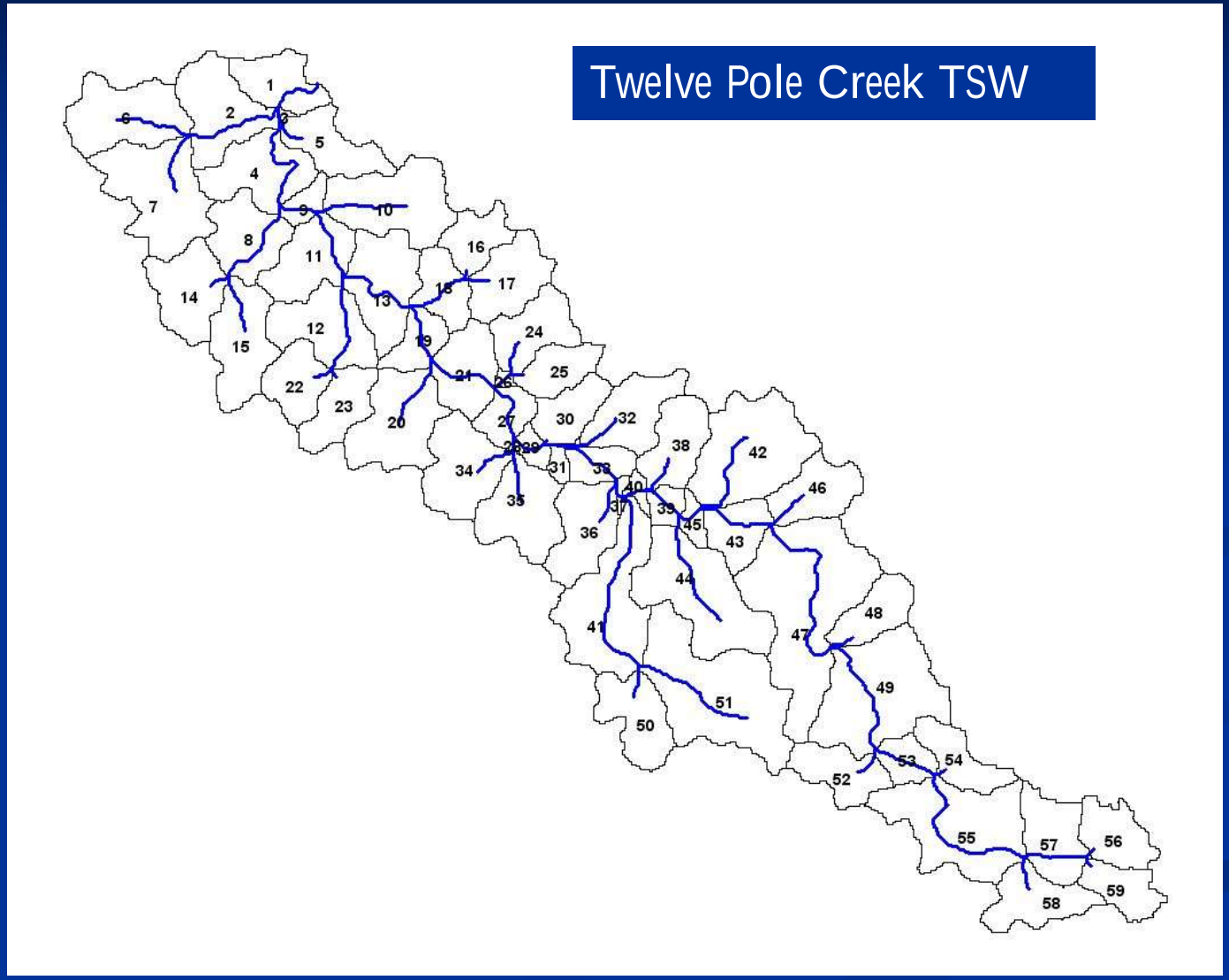
Hydrologic Modeling Strategy

- Apply HSPF to WVDEP CHIA Project
  - Fit HSPF to 235 CHIA Trend Station Watersheds (TSW)
- Construct CHIA Watershed Database
  - HSPF input files, meteorologic, and water quality data
- Develop Model Calibration and Verification Procedures
  - Hydrologic calibration and verification using 9 gaged watersheds
  - Water quality model verification using EQUIS data
- Design HSPF Mine Model Components
  - Surface and deep mine HSPF model outflows at NPDES, bond forfeiture, and AML points
- Provide WCMS/HSPF Interface and Incorporate into WCMS
  - User-friendly GUI/GIS application tools
  - Scenario development tools (mine sites)

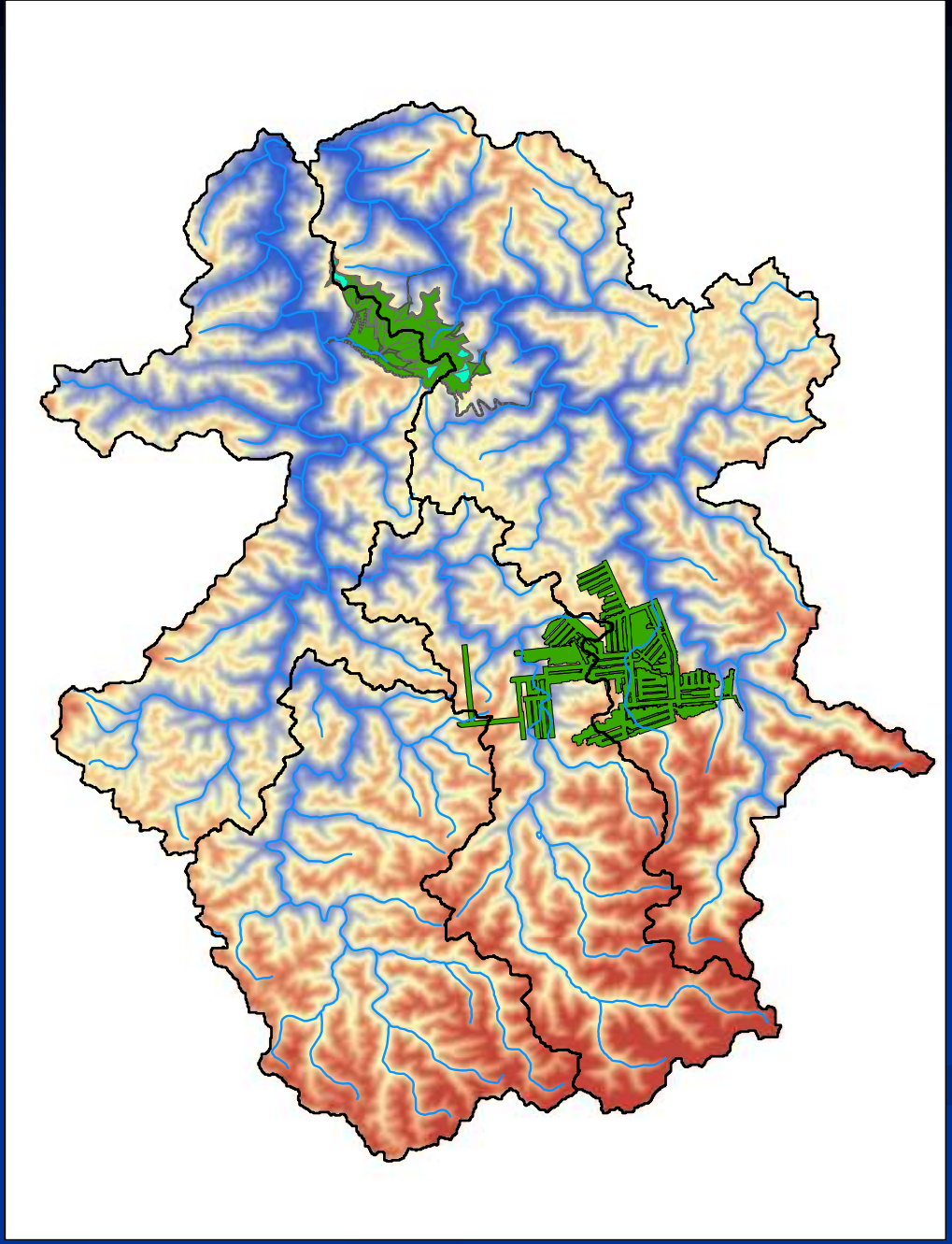
CHIA Trend Station Watersheds (TSW)



Example TSW Subdivision



Surface and Deep Mine HSPF Models



Surface Mine Segmentation

- Drainage Areas

↓

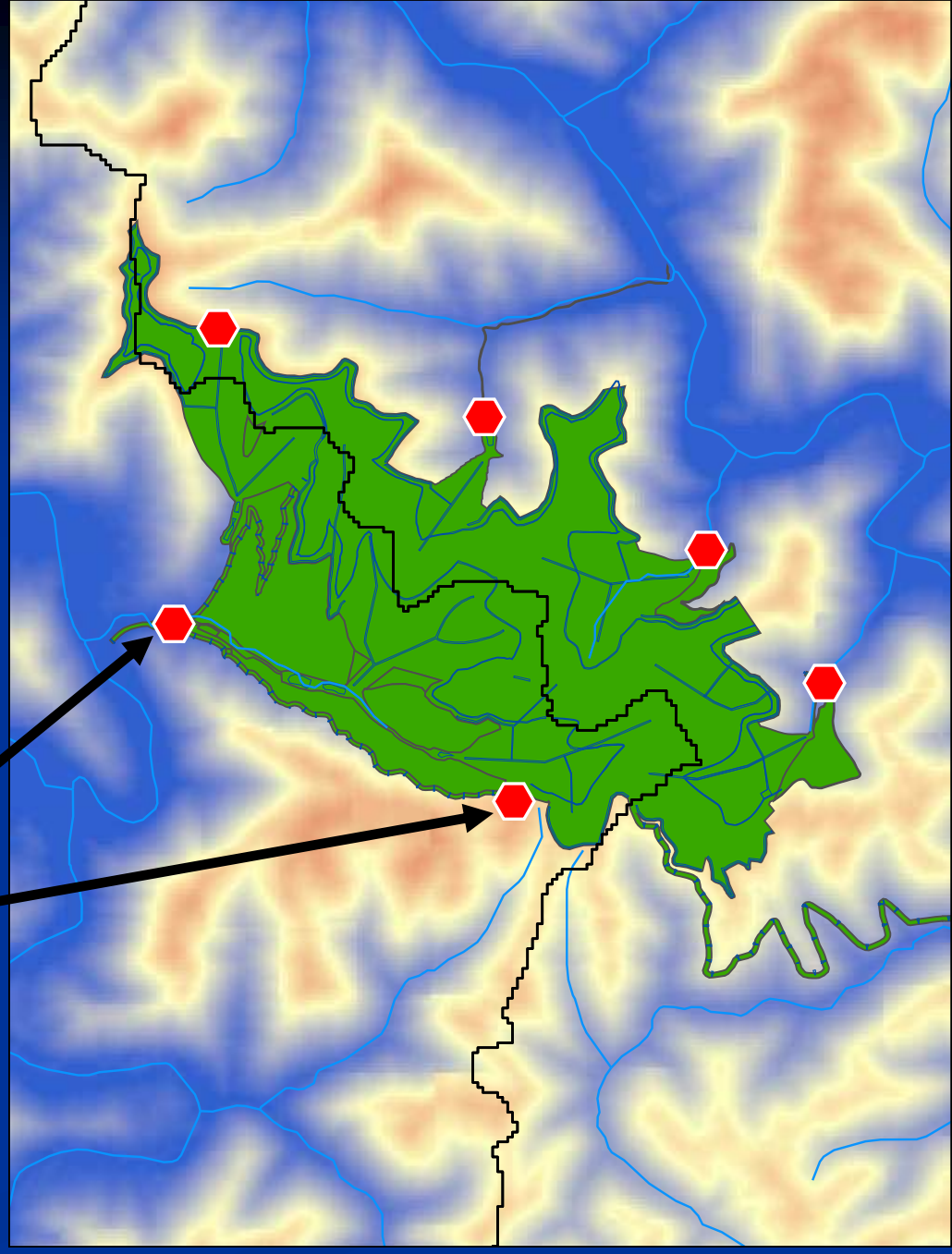
- Sediment Ponds

↓

NPDES Points

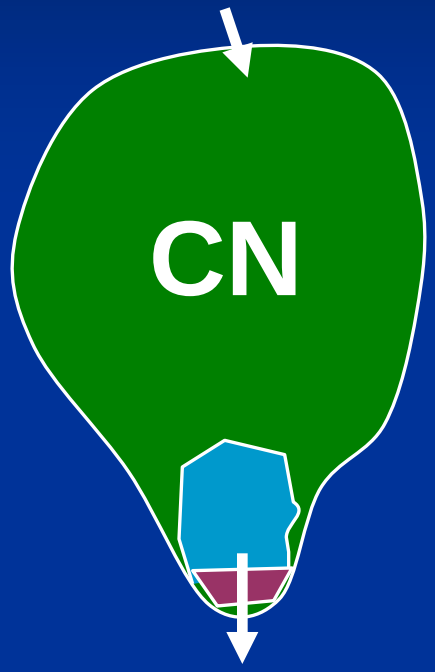
↓

Stream Segment



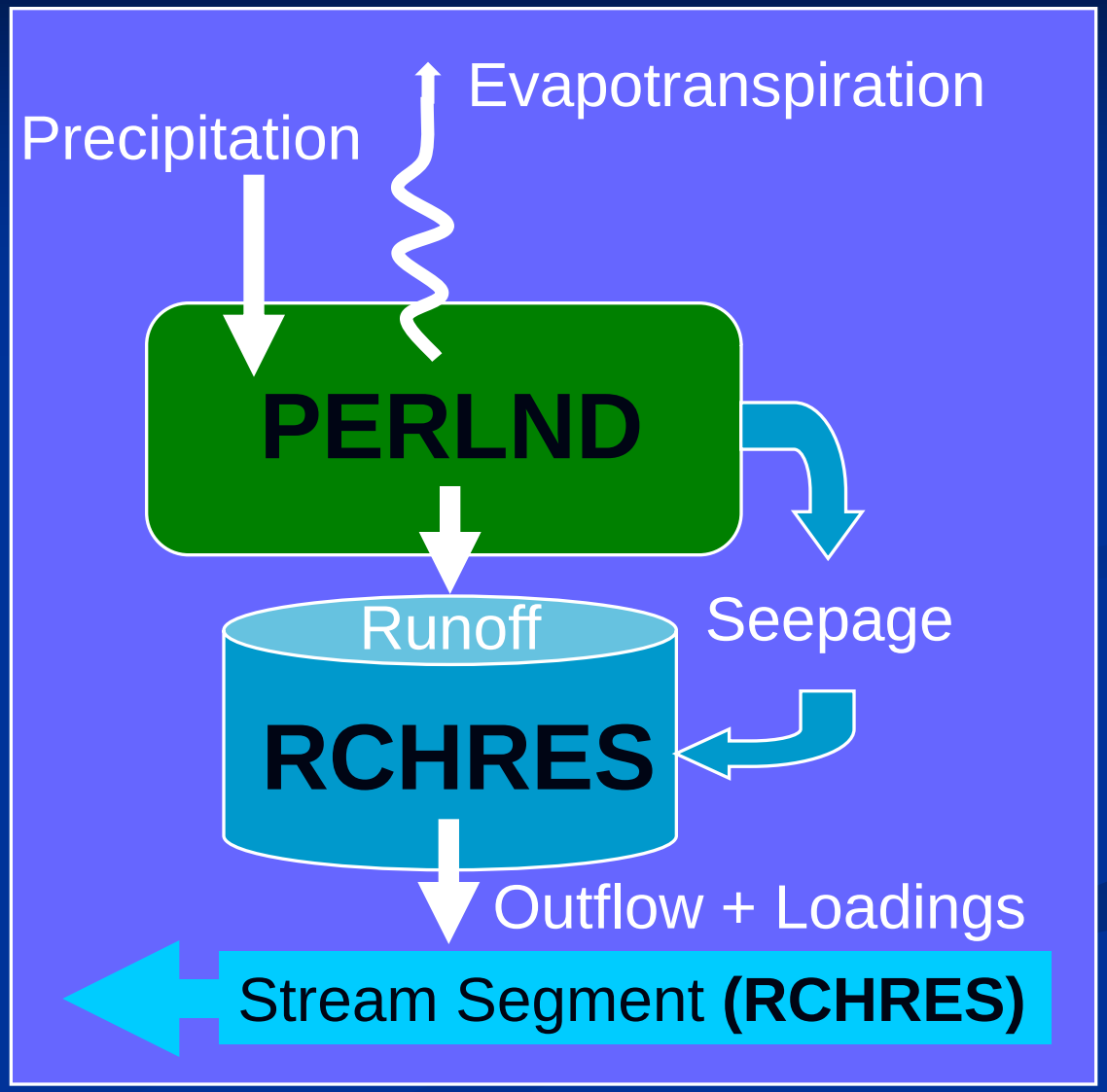
Surface Mine HSPF Model

Drainage Area



Volume Versus Outflow

+ Water Quality Loadings



Deep Mine Segmentation

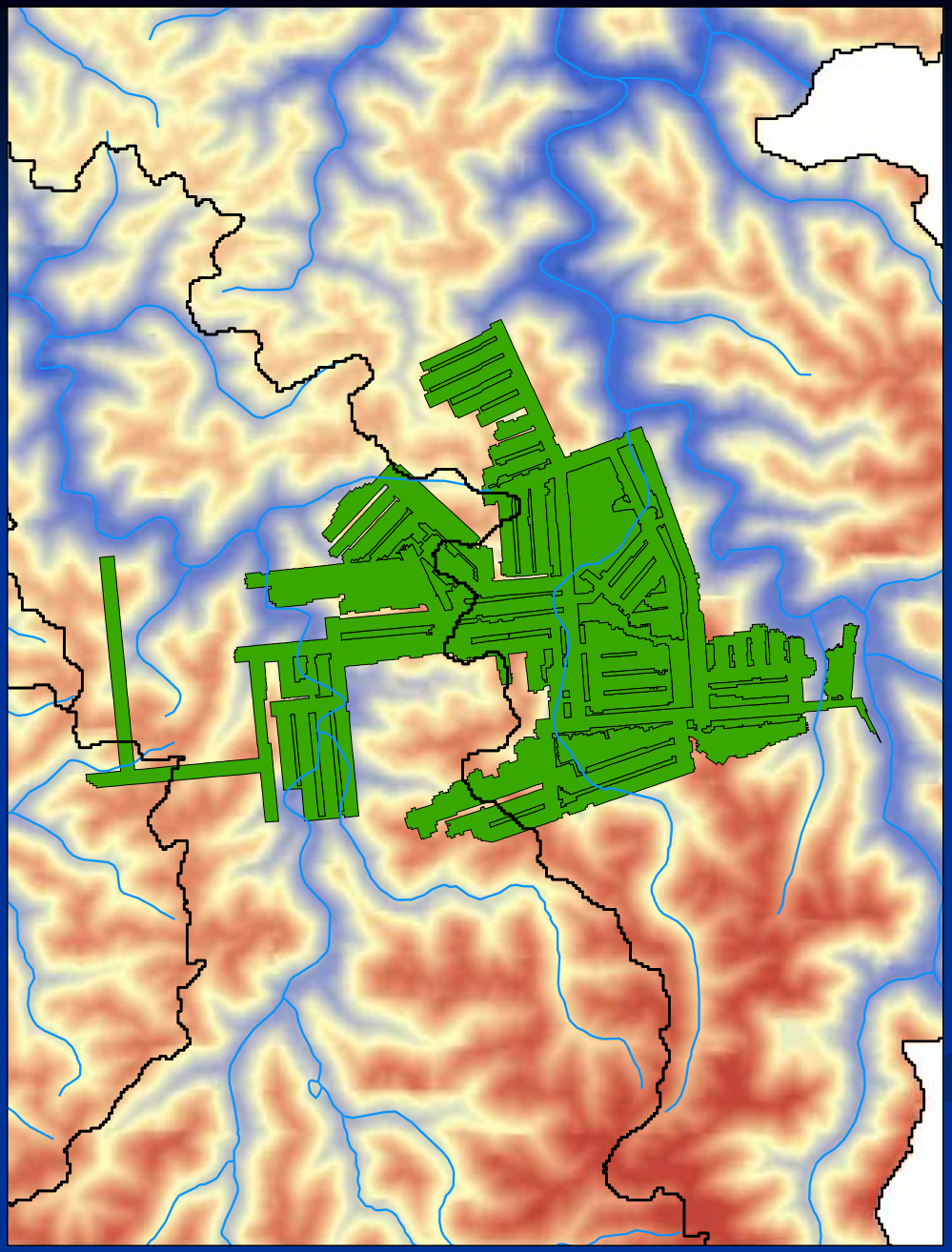
Surface Recharge Areas

↓

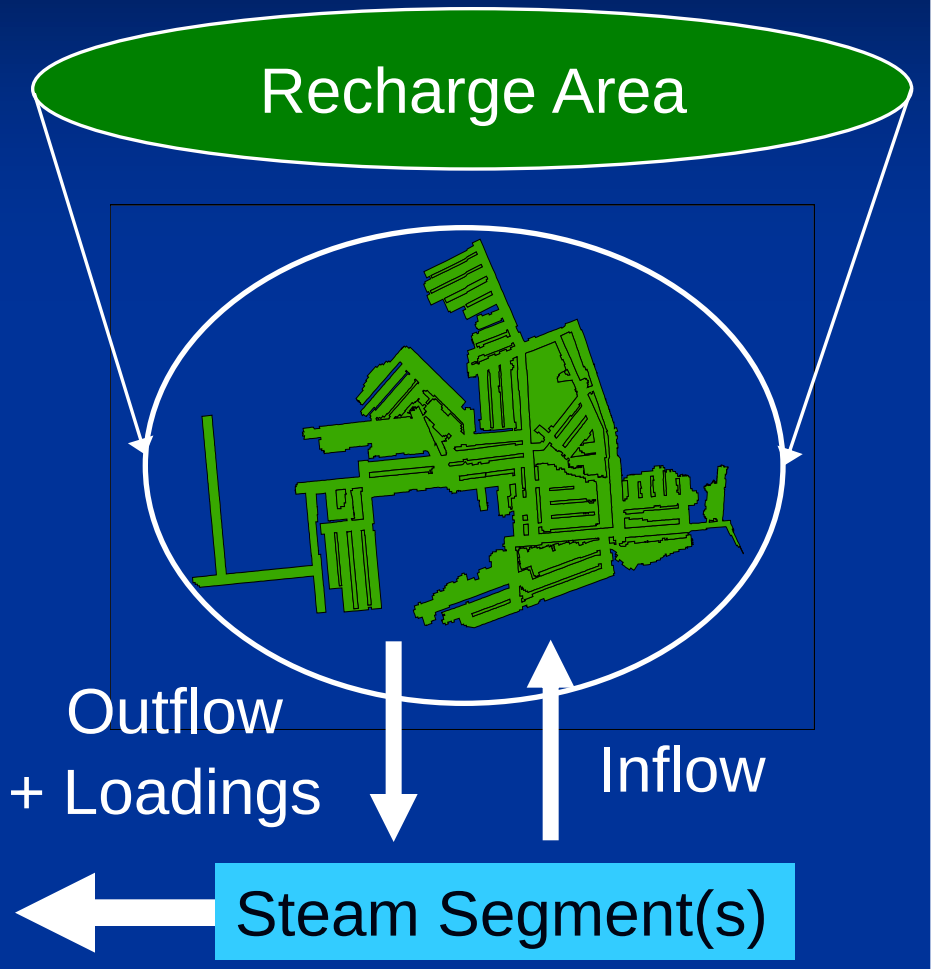
Mine Cavity Storage

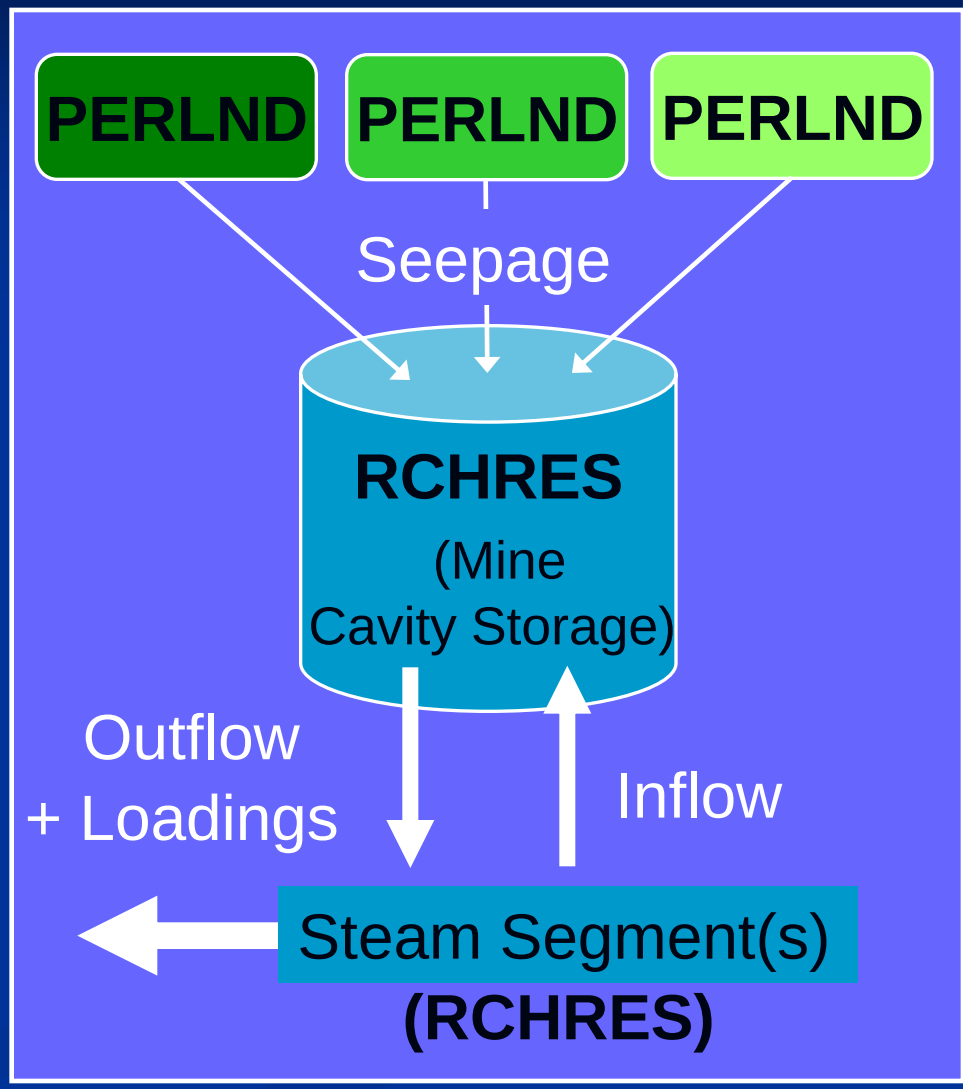
↕

Stream Segment Inflow - Outflow



Deep Mine HSPF Model





WCMS – HSPF Integration

- Macros have been developed to create input files for HSPF (similar to BASINS)
- Macros support modification of land use data to simulate the effects of proposed surface mining operations or other disturbances
- Implementation of links to water quality data in Oracle tables and modification of HSPF Acid subroutines continues
- Surface and deep mine modeling tools are in the design stage

Clear Fork CHIA

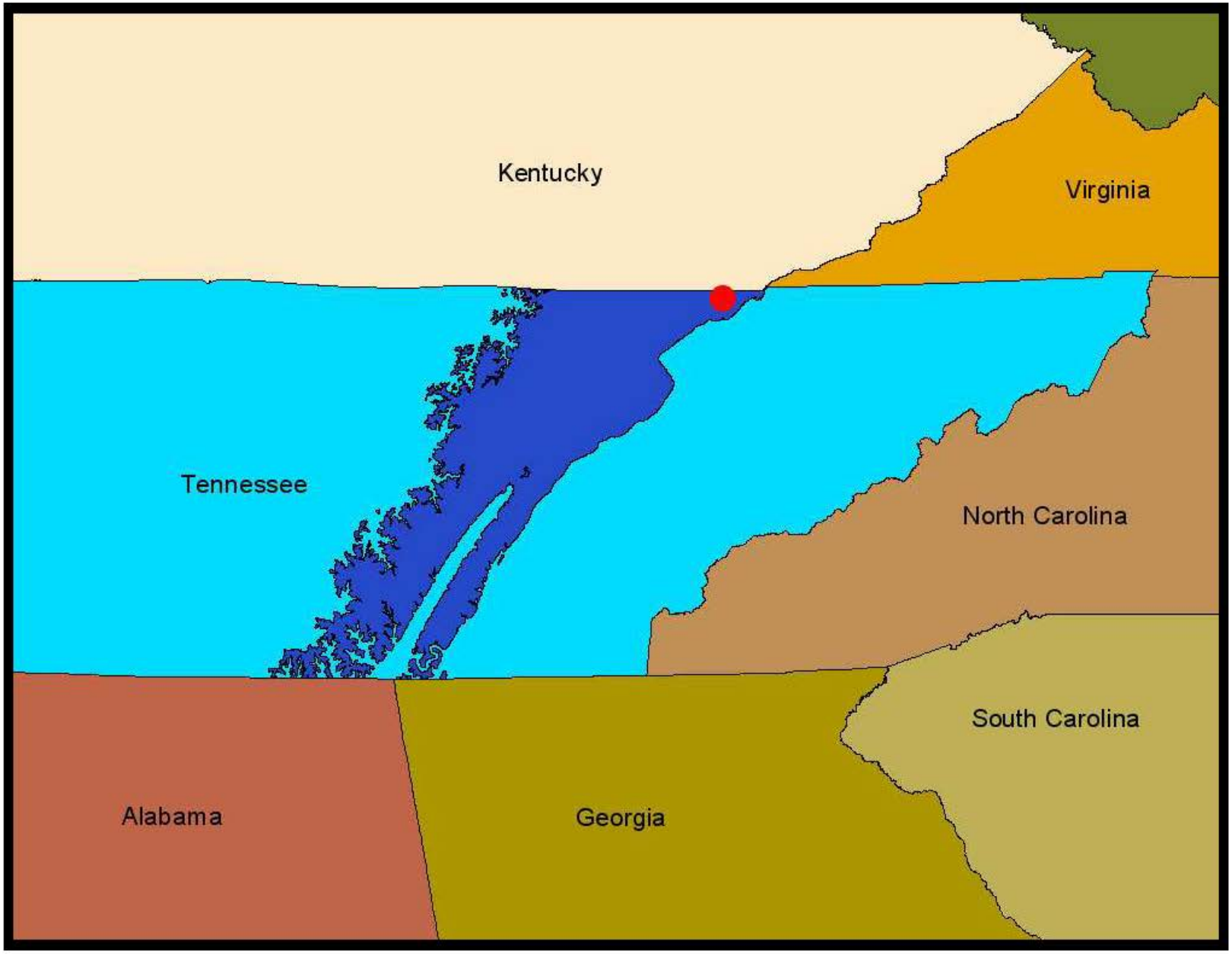
HFO

HFO

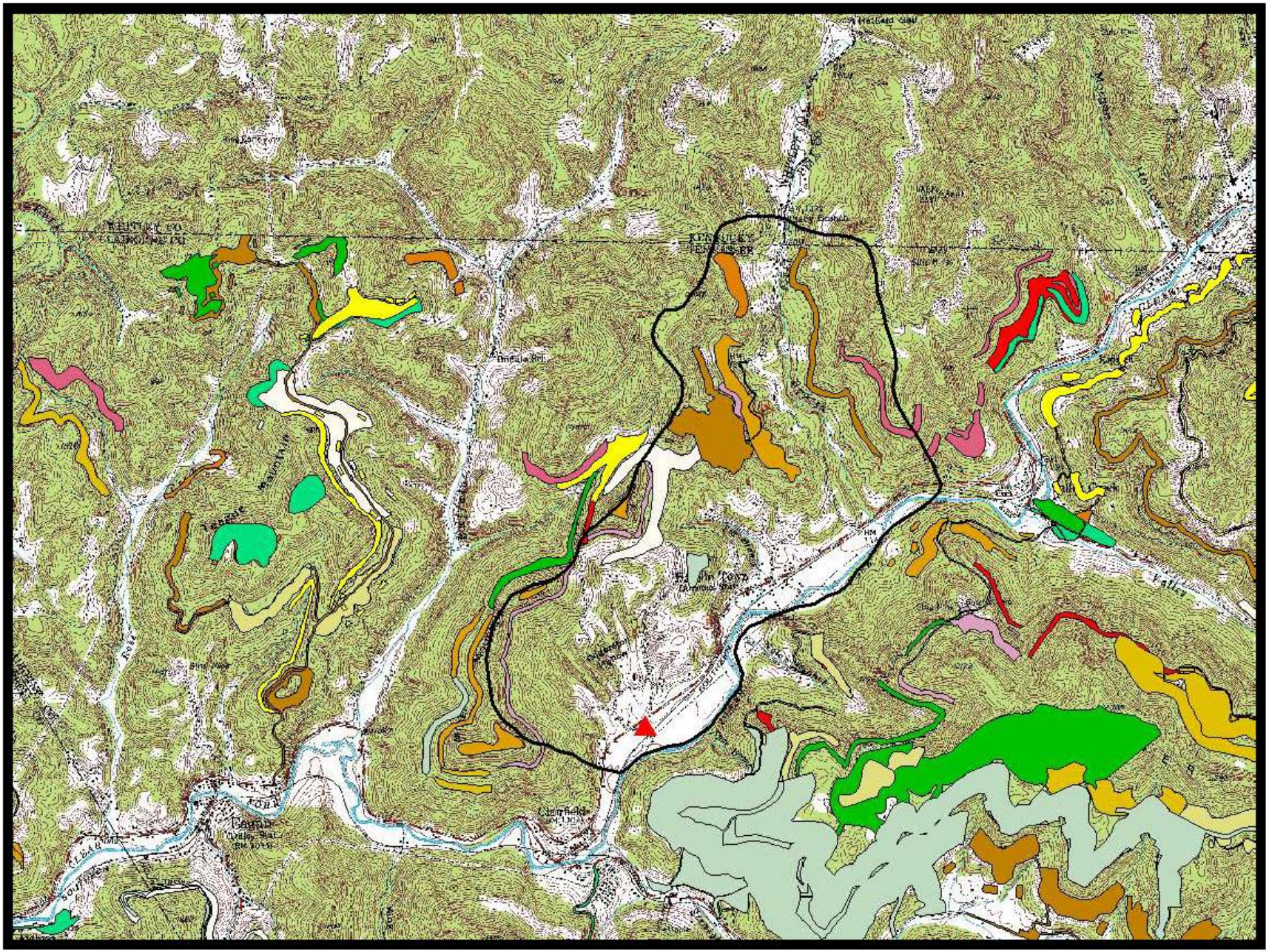
Issue:

1. Continued mining in the Clear Fork watershed will raise the TDS above 500 mg/L (EPA secondary drinking water standard)

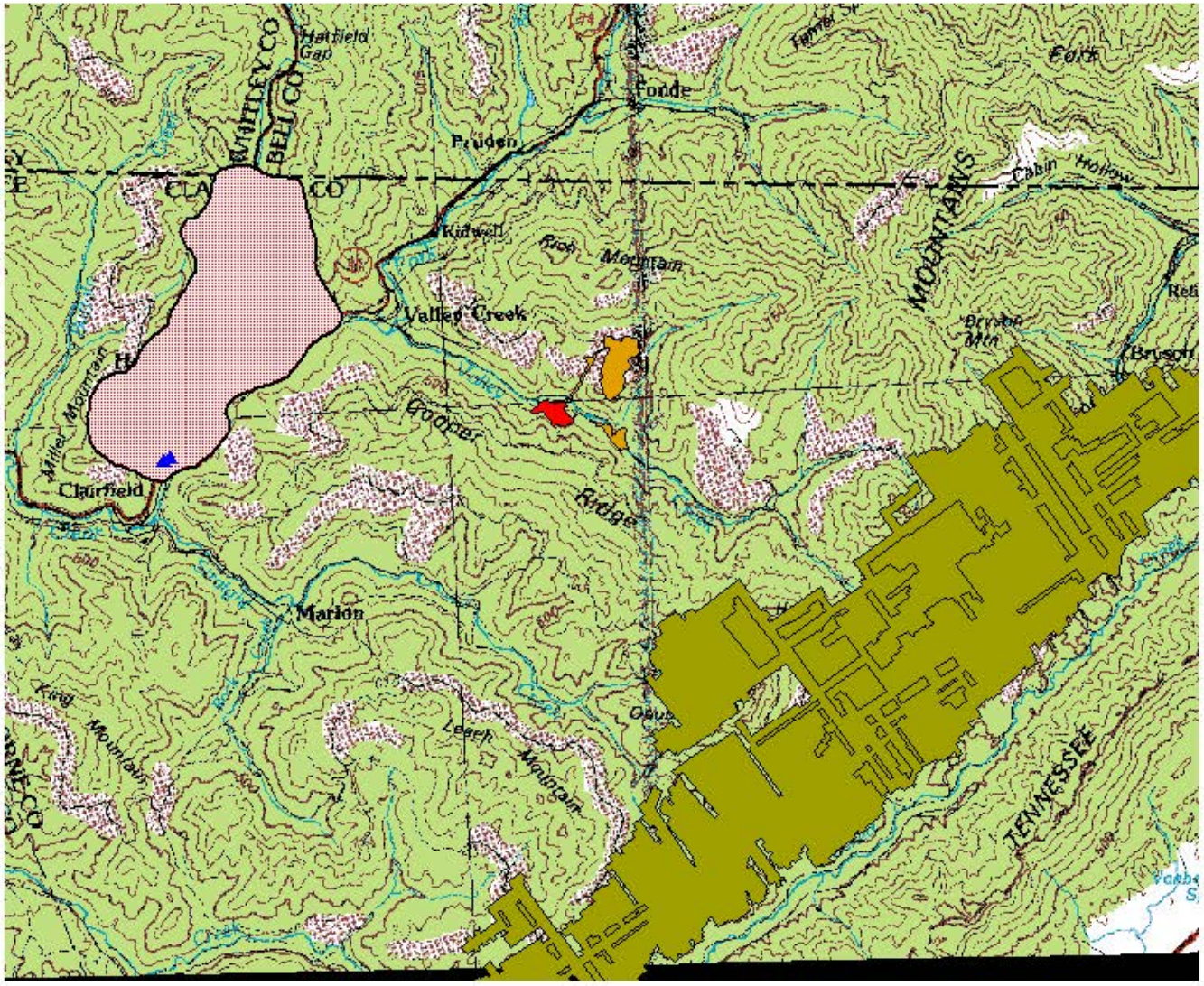
2. The Clear Fork Municipal water supply wells that serve ~500 rural users are located ~ 700 ft from Clear Fork Creek.

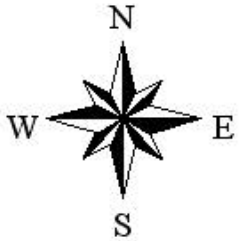

Kentucky
Virginia
Tennessee
North Carolina
South Carolina
Alabama
Georgia

Historical Mining in Clear Fork Watershed



Relative Position of Hydrologic Areas of Concern





- Utility and Test Wells
- Matthews Mine
- Wellhead Protection Area
- Jellico South Mine
- Jellico North Mine

3 0 3 6 Miles

HFO

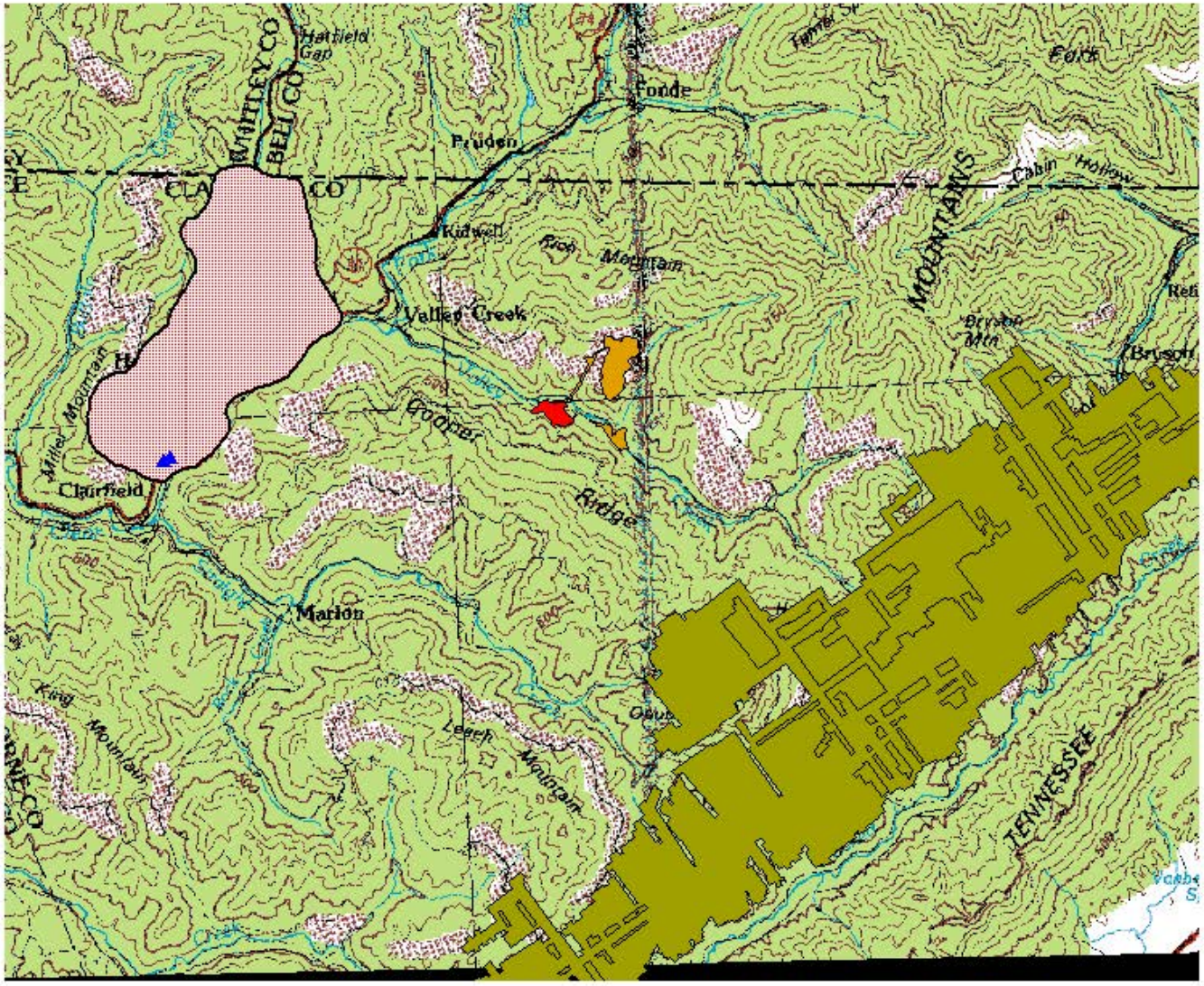
Clear Fork Water Quality

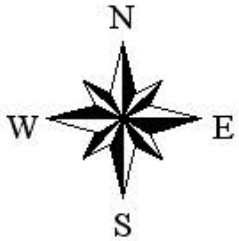
pH	7.8
Alkalinity	70
TDS	100 - 600
Spec. Con	250
Al	0.0403
As	0.000186
Ca	31.5
Cu	0.00253
K	2.17
Fe	0.283
Mg	20.5
Mn	0.206
Na	8.9
Zn	0.113
F	0.13
Cl	1.91
Nitrate-N	<0.01
Bromide	<0.03
Nitrite-N	0.27
Phosphate-P	<0.02
Sulfate	129

	Clear Fork	Pumping Well
pH	7.8	6.7
Alkalinity	70	170
TDS	100 - 600	104
Spec. Con	250	
Al	0.0403	0.00222
As	0.000186	0.000598
Ca	31.5	28.8
Cu	0.00253	0.00605
K	2.17	1.74
Fe	0.283	5.91
Mg	20.5	9.72
Mn	0.206	0.335
Na	8.9	41.1
Zn	0.113	0.0243
F	0.13	0.23
Cl	1.91	21.4
Nitrate-N	<0.01	<0.01
Bromide	<0.03	0.06
Nitrite-N	0.27	<0.01
Phosphate-P	<0.02	<0.02
Sulfate	129	40.6

Consistent with GW

Relative Position of Hydrologic Areas of Concern





- Utility and Test Wells
- Matthews Mine
- Wellhead Protection Area
- Jellico South Mine
- Jellico North Mine

3 0 3 6 Miles

	Mathews UG Mine
pH	7.8
Alkalinity	638
TDS	358
Spec. Con	
Al	0.0114
As	0.00151
Ca	14.1
Cu	0.00409
K	3.62
Fe	0.406
Mg	7.55
Mn	0.121
Na	320
Zn	0.0124
F	1.10
Cl	2.58
Nitrate-N	<0.04
Bromide	<0.12
Nitrite-N	<0.04
Phosphate-P	<0.08
Sulfate	130

Flow = 1000 gpm

HFO

Mathews Mine Discharge

HFO

Study Objectives:

1. Does a hydrologic connection exist between Clear Fork and the Municipal water supply aquifer?

2. If a connection exists, what percentage of the well water is pulled from Clear Fork?

3. If high TDS water continues to be discharged into Clear Fork, at what point will the well water exceed secondary drinking water standards?

Methodology used to identify a hydrologic connection btw pumping well and Clear Fork:

HFO

1. Perform a pump test using the pumping well and an observation well to identify a recharge boundary (Clear Fork).

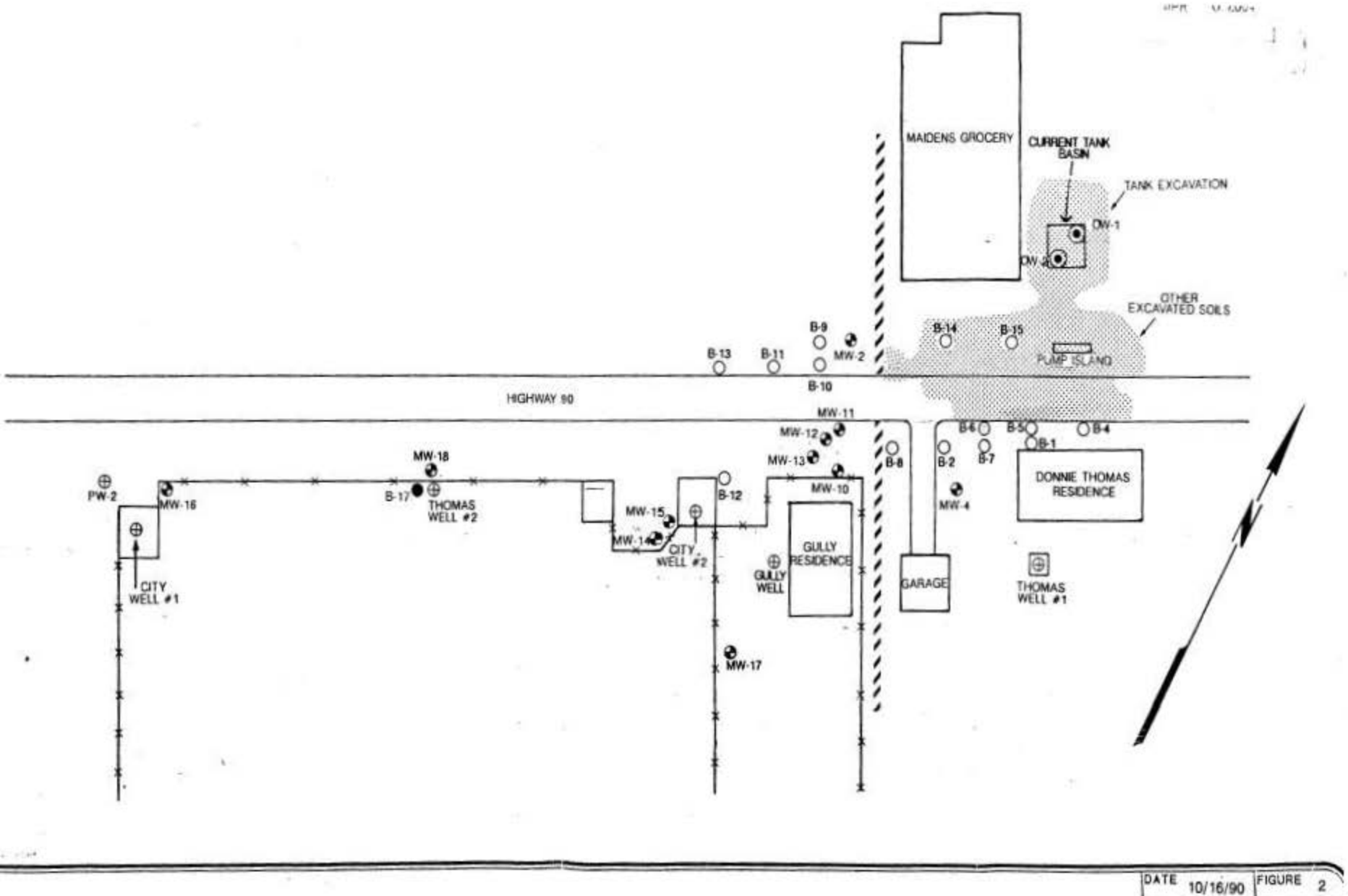
2. Collect water quality data during the pump test to try to identify and correlate any change in water quality with an appearance of a recharge boundary

HFO

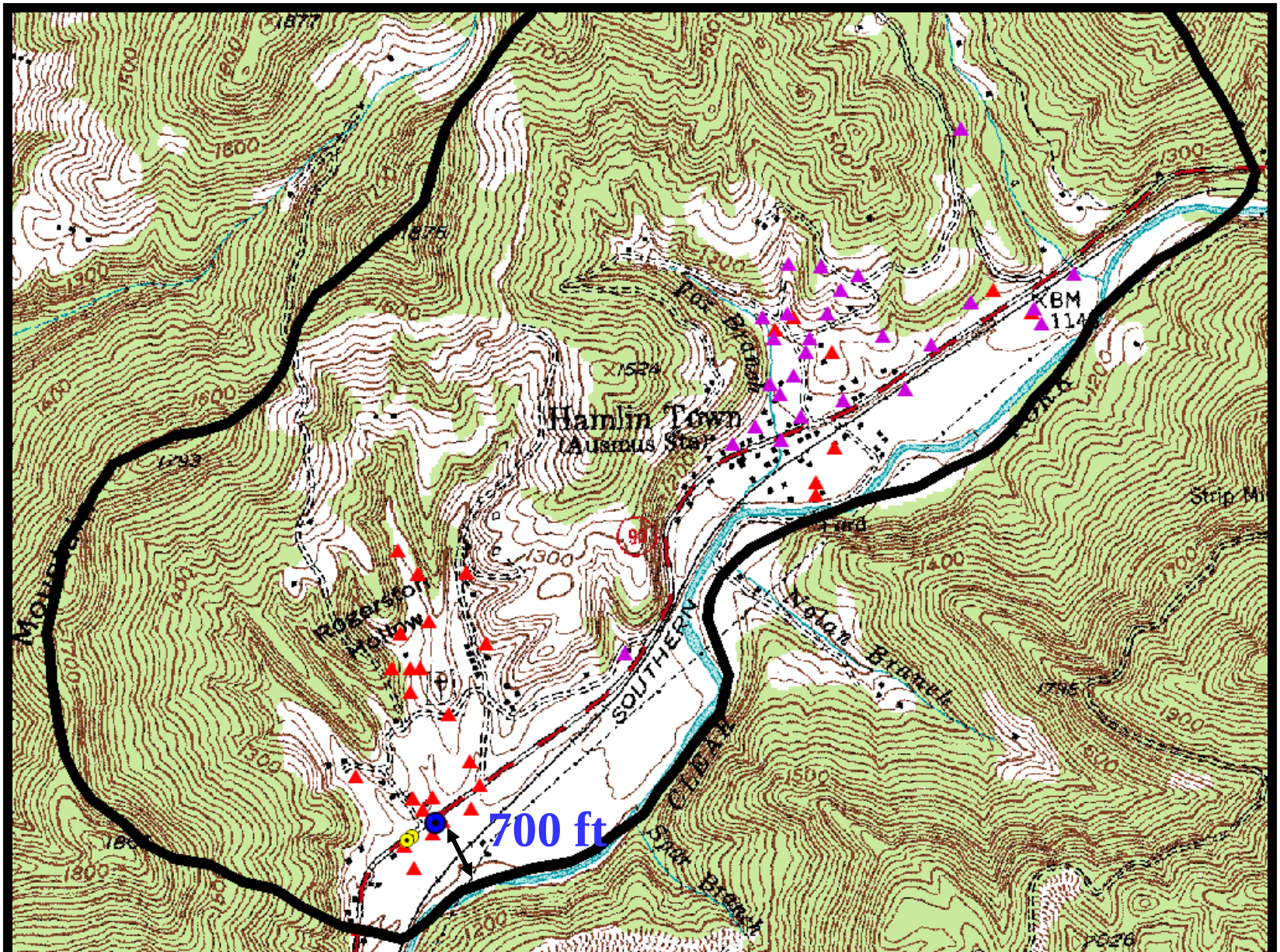
Pump Test Specifics

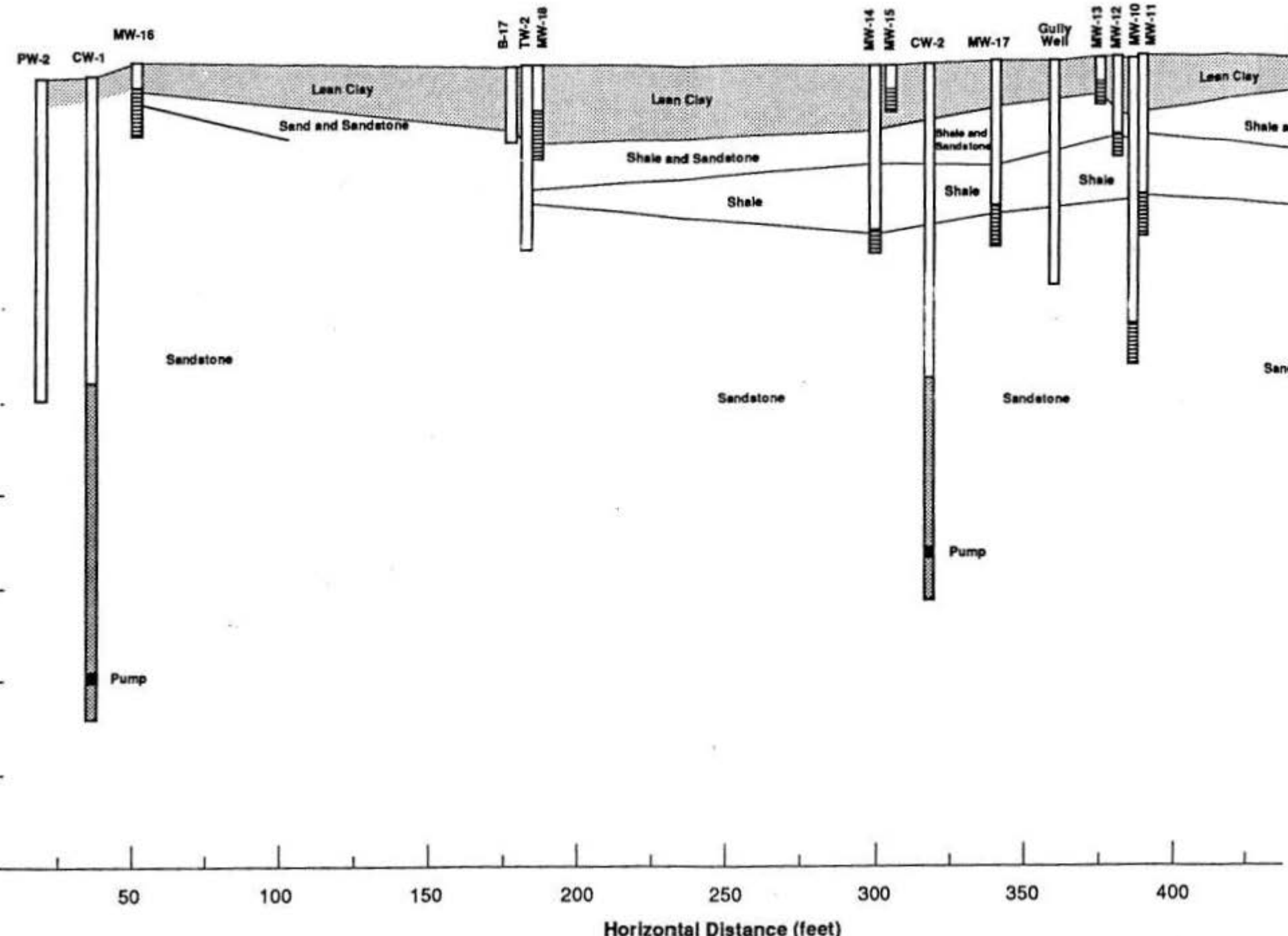
- In Jan. 2004, we pumped at 180 gpm for 24 hours.
- We decided that 24 hours should be sufficient since the municipality only pumps for 12 hours at a time.
- If no recharge boundary was identified with in 24 hours, then we will assume that any hydrologic connection is insignificant???

Finding an Observation Well



Hydrologic Connection between Clear Fork and the Water Well?




PW-2
CW-1
MW-16
B-17
TW-2
MW-18
MW-14
MW-15
CW-2
MW-17
Gully Well
MW-13
MW-12
MW-10
MW-11
Lean Clay
Sand and Sandstone
Lean Clay
Shale and Sandstone
Shale
Shale and Sandstone
Shale
Shale
Lean Clay
Sandstone
Sandstone
Sandstone
Pump
Pump
50
100
150
200
250
300
350
400
Horizontal Distance (feet)

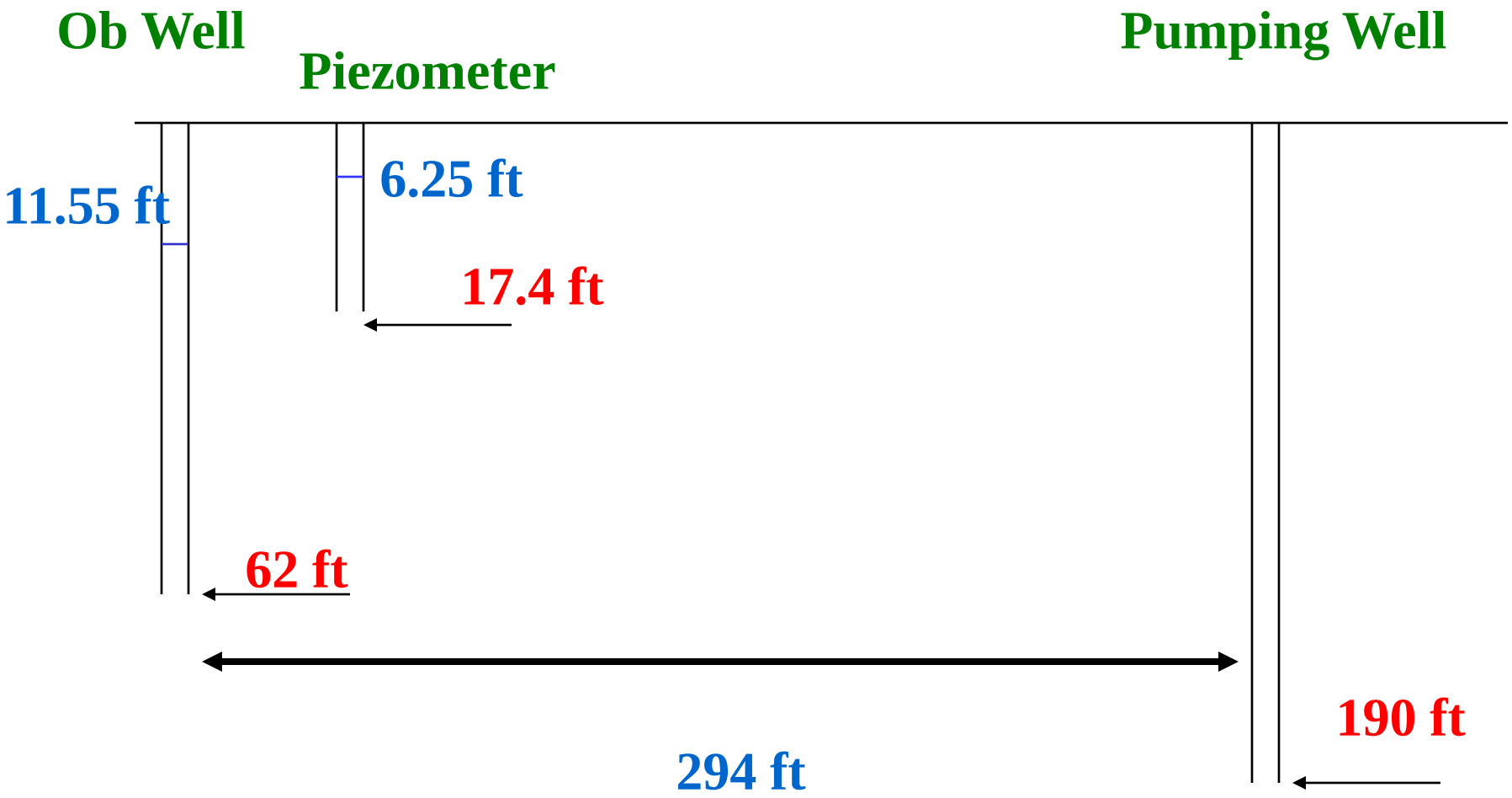
Observation Well

Distance btw pumping well and Observation well = 294 ft

Municipal Water Supply Well

Piezometer

Conditions Before Pump Test



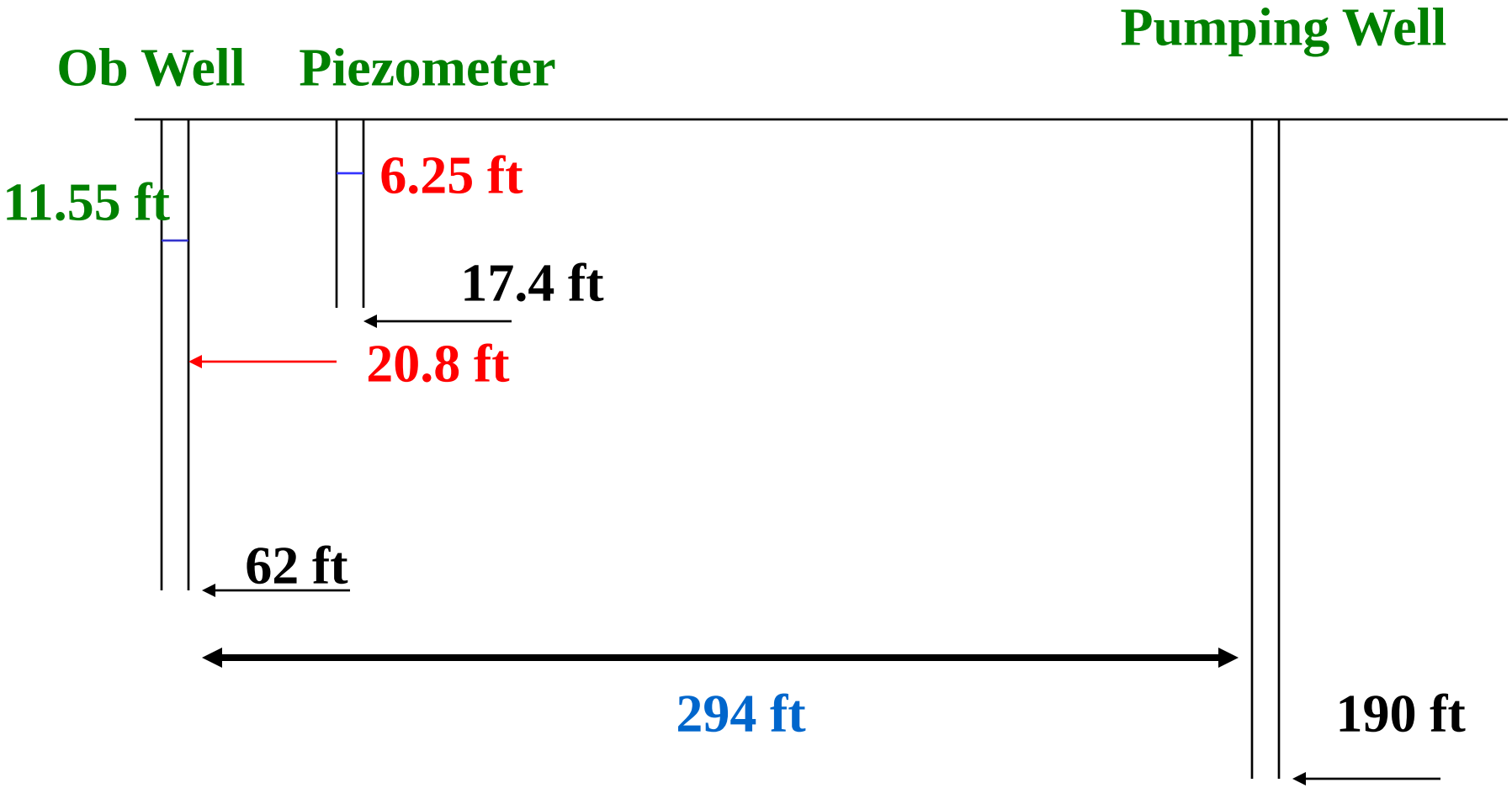
Collecting Data in the OB well while the municipality pumped the well

HFO

HFO

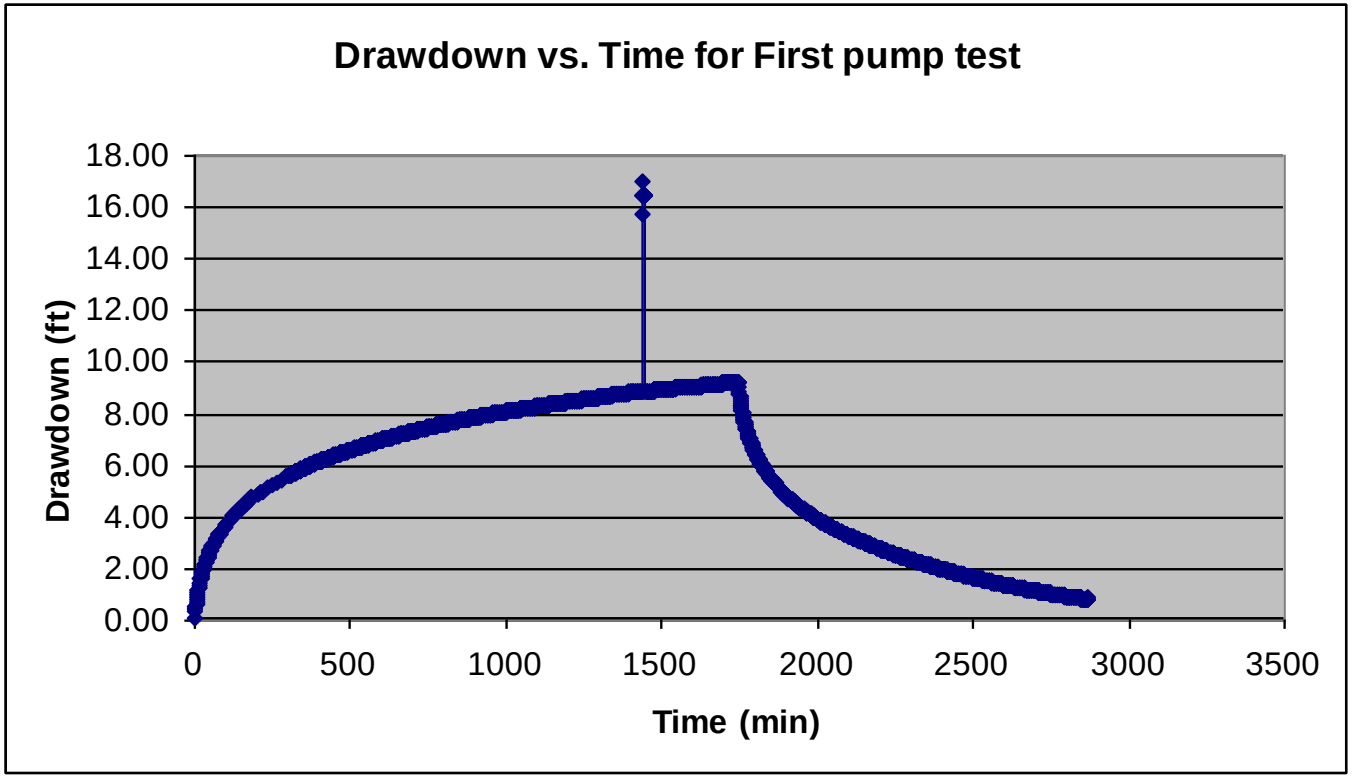
What is Rob Doing??????

Conditions at the end of 24 hours

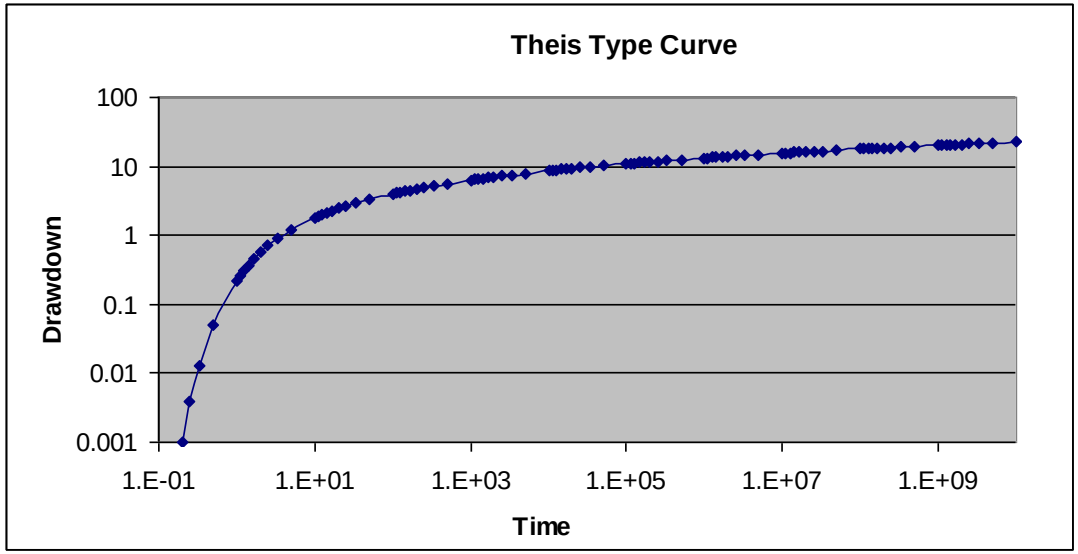


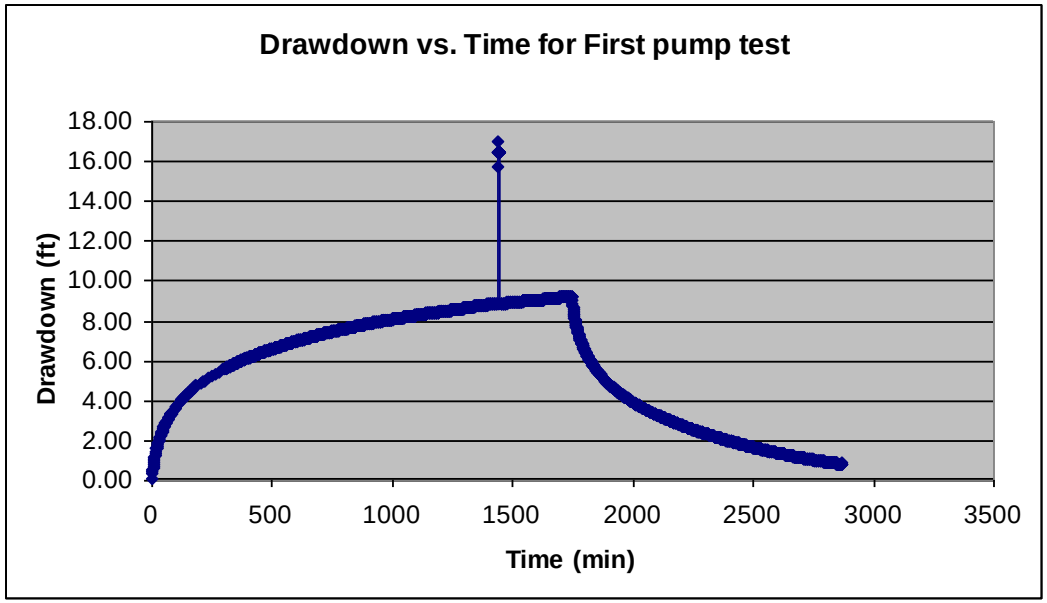
Shallow Piezometer remained constant

HFO


Drawdown vs. Time for First pump test
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Drawdown (ft)
0
500
1000
1500
2000
2500
3000
3500
Time (min)

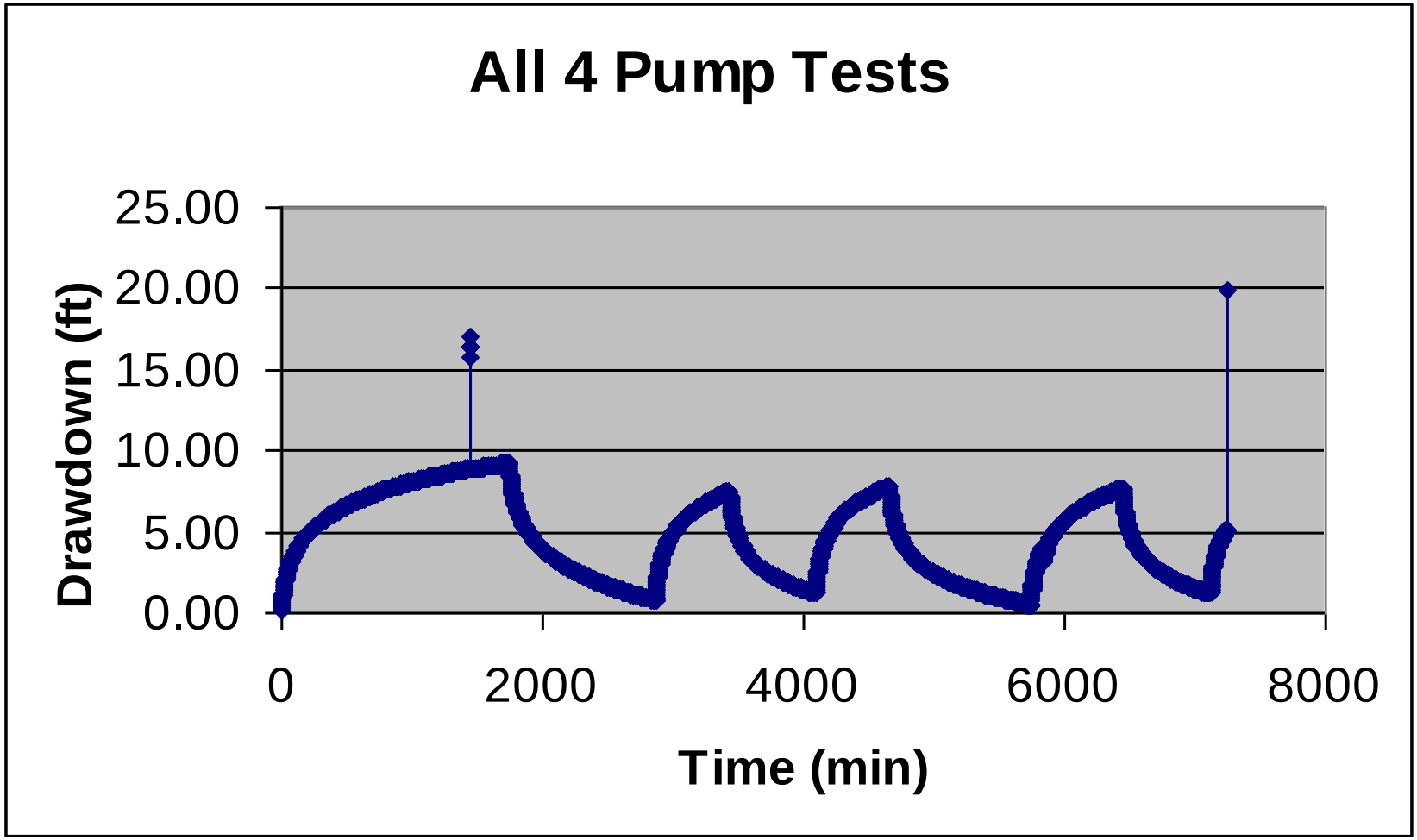
Looking for Deviations from the Theis Type Curve





Drawdown Curves

HFO



HFO

Samples pulled during pump test

	Start	Day 1: 4:05:00 AM	Day 2: 9:30 am	Day 2: 3:15 pm
Al	0.0022	-0.0020	-0.0020	0.0058
As	0.0006	0.0008	0.0009	0.0009
Ca	28.8	25.6	24.6	23.7
Cu	0.0	0.0	0.0	0.0
K	1.7	1.8	1.7	1.7
Fe	5.9	5.3	5.3	5.5
Mg	9.7	8.2	8.3	8.0
Mn	0.3	0.3	0.3	0.3
Na	41.1	58.6	67.0	67.0
Zn	0.0	0.0	0.0	0.0
F	0.23	0.33	0.30	0.30
Cl	21.4	31.6	35.1	35.6
Nitrate-N	<0.01	<0.01	<0.01	<0.01
Bromide	0.06	0.13	0.13	0.13
Nitrite-N	<0.01	<0.01	<0.01	<0.01
Phosphate-P	<0.02	<0.02	<0.02	<0.02
Sulfate	40.6	36.9	34.0	33.1

HFO

Conclusions

- We have no evidence that a hydrologic connections exists between Clear Fork and the aquifer.
- Perform another pump test during low flow conditions (this fall).
- Use other abandoned water wells to determine the shape of the cone of depression (does the area of influence appear to be in the direction of Clear Fork?)
- Isotope analysis??

HFO

THE END

AS YOU CAN CLEARLY SEE IN SLIDE 397...
GAAAAH!
"POWERPOINT" POISONING.
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Watershed Modeling System

What are Some of the Goals for a Large Watershed Model?

- Ability to Predict Flooding and Floodplain Impacts Caused by Mining and Land Use Changes
- Ability to Predict Changes in Sediment Loading caused by Mining, Road Construction, or Other Land Use Changes
- Ability to Predict Water Quality Impacts and Changes Caused by Mining and Other Activities Within the Watershed
- Ability to Account for Water Losses and Gains Within the Watershed Caused by Mining or Other Activities
- Ability to Account for Ground Water Contributions and Interactions Under Baseflow Conditions
- Compatible With Other TIPS and OSM Software Systems

TIPS Large Watershed Modeling Software Review

Targeted activities, include:

- **Predictive impact analyses in support of permitting activities (e.g., CHIA preparation, PHC evaluation)**
- **Assessing impacts on water quantity, quality, and seasonal variation**
- **Conducting NEPA hydrologic impact studies**
- **Assessing impacts of discharges from AML sites**
- **Evaluate flood hazards/impacts associated with mining**
- **Defending technical findings in litigation**

Large Watershed Model Search

- **Software considered included:**
  - **Watershed Modeling System (WMS)**
  - **BASINS**
  - **Watershed Characterization Modeling System (WCMS)**
  - **HEC-RAS and HEC-HMS**
  - **MIKE-SHE/11**
  - **ARC-HYDRO**

History of WMS

- Developed by the Environmental Modeling Research Laboratory (EMRL) at BYU
- EMRL sponsored by U.S. Army Corp. of Engineers, EPA, Federal Highway Administration, and others
- Distribution, training, and support of Software is through Environmental Modeling Systems, Inc. (EMS-I)

What Does WMS Do? (1)

- Provides a Graphical User Interface for Various Hydrologic Models
- Interfaces Well With Other TIPS Supported Software Including:
  - AutoCAD
  - ArcView 3X
  - ArcGIS 8X
  - HEC RAS
- Supports a Wide Range of Image Formats
  - GeoTIFF
  - TIFF
  - JPEG
  - MrSID
- Allows the Use and Conversions Between Different Coordinate or Projection Systems
- GIS Information or Modeling Results can be imported or exported for use in other Applications or by WMS

What Does WMS Do? (2)

- Allows for Automated watershed delineation using digital elevation data obtained from:
  - Digital Elevation Models (DEMs)
  - USGS National Elevation Dataset (NED)
  - Triangulated Irregular Networks (TINS)
  - ArcGIS Elevation Grids
  - Survey Data
- Automates the calculation of basin information needed to run the various hydrologic models
  - Composite Curve Numbers (Loss Coefficients)
  - Channel and Storage Routing, Time of Concentration/Lag Times
  - Basin Elevations, Slopes, Flow Lengths, etc.
- Allows for floodplain modeling and mapping based on digital terrain information and hydrologic model results

What Models Will WMS Support?

- HEC-1
- TR-20
- TR-55
- Rational
- MODRAT (Modified Rational)
- NFF (National Flood Frequency)
- HSPF (Hydrologic Simulation Program – Fortran)
- HEC-RAS (Pre- and Post-Processing Interface)
- GSSHA (Gridded Surface Subsurface Hydrologic Analysis – Interface Pending)
- CE-QUAL-W2 (Enhanced Stream Water Quality Model – Interface Pending)

The GSSHA Module

- GSSHA – Stands for Gridded Surface Subsurface Hydrologic Analysis
- GSSHA is a 2-D grid-based finite difference model
- Stand alone model that can be run at the command line or through the WMS Interface
- Intended to simulate different types of runoff production using the physical processes operating in the watershed
- A process-based model with multiple solution methods available for many of the simulation processes

What Is Considered in GSSHA?

- Major components of the model include:
  - Precipitation distribution
  - Snowfall accumulation and melting
  - Interception
  - Infiltration
  - Evapotranspiration
  - Surface Water Retention
  - Surface Runoff Routing
  - Channel Flow Routing
  - Unsaturated Zone Modeling
  - Saturated Ground Water Flow
  - Overland Sediment Erosion, Transport, and Deposition
  - Channel Routing of Sediment

The CE-QUAL-W2 Module

- CE-QUAL-W2 is a 2-D hydrodynamic model developed by the Army Corp of Engineers
- Models longitudinal-vertical hydrodynamics and water quality in stratified and non-stratified systems
- Designed for use in rivers, estuaries, lakes, reservoirs, and river basin systems
- Assumes lateral homogeneity

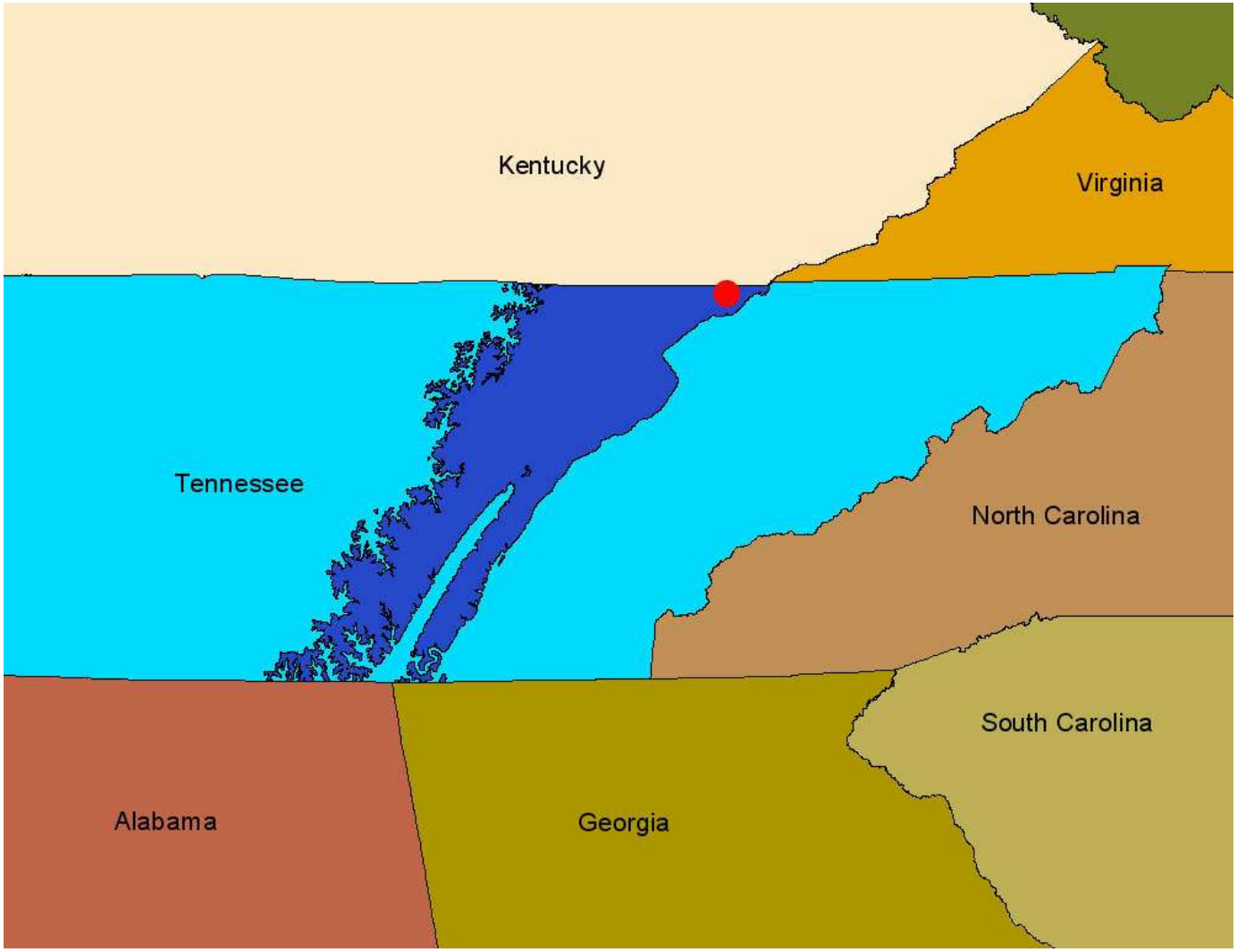
What are CE-QUAL-W2 Capabilities?

- Hydrodynamics – Surface elevations, temperature, and velocity
- Water Quality – 21 Constituents including: TDS, pH, DO, TOC, NH3, phosphates, nutrients, various conservative pollutants, algae, etc.
- Algorithm is modular allowing additional constituents to be added as subroutines
- Multiple Inflows and Outflows - Allows for point/non-point pollution sources, branches, and precipitation
- Allows for long-term water-quality responses

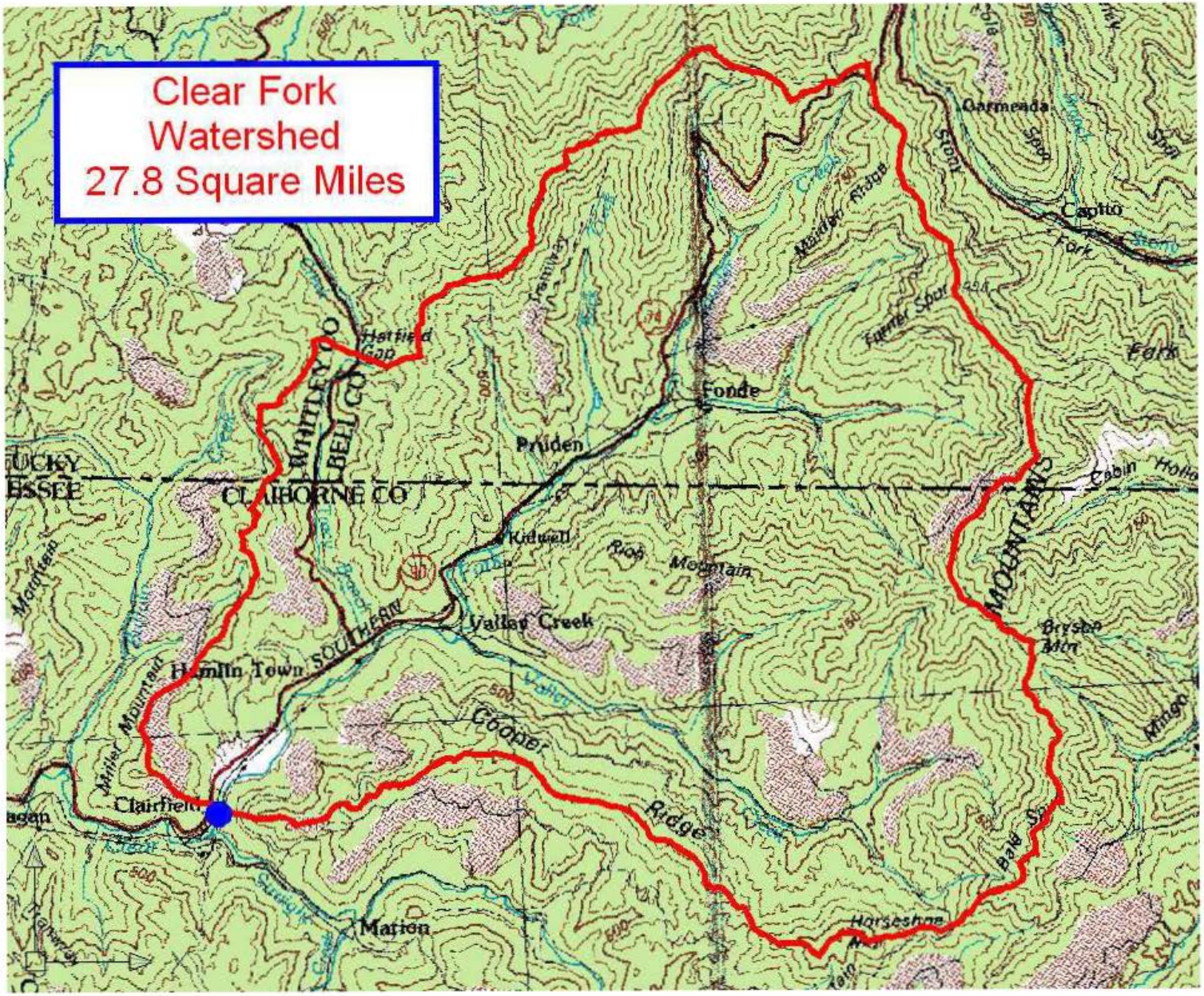
WMS Demonstration
Clear Fork Watershed - Tennessee

- Large Concentration of Surface Mining Proposed
- Public Water Utility System Potentially Affected
- Residential Area and School Located in Floodplain of Clear Fork Creek

Clear Fork Study Area in Kentucky and Tennessee and is Part of the Cumberland River Drainage System



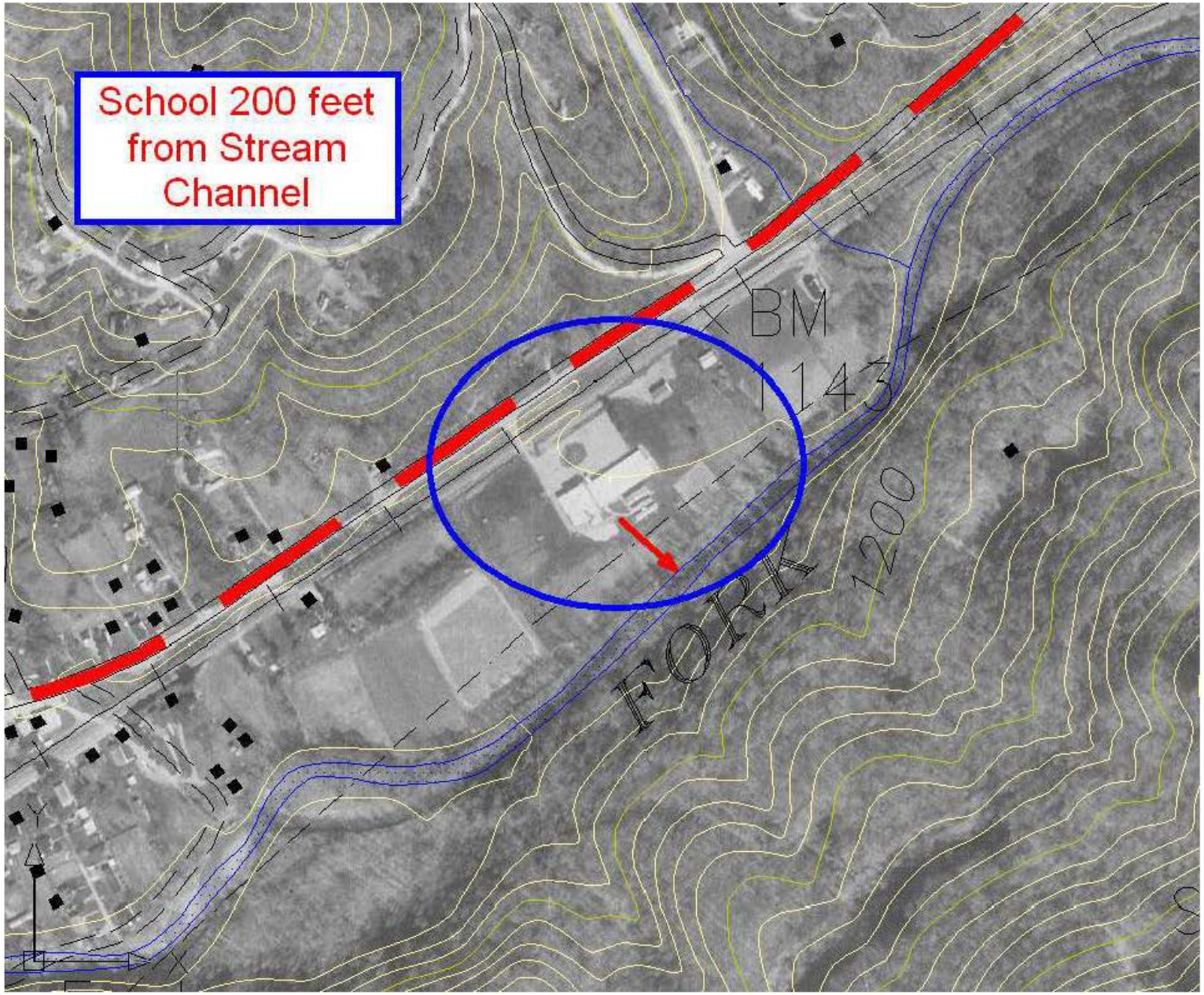
General Overview of Watershed



Clear Fork Watershed Looking North into Kentucky

Clear Fork Watershed Looking Downstream From the Headwaters area in Kentucky

Position of School and Residents Relative to Stream



Clairfield Elementary School and Floodplain area

Clear Fork Looking Upstream Behind School

Clear Fork Looking Downstream Behind School

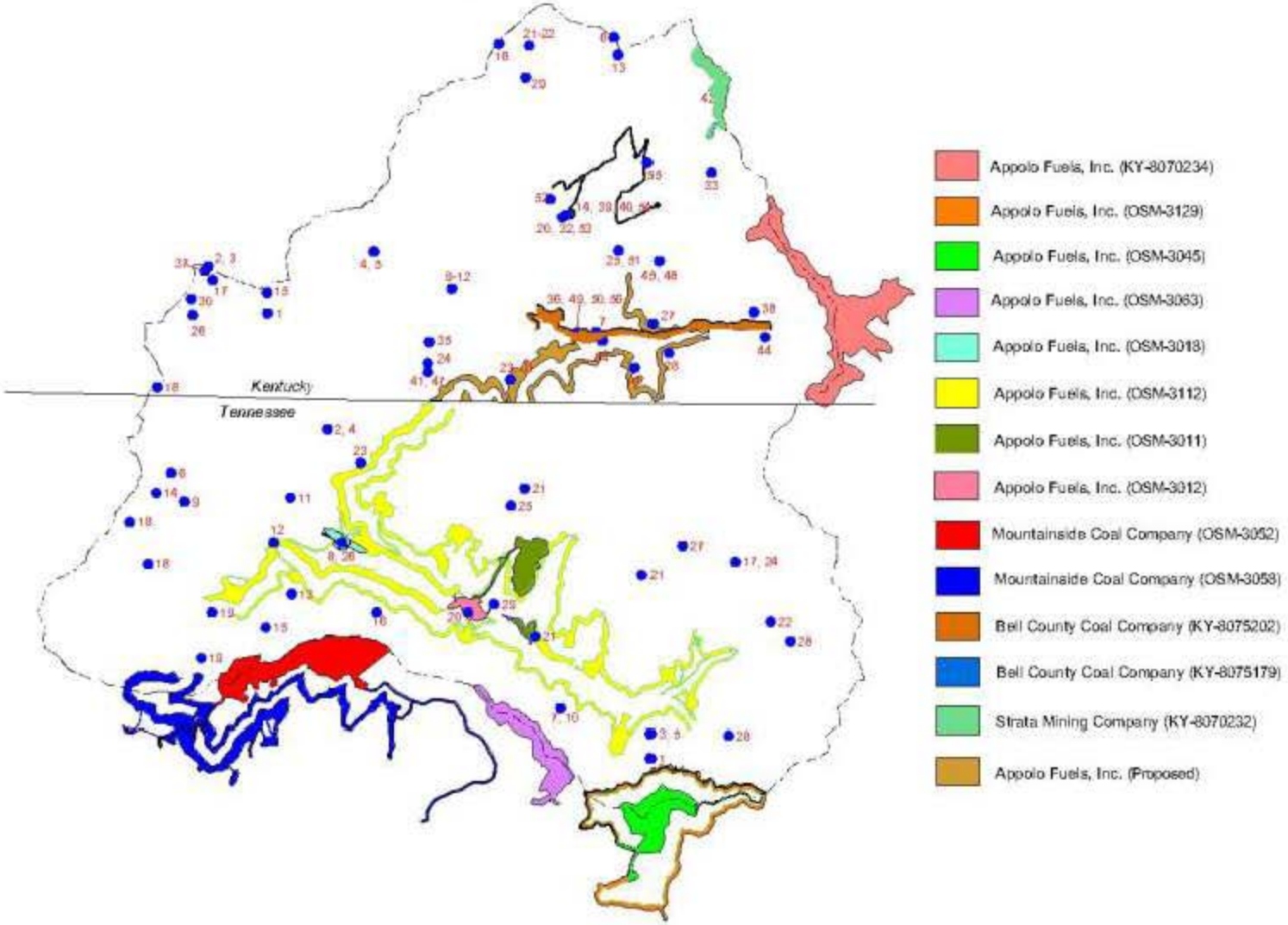
Clear Fork Approximately 9.5 feet Below Floodplain

Clear Fork Approximately 9.5 feet Below School Yard

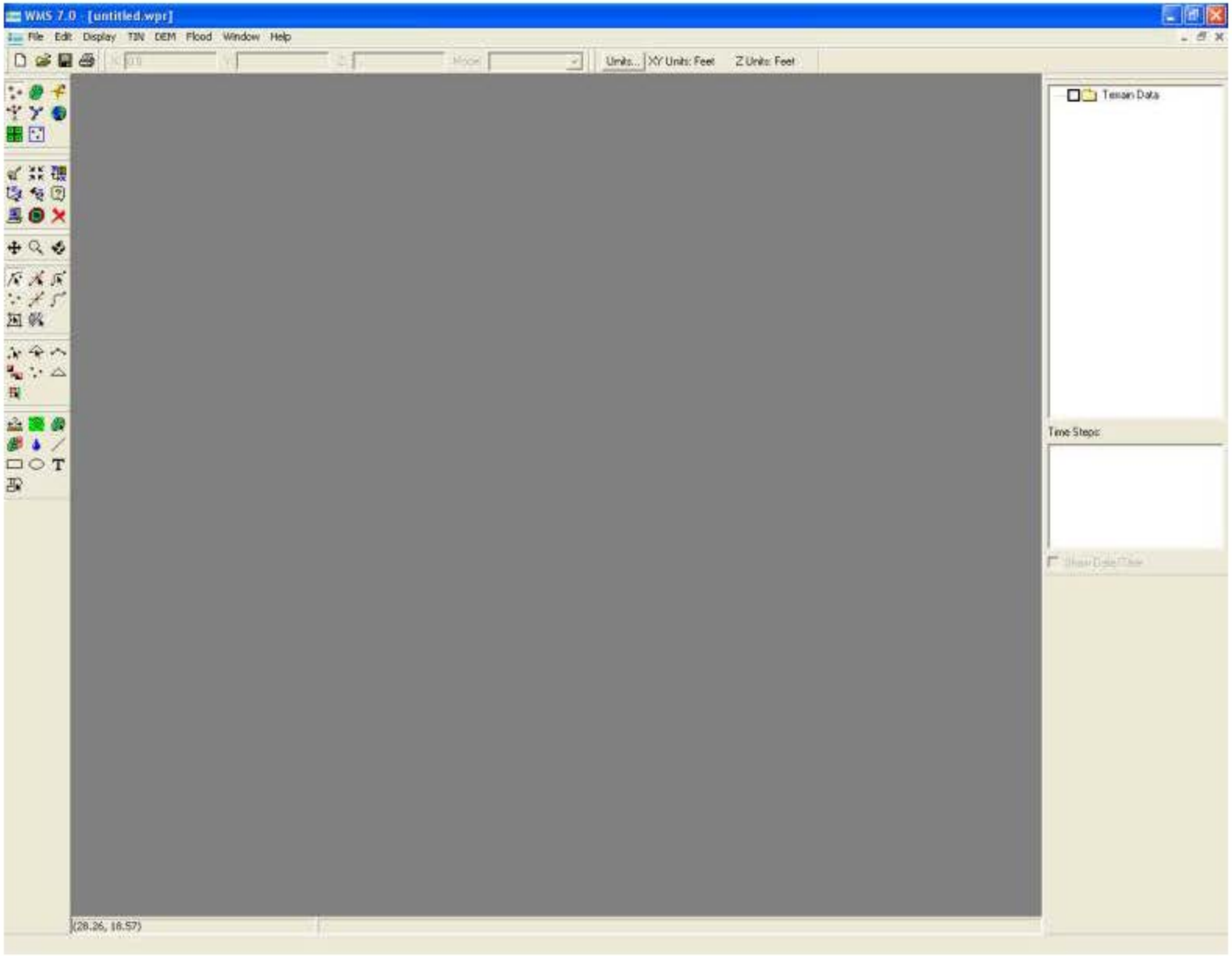
School and Playground Relative to Stream Bank

Looking Upstream Along the Floodplain

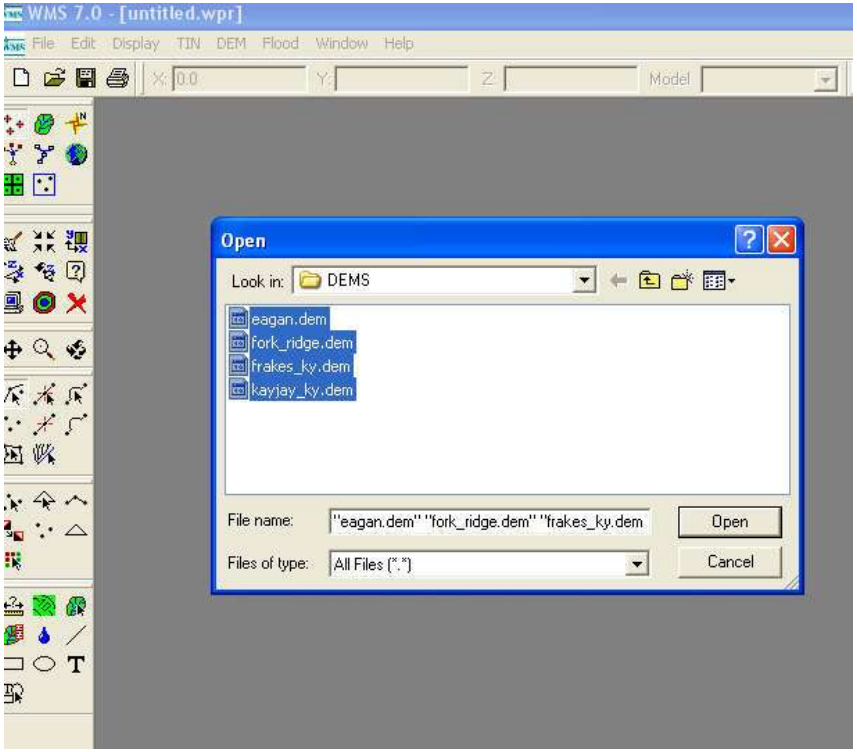
Distribution of Active Mining in CIA 10, T-1A Watershed



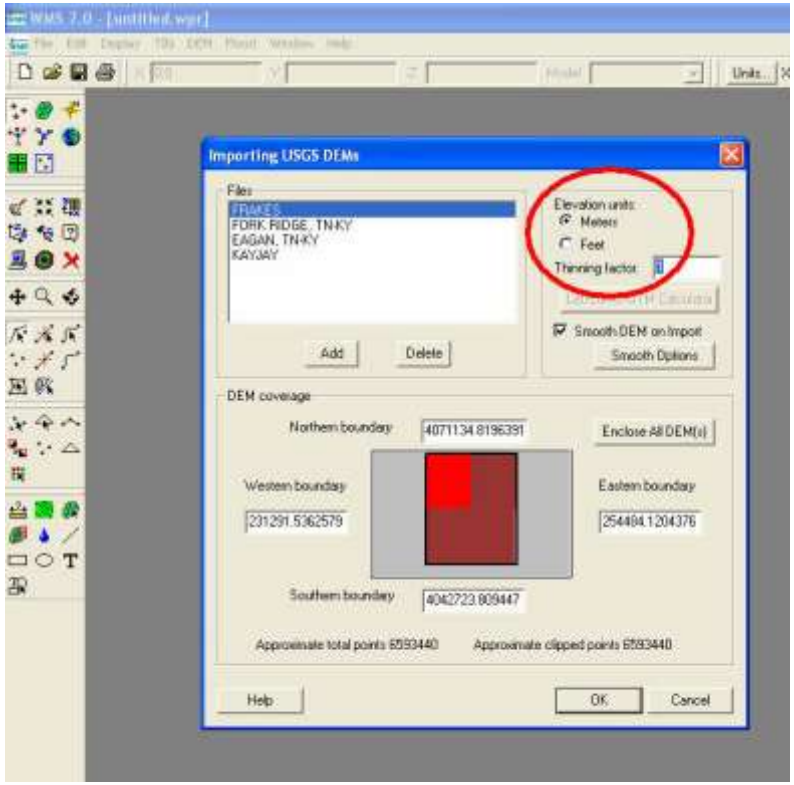
Typical WMS Workspace



Open Digital Terrain Data As the Basis for Your Model Development

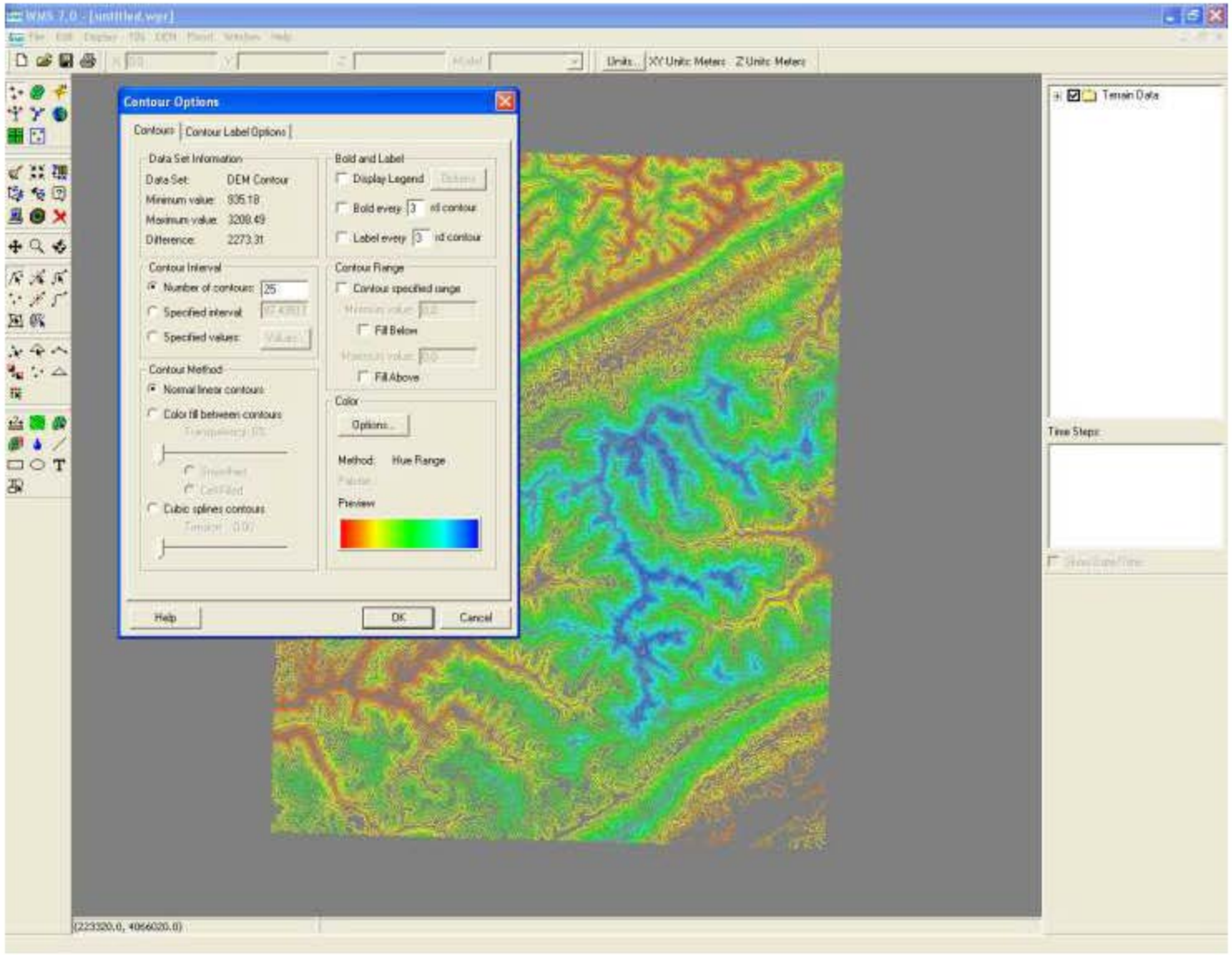


Open USGS DEMS

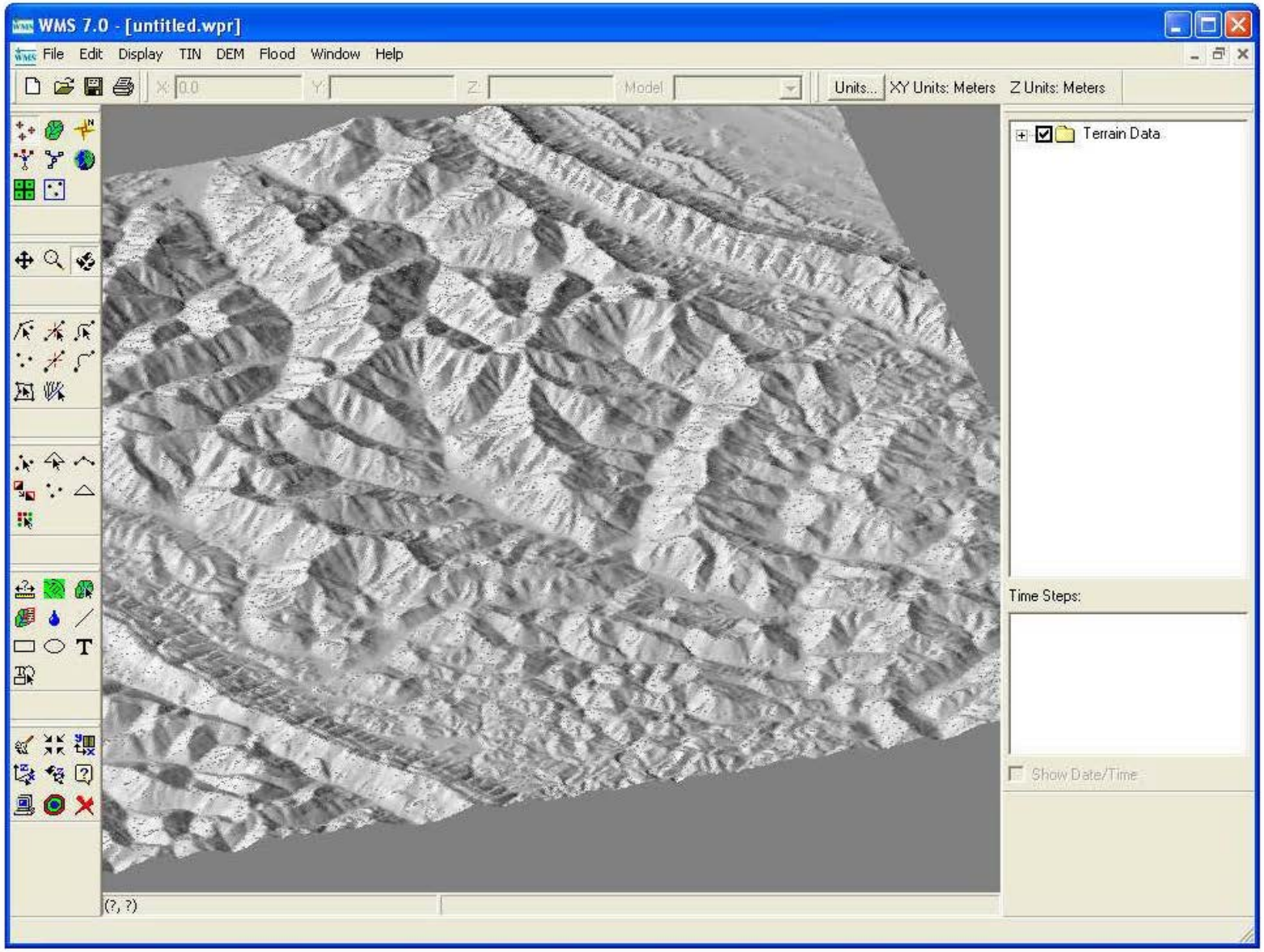


Set Elevation Units and Thinning Factors

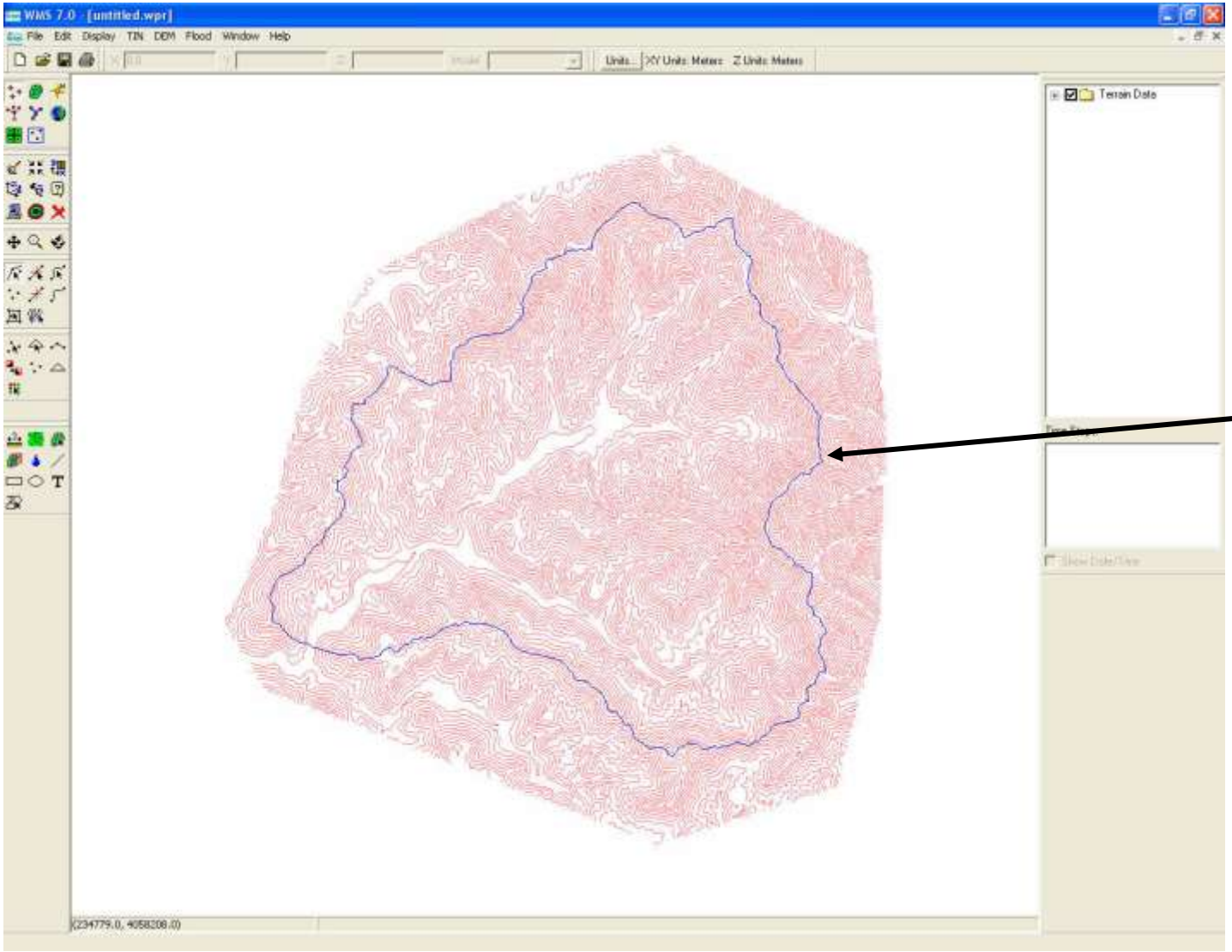
Contouring Can be Easily Set to User Preferences



WMS will allow shading and 3D Perspective Viewing

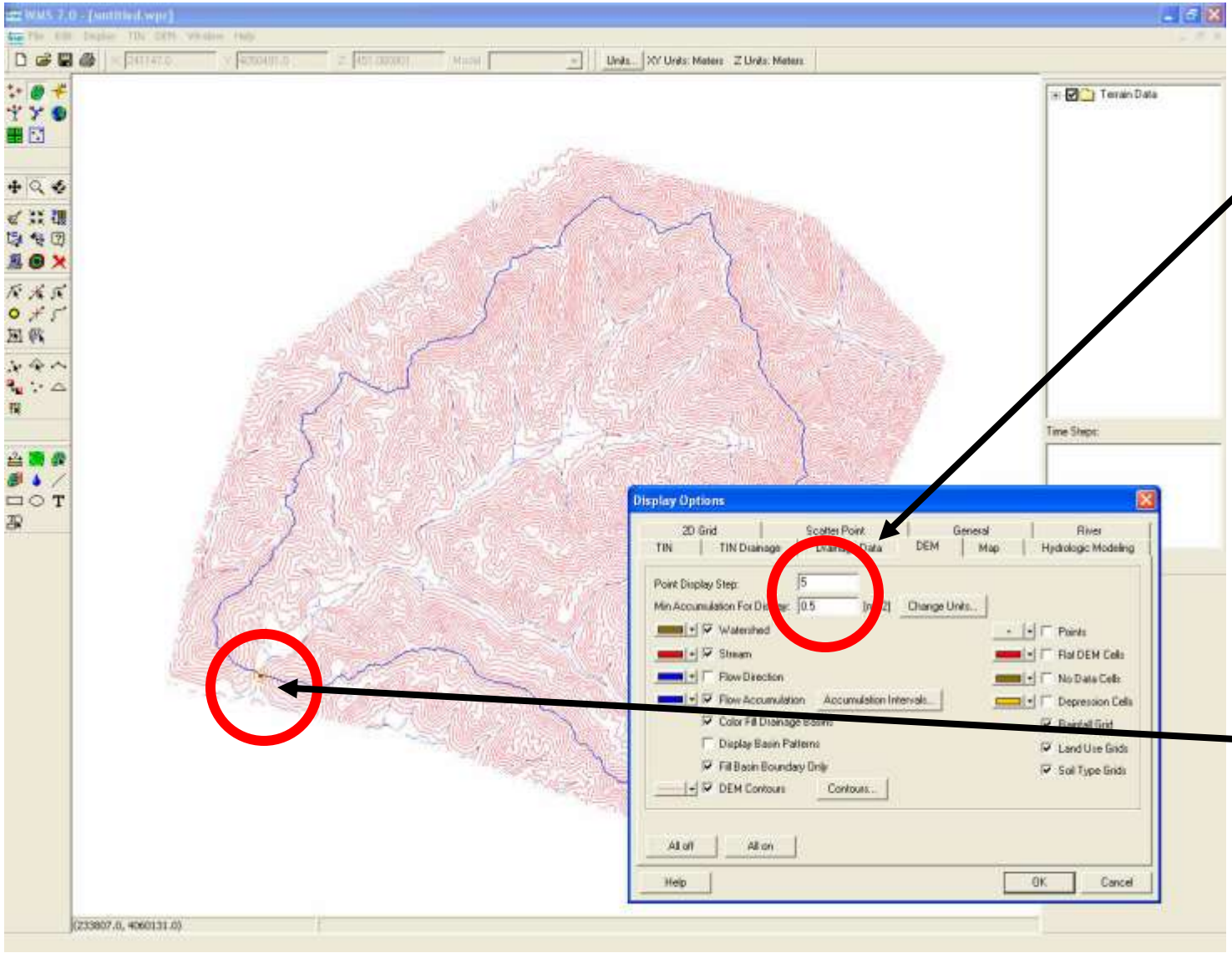


DEMs Can Be Clipped to Project Area to Improve System Performance



Watershed Boundary was Easily Brought into WMS as an AutoCAD DWG File and was used as a Reference for Trimming the Cumulative Impact Area out of the DEM

WMS Automatically Calculates Flow Accumulations and Delineates Stream Channels Based on Drainage Area Specified

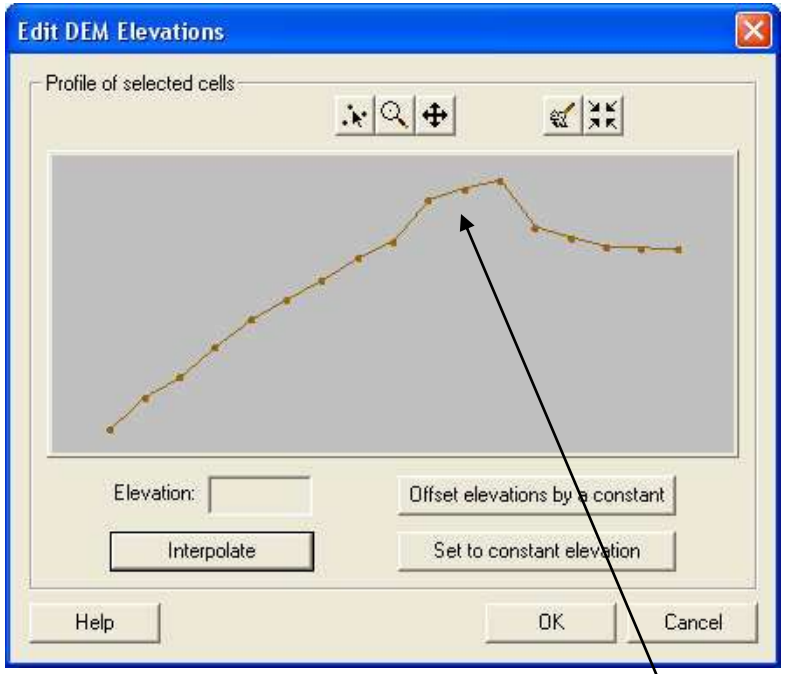


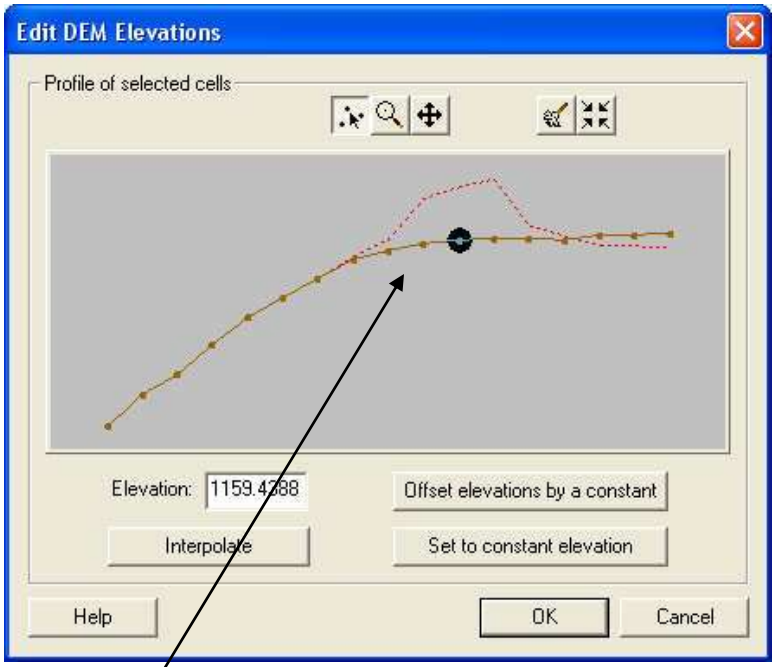
Specify the Drainage Area Size on Which You Want WMS to Generate Flow Arcs

Specify the Drainage Outlet for the Watershed Basin on the Resulting Stream Arc

WMS Will Let You Edit Stream Arcs to Account for Culverts or Embankments Caused by Roadways or Ditches

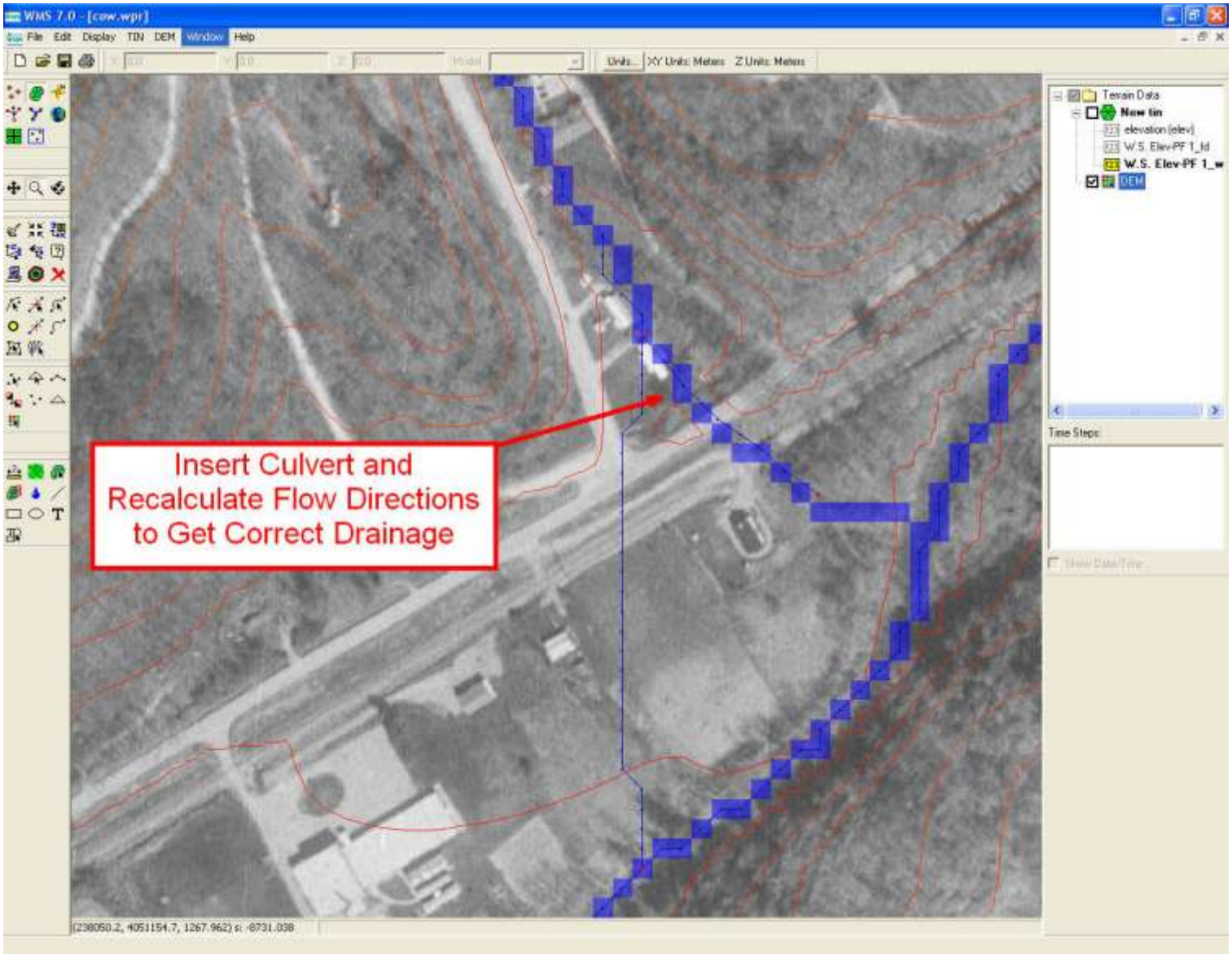
The Box Culvert was Added by Editing the Stream Section Directly Adjacent to the Road Crossing



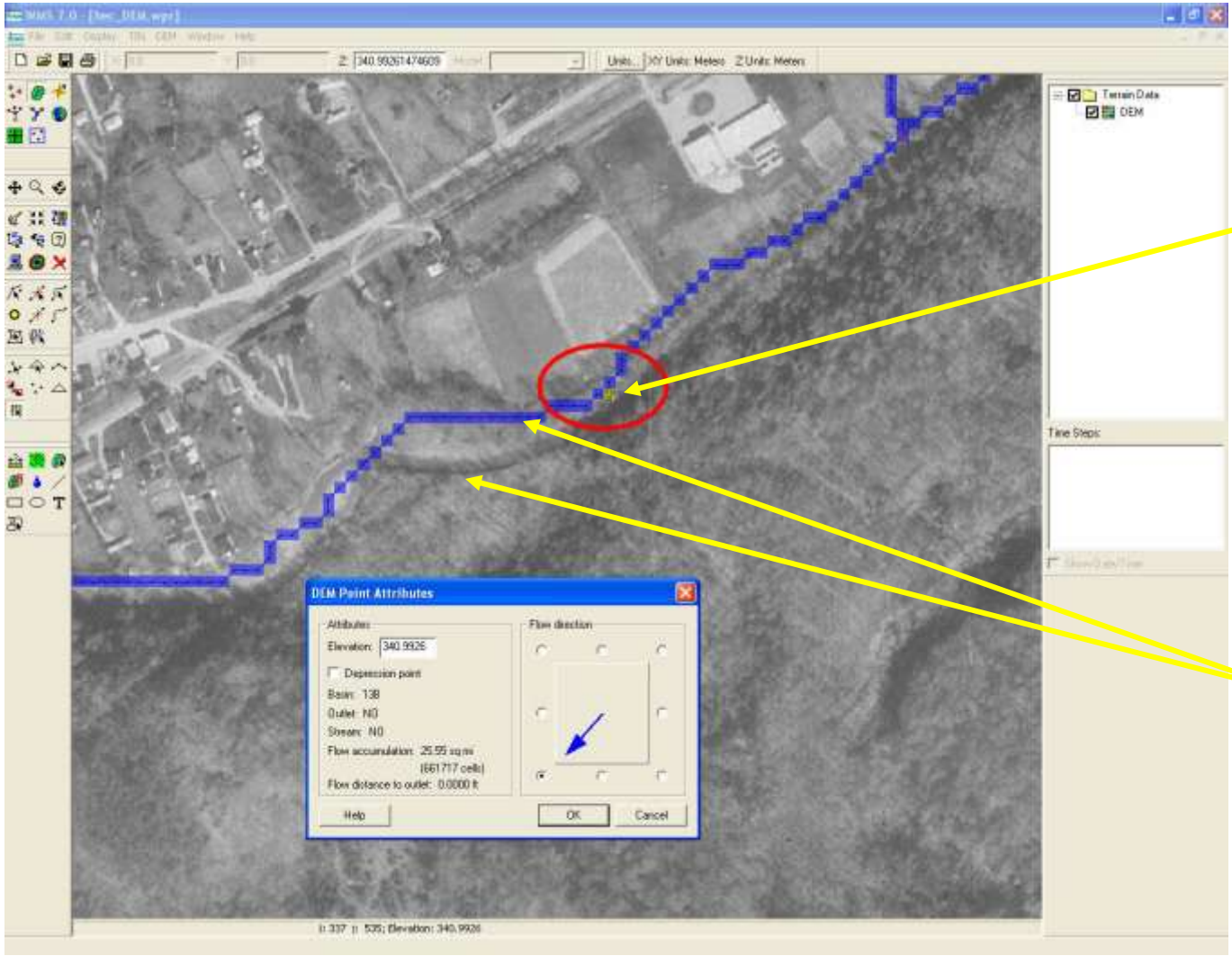


Road Embankment Detected by the DTM Which is Removed or Lowered along the Stream

Once the Culvert is Inserted, the Drainage Can be Easily Recalculated



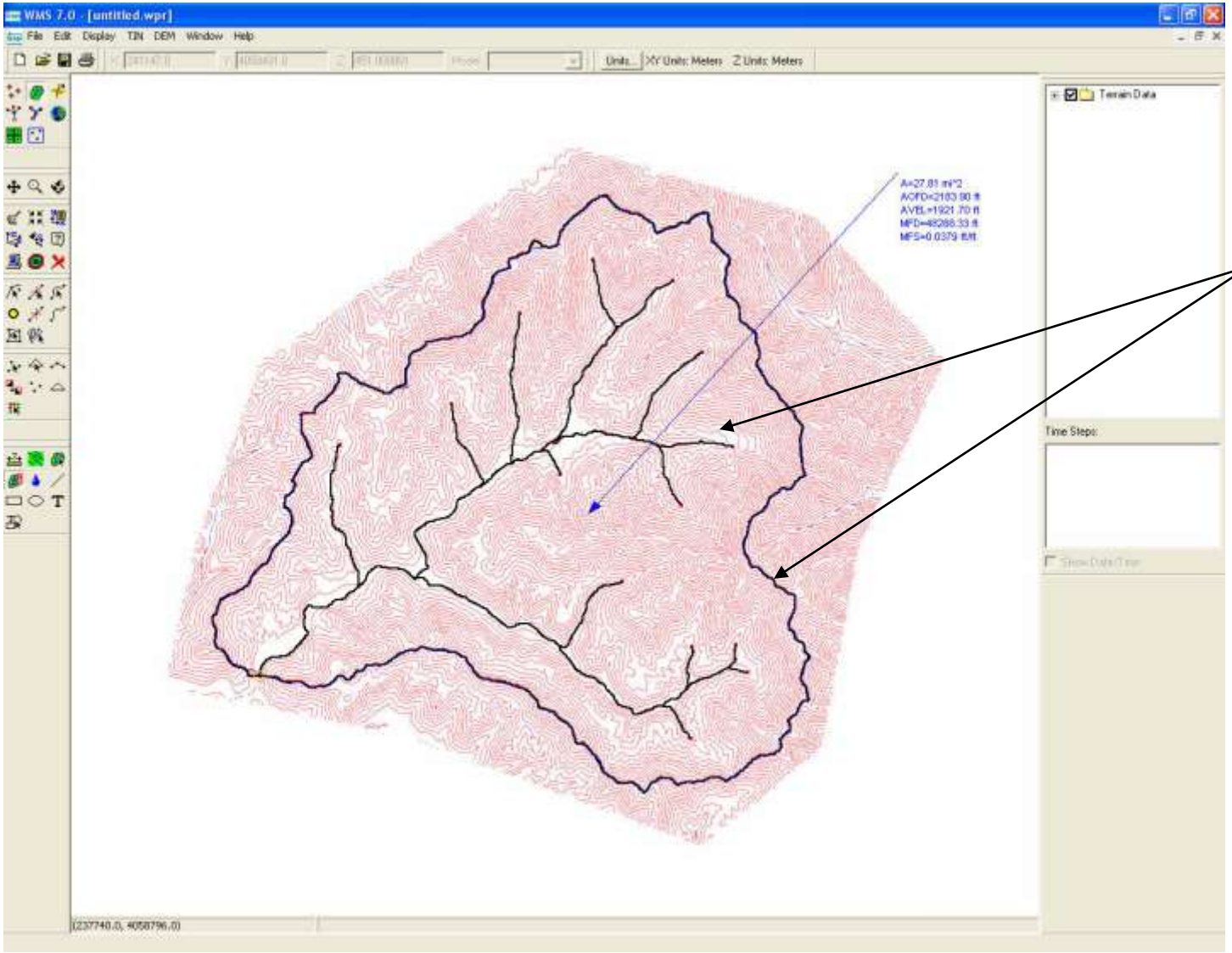
WMS Will Also Let You Change Flow Directions in Response to DEM Irregularities or Lack of Data Points



You Can Specify Individual Pixels and Change the Flow Direction or Redigitize the Stream

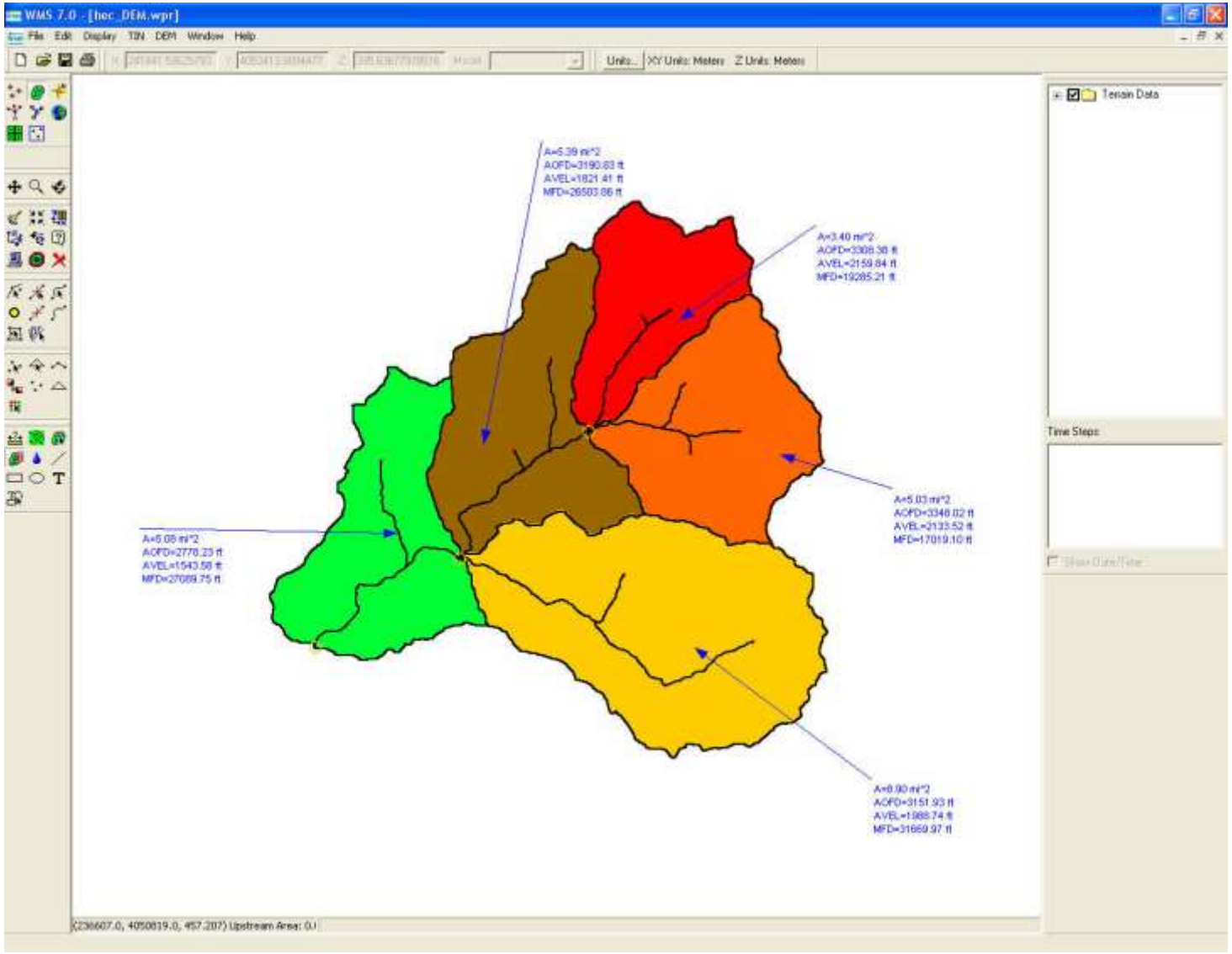
Calculated Stream Channel is Not within Actual Stream

WMS Will Take the Corrected Stream Arcs and Generate Feature Objects Which Will be Used in the Hydrologic Models

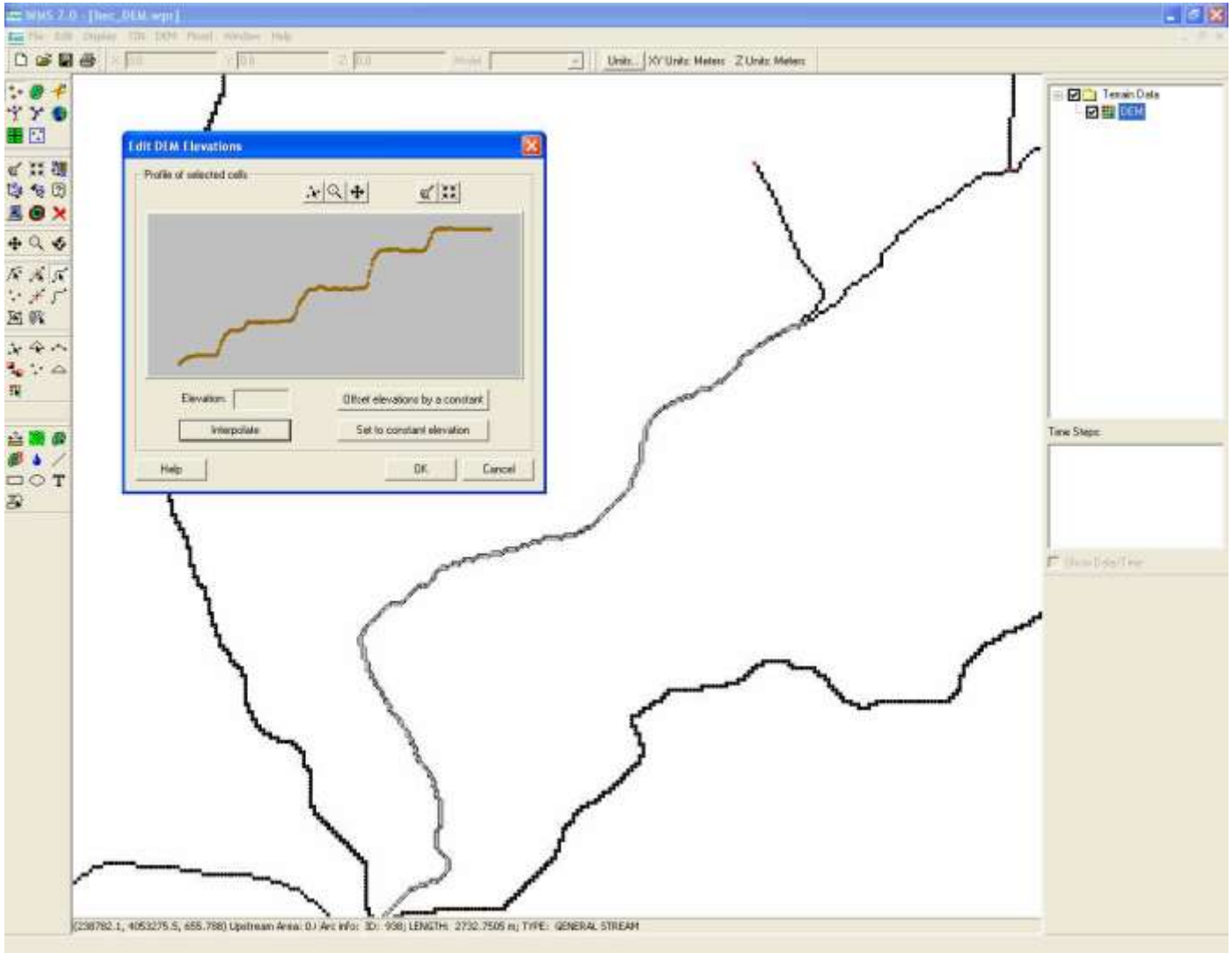


Feature Objects (Basin Boundary and Stream Arcs) can be Imported into WMS or Exported for Use in Other Applications

A Watershed Topology of the Area can be Constructed by adding Outlets to Major Sub-Basins

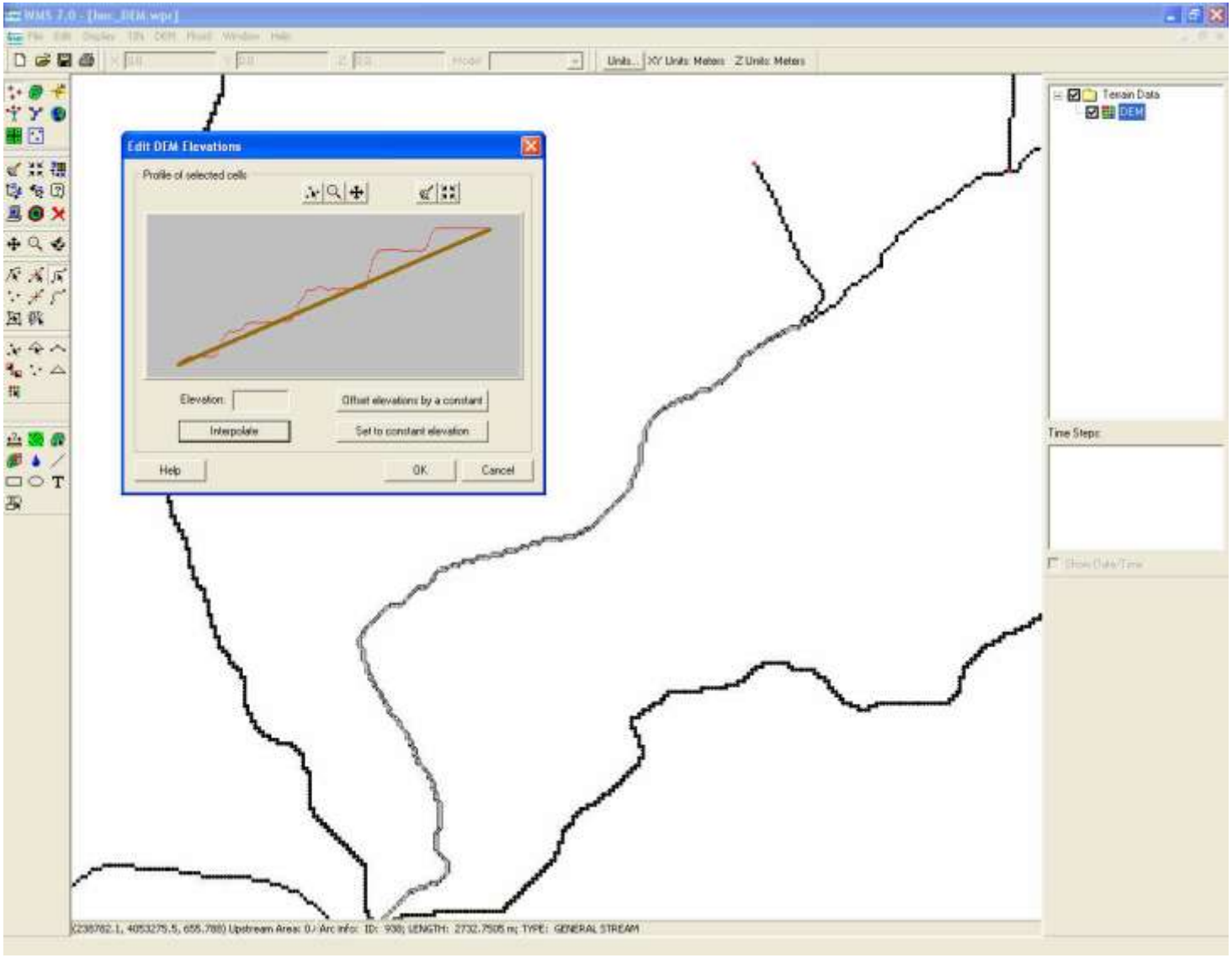


Stream Channel Profiles Can be Edited Prior to Running Hydrologic Models to Smooth Irregularities Caused DEM Cell Spacing

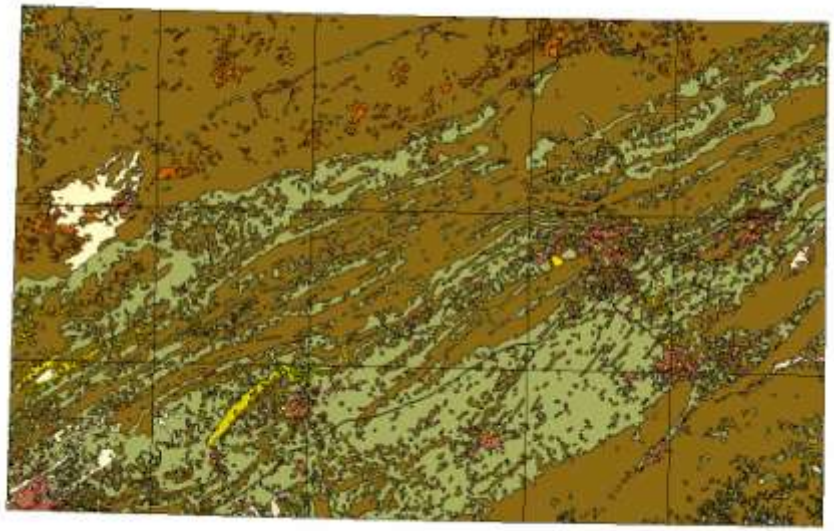


Stream Arcs can be Broken into Smaller Sections before Interpolating or Smoothing the Data and Then Joined Back to Prevent Over Interpolation

WMS Displays the Proposed Interpolated Stream Channel Profile for the Selected Stream Arc



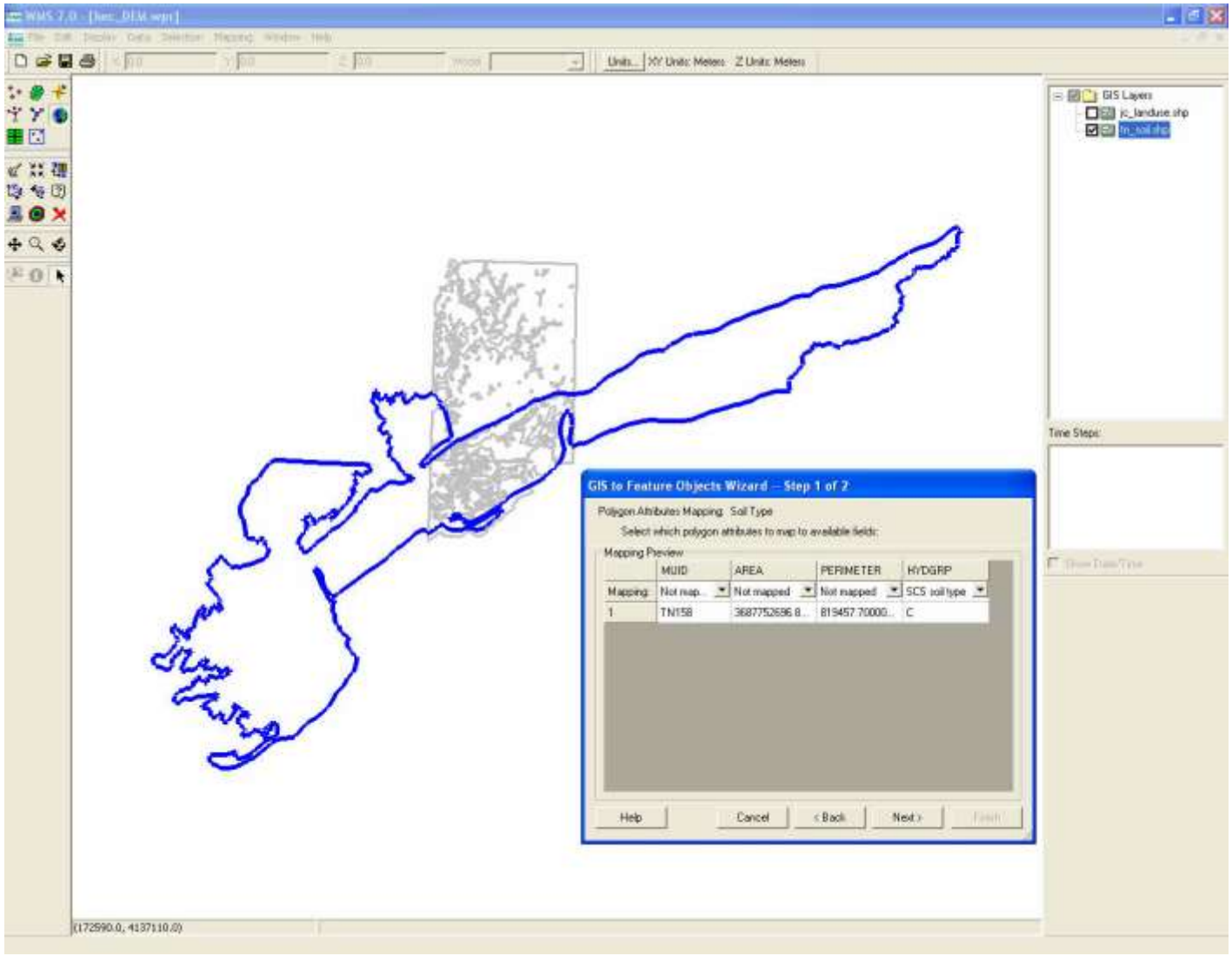
WMS Allows You to Utilize ESRI Shape or ArcGIS Coverages to Develop Land Use and Soils Information which can be Incorporated into the Hydrologic Modeling



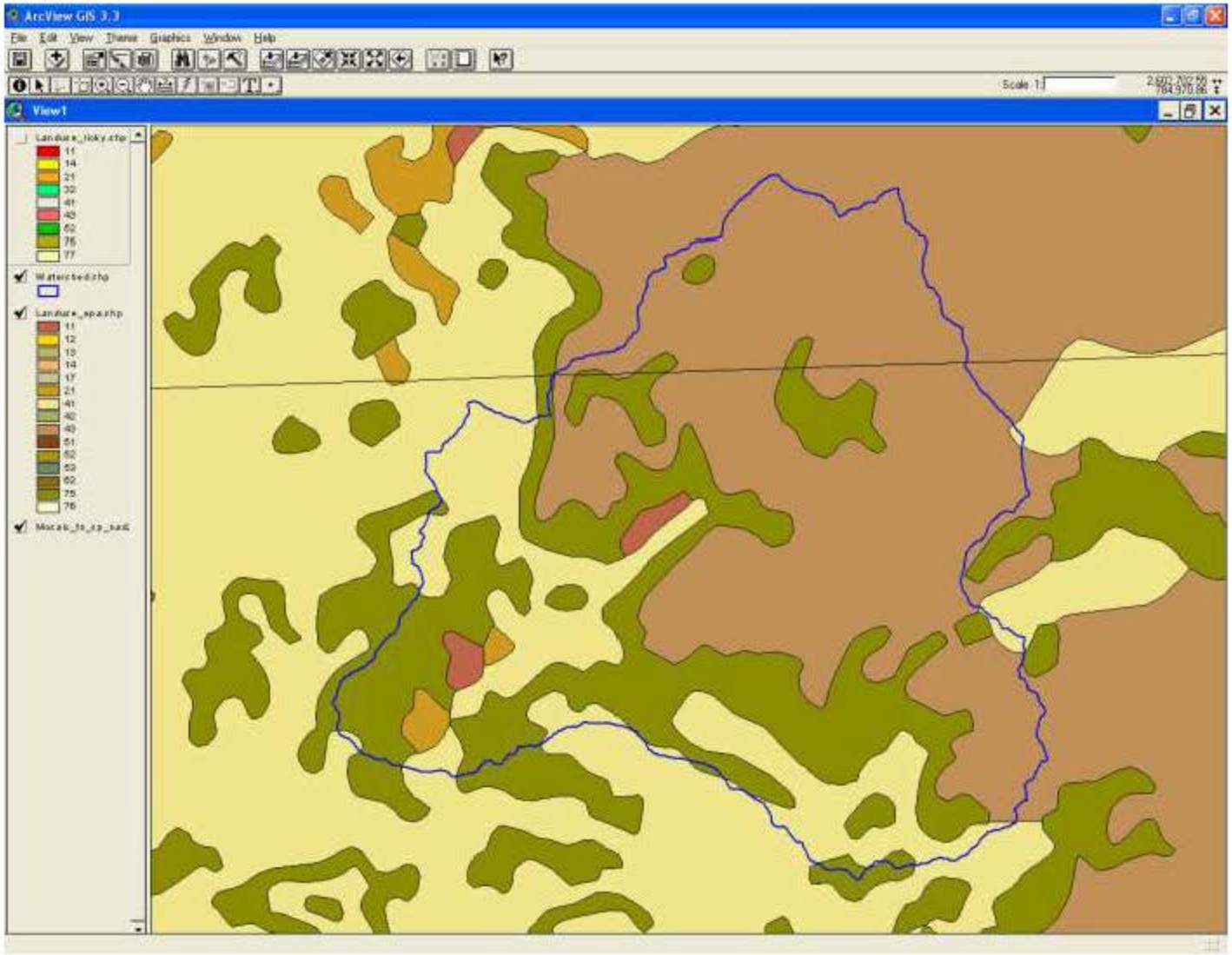
Land Use Data is Available From Multiple Sources or Can be Developed From Local Aerial Photography

Statsgo and SSurgo Soils Data is Available from NRCS in Digital Format

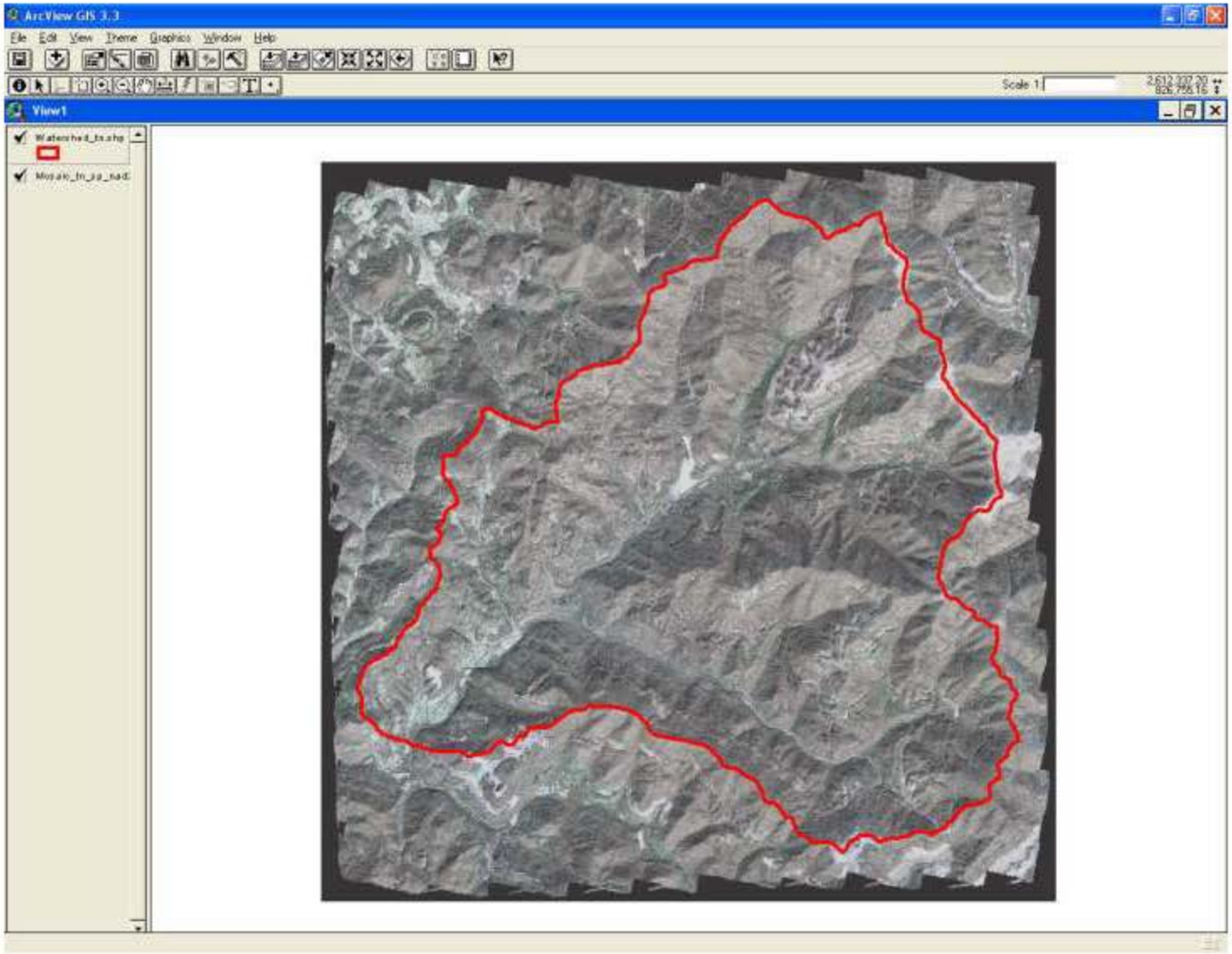
WMS Allows You to Link the Attribute Tables from the Shape Files or Coverages for the Watershed and Attaches the Information to the Resulting Feature Objects



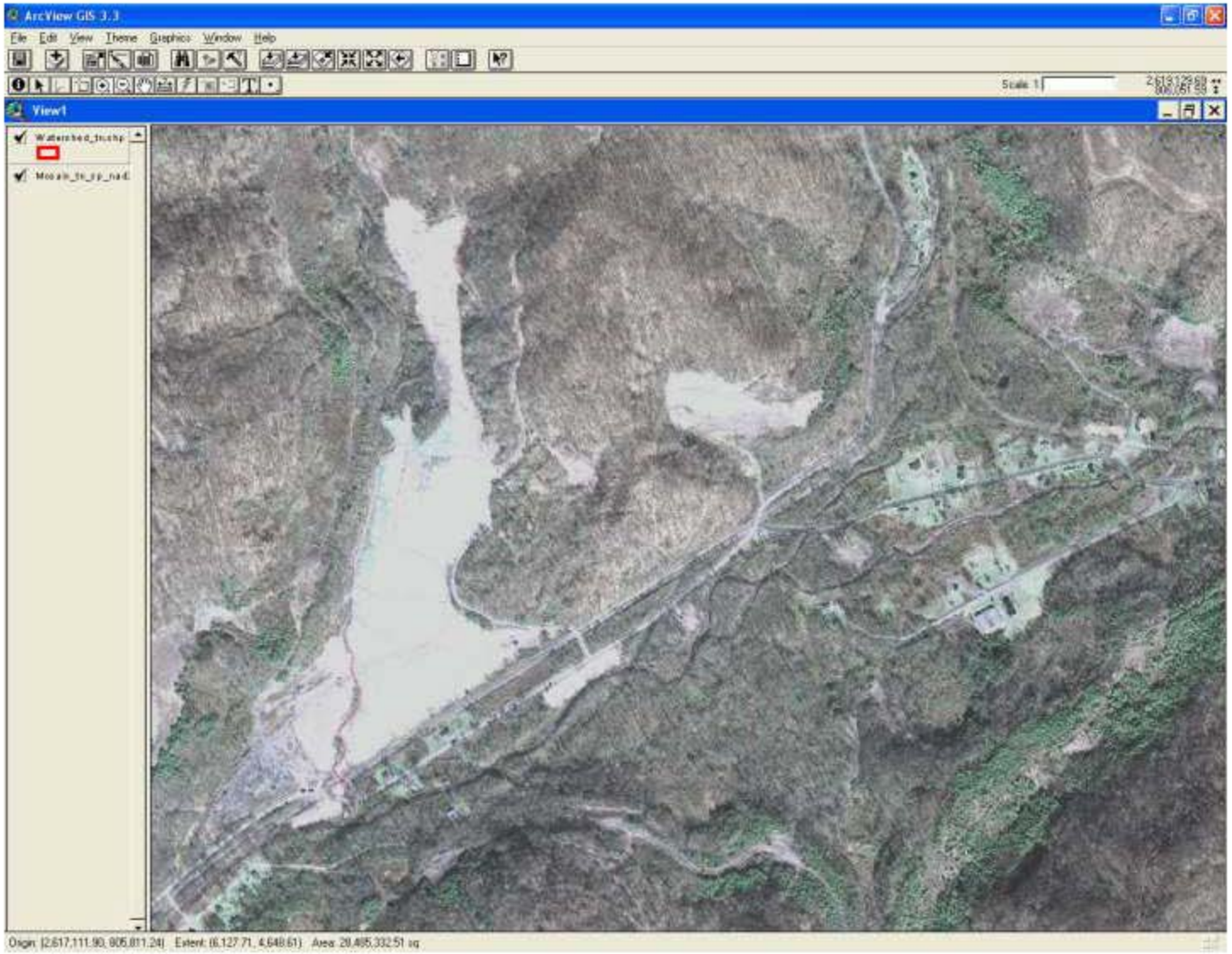
Existing Land Use and Soils Information was Limited



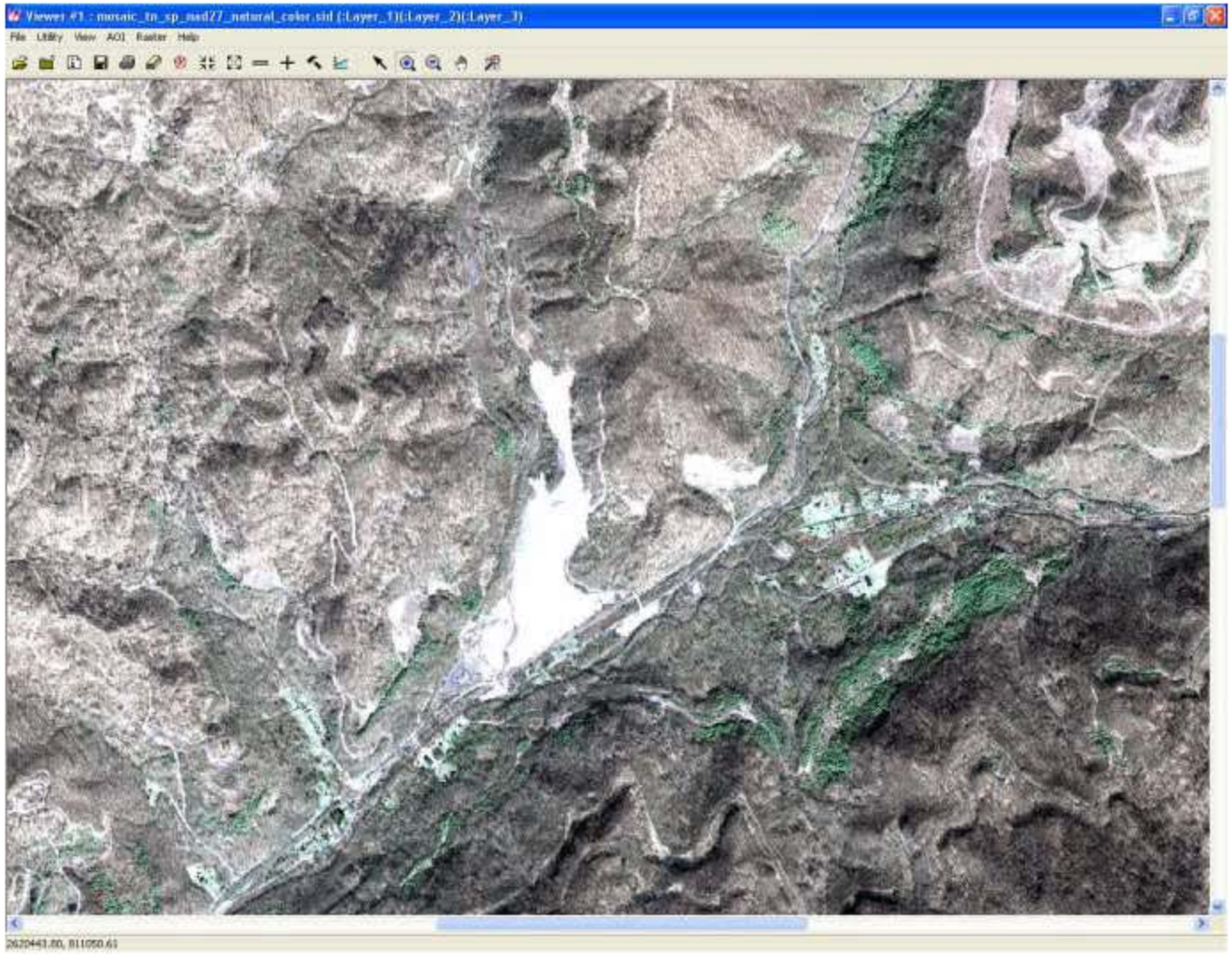
To Assist in Evaluating Land Uses in the Watershed, TIPS purchased IKONOS Satellite Imagery to Identify Existing Conditions



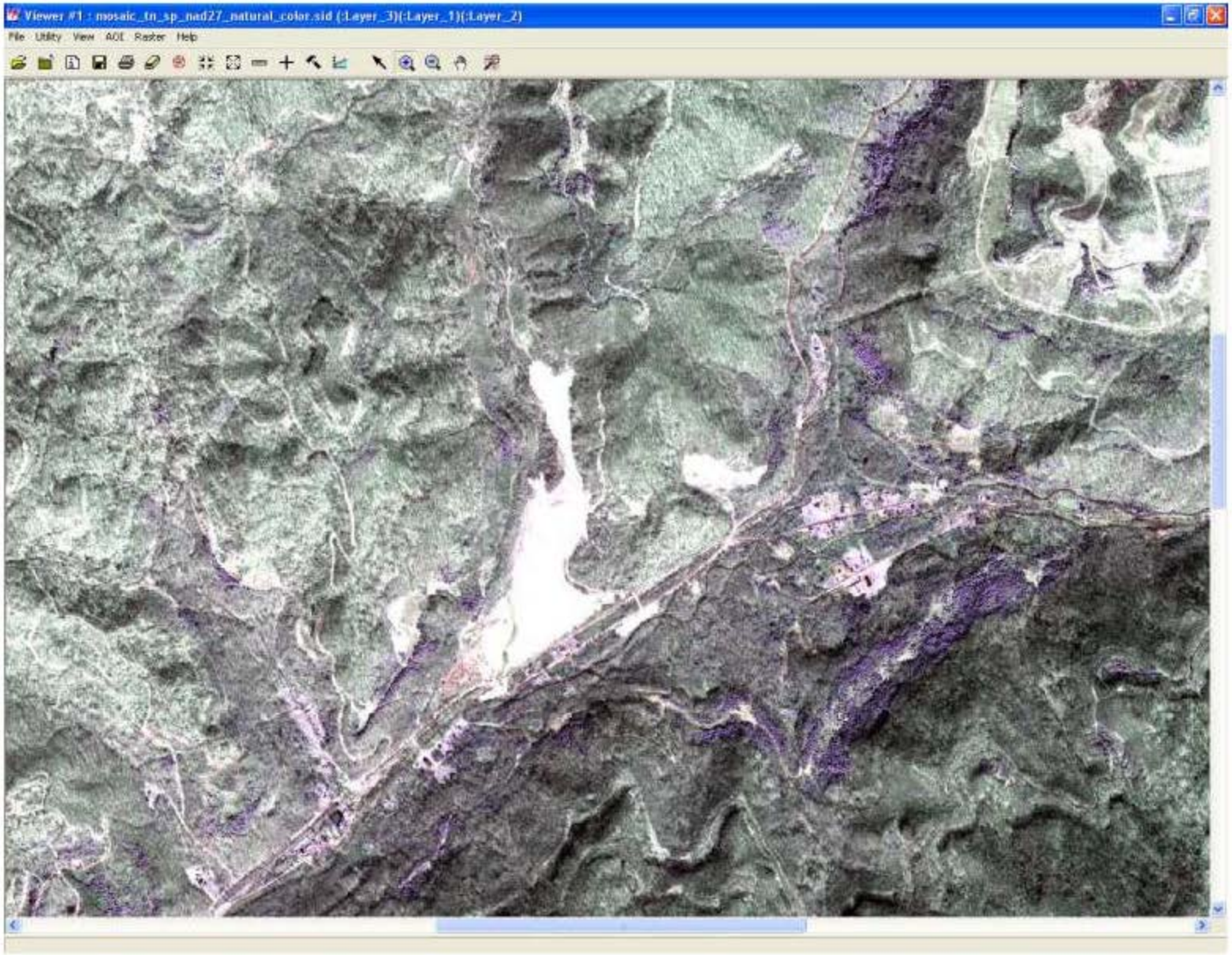
Thin Snow Cover on the Day of the Image Resulted in Poor Classification



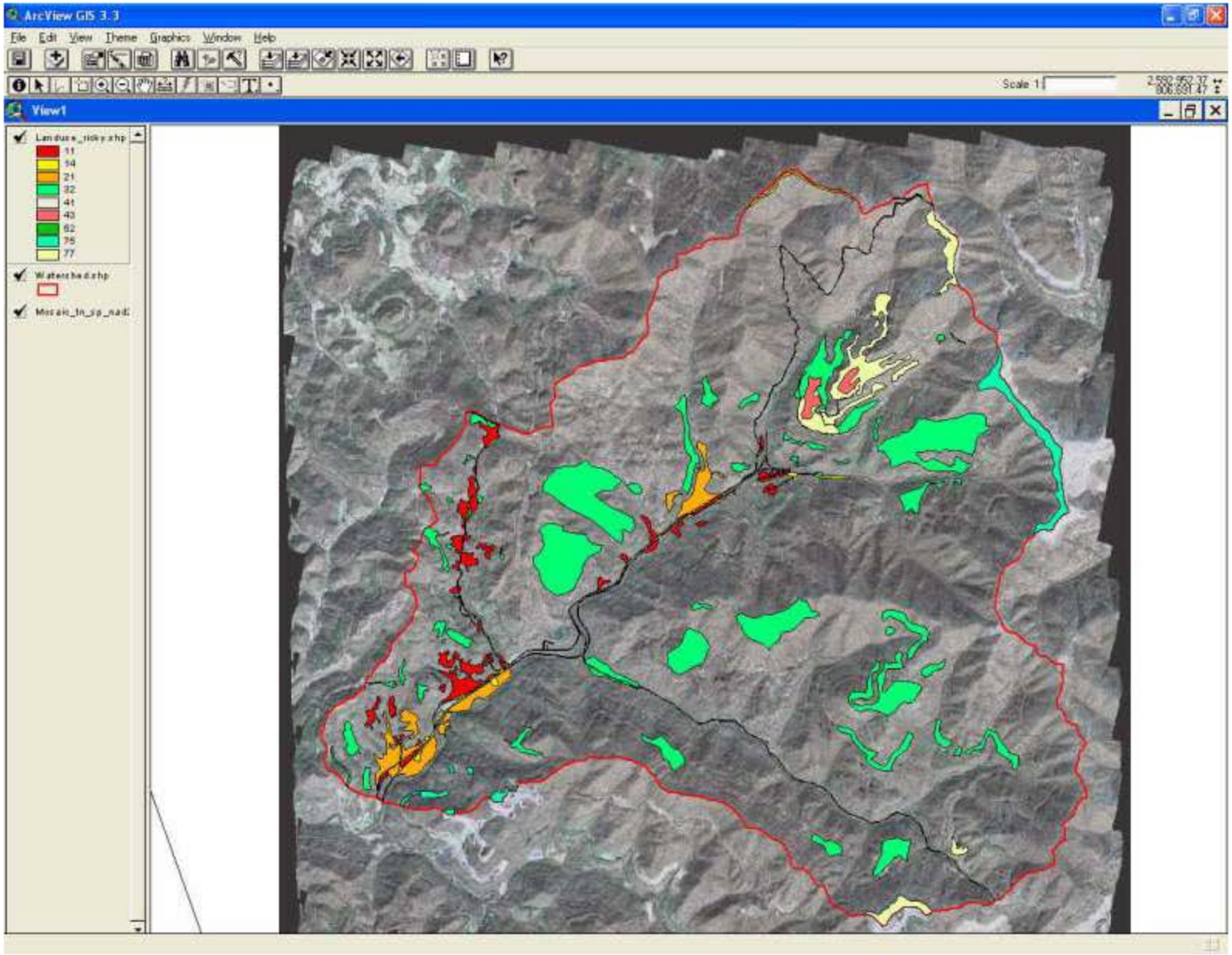
Anderson Level-2 Classification was Attempted with ERDAS Image and ArcGIS Spatial Analyst



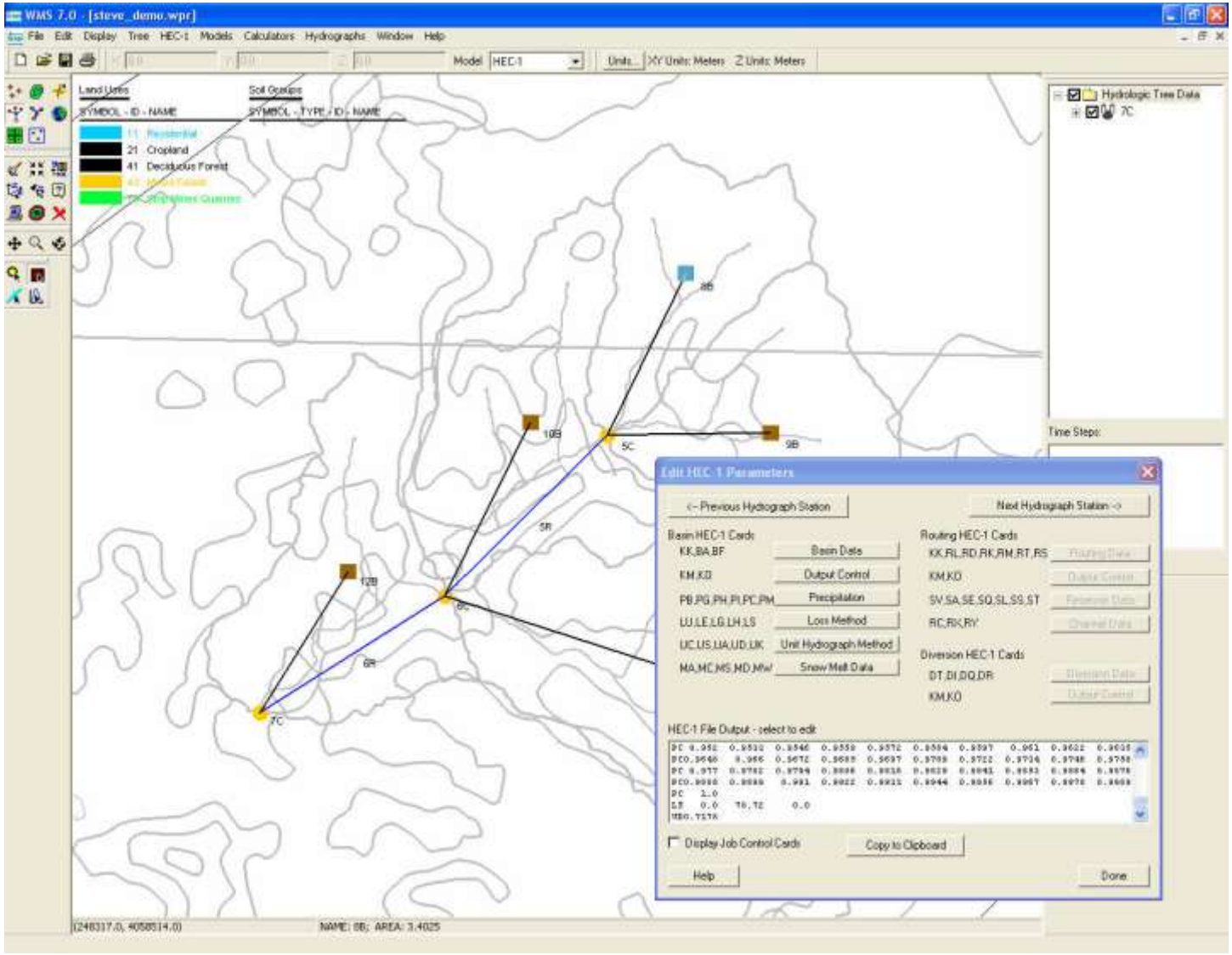
Shadows and Snow Cover along With Poor Definition Failed to Produce a Useful Classification



As a result, Land Use was Done by Standard “Heads Up” Digitizing

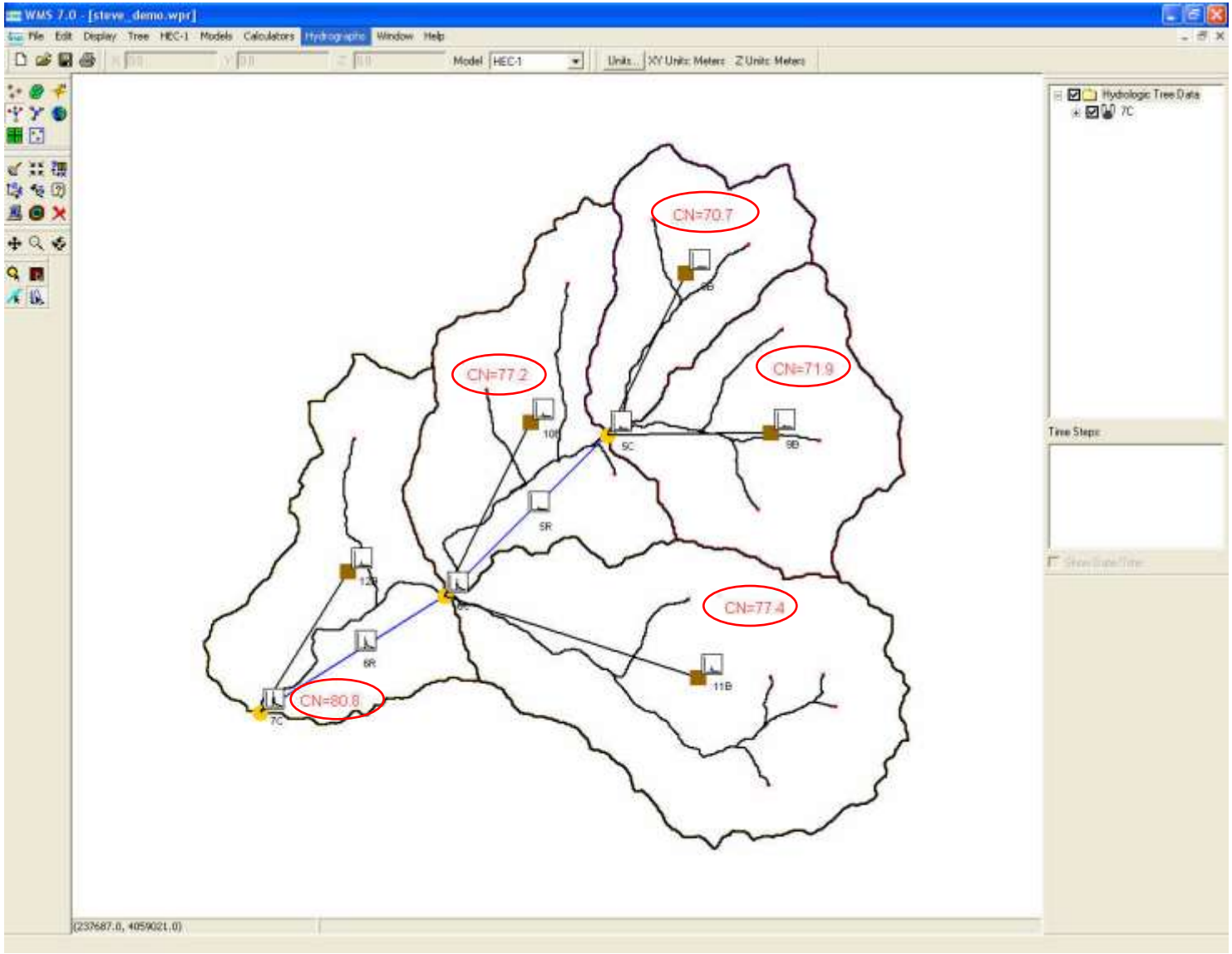


WMS Allows You to Interactively Enter Parameter Information Needed for the Hydrologic Simulation by Clicking on the Individual Basin Icon

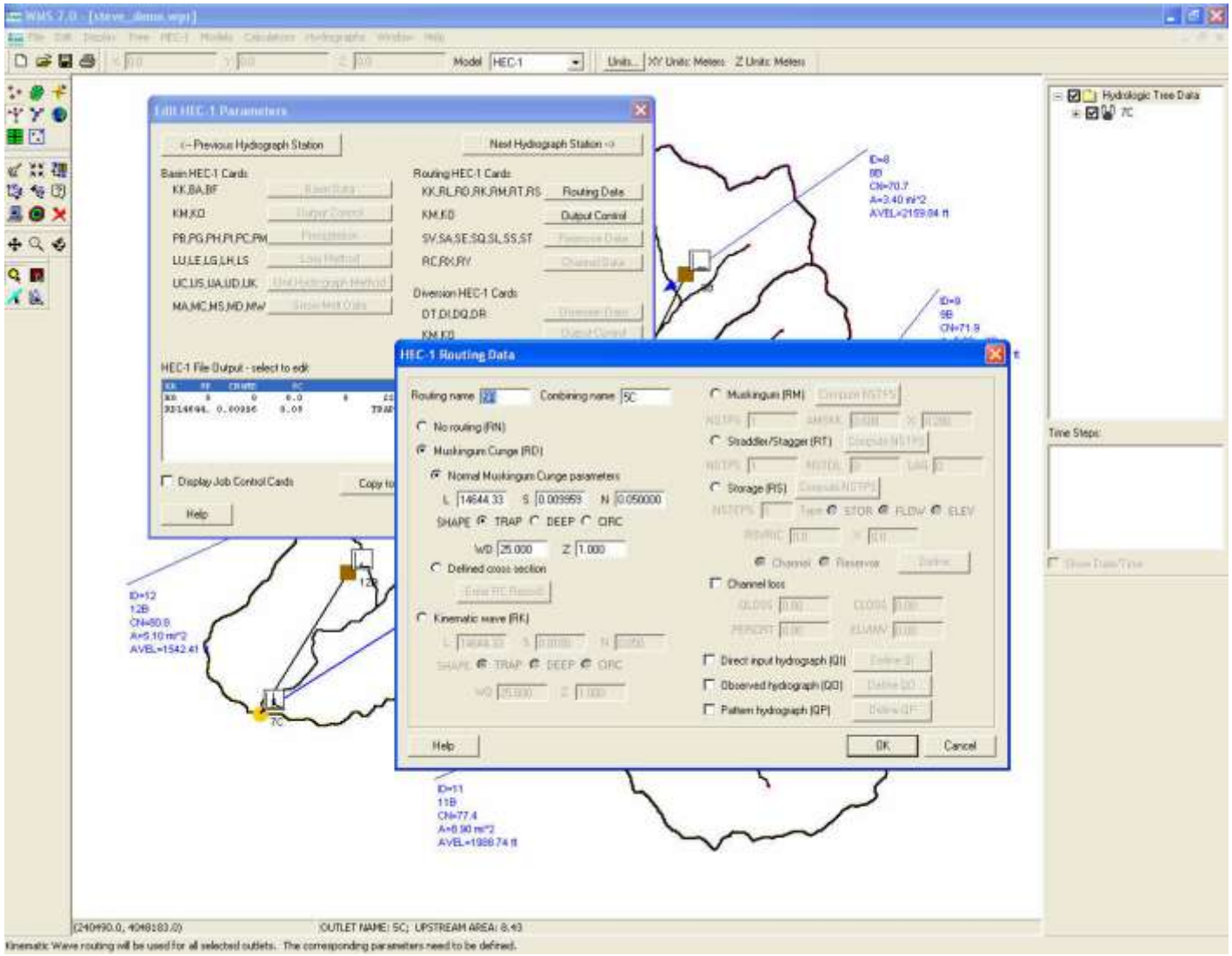


In this HEC-1 Simulation You Can Enter Information Relative to Storm Type, Precipitation, Loss Equations, Unit Hydrograph Method, Etc. for each Basin

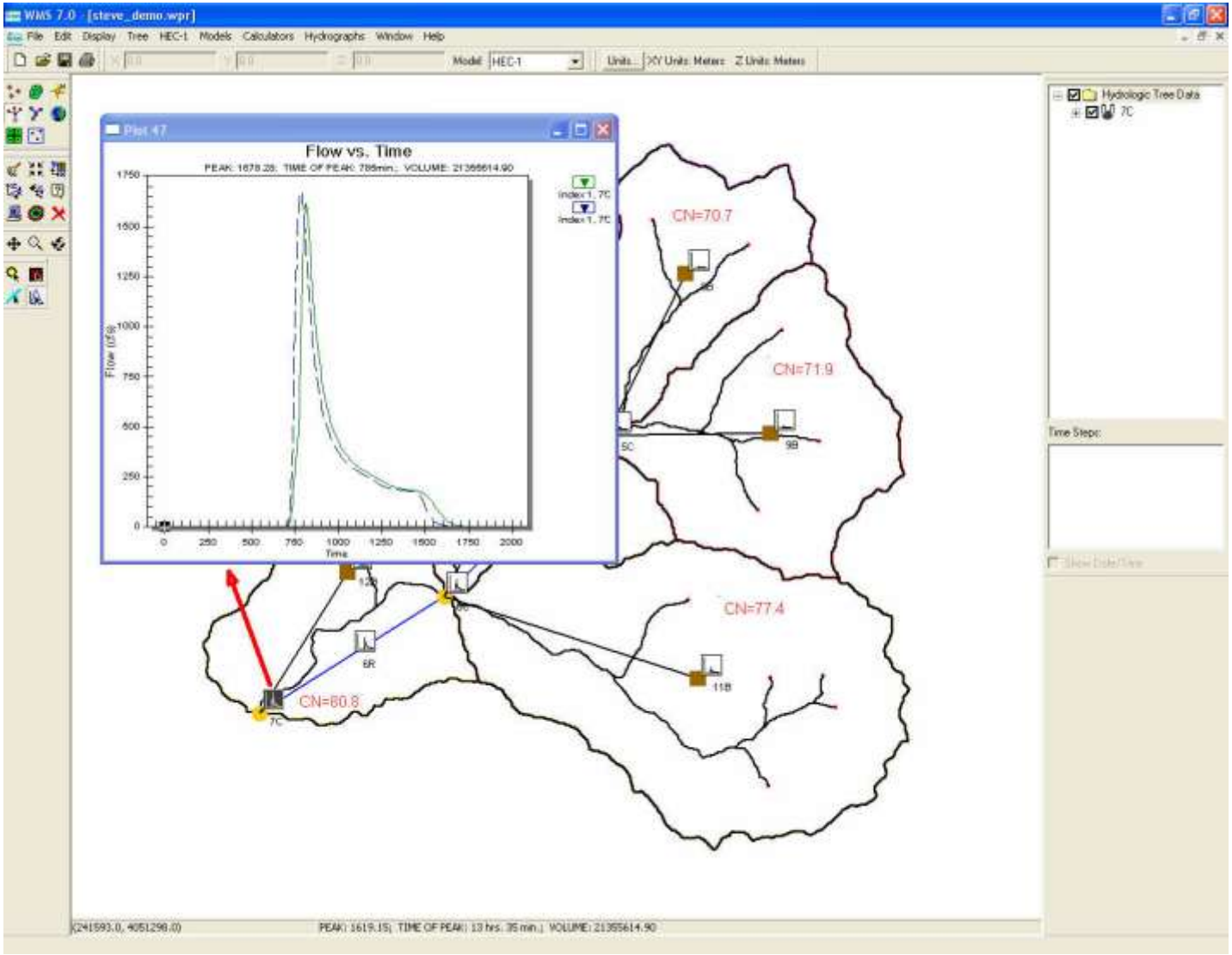
WMS Will Recalculate the Weighted Curve Numbers for Each Basin Which has Been Defined Based on Soils and Land Use



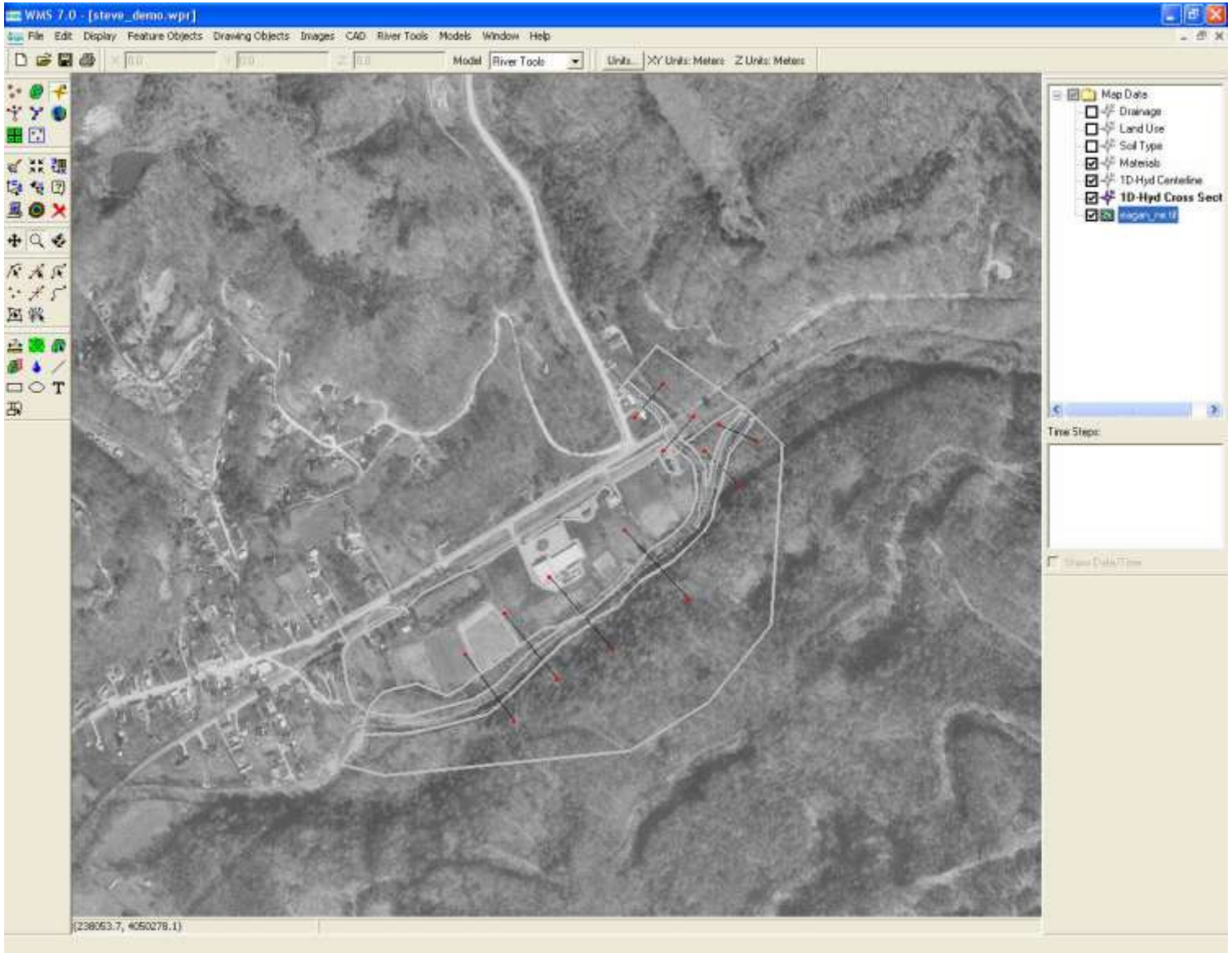
WMS Allows You to Route the Flow Hydrograph to account for Lag Time and Attenuation between the Upper and Lower Reaches of the Watershed



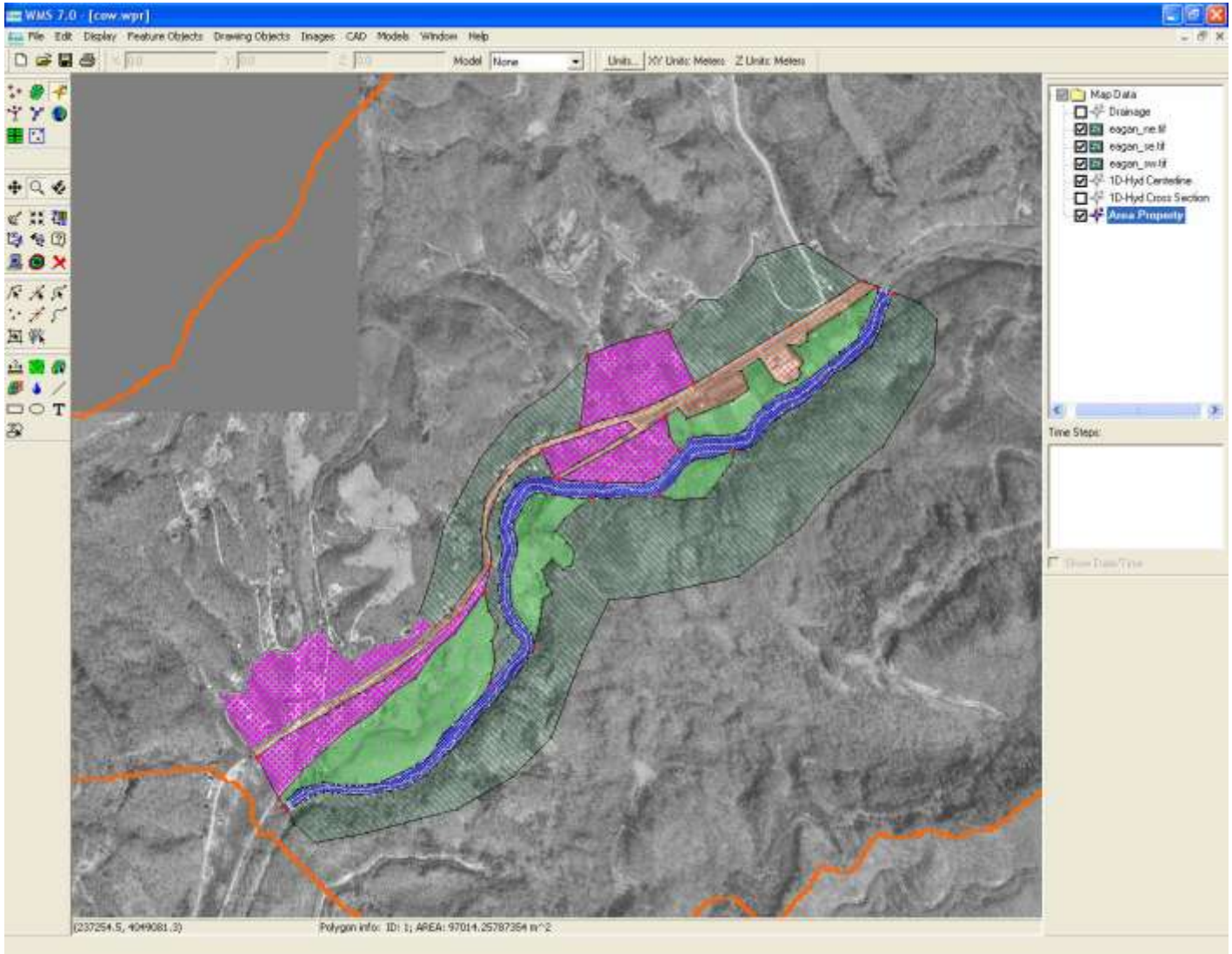
Results Can be Plotted Against Previous Simulations to Compare Results of the Various Settings or Methods Used



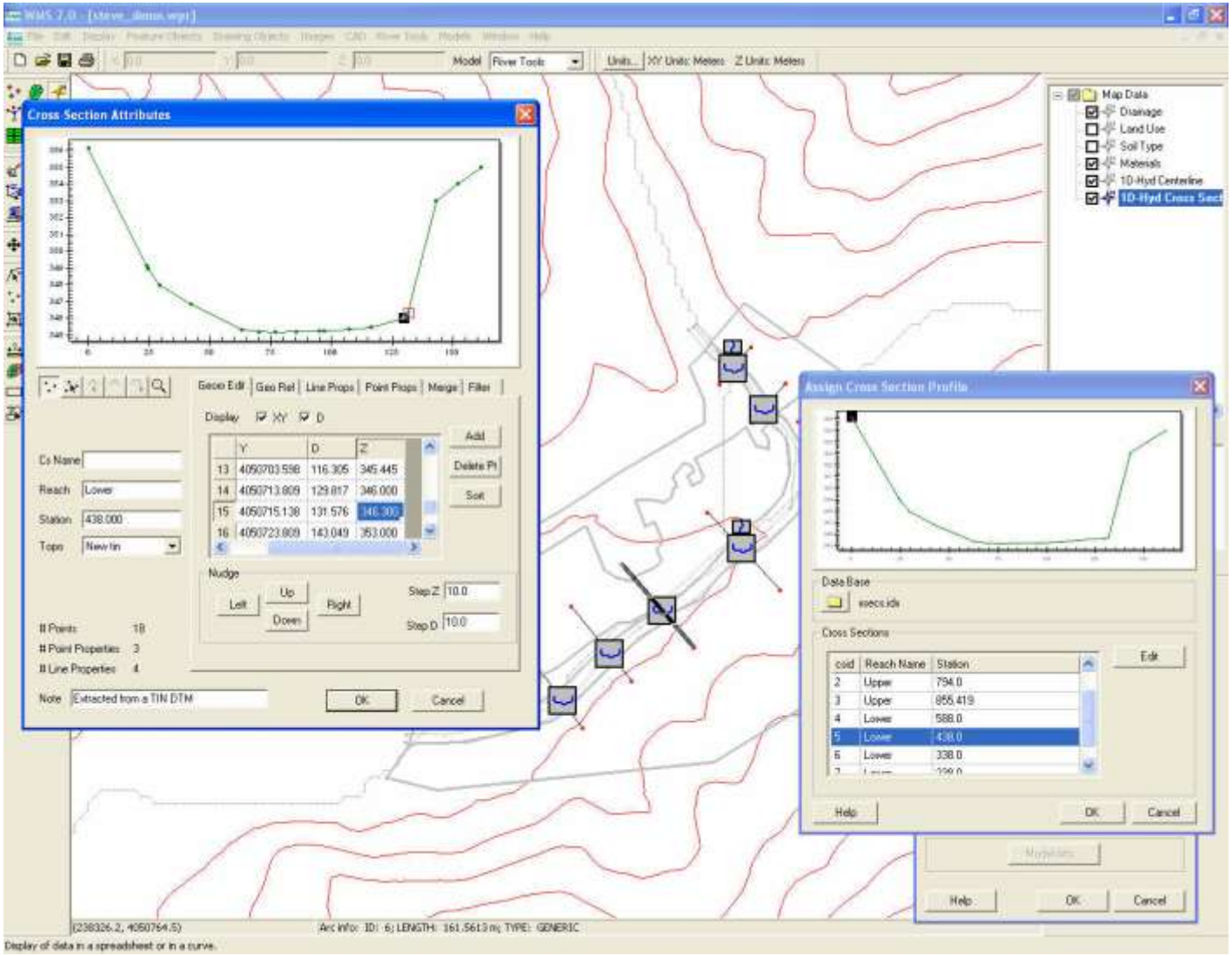
After Peak Flows Are Calculated, WMS Will Let You Delineate Cross Sections and Profiles to Export to HEC RAS to Determine Flooding Potential



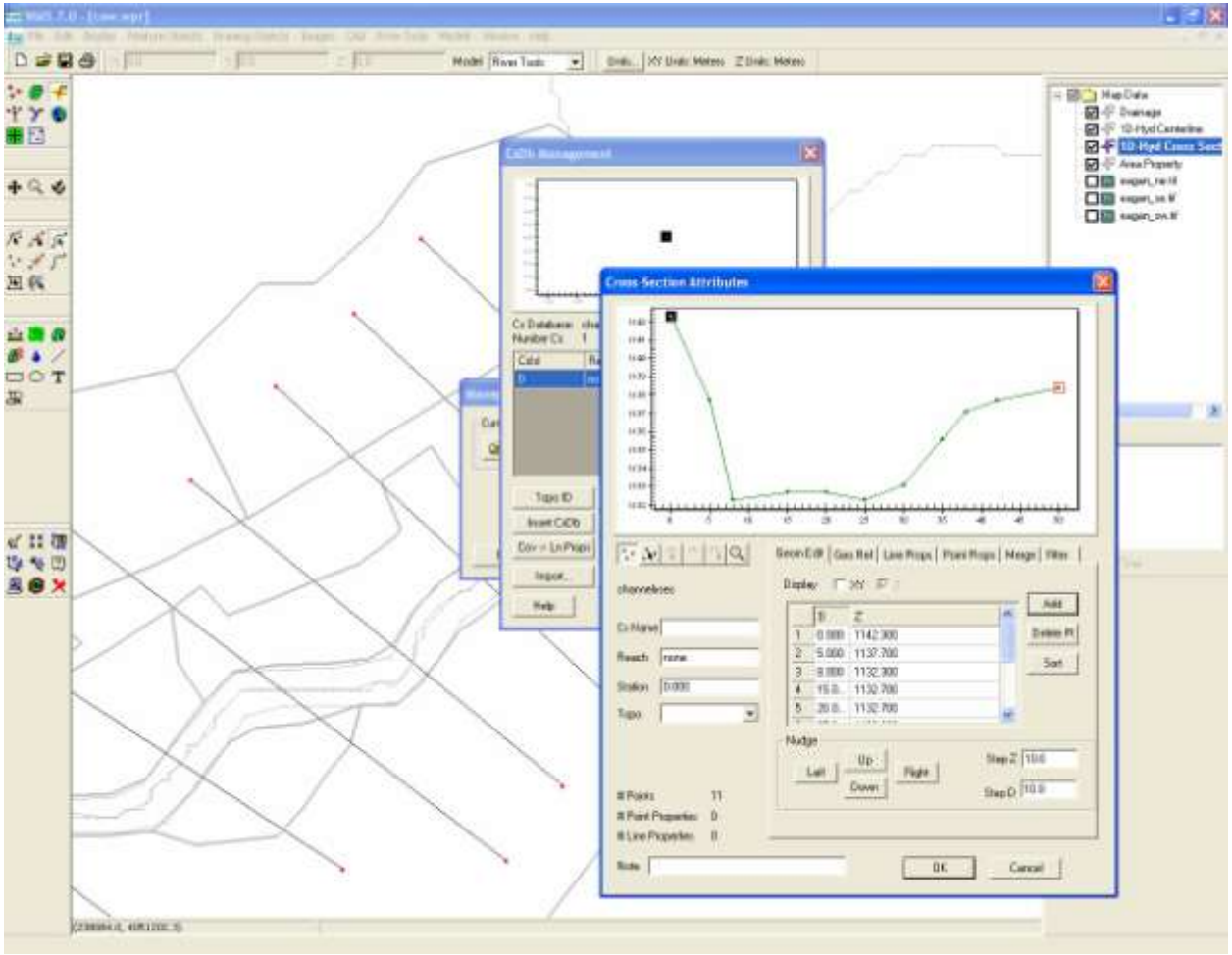
WMS Requires the Specification of Mannings Roughness Values for Materials in the Cross Sections Prior to Exporting to HEC RAS



Cross Sections Can be Previewed and Edited Prior to Exporting to HEC RAS

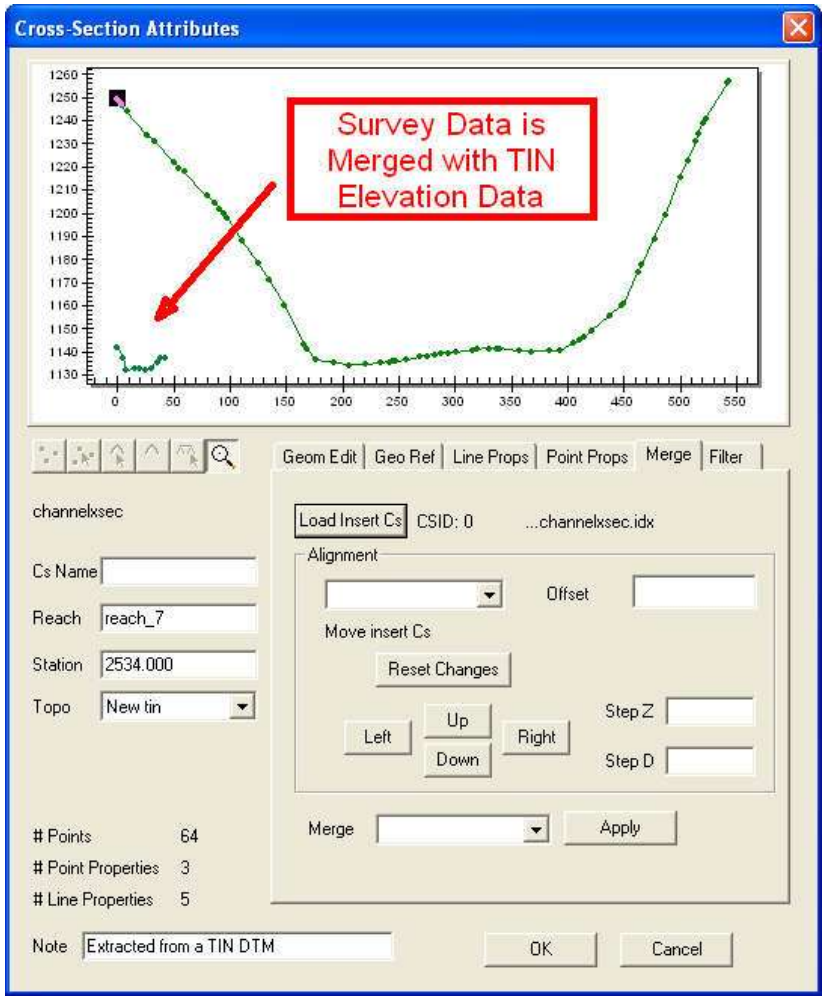


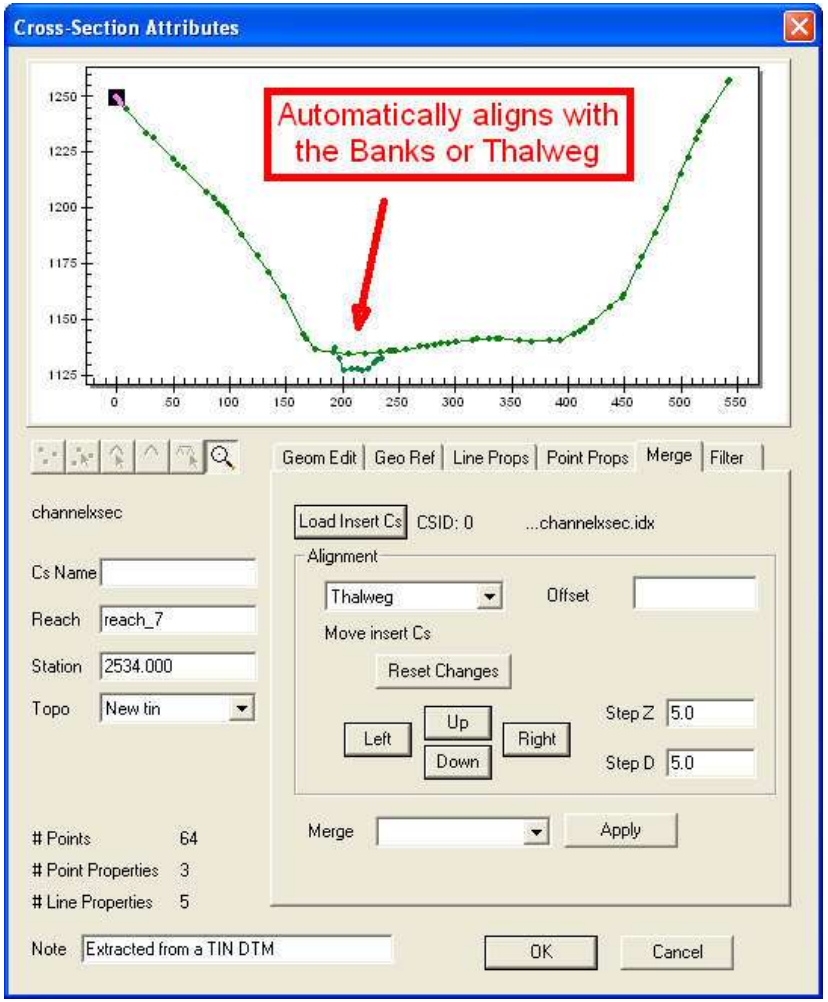
Surveyed Cross Sections Can also be Merged With DTM Data Generated from TINS or DEMs to More Accurately Represent the Stream or Floodplain



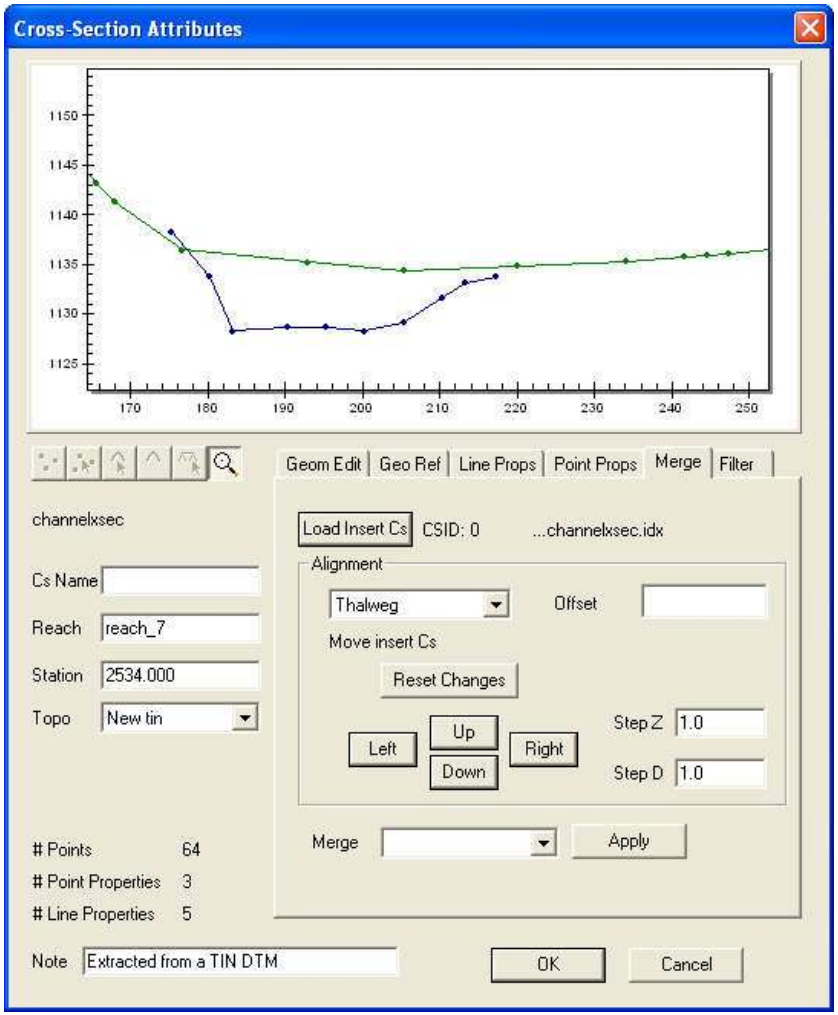
Here 10 Survey Points Across the Stream From Bank to Bank were Manually Entered Into WMS

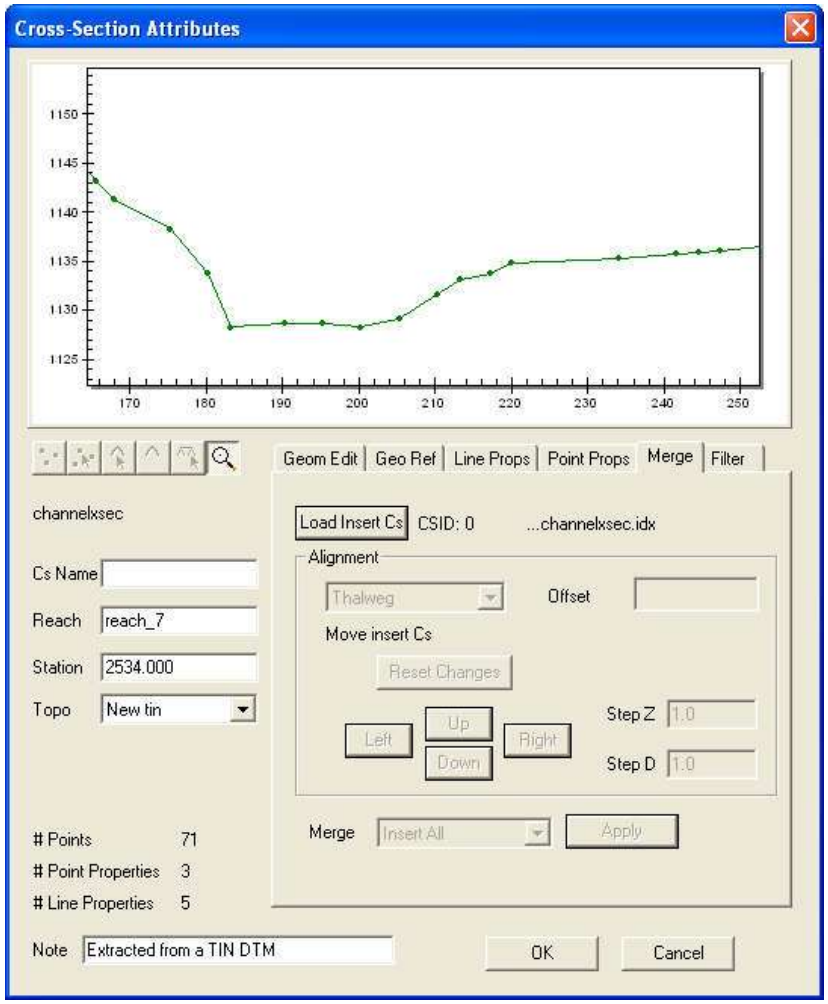
The Data from the DTM and the Survey Can Then Be Merged into a Single Cross Section



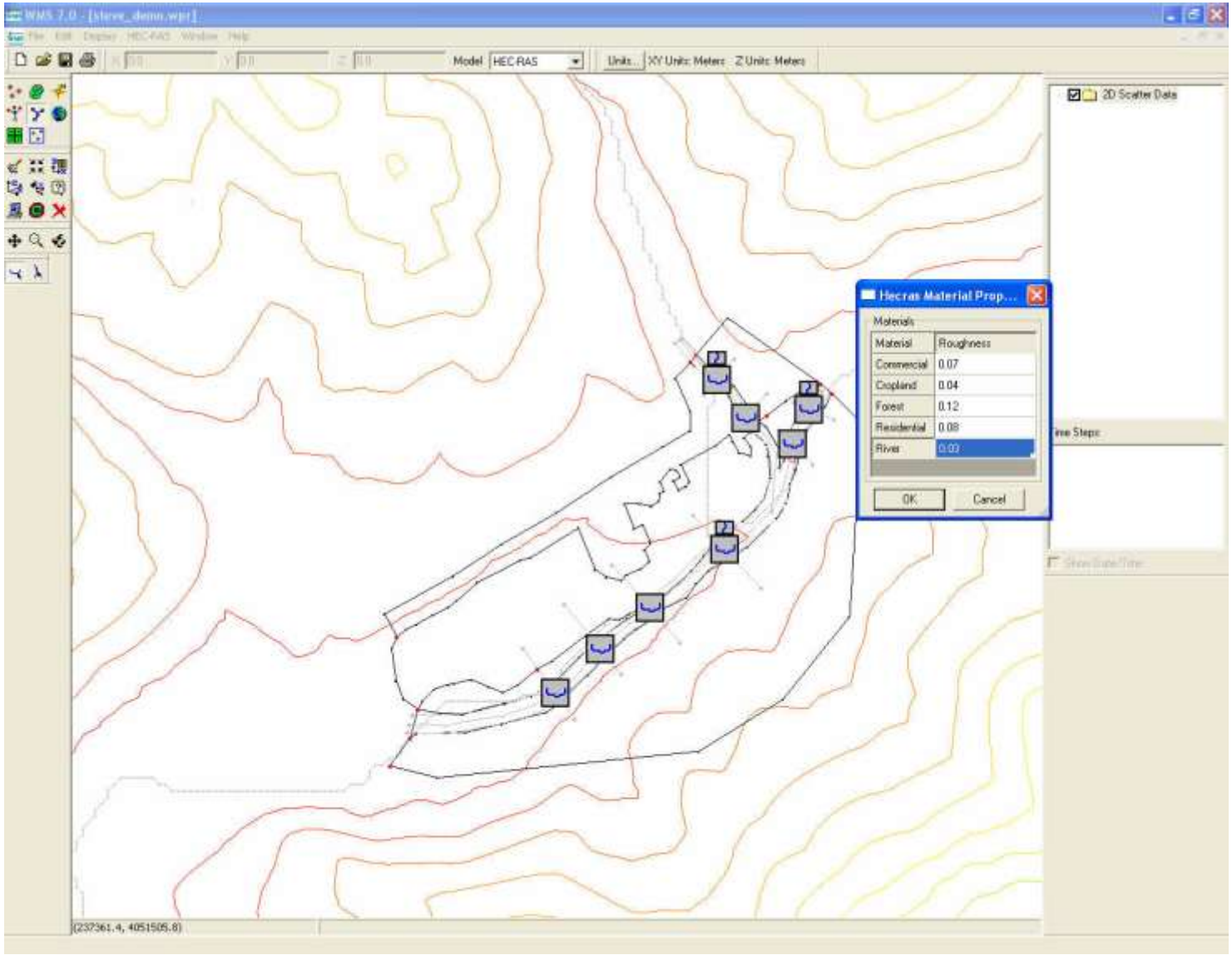


Once the Alignment has Been Verified, The Data Can Then Be Merged or Blended into the Cross Section File

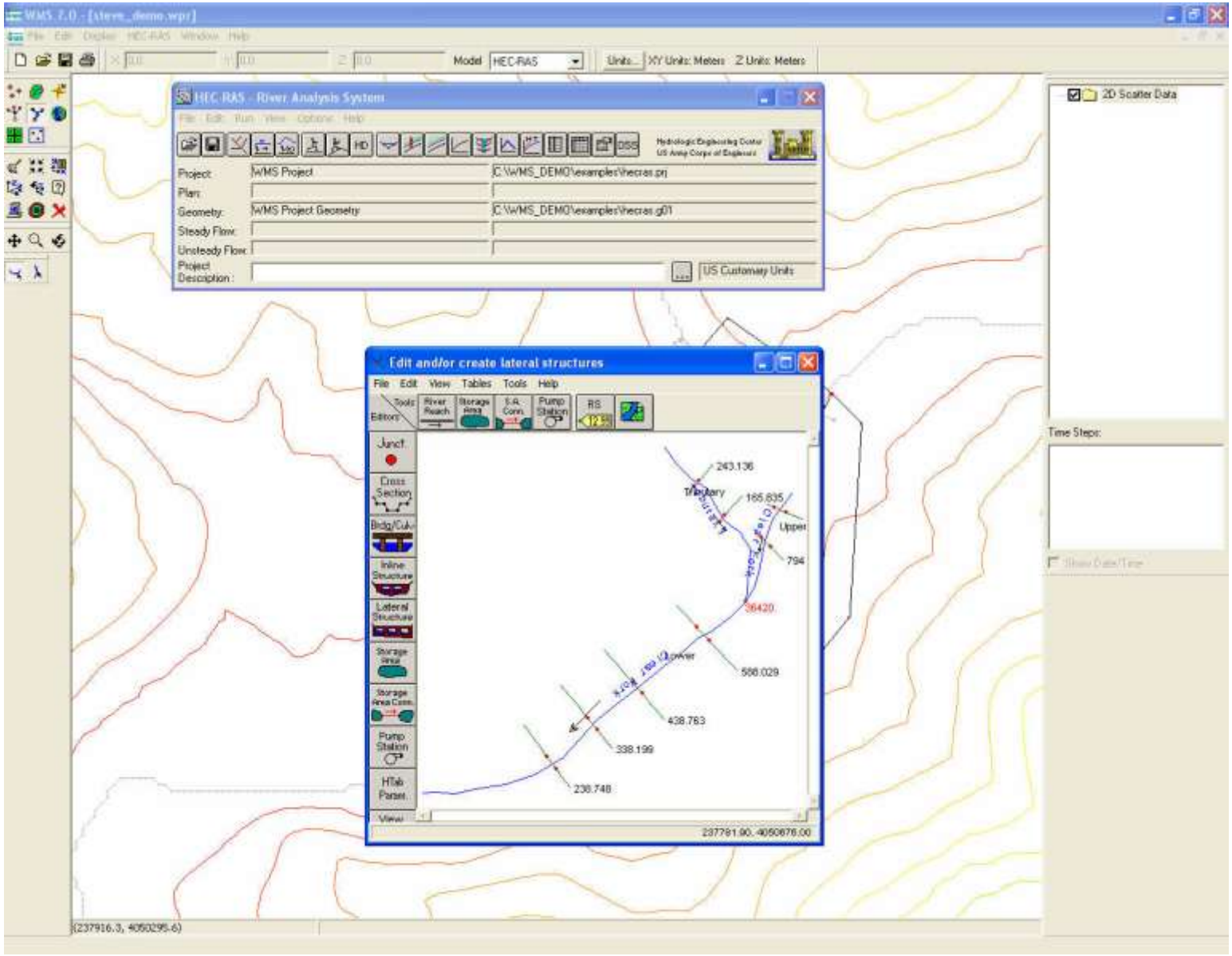




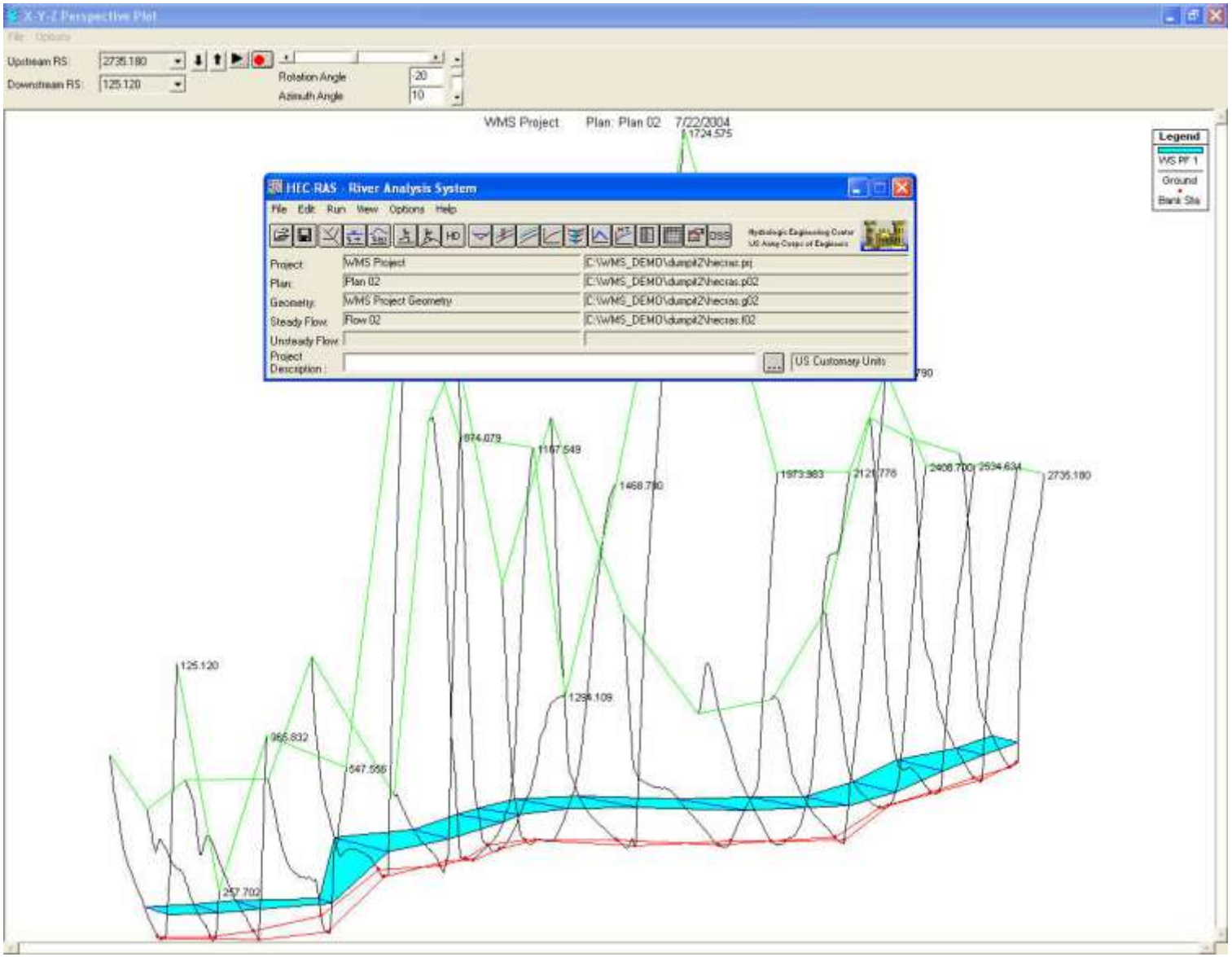
WMS Will Then Convert the Cross Sections and Profiles to a HEC RAS Geometry File for Export



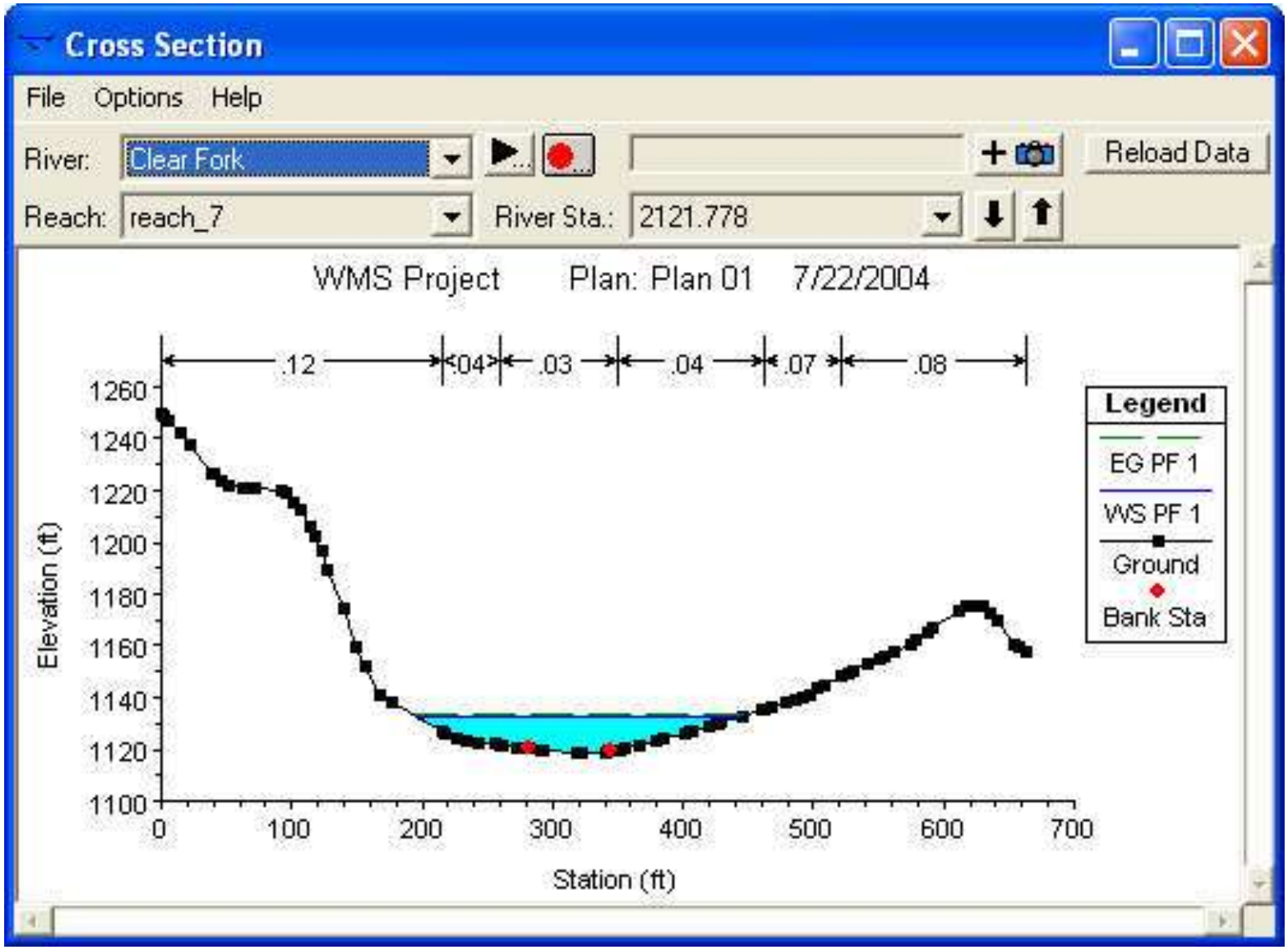
Once Exported, HEC RAS will Automatically Launch and Allow For Calculation of the Flow Analysis



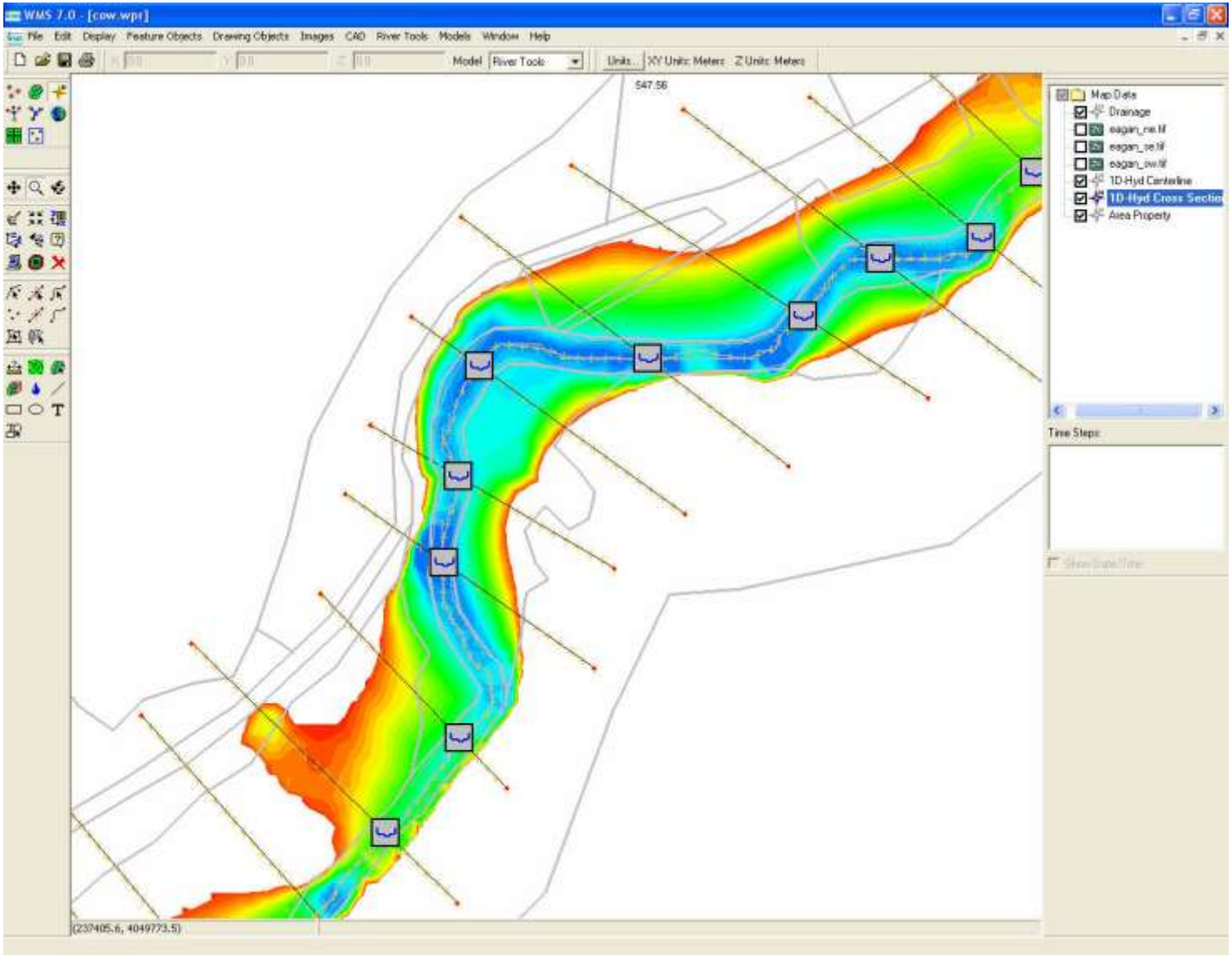
HEC RAS will Allow You to Preview The Stream Profile in 3D



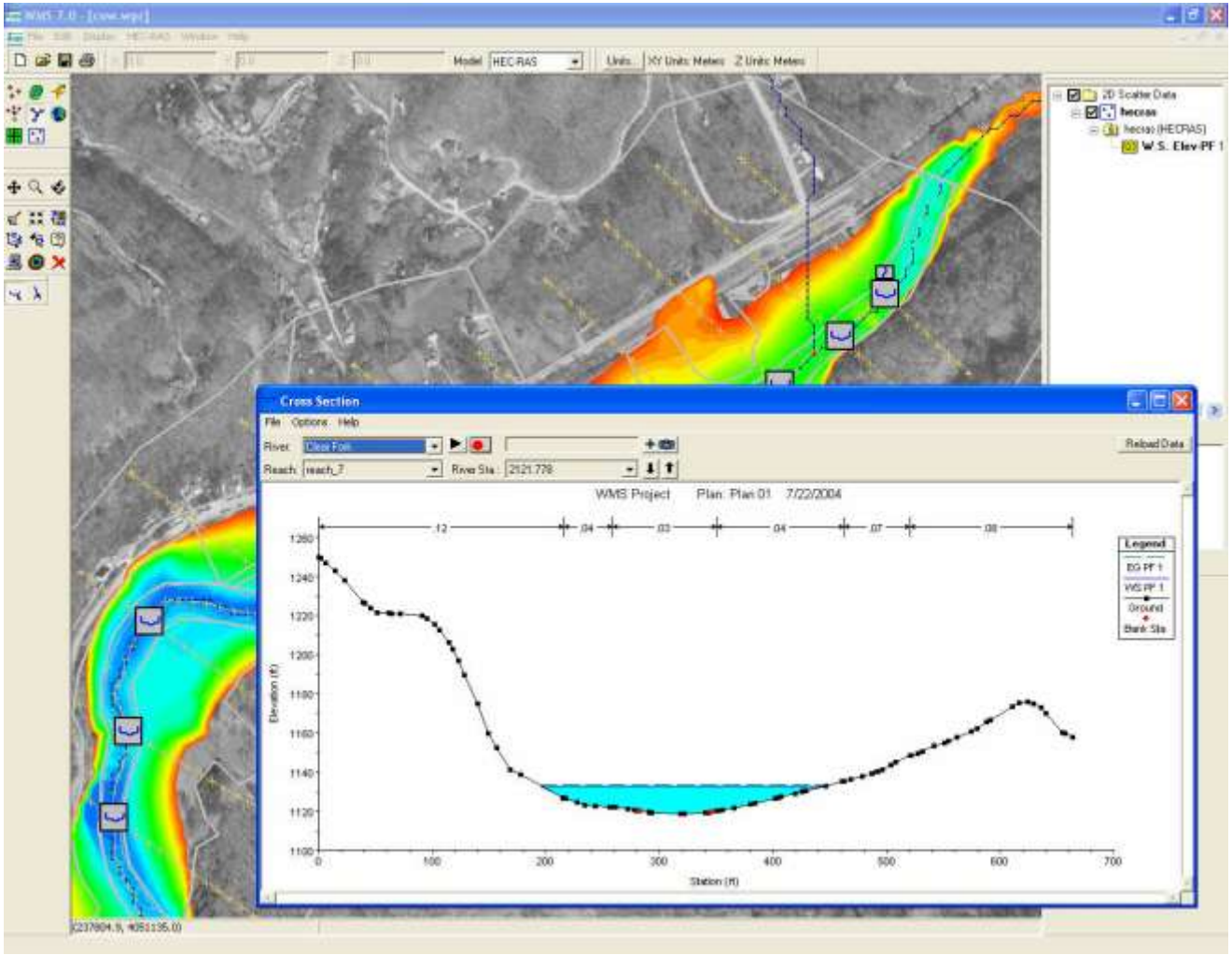
You Can Also Preview the Cross Sections and Calculated Flood Depths in Either WMS or HEC RAS



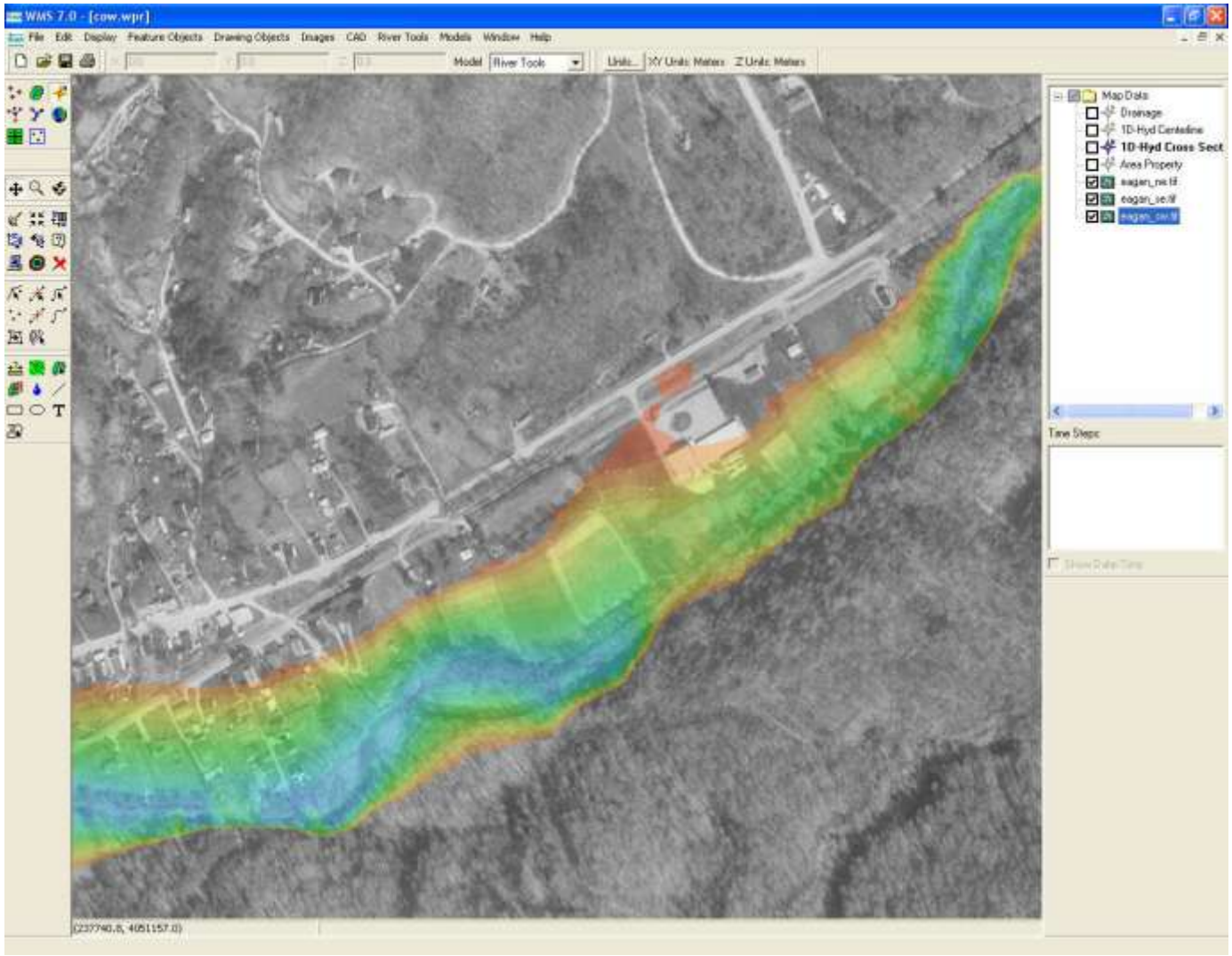
WMS Will Then Import the Resulting HEC RAS Project File and Delineate a Floodplain Map Based On the Cross Sectional Information



WMS Allows You to Quickly Plot the Cross Sections or Profiles Anywhere Along the Floodplain



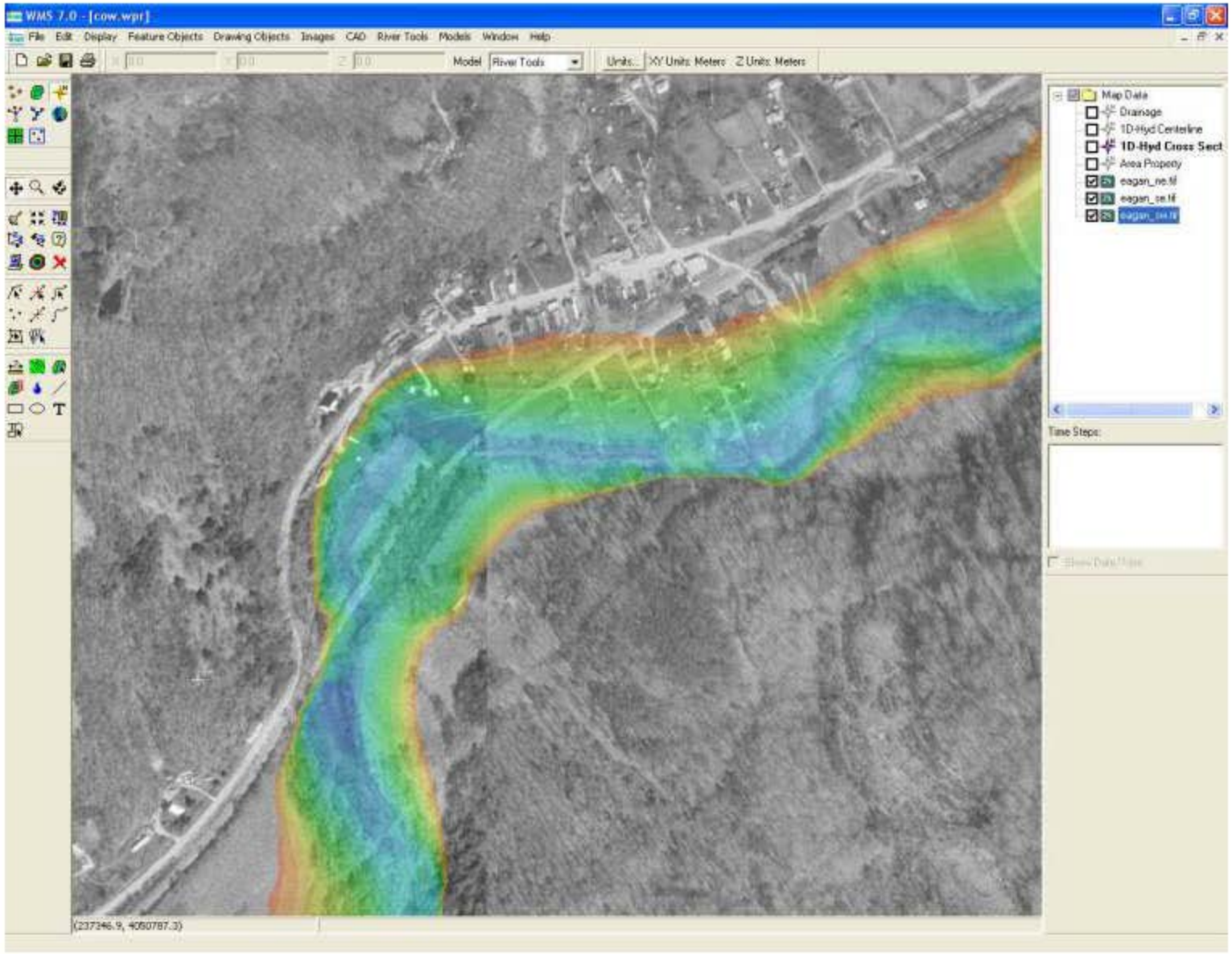
By Using Color Filled Contours and Transparency, The Floodplain can Identify Potentially Affected Structures



This Floodplain was based on 6,000 CFS which was an estimated 10 year, 24 hour event

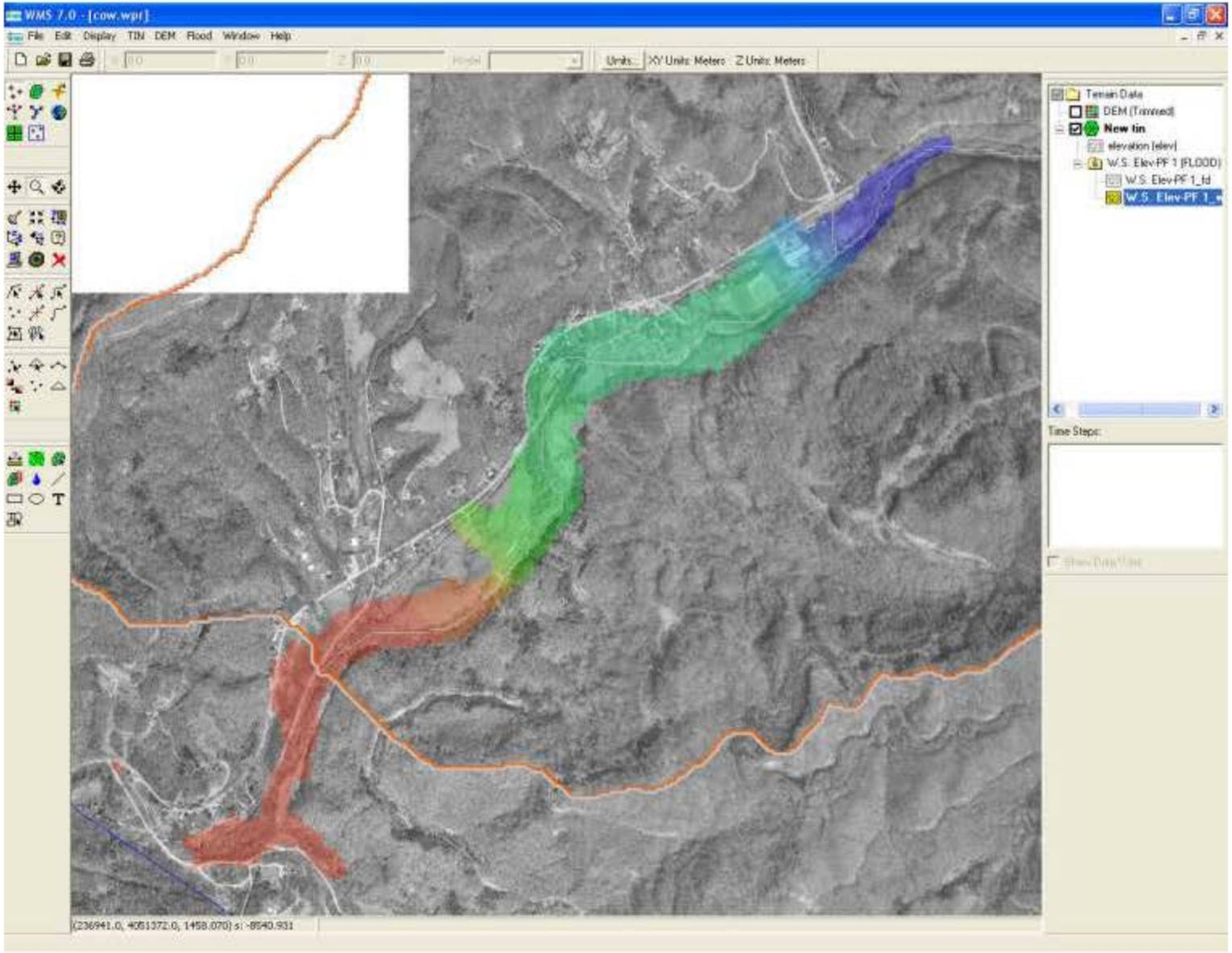
Depth of water contours are Based on 1 foot intervals

Midsection of Floodplain Evaluation

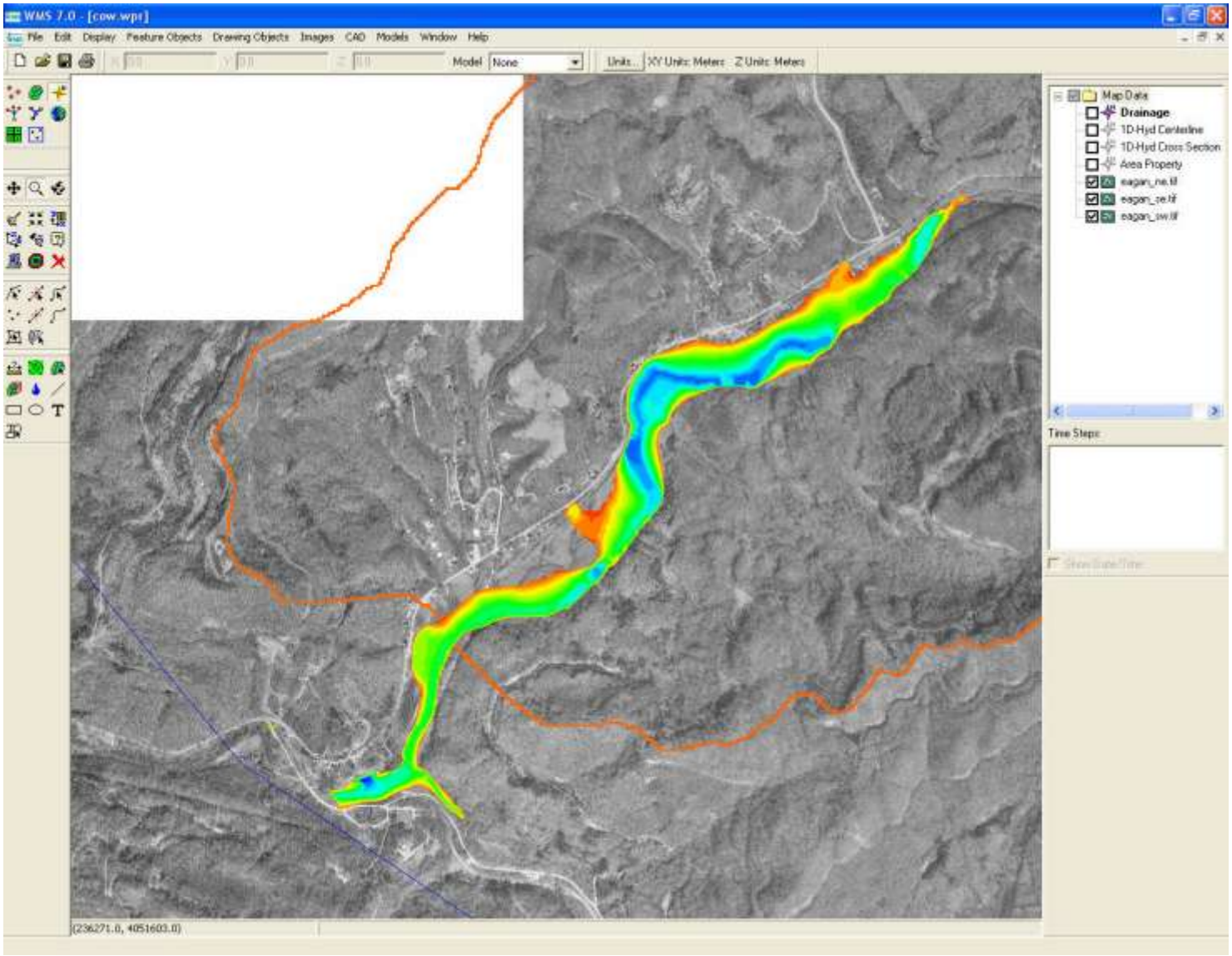


Lower Section of Floodplain Evaluation

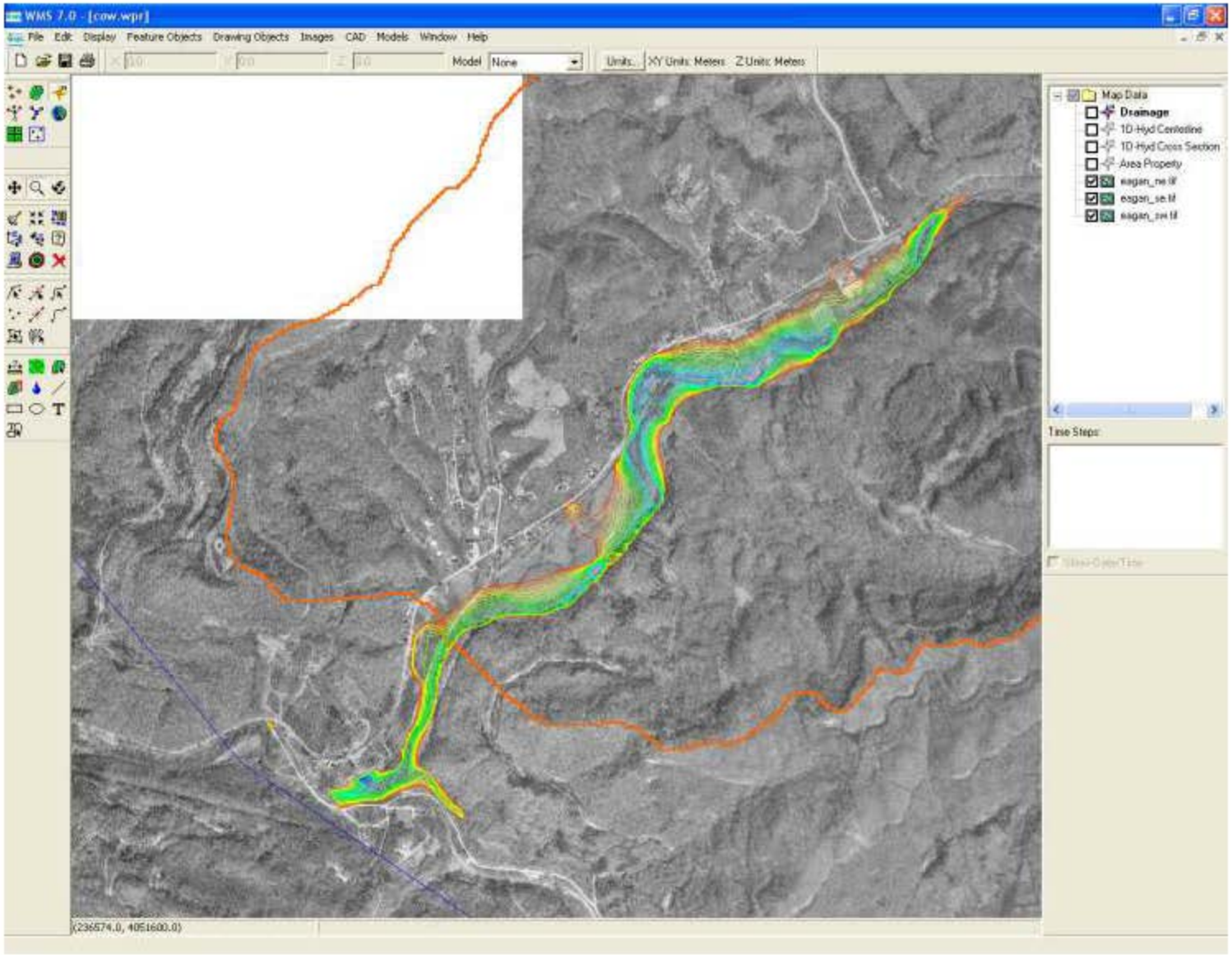
WMS also Calculates an Elevation Grid for the Flood Surface



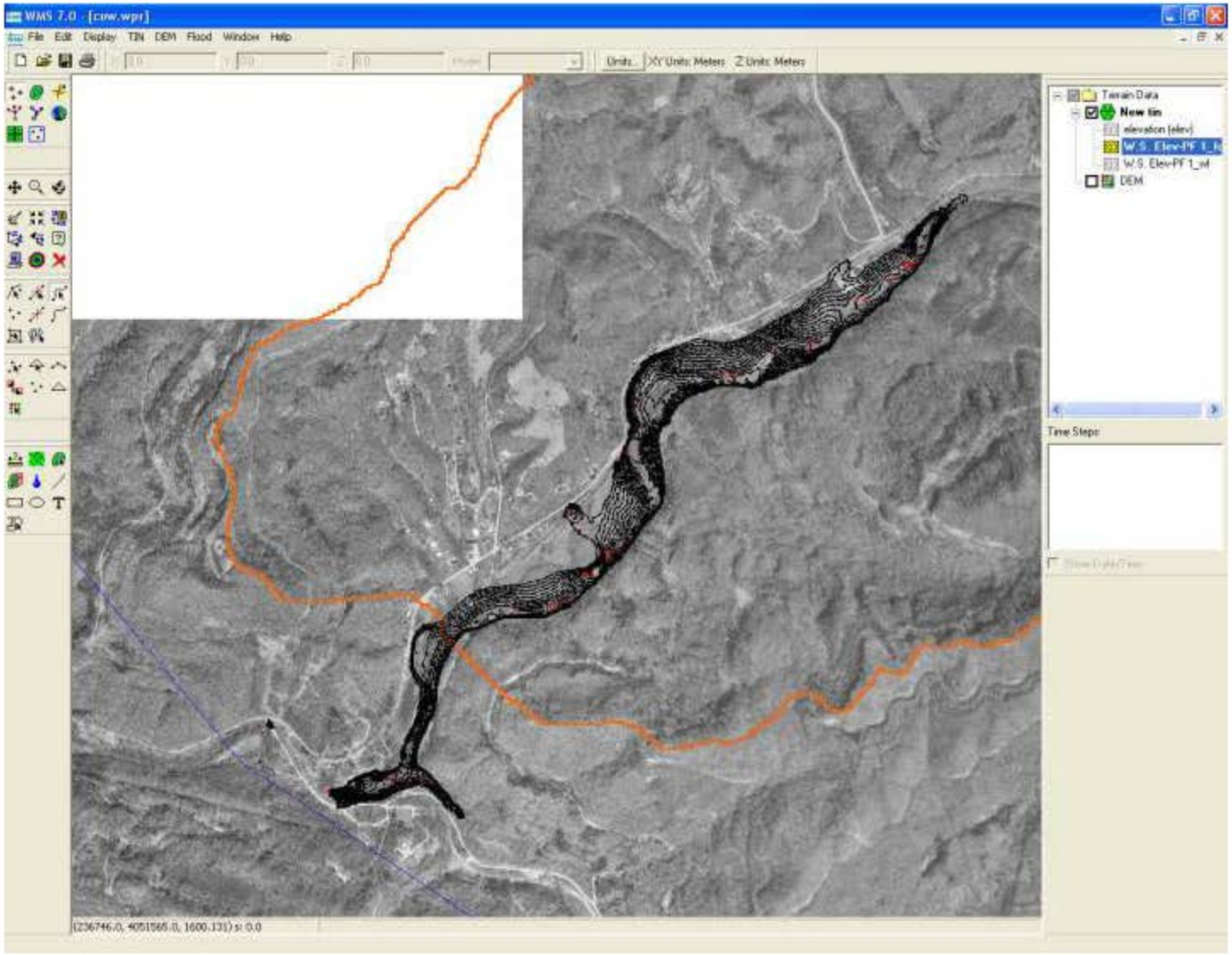
Once Floodplain Maps or other Feature Objects Have Been Generated, They can be Exported to ESRI, AutoDesk, or ASCII Files



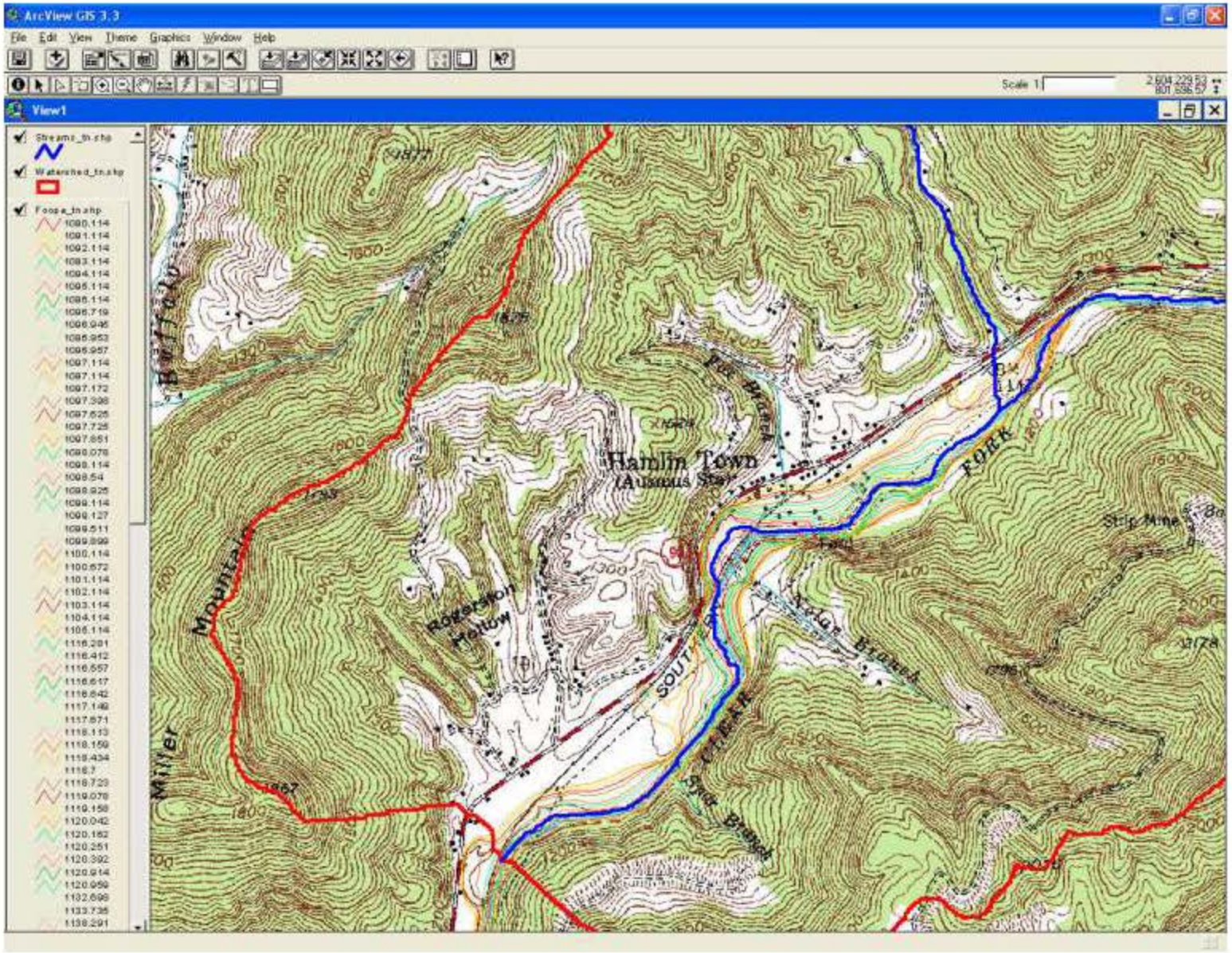
WMS Converts the Flood Depth Contour Lines to Feature Objects



Feature Objects Can Then be Exported to ESRI Shape Files



The Results Can Then Be Used in ArcMAP or ArcView



WMS Issues Identified During Initial Testing

- Some stability problems were noted during testing – especially during coordinate conversions, TIN generation, and simulations
- No “Undo” option which requires frequent “Saves”
- On-screen digitizing somewhat limited (panning and zooming not available)
- Multiple coordinate systems were often problematic (This project had 5 coordinate systems)
- AutoCAD Drawings Must be version 2002 or older
- Current version of HEC RAS not supported – Must be 3.1.1 or older
- Most capabilities of the software seem to be covered in existing TIPS or public domain software systems (However does offer a good graphical user interface)
- Water Quality and Sediment modules are not fully functional from within WMS at this time
- DEM data typically too coarse for floodplain delineation in low order watersheds

Conclusion and Summary

- WMS Interfaces Well With Other TIPS Supported Software (ArcView, ArcGIS, AutoCAD, HEC RAS)
- Automates Watershed Delineations and stream Channel Generation
- Allows for Export of Modeling Results and Features Objects to Other Software applications
- Uses Common Hydrologic Models to Generate Peak Flow Estimates
- Allows for Front End and Post-Processing for Other Hydrologic Models (GSSHA, HEC RAS, CE-QUAL-W2)