Rapid River Classification Using GIS-Delineated Functional Process Zones

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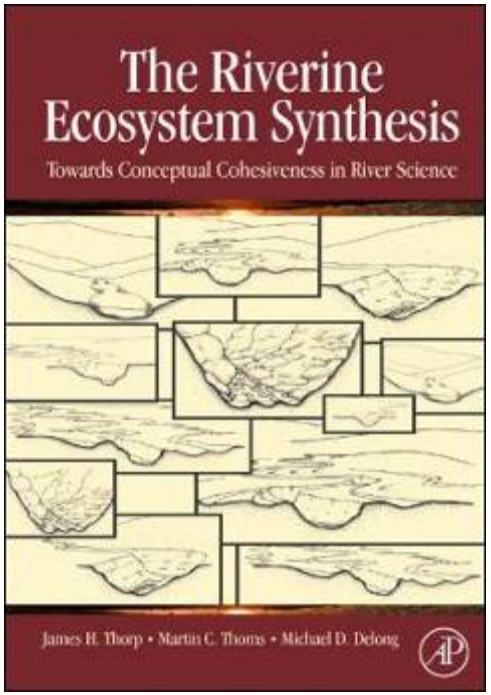
Office of Research and Development
National Exposure Research Laboratory

July 19, 2010

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 gradual shift in ecological communities and ecosystem properties as you move downstream.
- Scale dependent
- Stream order used to measure change in size of 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 riverine ecosystem and impact ecological communities and ecosystem properties.

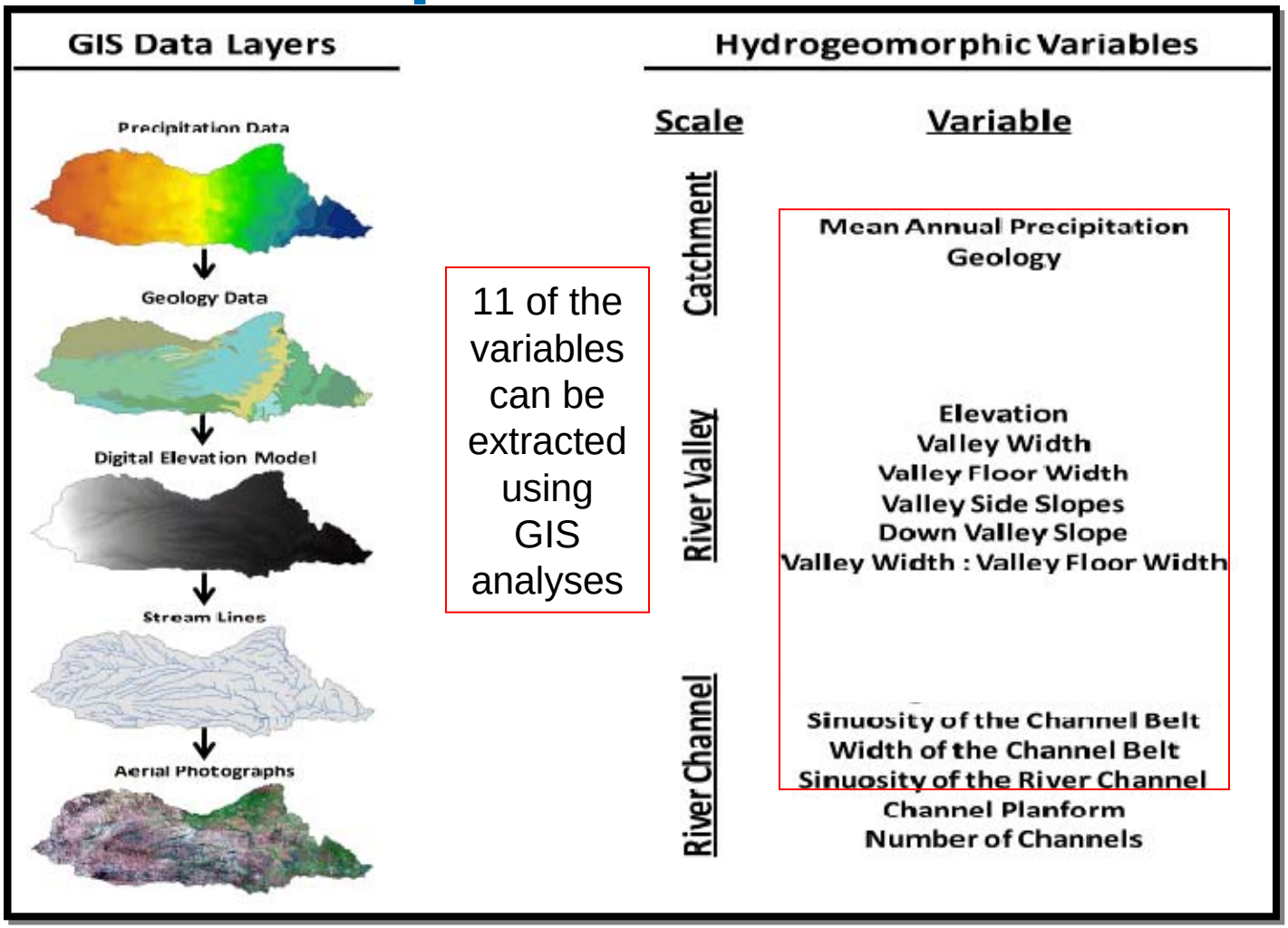
Functional Process Zones

- 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

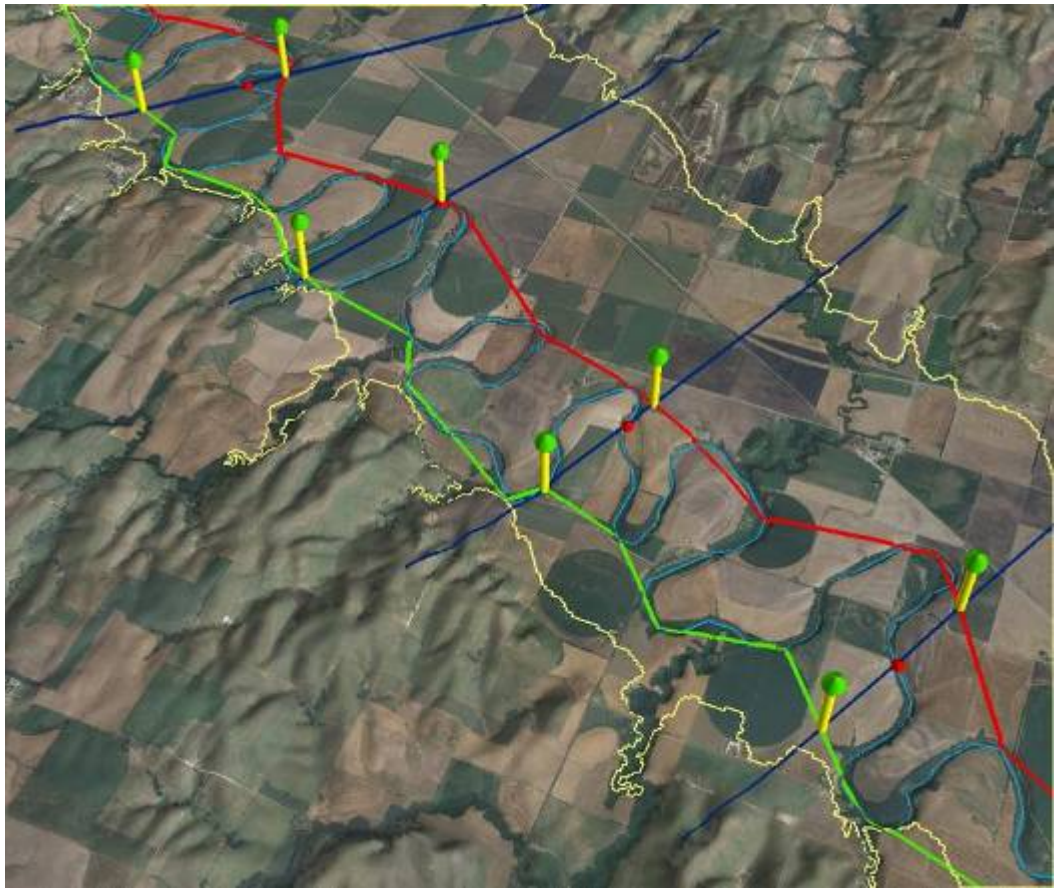
Requires the Calculation of 13 Dependent and Independent Variables



Seven Required Input Datasets

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

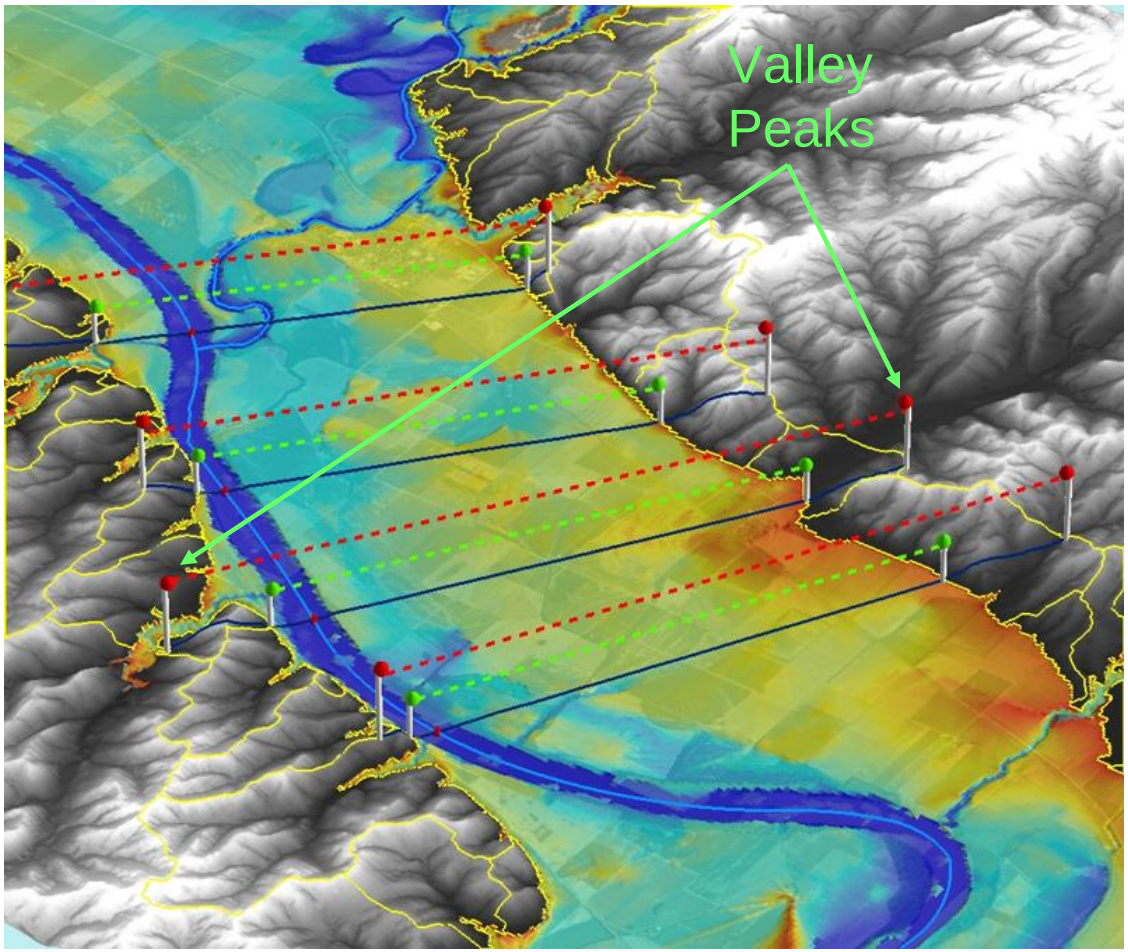
Channel Belt



Kansas River, KS

- A band running along valley floor that contains a meandering channel
- Variable: Channel Belt Width and Channel Belt Sinuosity.

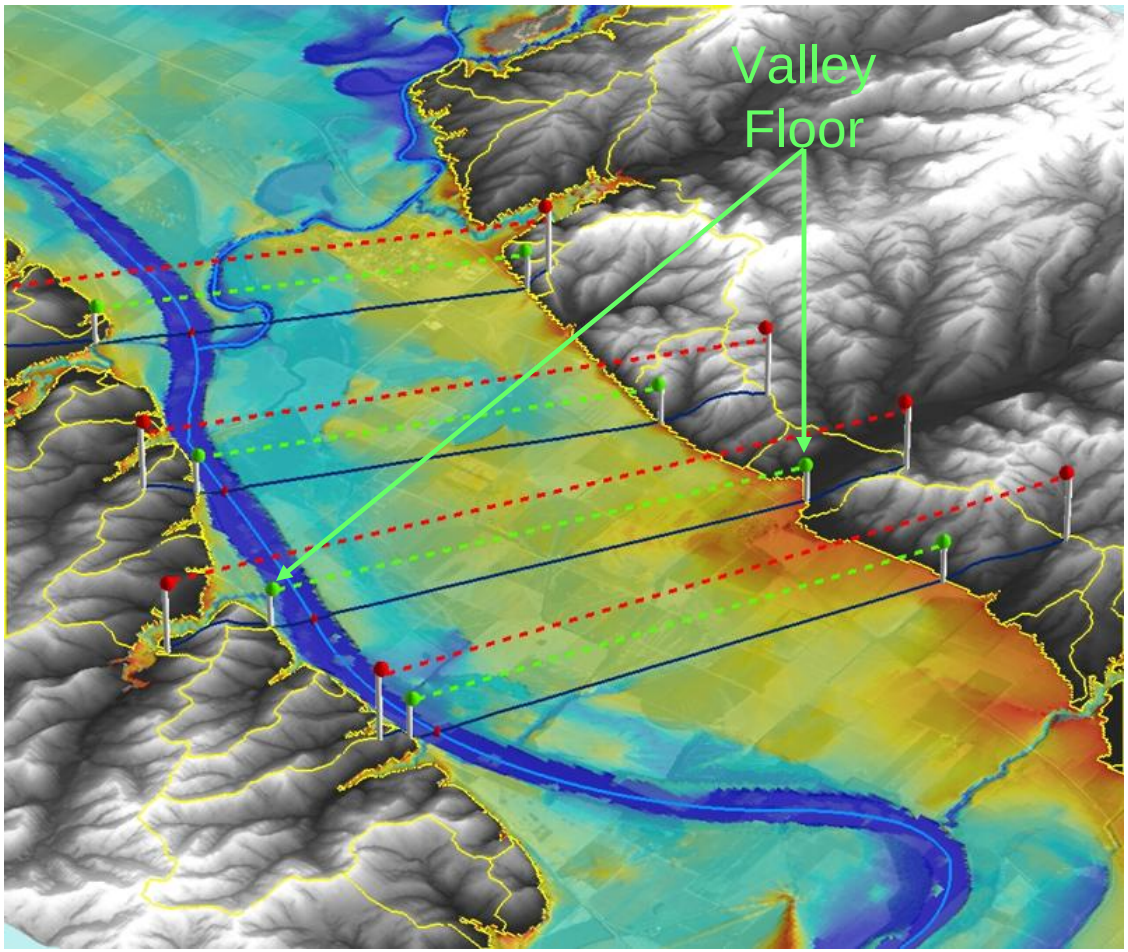
Microsheds



Kansas River, KS

- Created using ArcHydro to help identify the valley peaks.
- Outline of Microshed identifies valley peak at transect intersection
- Variable: Valley Width

Floodplain

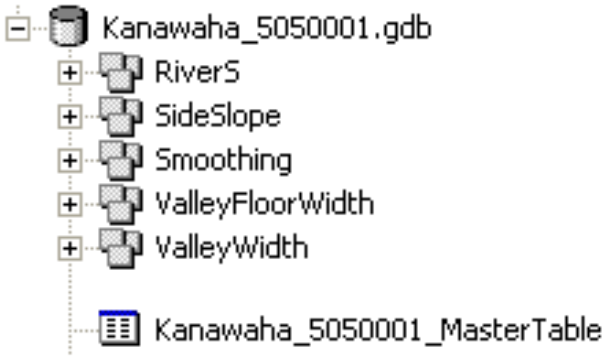


Kansas River, KS

- MATLAB® based floodplain (FLDPLN) model
- Uses backfilling and spillover flooding procedures to determine depth-to-flood value for each pixel in surface raster
- Variable: Valley Floor Width

Organization

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



Naming Conventions and Unit of Analysis

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

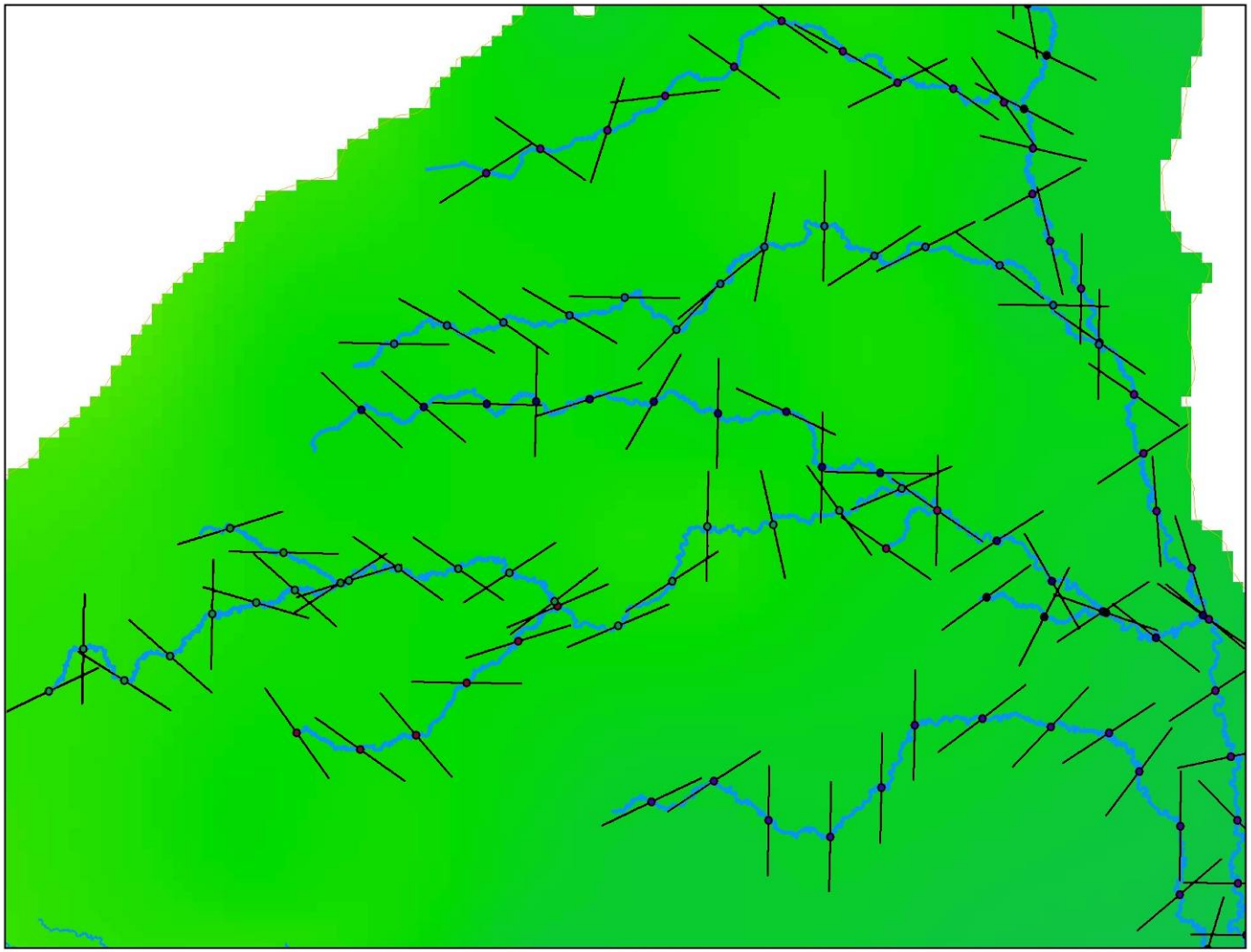
Sampling Points

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

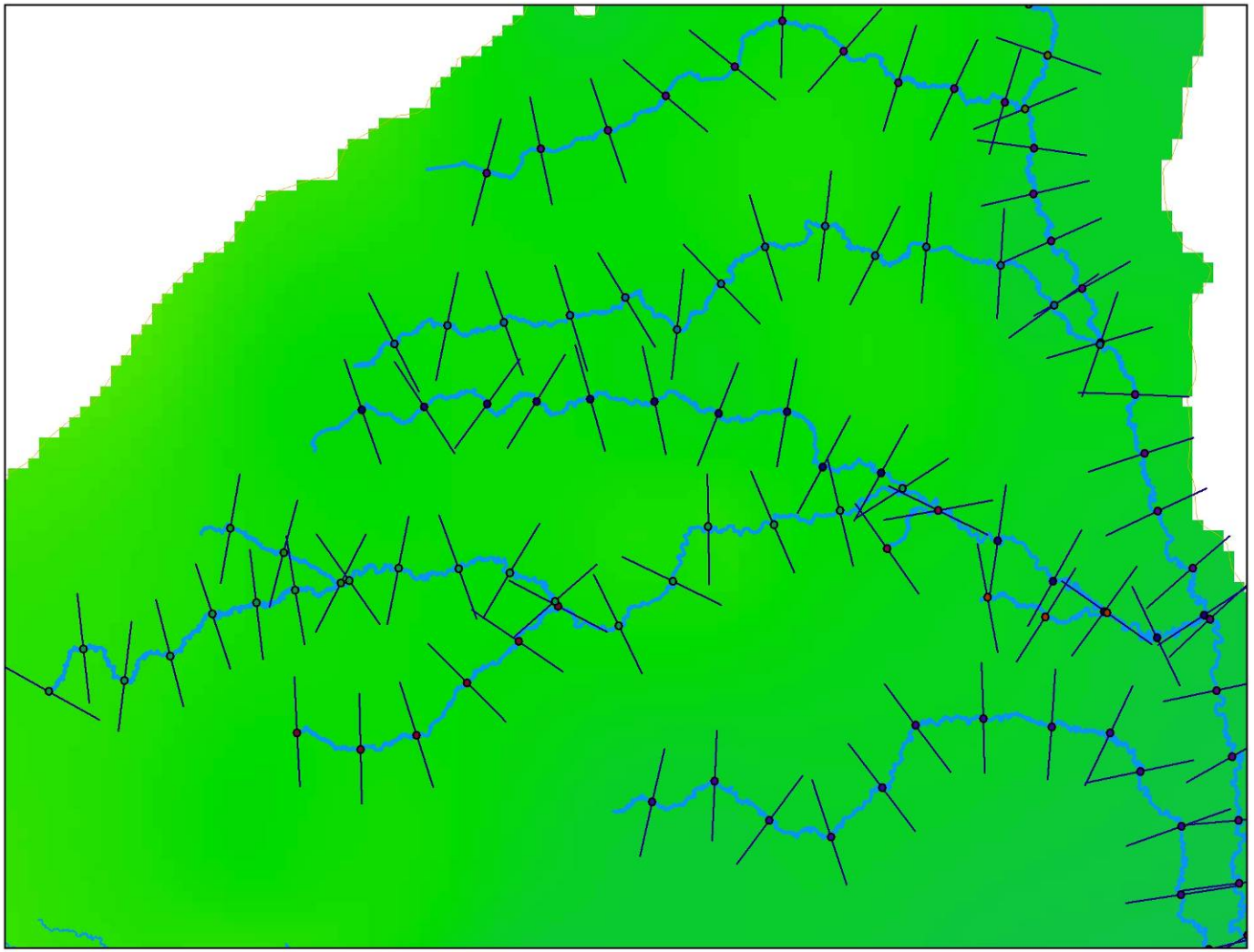
Transects

- Transects generated perpendicular to each sample point
- The slope of hydrology line at sample point determines angle of 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

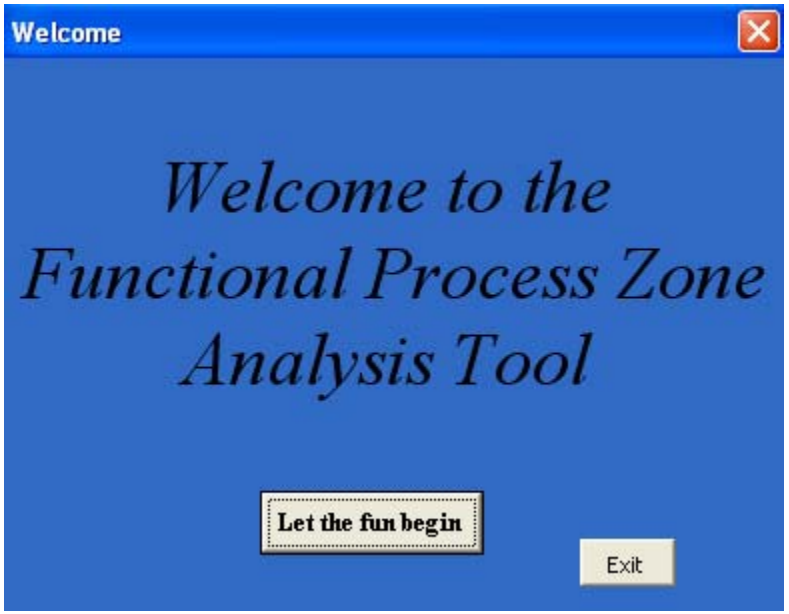


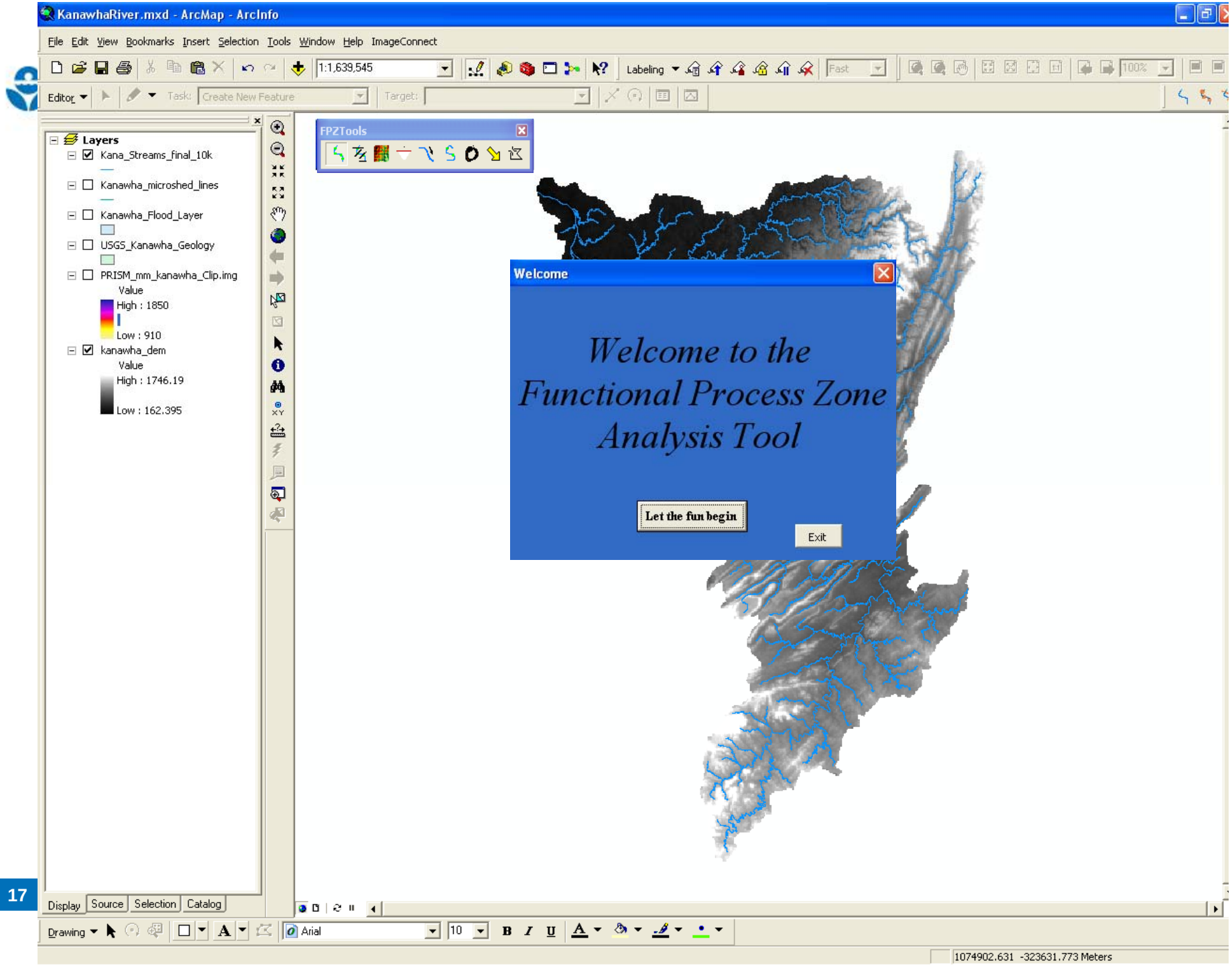
Transects created using smoothed hydrology



FPZ Tool in ArcGIS

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




KanawhaRiver.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
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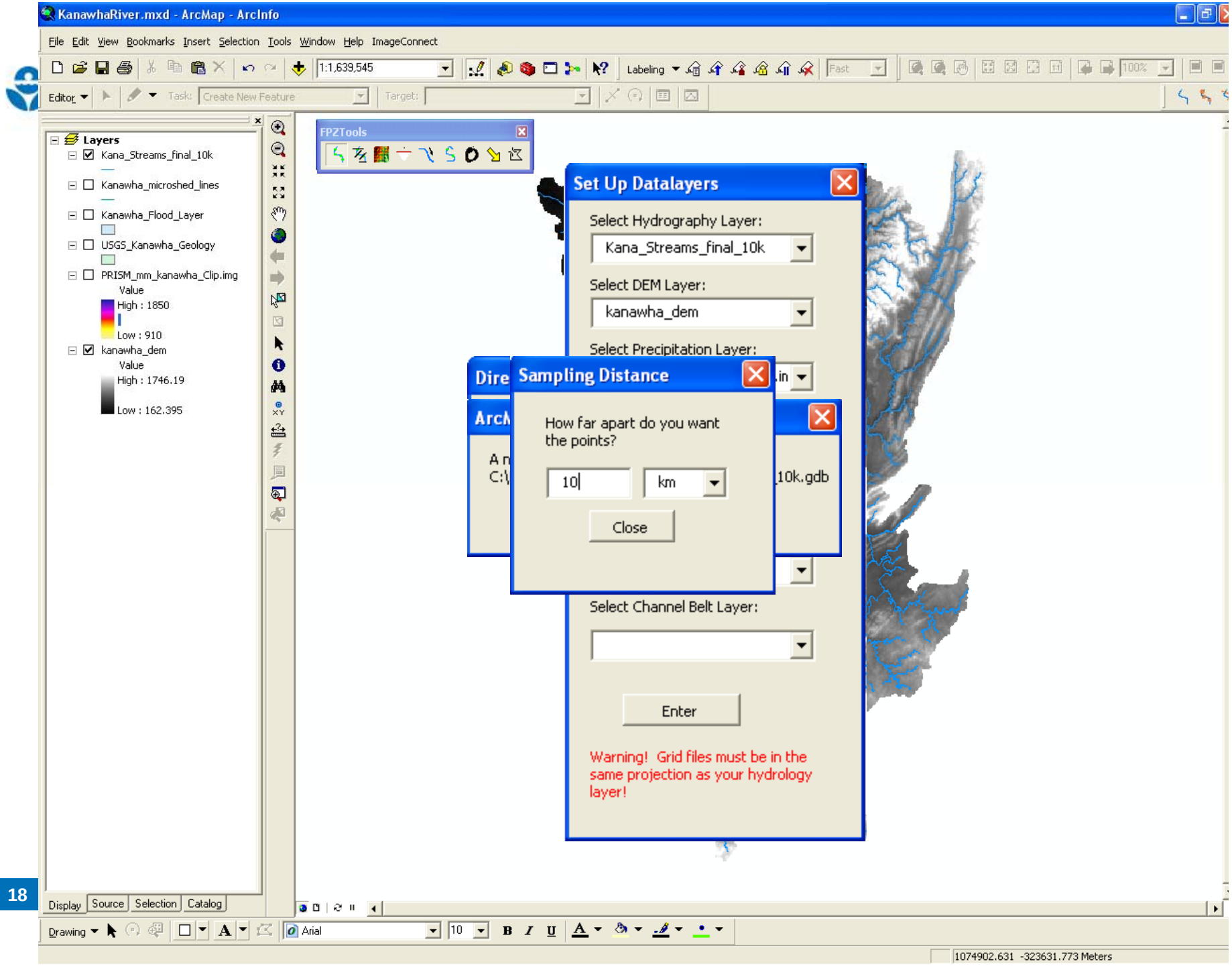
Labeling
Editor
Task: Create New Feature
Target:
Layers
Kana_Streams_final_10k
Kanawha_microshed_lines
Kanawha_Flood_Layer
USGS_Kanawha_Geology
PRISM_mm_kanawha_Clip.img
Value
High : 1850
Low : 910
kanawha_dem
Value
High : 1746.19
Low : 162.395
Display Source Selection Catalog
FPZTools
Welcome
Welcome to the Functional Process Zone Analysis Tool
Let the fun begin
Exit
Drawing
Arial
10
1074902.631 -323631.773 Meters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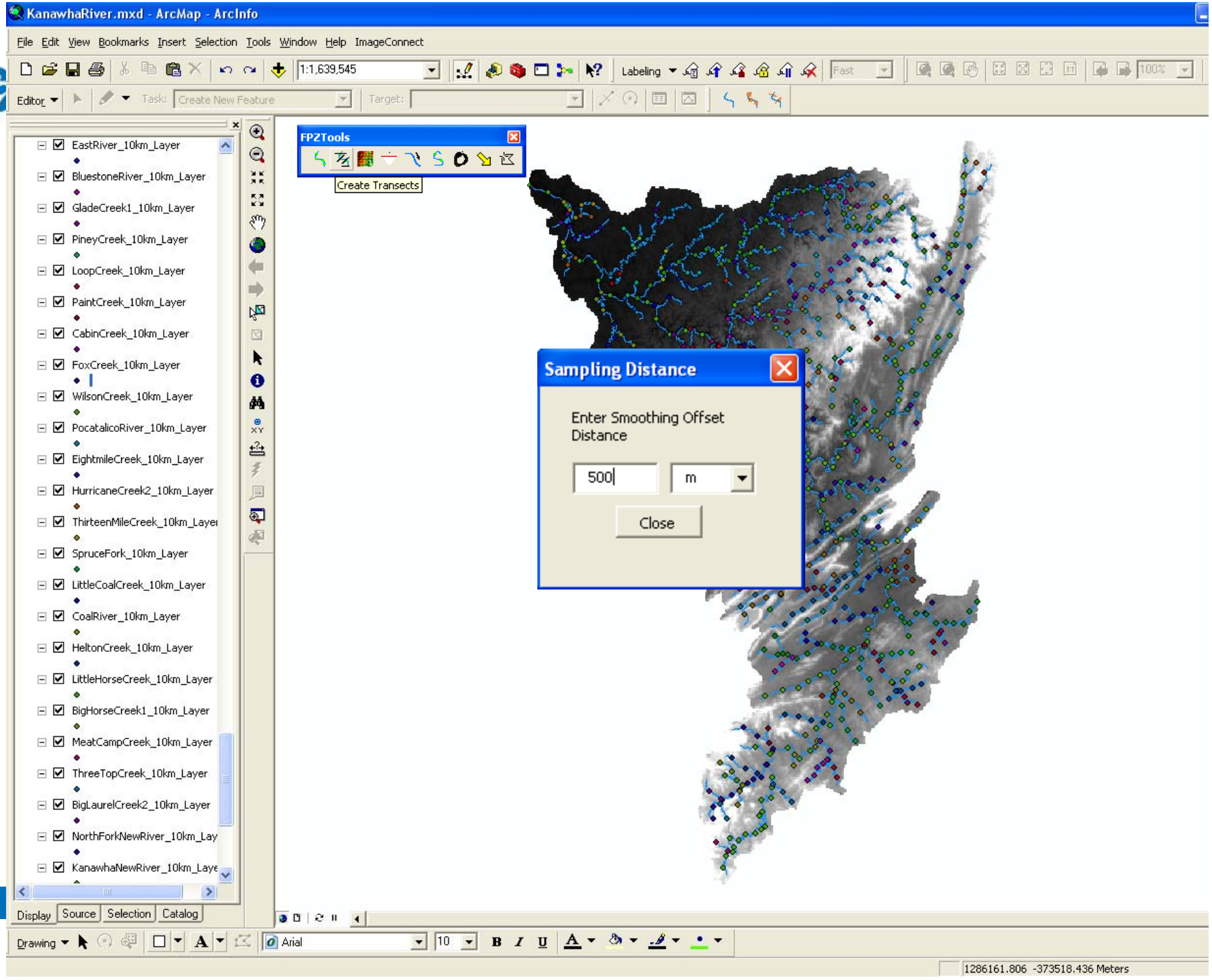
Labeling
Editor
Task: Create New Feature
Target:
Layers
Kana_Streams_final_10k
Kanawha_microshed_lines
Kanawha_Flood_Layer
USGS_Kanawha_Geology
PRISM_mm_kanawha_Clip.img
Value
High : 1850
Low : 910
kanawha_dem
Value
High : 1746.19
Low : 162.395
Display
Source
Selection
Catalog
FPZTools
Set Up Datalayers
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
Drawing
Arial
10
1074902.631 -323631.773 Meters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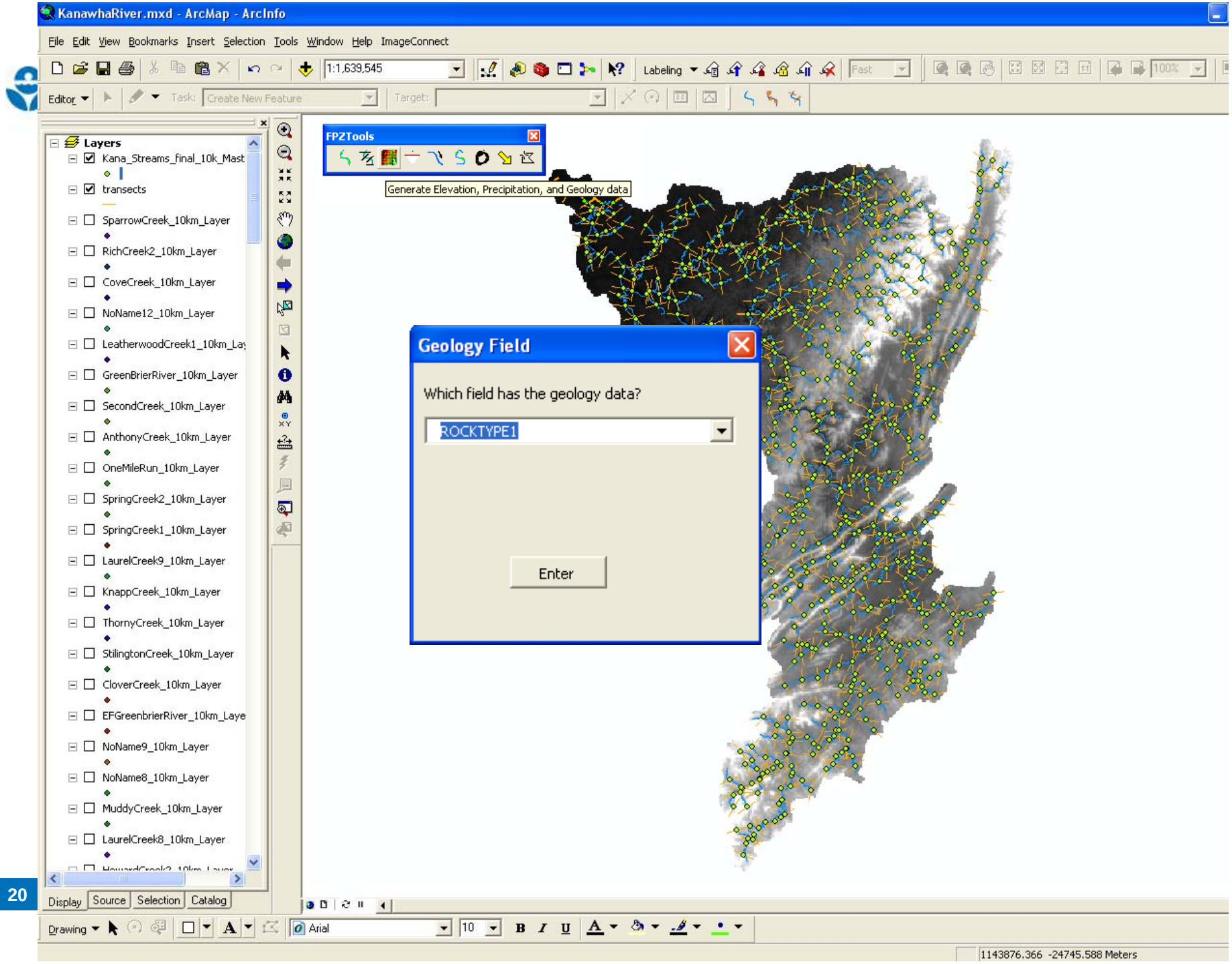
Labeling
Editor
Task: Create New Feature
Target:
FPZTools
Create Transects
Sampling Distance
Enter Smoothing Offset Distance
500
m
Close
EastRiver_10km_Layer
BluestoneRiver_10km_Layer
GladeCreek1_10km_Layer
PineyCreek_10km_Layer
LoopCreek_10km_Layer
PaintCreek_10km_Layer
CabinCreek_10km_Layer
FoxCreek_10km_Layer
WilsonCreek_10km_Layer
PocatalicoRiver_10km_Layer
EightmileCreek_10km_Layer
HurricaneCreek2_10km_Layer
ThirteenMileCreek_10km_Layer
SpruceFork_10km_Layer
LittleCoalCreek_10km_Layer
CoalRiver_10km_Layer
HeltonCreek_10km_Layer
LittleHorseCreek_10km_Layer
BigHorseCreek1_10km_Layer
MeatCampCreek_10km_Layer
ThreeTopCreek_10km_Layer
BigLaurelCreek2_10km_Layer
NorthForkNewRiver_10km_Lay
KanawhaNewRiver_10km_Laye
Display Source Selection Catalog
Drawing
Arial
10
1286161.806 -373518.436 Meters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Editor
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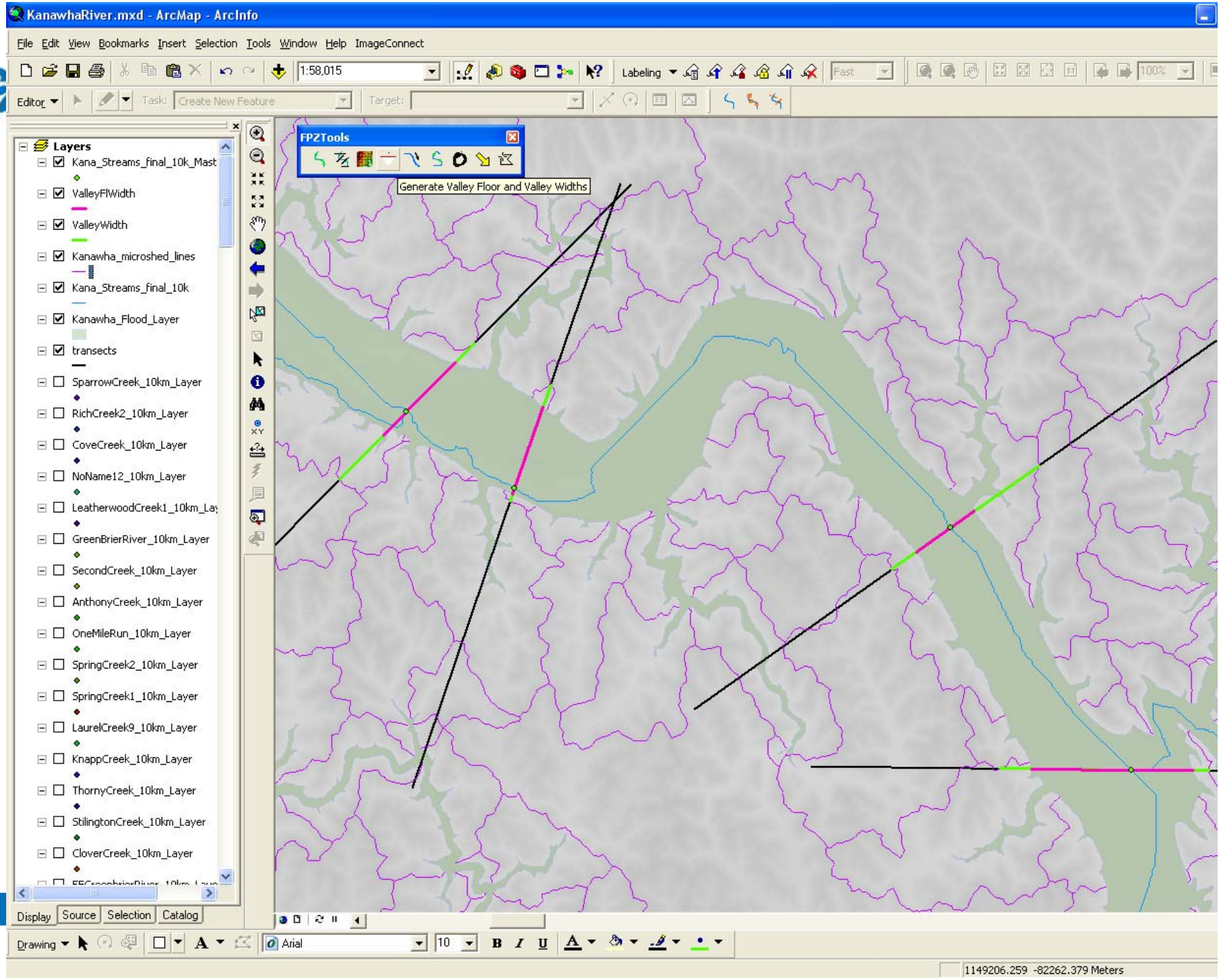
Kana_Streams_final_10k_Mast
transects
SparrowCreek_10km_Layer
RichCreek2_10km_Layer
CoveCreek_10km_Layer
NoName12_10km_Layer
LeatherwoodCreek1_10km_Lay
GreenBrierRiver_10km_Layer
SecondCreek_10km_Layer
AnthonyCreek_10km_Layer
OneMileRun_10km_Layer
SpringCreek2_10km_Layer
SpringCreek1_10km_Layer
LaurelCreek9_10km_Layer
KnappCreek_10km_Layer
ThornyCreek_10km_Layer
StilingtonCreek_10km_Layer
CloverCreek_10km_Layer
EFGreenbrierRiver_10km_Laye
NoName9_10km_Layer
NoName8_10km_Layer
MuddyCreek_10km_Layer
LaurelCreek8_10km_Layer
Display Source Selection Catalog
FPZTools
Generate Elevation, Precipitation, and Geology data
Geology Field
Which field has the geology data?
ROCKTYPE1
Enter
Drawing
Arial
10
1143876.366 -24745.588 Meters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Labeling
Fast
100%
Editor
Task: Create New Feature
Target:
FPZTools
Generate Valley Floor and Valley Widths
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_Lay
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
StilingtonCreek_10km_Layer
CloverCreek_10km_Layer
Display Source Selection Catalog
Drawing
Arial
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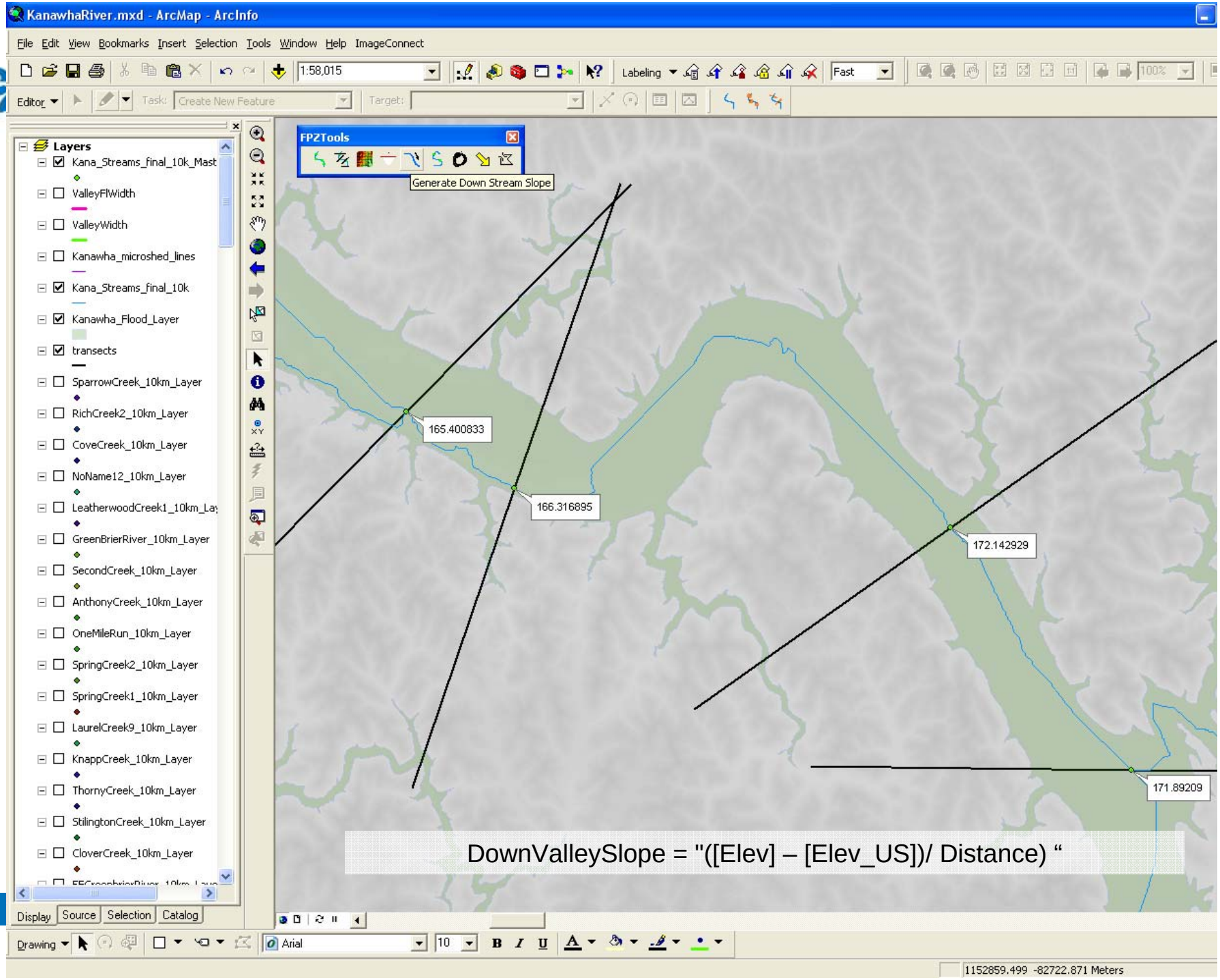
1149206.259 -82262.379 Meters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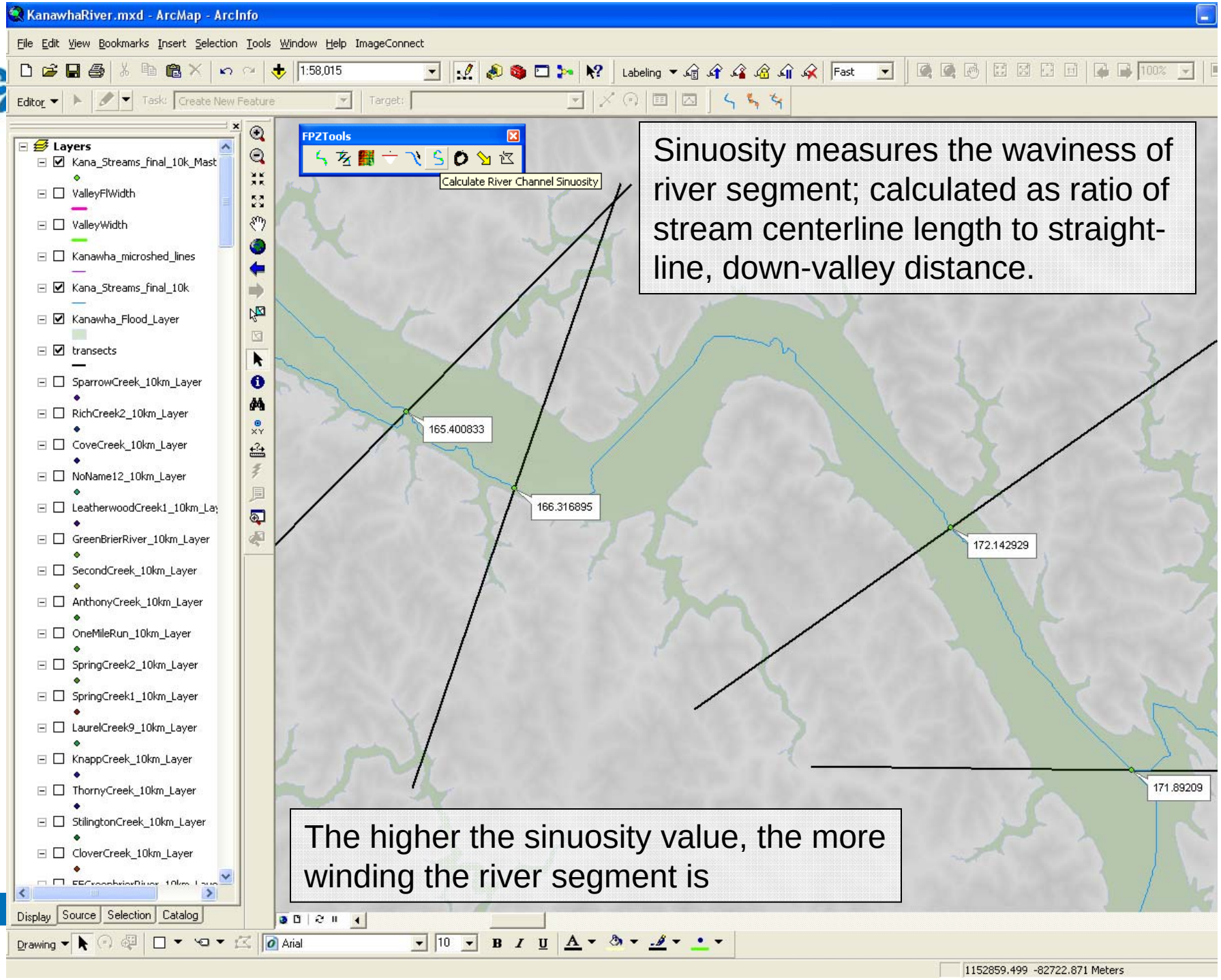
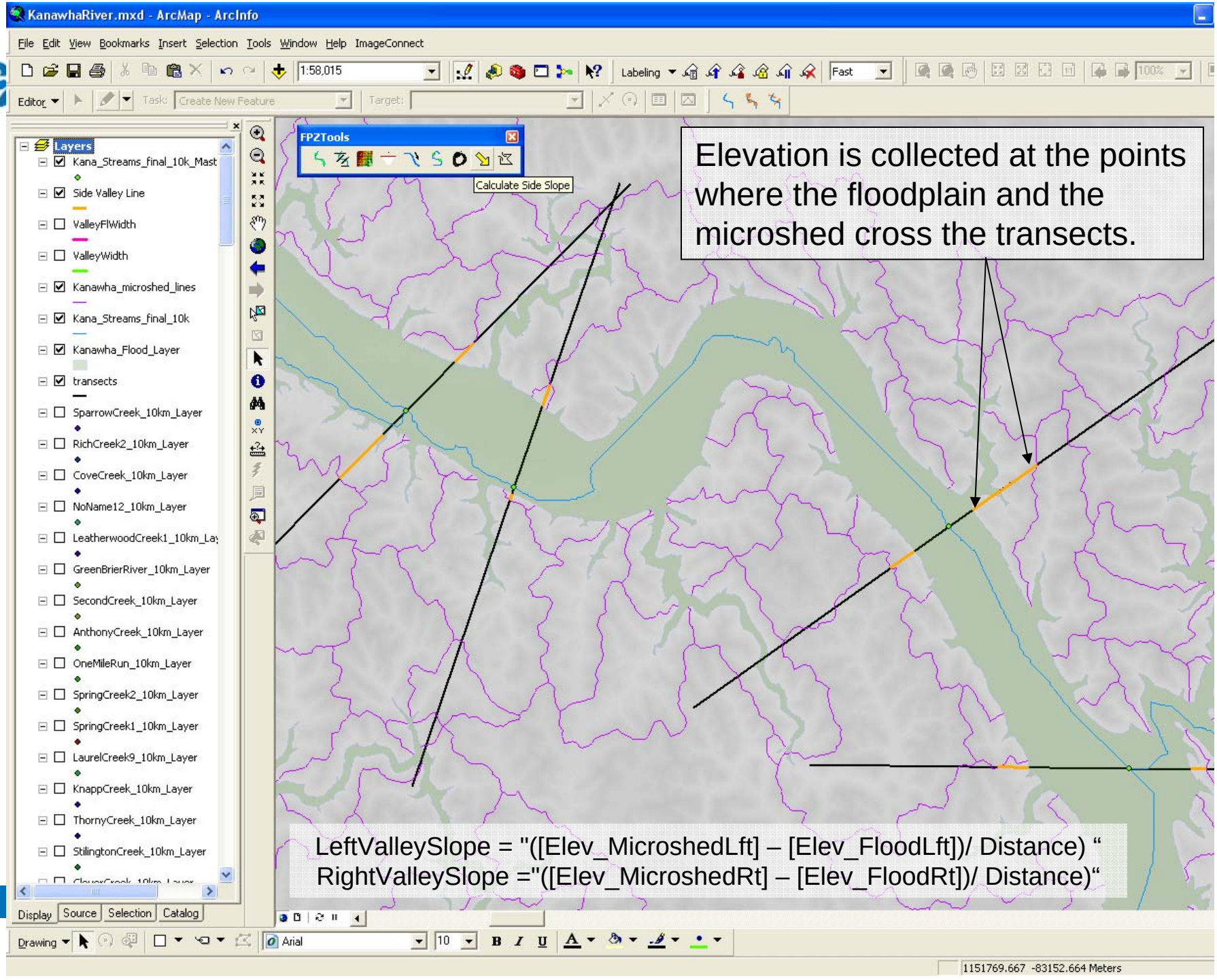
Labeling
Fast
Editor
Task: Create New Feature
Target:
FPZTools
Generate Down Stream Slope
Layers
Kana_Streams_final_10k_Mast
ValleyFlWidth
ValleyWidth
Kanawha_microshed_lines
Kana_Streams_final_10k
Kanawha_Flood_Layer
transects
SparrowCreek_10km_Layer
RichCreek2_10km_Layer
CoveCreek_10km_Layer
NoName12_10km_Layer
LeatherwoodCreek1_10km_Lay
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
StilingtonCreek_10km_Layer
CloverCreek_10km_Layer
165.400833
166.316895
172.142929
171.89209
DownValleySlope = "([Elev] – [Elev_US])/ Distance) “
Display Source Selection Catalog
Drawing
Arial
10
1152859.499 -82722.871 Meters



Sinuosity measures the waviness of river segment; calculated as ratio of stream centerline length to straight-line, down-valley distance.

The higher the sinuosity value, the more winding the river segment is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File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
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Labeling
Fast
Editor
Task: Create New Feature
Target:
FPZTools
Calculate Side Slope
Layers
Kana_Streams_final_10k_Mast
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_Lay
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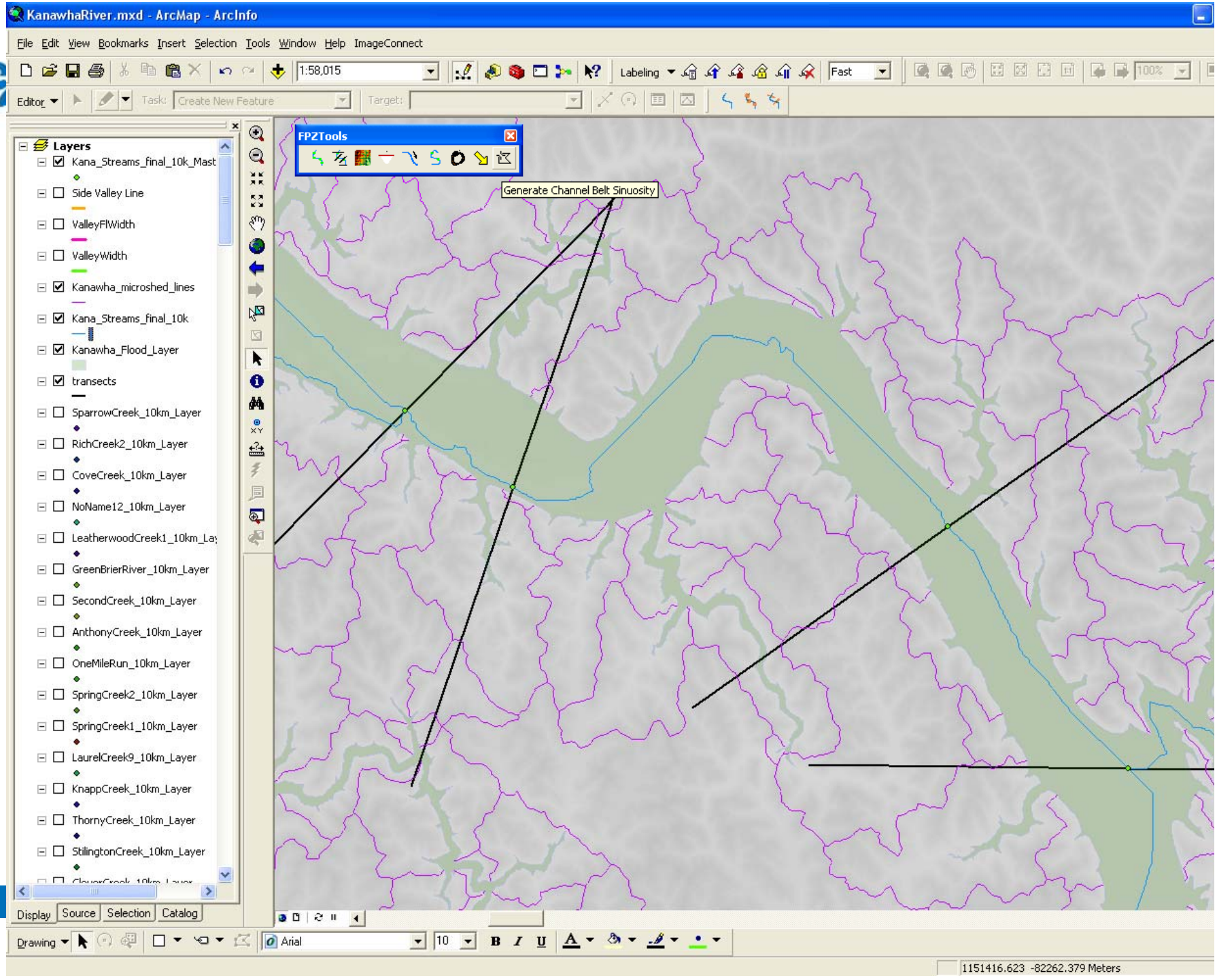
SecondCreek_10km_Layer
AnthonyCreek_10km_Layer
OneMileRun_10km_Layer
SpringCreek2_10km_Layer
SpringCreek1_10km_Layer
LaurelCreek9_10km_Layer
KnappCreek_10km_Layer
ThornyCreek_10km_Layer
StilingtonCreek_10km_Layer
Display Source Selection Catalog
Drawing
Arial
10
1151769.667 -83152.664 Meters
Elevation 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)“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Labeling
Fast
Editor
Task: Create New Feature
Target:
FPZTools
Generate Channel Belt Sinuosity
Layers
Kana_Streams_final_10k_Mast
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_Lay
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OneMileRun_10km_Layer
SpringCreek2_10km_Layer
SpringCreek1_10km_Layer
LaurelCreek9_10km_Layer
KnappCreek_10km_Layer
ThornyCreek_10km_Layer
StilingtonCreek_10km_Layer
Display Source Selection Catalog
Drawing
Arial
10
1151416.623 -82262.379 Meters

Final Master Table

Attributes of Kanawha_Final10k_MasterTable

Segment ID	Unit	Mean Annual	Geology	Elevatio	Valley Width	Valley Floor Width	Ratio VW to VF	Left V Slope	Right V Slope	Down V Slope	Sine L CB	Sine R CB	Channel Belt Width	Sine RC	Planform	X Coord	Y Coord
KanawhaNewRiver_0	km	1041	alluvium	164.157	8004.918217	1101.22027	7.269134	<Null>	0.016355	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	1129960.1	-54415.31
KanawhaNewRiver_10	km	1053.848375	alluvium	164.399	3133.826058	1967.523172	1.592777	0.041128	0.131058	-0.000024	<Null>	<Null>	<Null>	1.048425	<Null>	1138852.3	-57865.65
KanawhaNewRiver_20	km	1069.3861	alluvium	165.917	3798.390194	1797.103113	2.113618	0.04623	0.087295	-0.000152	<Null>	<Null>	<Null>	1.070166	<Null>	1146546.9	-63167.56
KanawhaNewRiver_30	km	1073.353106	alluvium	165.182	2620.449962	1683.080557	1.556937	0.522863	0.055468	0.000073	<Null>	<Null>	<Null>	1.048412	<Null>	1148185.6	-72563.98
KanawhaNewRiver_40	km	1068.126304	alluvium	164.331	1985.562002	1446.611082	1.372561	0.410861	0.164163	0.000085	<Null>	<Null>	<Null>	1.061522	<Null>	1145620.9	-81628.58
KanawhaNewRiver_50	km	1060	alluvium	166.316	1911.793268	1444.558256	1.323445	0.718377	0.270355	-0.000199	<Null>	<Null>	<Null>	1.061755	<Null>	1152589.6	-87964.41
KanawhaNewRiver_60	km	1068.537876	alluvium	172.142	2811.678346	1107.091541	2.539698	0.210909	0.085329	-0.000583	<Null>	<Null>	<Null>	1.461532	<Null>	1159405.0	-88568.18
KanawhaNewRiver_70	km	1086.094456	alluvium	171.892	2152.090629	1481.509493	1.452634	0.097954	0.011545	0.000025	<Null>	<Null>	<Null>	1.224584	<Null>	1160721.1	-96627.48
KanawhaNewRiver_80	km	1112.231751	alluvium	172.521	2527.287366	1602.006439	1.577576	0.088385	0.221692	-0.000063	<Null>	<Null>	<Null>	1.201507	<Null>	1165908.4	-103136.1
KanawhaNewRiver_90	km	1119.042781	alluvium	172.595	2476.600981	1688.832938	1.466457	0.093537	0.746032	-0.000007	<Null>	<Null>	<Null>	1.262471	<Null>	1173829.3	-103147.3
KanawhaNewRiver_100	km	1131.17885	alluvium	172.781	1970.468874	1103.148488	1.786223	0.291306	0.354656	-0.000019	<Null>	<Null>	<Null>	1.081944	<Null>	1182439.6	-106507.2

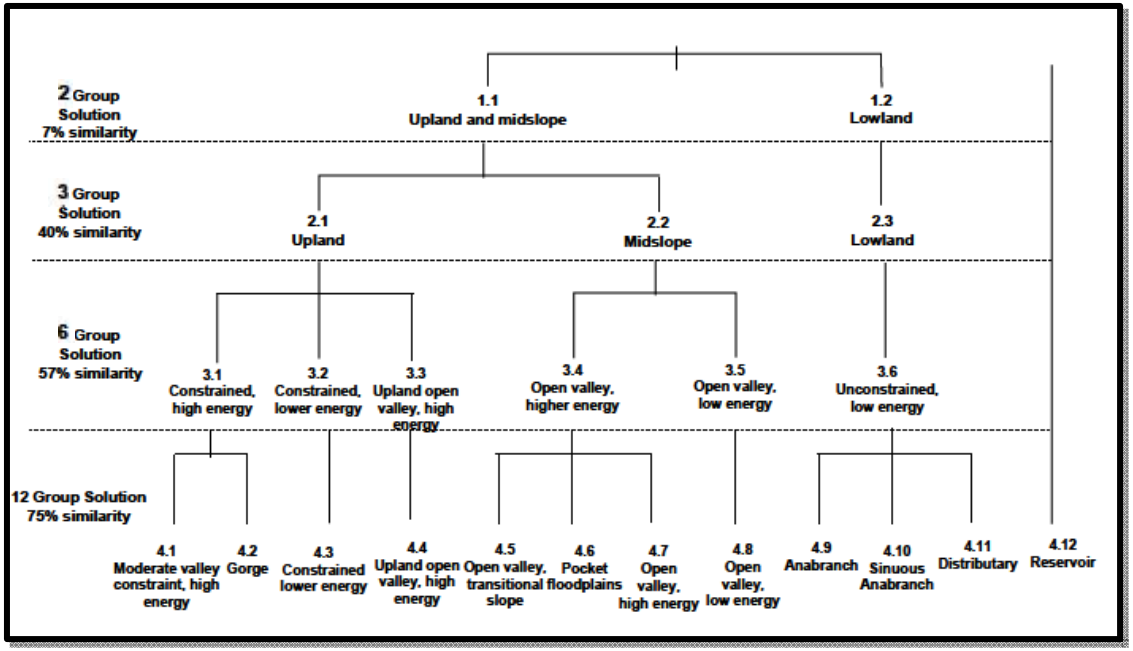
Record: 0 Show: All Selected Records (0 out of 727 Selected) Options

Preliminary Study of the Kanawha River Basin

- ~ 32,000 km^2
- Highly constricted mountainous system
- Special Features:
  - Contains 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

- Cluster analysis is used to identify groups of sample segments with similar hydrogeomorphic characteristics (i.e., FPZs)



Preliminary Study of the Kanawha River Basin

- 6 Distinct FPZs identified

Lowland Alluvial Zone

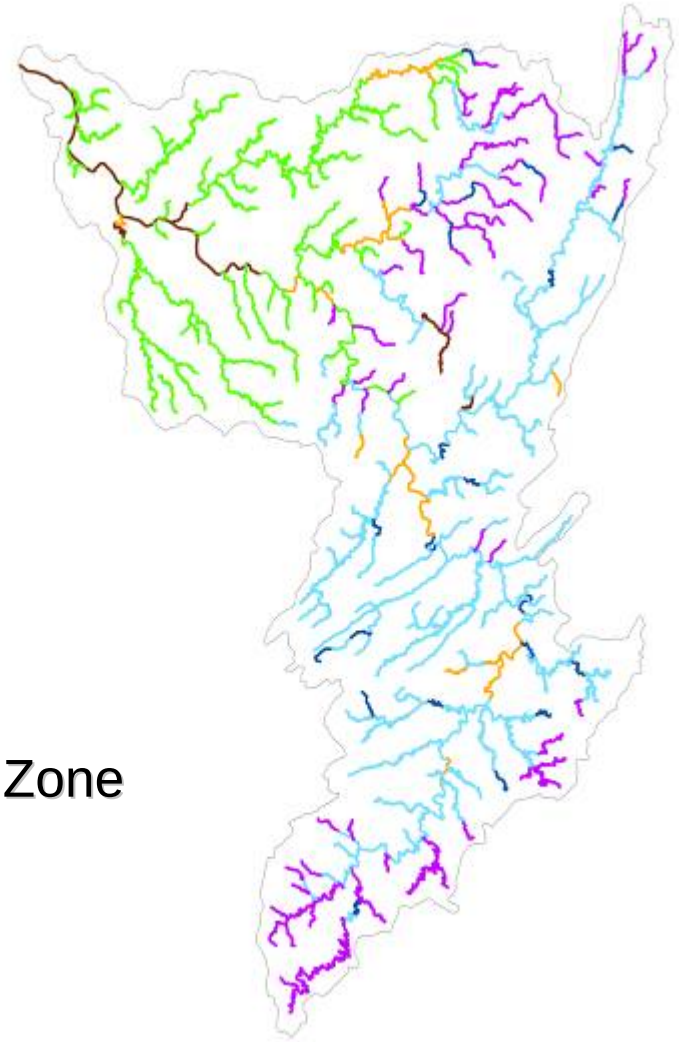
Lowland Constricted Zone

Constricted upland Zone

Open Valley Upland Zone

Constricted High Energy Upland Zone

Reservoir Zone



Next Steps

Environmental Application of FPZs

- Development of monitoring design sampling plan based on 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:

Collaborators at Kansas University

Dr. Martin Thoms (University of New England, Armendale, NSW Australia)

Members of the Riverine Landscapes Research Lab at the University of Canberra, Canberra, Australia.

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