Rapid River Classification Using GIS-Delineated Functional Process Zones

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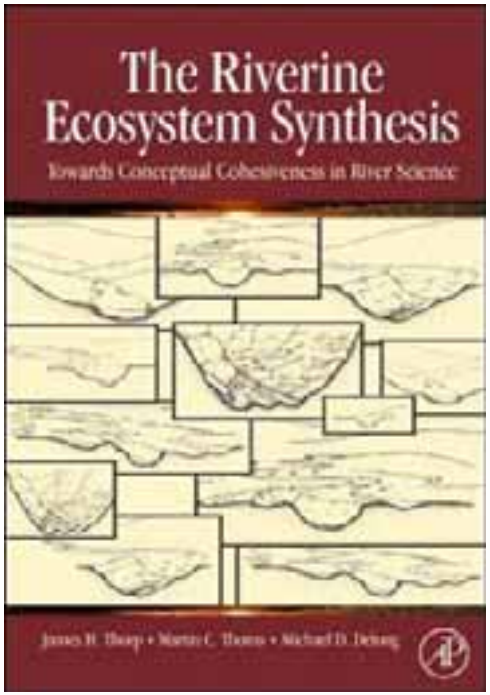
Overview

- Background on Functional Process Zones
- GIS Automation and Methodology
- Results of Preliminary Project on Kanawha River Watershed, WV

In the Beginning . . .



- Dr. James Thorp – Kansas University, KS
- Dr. Martin Thoms –University of New England, Armendale, NSW Australia
- Dr. Michael Delong – Winona State University, MN

River Continuum Concept (RCC)

- Linear model – Rivers viewed as continuous, longitudinal gradients of physical conditions.
- Clinal view – predicts a gradual shift in ecological communities and ecosystem properties as you move downstream.
- Scale dependent.
- Stream order is used to measure change in the size of the system.

Riverine Ecosystem Synthesis (RES)

- Rivers viewed as non-continuous, repeatable hydrogeomorphic patches.
- Ecosystem structure and function vary by patches (i.e., zones).
- Less scale dependent – patches exist at many scales.
- Functional process zones (FPZs) describe patches at the reach-to-valley scale.
- FPZs reflect hydrogeomorphic functions that shape sections of the riverine ecosystem and impact ecological communities and ecosystem properties.

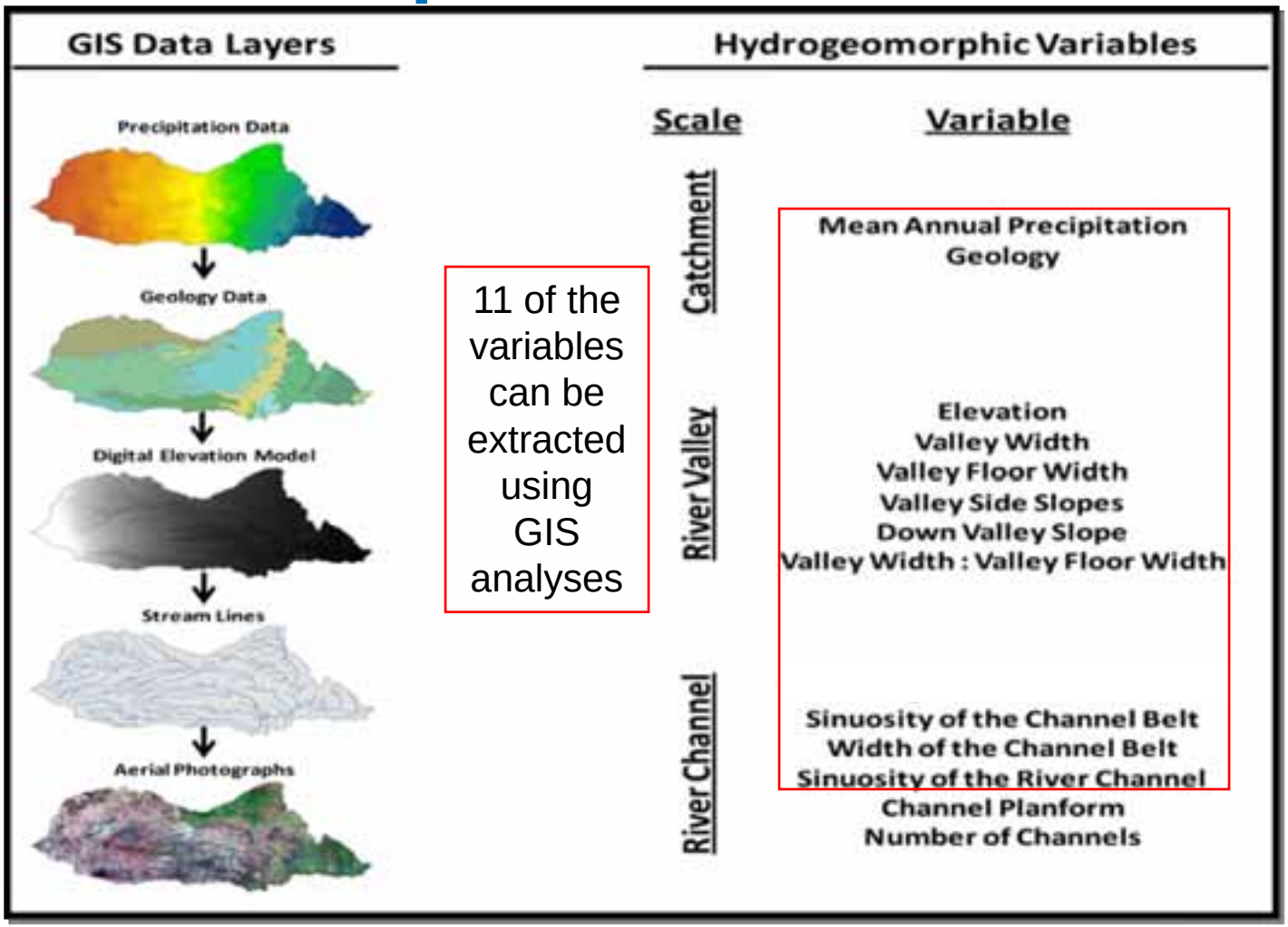
Functional Process Zones

- Identify structurally and functionally similar river segments - improving bioassessment, monitoring, and restoration activities

Environmental Applications

- Aid in river classification
- Help determine monitoring design and assessment
- Help identify appropriate reference conditions
- Help determine ecosystem services
  - River rehabilitation

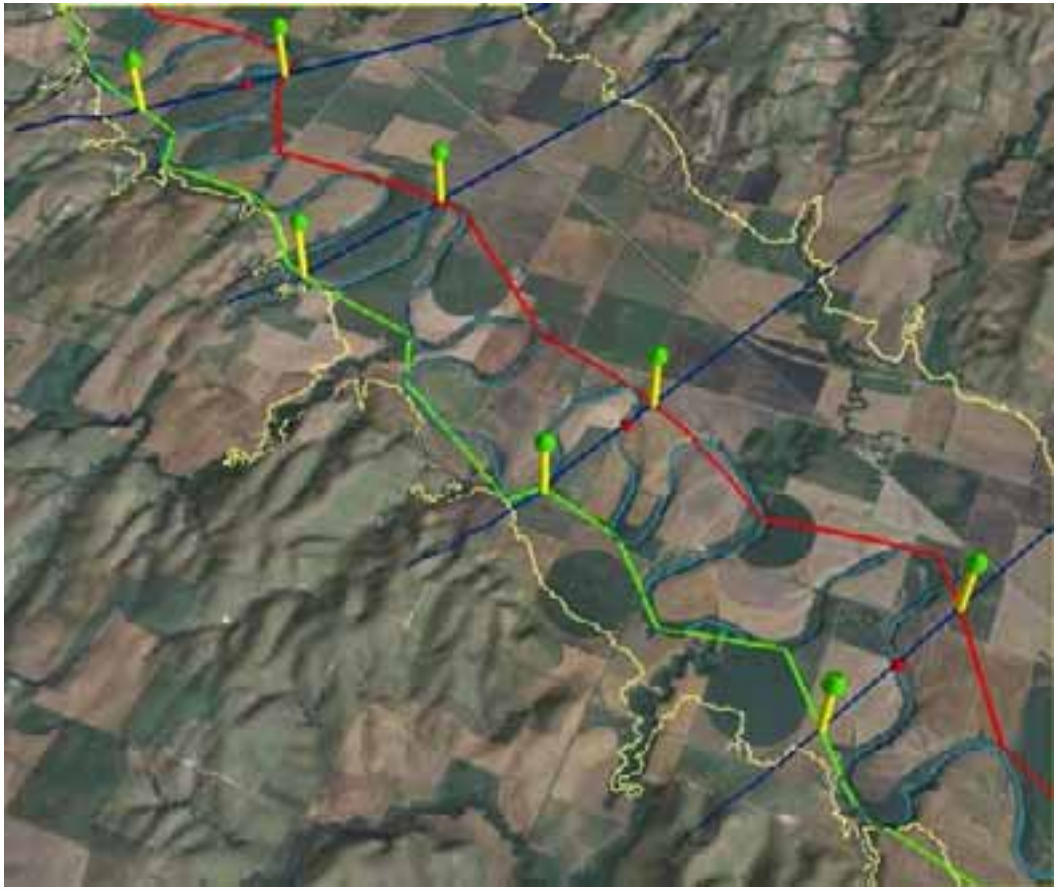
Requires the Calculation of 13 Dependent and Independent Variables



Seven Required Input Datasets

- Hydrography
- Digital Elevation Model
- Precipitation
- Geology
- Floodplain
- Microshed
- Channel Belt

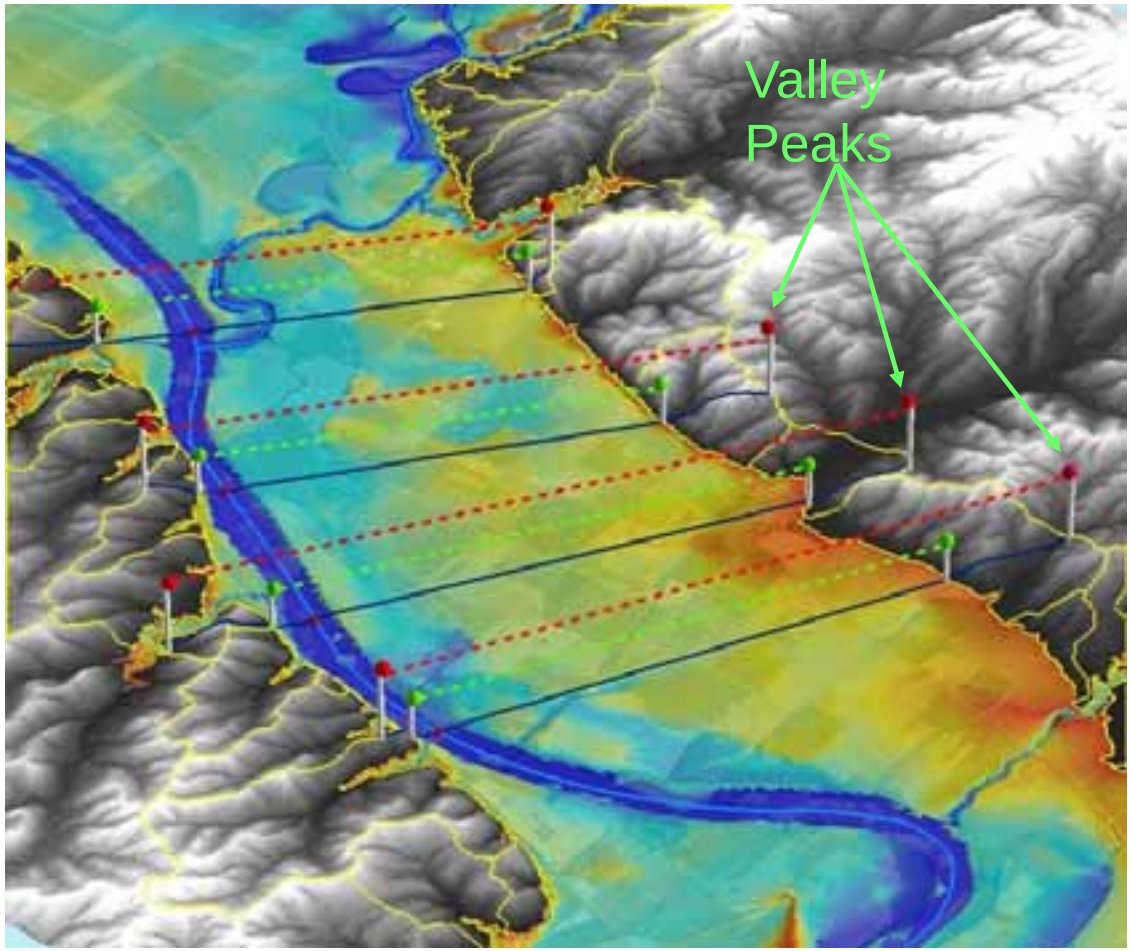
Channel Belt



Kansas River, KS

- A band running along a valley floor that contains a meandering channel

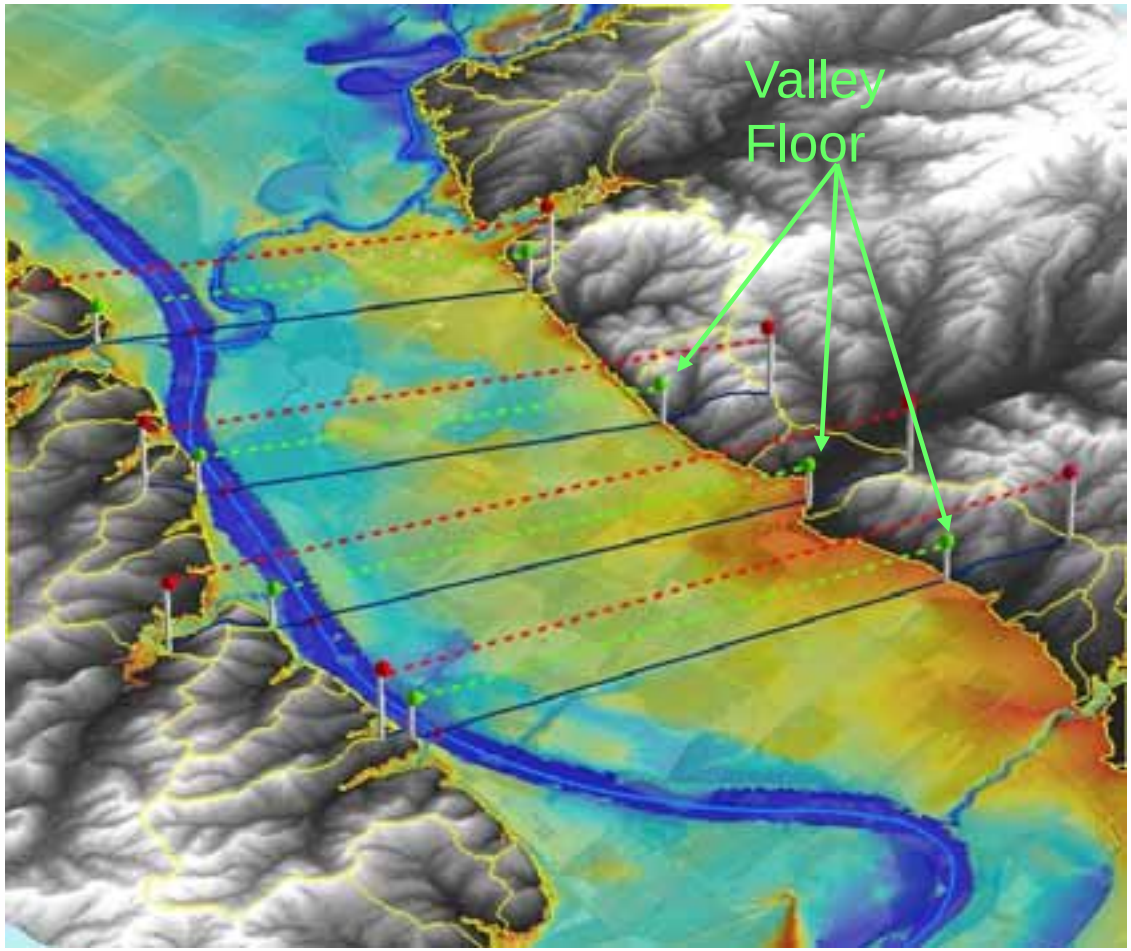
Microsheds



- Created using ArcHydro to help identify the valley peaks.

Kansas River, KS

Floodplain

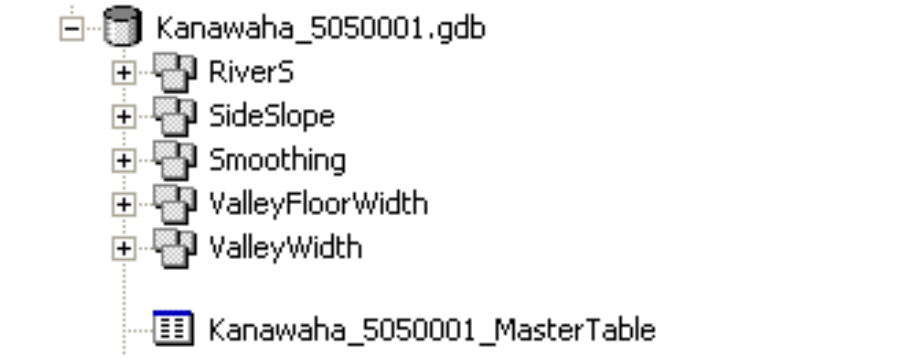


Kansas River, KS

- MATLAB® based floodplain (FLDPLN) model that uses backfilling and spillover flooding procedures to determine a depth-to-flood value for each pixel in a surface raster.

Let's Get Organized

- Geodatabase (personal vs. file)
  - Has feature datasets for each variable that requires complex analysis.
  - Reports all results to a Master Table.



Naming Conventions and Unit of Analysis

- Important be able to track segments through the entire process.
- Need to establish a unit of analysis.
  - Used points generated along a stream at a user defined distance.
  - Each point is attributed with the river name and the distance along the line.

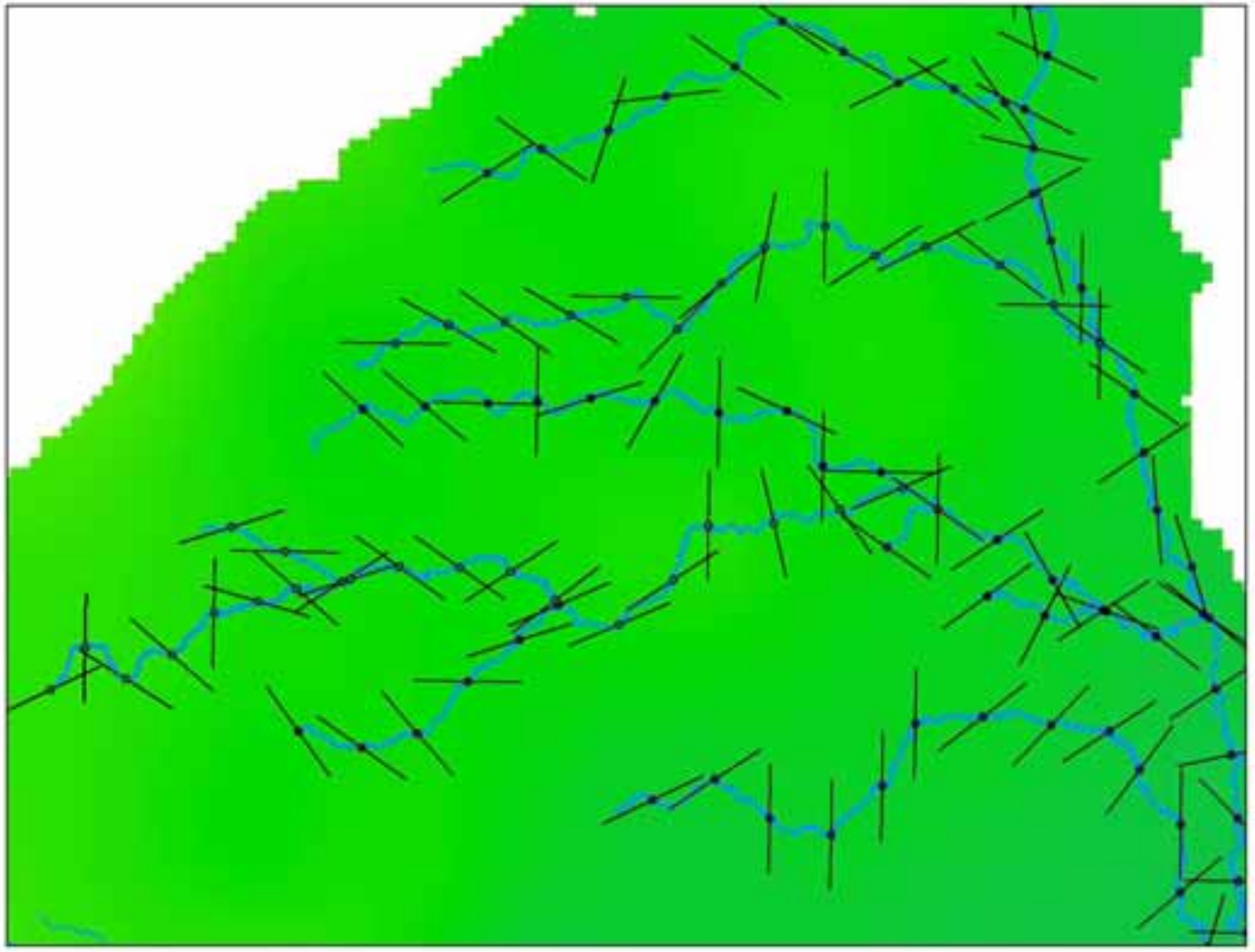
Sampling Points

- Sampling points are created through a series of event tables.
- Each sample point has a row in the Master Table.
- Precipitation, Elevation, Geology, and Down Valley Slope can be extracted directly from the sampling points.
- All other variables required the use of transects.

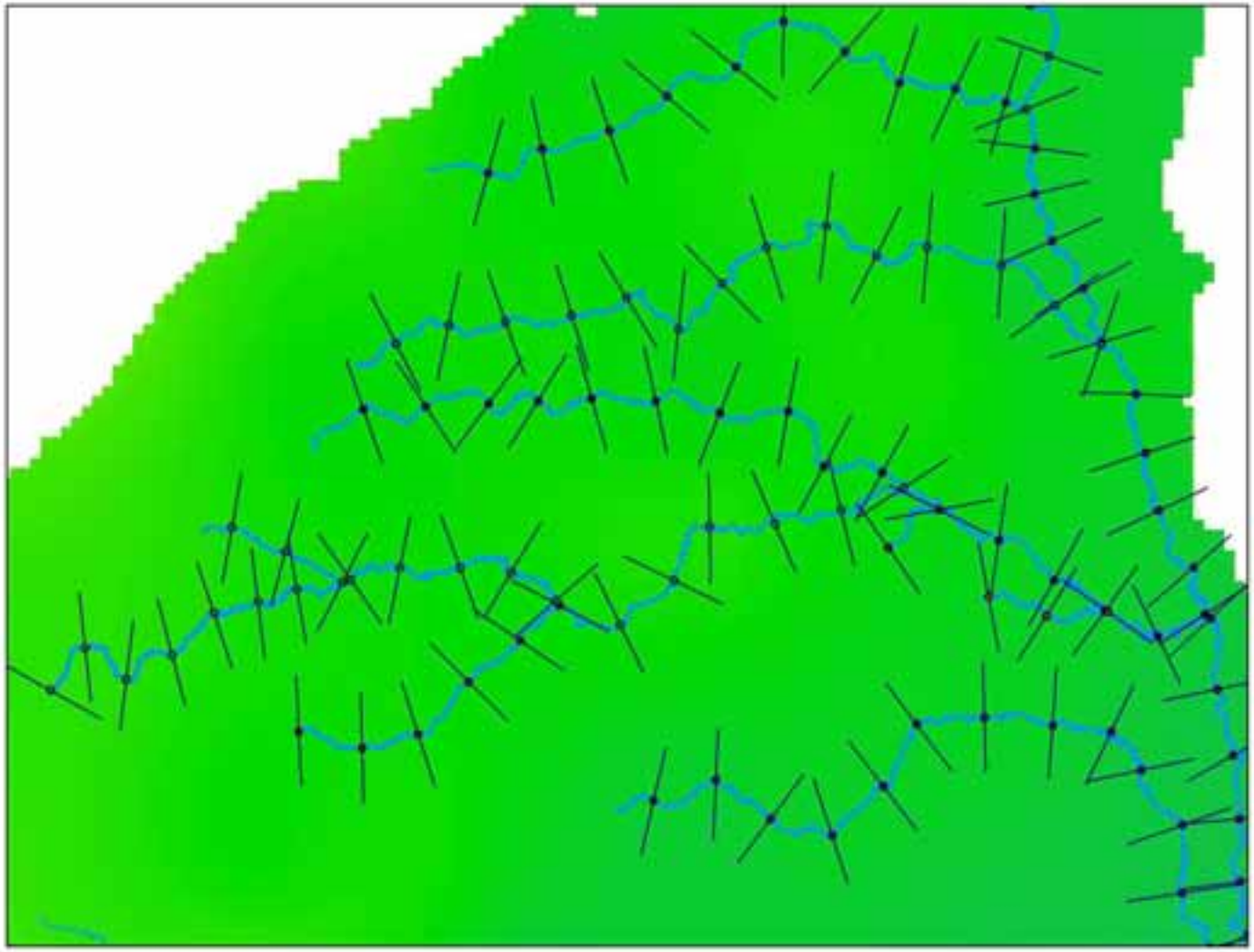
Transects

- Transects are generated perpendicular to each sample point.
- The slope of the hydrology line at the sample point determines the angle of the transect.
- A creative solution needed. High resolution hydrology had too many minute changes causing the transects to generate at odd angles.

Transects created using original hydrology

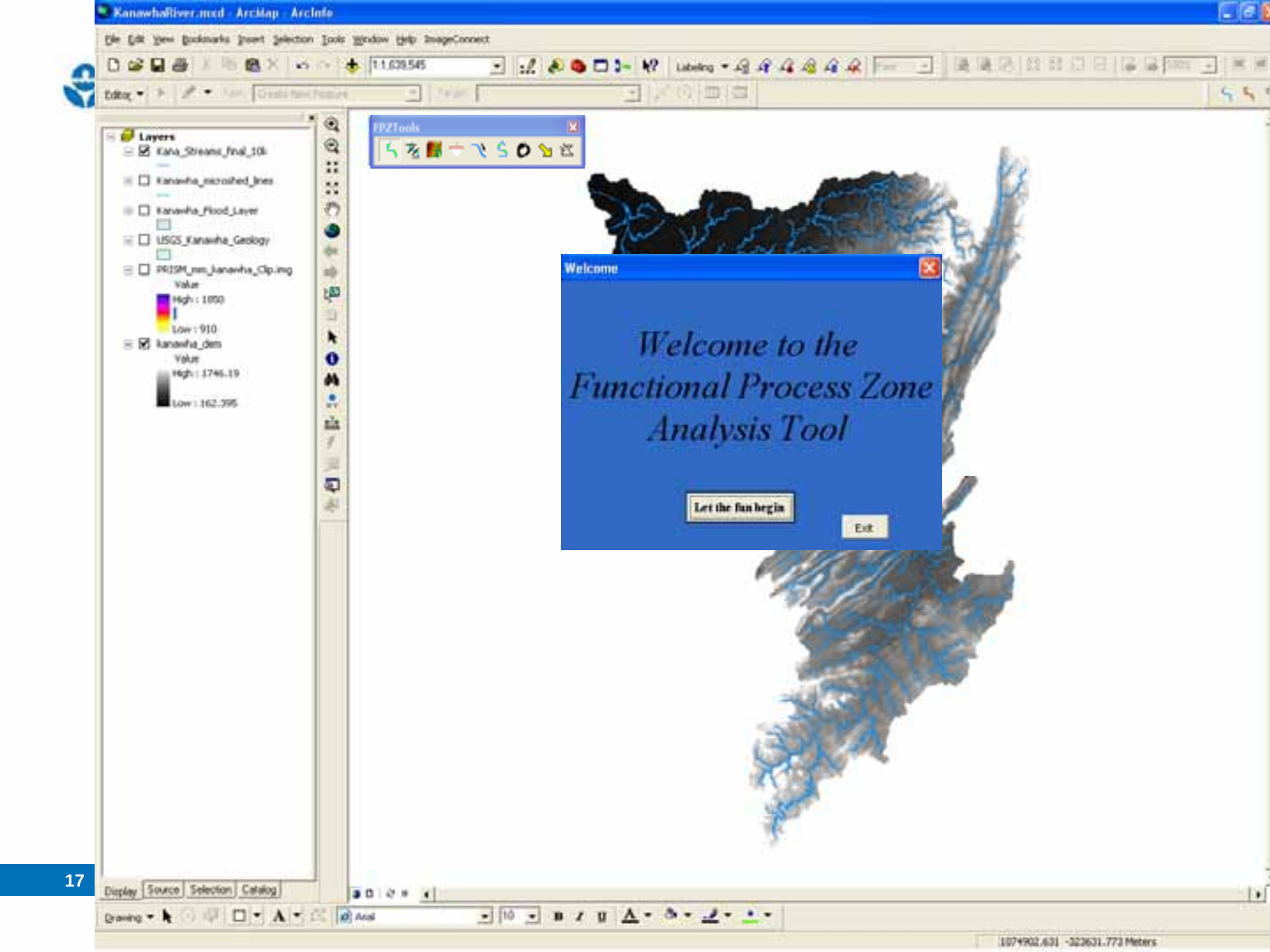


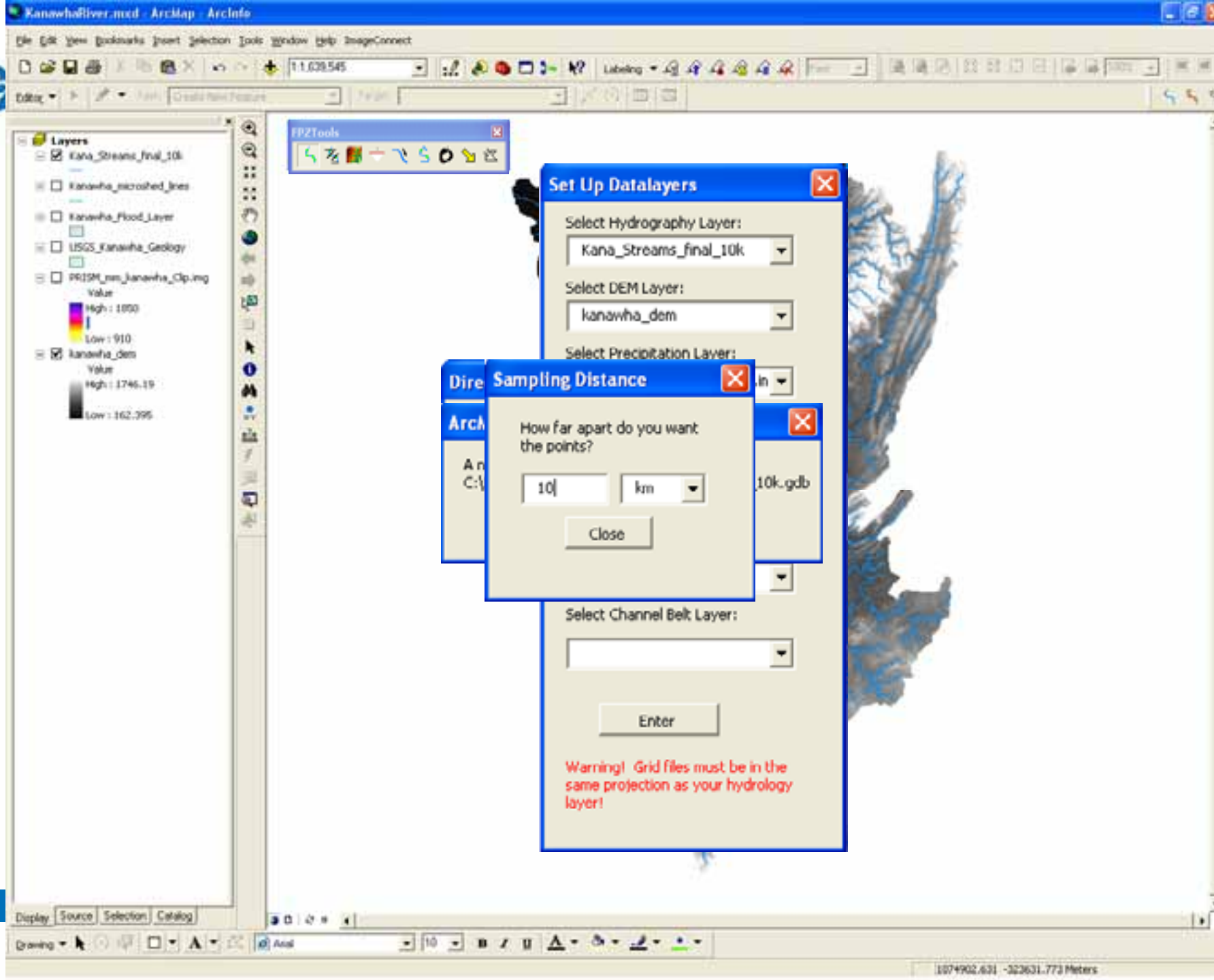
Transects created using smoothed hydrology

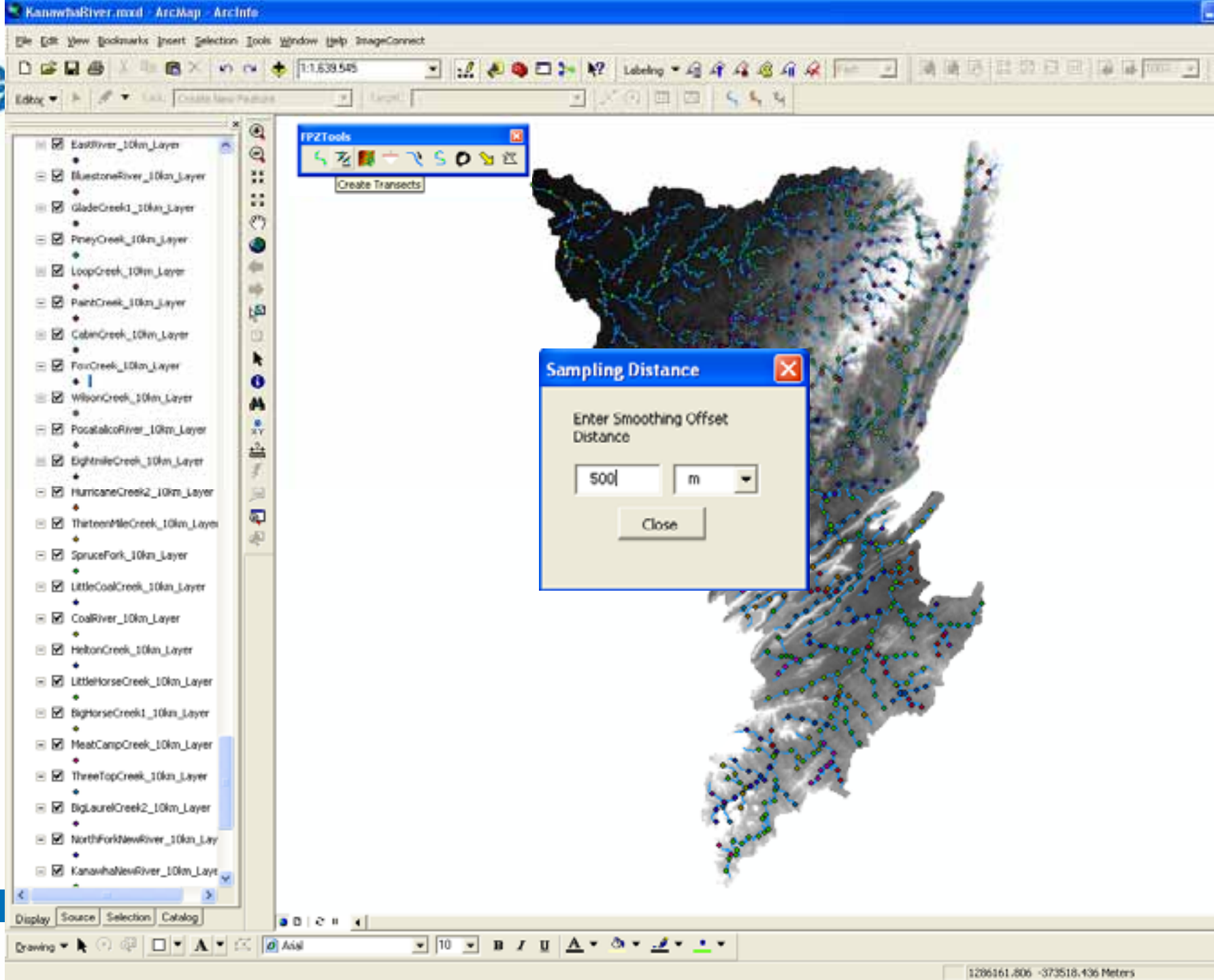


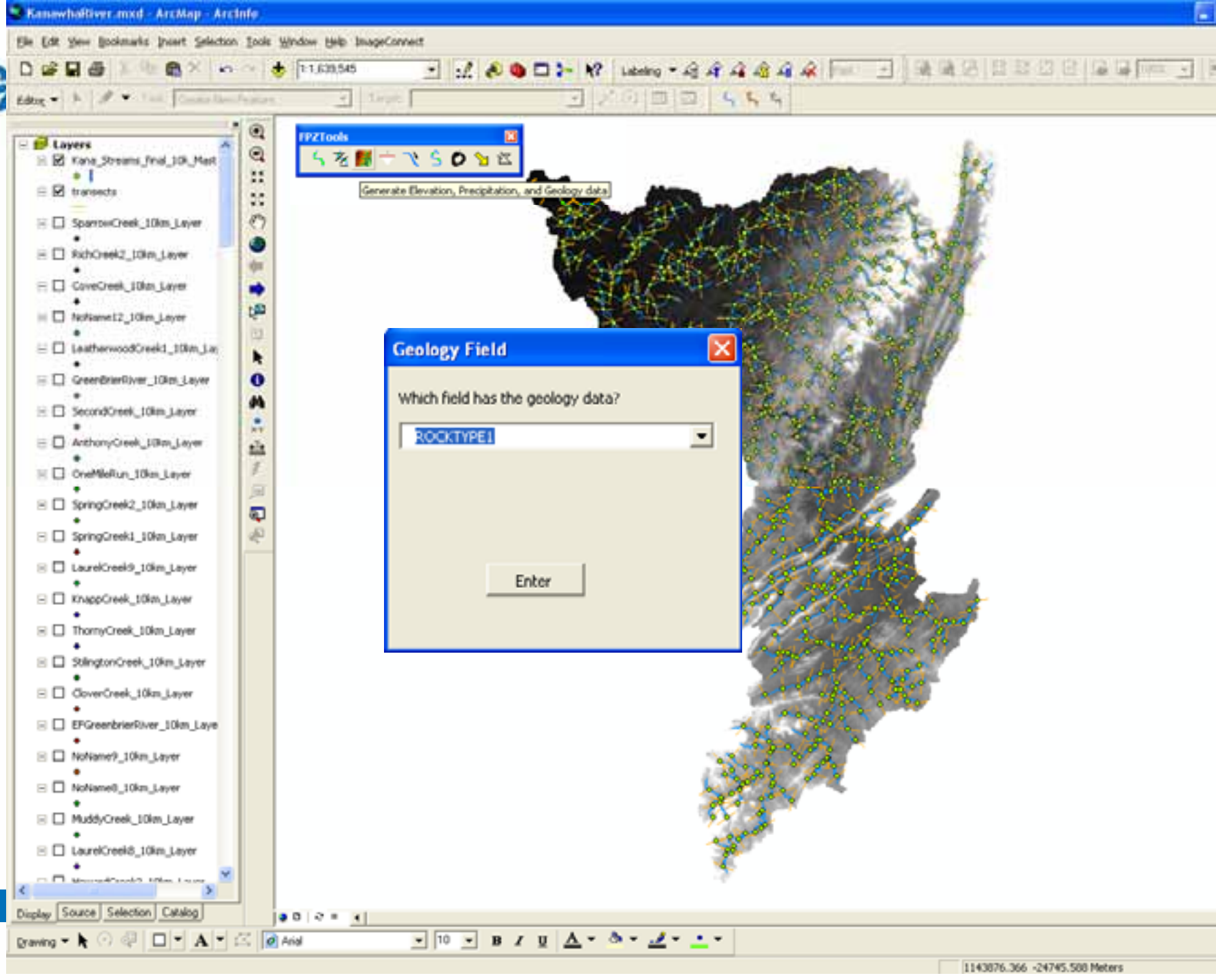
FPZ Tool in ArcGIS

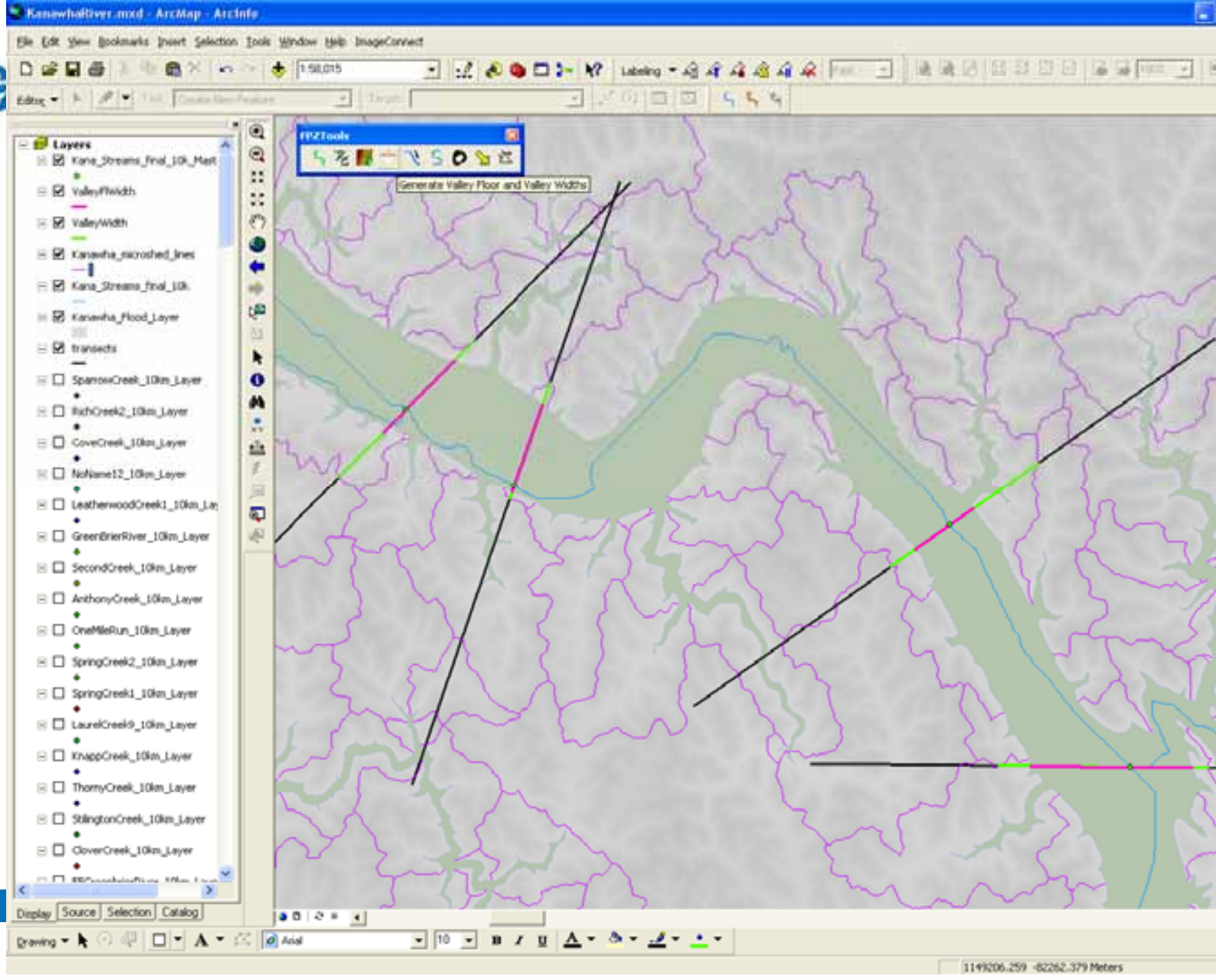
- Built in VBA and accessible through a customized toolbar.
- First tool sets up the geodatabase (named for the input hydrology layer), Master Table, and sampling points.
- All user inputs recorded in a text file automatically saved to the default temp location.

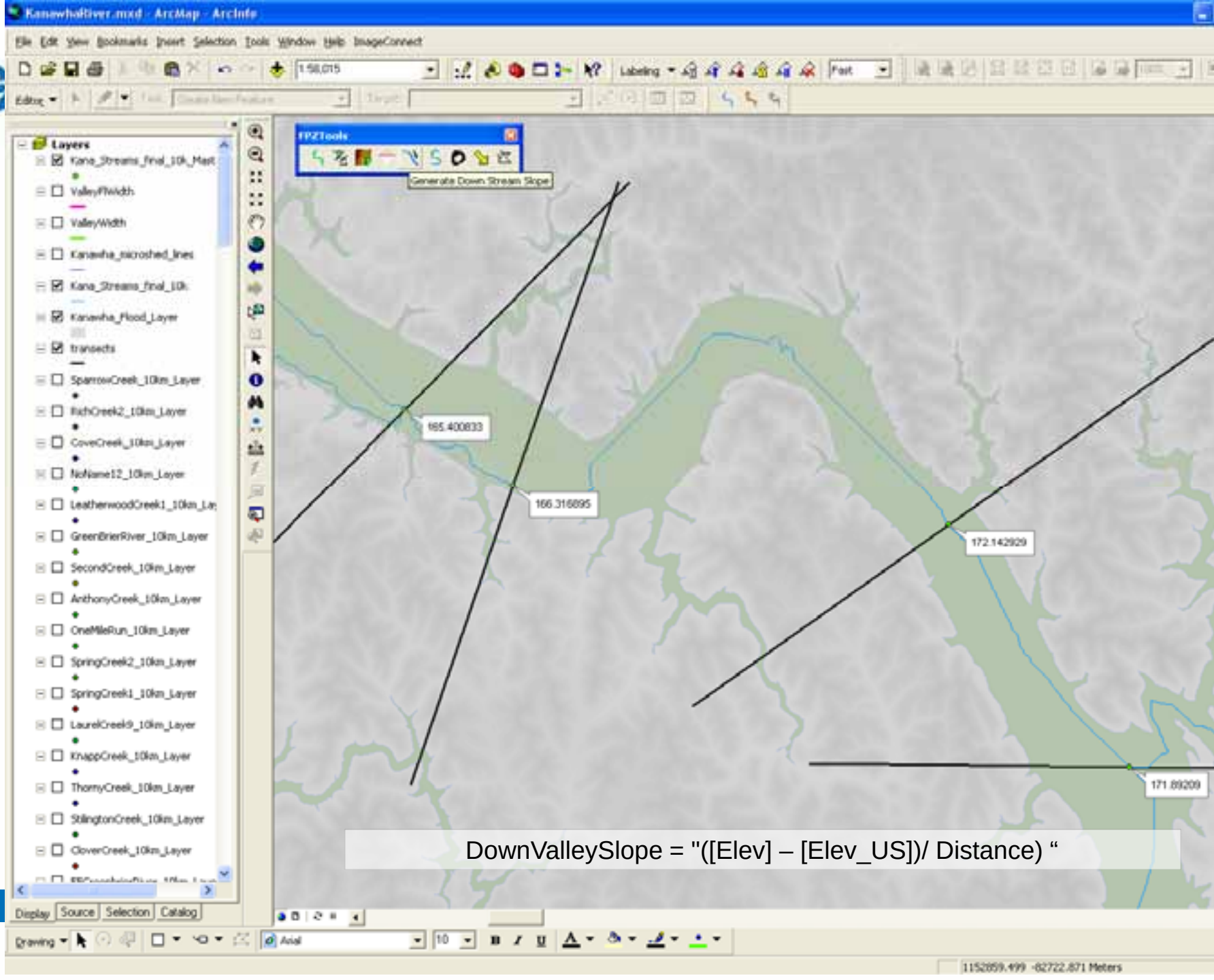

KanawhaRiver.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
Layers
Kana_Streams_final_10i
Kanawha_microshed_lines
Kanawha_Flood_Layer
USGS_Kanawha_Geology
PRISM_mn_kanawha_Clip.img
Value
High : 1050
Low : 910
kanawha_dem
Value
High : 1746.19
Low : 162.395
Display Source Selection Catalog
FP2Tools
Welcome
Welcome to the Functional Process Zone Analysis Tool
Let the fun begin
Exit
Drawing
Arial
1074902.631 -323631.773 Meters

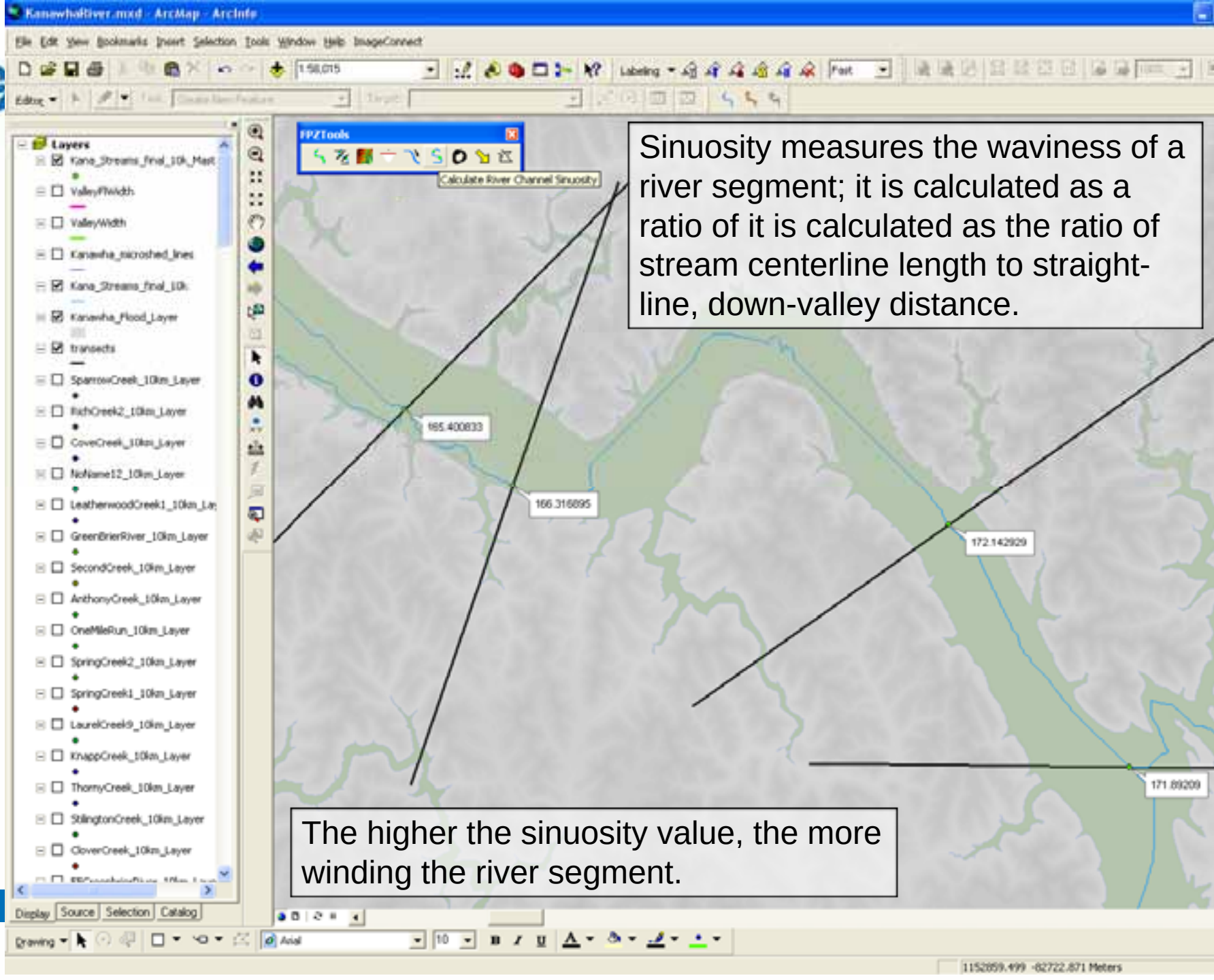

KanawhaRiver.mxd - ArcMap - ArcInfo
FPZTools
Set Up Datalayers
Select Hydrography Layer:
Kana_Streams_final_10k
Select DEM Layer:
kanawha_dem
Select Precipitation Layer:
Select Channel Belt Layer:
Enter
Warning! Grid files must be in the same projection as your hydrology layer!
Sampling Distance
How far apart do you want the points?
10
km
Close
Layers
Kana_Streams_final_10k
Kanawha_microshed_lines
Kanawha_Flood_Layer
USGS_Kanawha_Geology
PRISM_nm_kanawha_Clip.img
Value
High : 1050
Low : 910
kanawha_dem
Value
High : 1746.19
Low : 162.395
Display
Source
Selection
Catalog

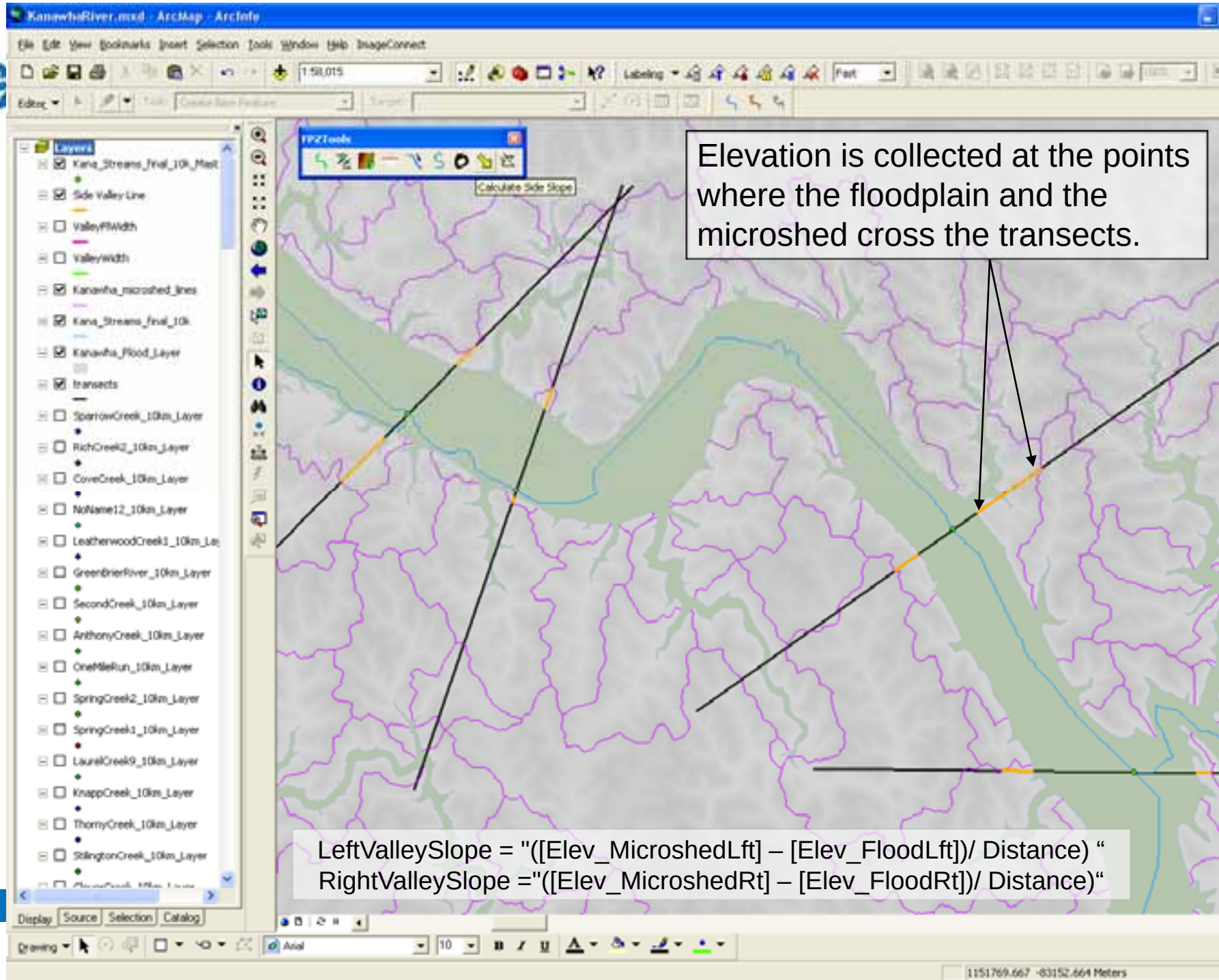

KanawhaRiver.mxd - ArcMap - ArcInfo
FPZTools
Create Transects
Sampling Distance
Enter Smoothing Offset Distance
500
m
Close
Display
Source
Selection
Catalog

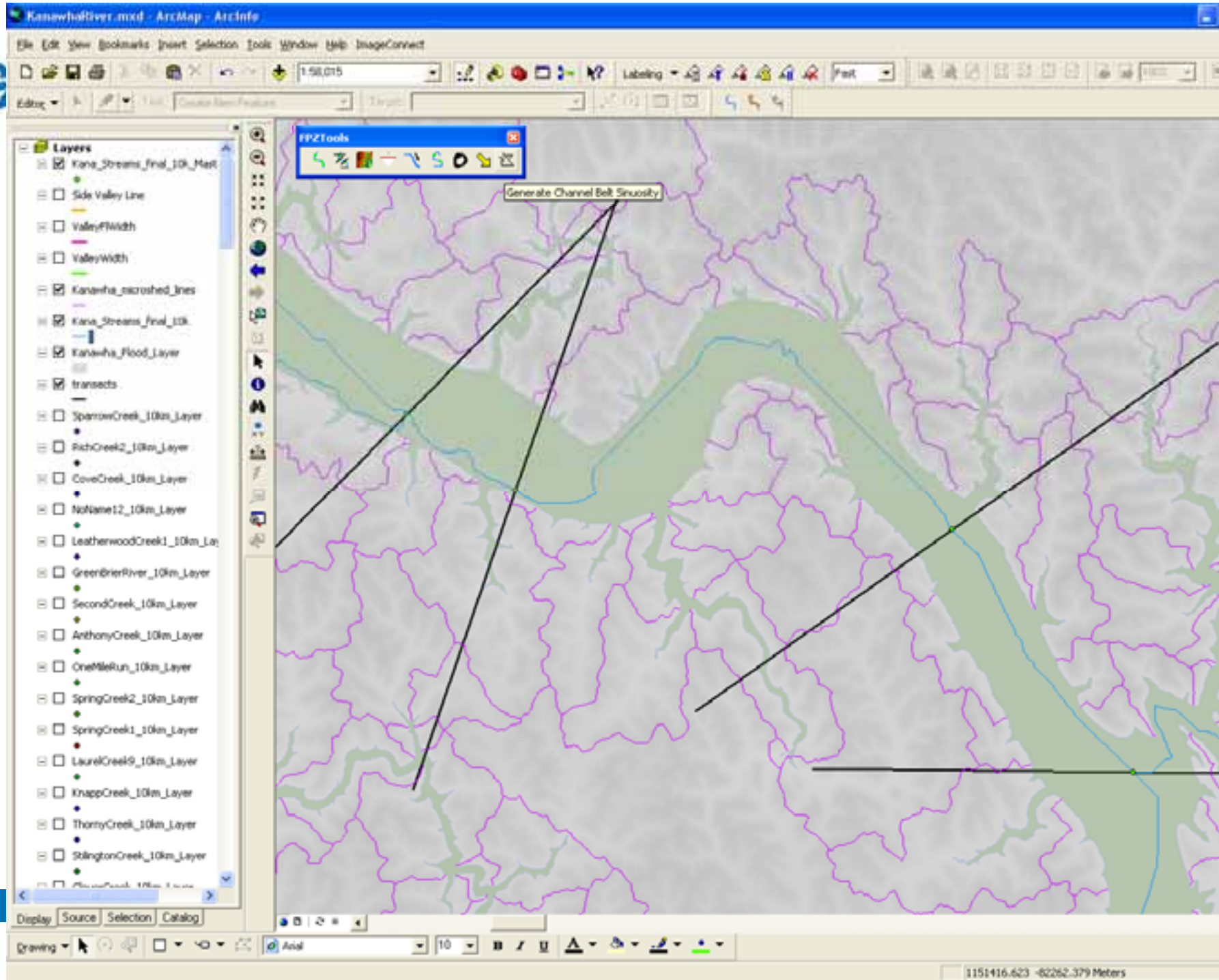

KanawhaRiver.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
Layers
FPZTools
Generate Elevation, Precipitation, and Geology data
Geology Field
Which field has the geology data?
ROCKTYPE1
Enter
Display Source Selection Catalog
Drawing
Arial
10


KanawhaRiver.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
Editor
Layers
Kana_Streams_final_10k_Mast
ValleyFlWidth
ValleyWidth
Kanawha_microshed_lines
Kana_Streams_final_10k
Kanawha_Flood_Layer
transects
SparrowCreek_10km_Layer
RichCreek2_10km_Layer
CoveCreek_10km_Layer
NoName12_10km_Layer
LeatherwoodCreek1_10km_La
GreenBrierRiver_10km_Layer
SecondCreek_10km_Layer
AnthonyCreek_10km_Layer
OneMileRun_10km_Layer
SpringCreek2_10km_Layer
SpringCreek1_10km_Layer
LaurelCreek9_10km_Layer
KnappCreek_10km_Layer
ThornyCreek_10km_Layer
StillingtonCreek_10km_Layer
CloverCreek_10km_Layer
Display Source Selection Catalog
FPZTools
Generate Valley Floor and Valley Widths
Drawing
Arial
10
1149206.259 -82262.379 Meters


KanawhaRiver.mxd - ArcMap - ArcInfo
FPZTools
Generate Down Stream Slope
Layers
Kana_Streams_final_10k_Mast
ValleyFlWidth
ValleyWidth
Kanawha_microshed_lines
Kana_Streams_final_10k
Kanawha_Flood_Layer
transects
SparrowCreek_10km_Layer
RichCreek2_10km_Layer
CoveCreek_10km_Layer
NoName12_10km_Layer
GreenBrierRiver_10km_Layer
SecondCreek_10km_Layer
AnthonyCreek_10km_Layer
OneMileRun_10km_Layer
SpringCreek2_10km_Layer
SpringCreek1_10km_Layer
LaurelCreek9_10km_Layer
KnappCreek_10km_Layer
ThornyCreek_10km_Layer
StillingtonCreek_10km_Layer
CloverCreek_10km_Layer
Display
Source
Selection
Catalog
Drawing
Arial
10
185.400833
166.316895
172.142929
171.89209
DownValleySlope = "([Elev] – [Elev_US])/ Distance) “


Sinuosity measures the waviness of a river segment; it is calculated as a ratio of it is calculated as the ratio of stream centerline length to straight-line, down-valley distance.
FPZTools
Calculate River Channel Sinuosity
165.400833
166.316895
172.142929
171.89209
The higher the sinuosity value, the more winding the river segment.


Elevation is collected at the points where the floodplain and the microshed cross the transects.
LeftValleySlope = "([Elev_MicroshedLft] – [Elev_FloodLft])/ Distance) “
RightValleySlope ="([Elev_MicroshedRt] – [Elev_FloodRt])/ Distance)“


KanawhaRiver.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
Layers
Kana_Streams_final_10k_Mask
Side Valley Line
ValleyFlWidth
ValleyWidth
Kanawha_microshed_lines
Kana_Streams_final_10k
Kanawha_Flood_Layer
transects
SparrowCreek_10km_Layer
RichCreek2_10km_Layer
CoveCreek_10km_Layer
NoName12_10km_Layer
LeatherwoodCreek1_10km_La
GreenBrierRiver_10km_Layer
SecondCreek_10km_Layer
AnthonyCreek_10km_Layer
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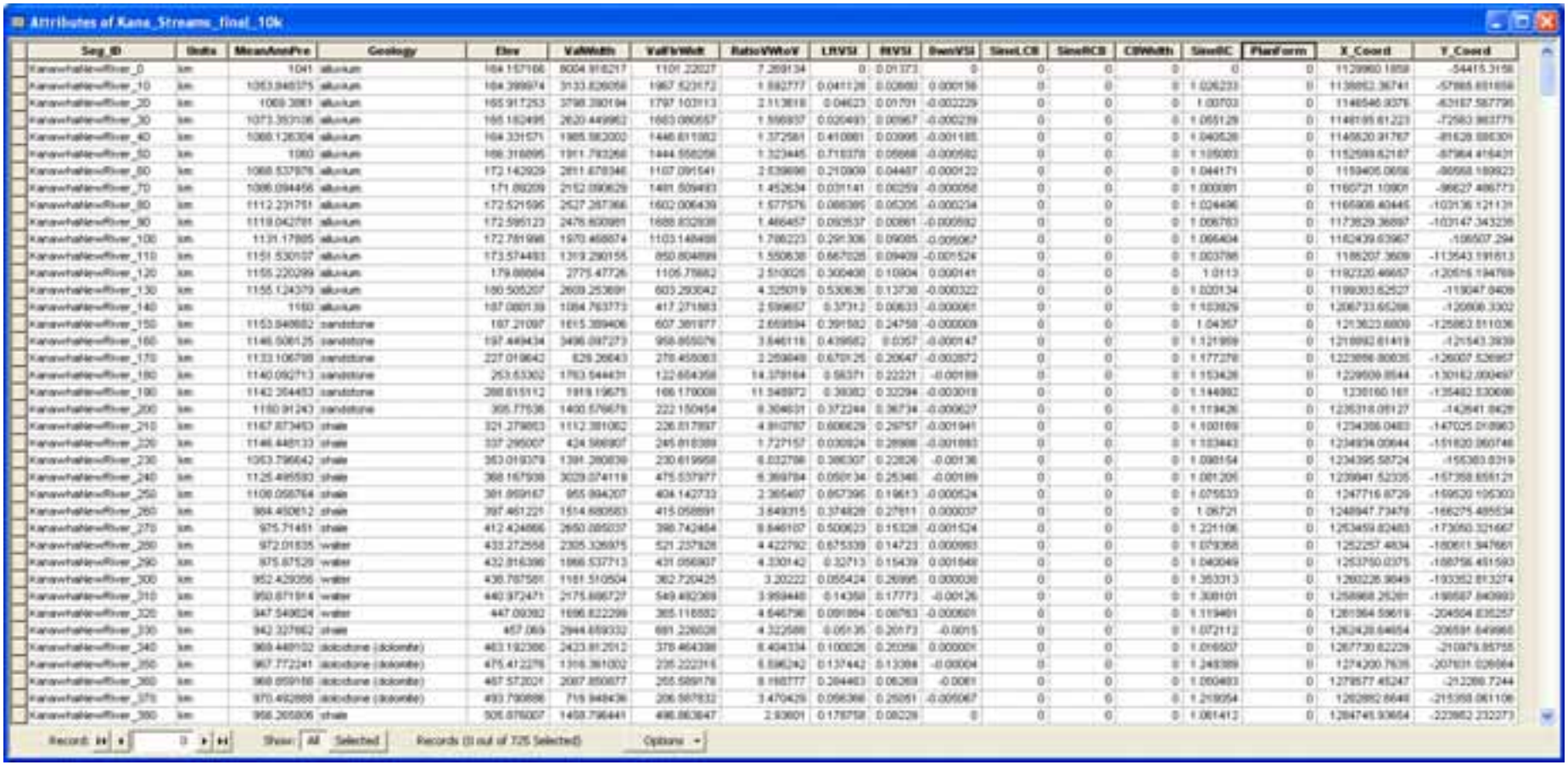
SpringCreek2_10km_Layer
SpringCreek1_10km_Layer
LaurelCreek9_10km_Layer
KnappCreek_10km_Layer
ThornyCreek_10km_Layer
StillingtonCreek_10km_Layer
Display Source Selection Catalog
FPZTools
Generate Channel Belt Sinuosity
Drawing
Arial
10
1151416.623 -82262.379 Meters

Final Master Table

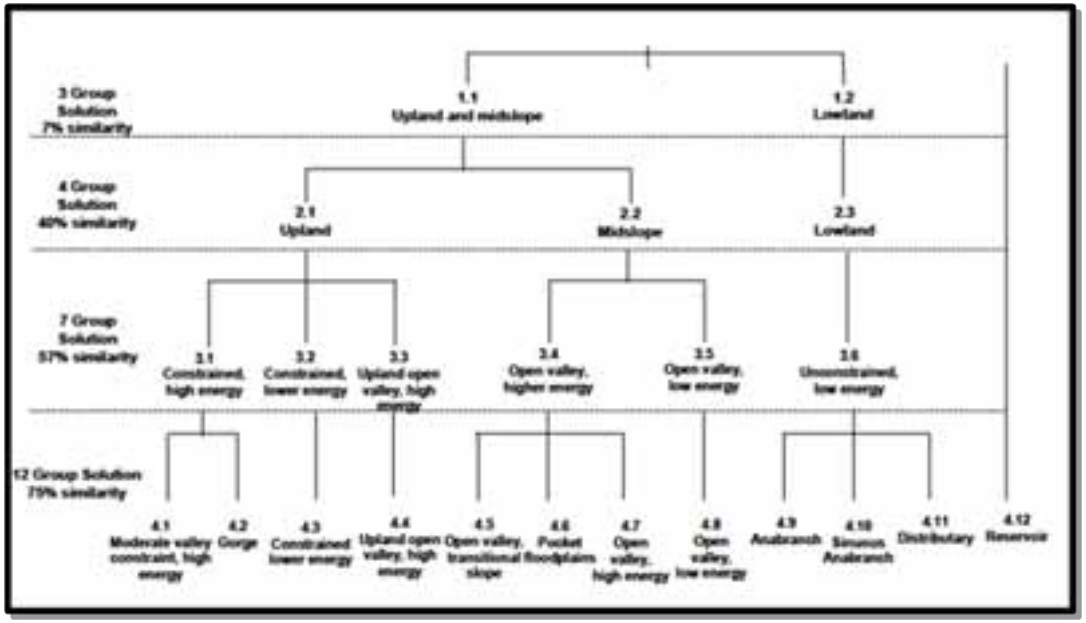


Preliminary Study of the Kanawha River Basin

- ~ 32,000 km^2
- Highly constricted mountainous system
- Special Features:
  - Contains a waterfall that limits species migration.
  - The oldest river in North America.
  - Rivers with significant free-flowing sections & good water quality.
  - Rivers with minimal or no impoundments (i.e., dams).

River Typing

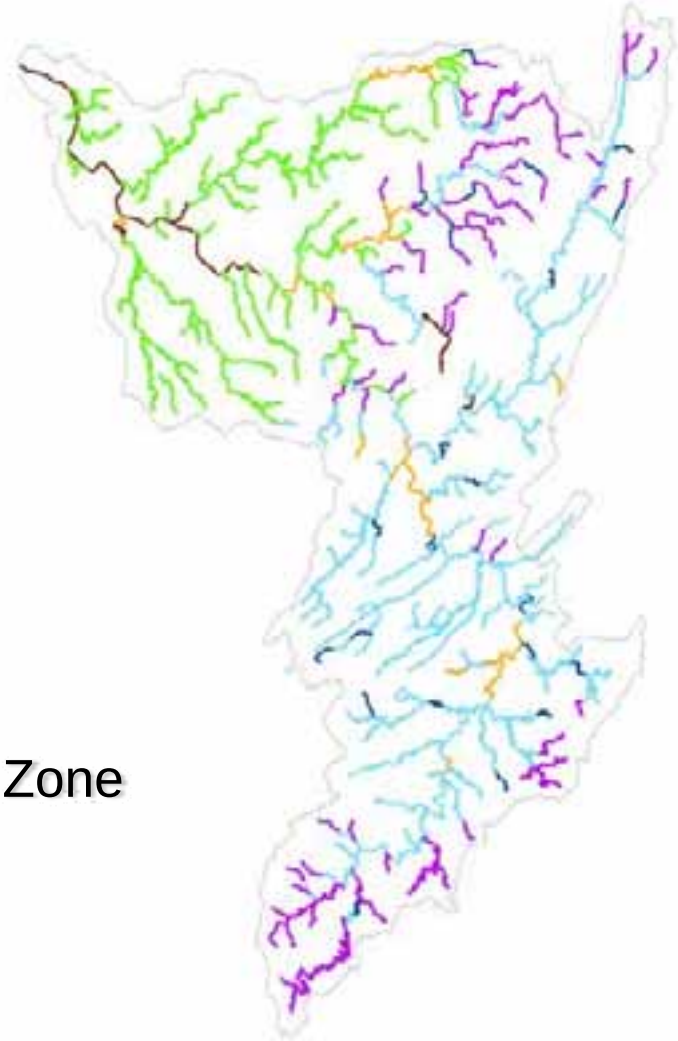
- UPGMA (Flexible-Unweighted Pair-Groups with Arithmetic Averages) is used to identify groups of sample segments with similar hydrogeomorphic characteristics (i.e., FPZs)



- The validity of the groups is then assessed with Multidimensional Scaling.

Preliminary Study of the Kanawha River Basin

- 6 Distinct FPZs identified
  - Lowland Alluvial Zone
  - Lowland Constricted Zone
  - Constricted upland Zone
  - Open Valley Upland Zone
  - Constricted High Energy Upland Zone
  - Reservoir Zone



Next Steps

Environmental Application of FPZs

- Development of a monitoring design sampling plan based on the FPZs for the Kanawha River watershed.
  - Field work scheduled to begin Summer 2010.

GIS Application of FPZs

- Conversion of VBA scripts to Python.
- Completion of FPZ calculation for the Kansas River Watershed.

Acknowledgements

Special Thanks to:

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