



Rapid River Classification Using GIS-Delineated Functional Process Zones

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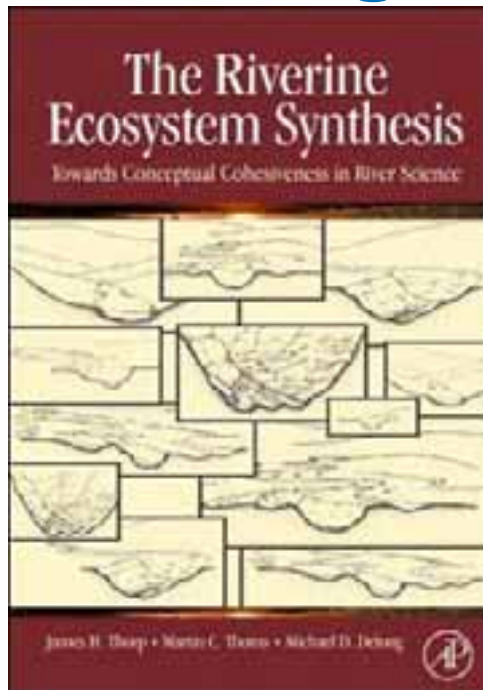
¹Dynamac Corporation c/o USEPA, ²University of Kansas, Kansas Biological Survey, ³USEPA, National Exposure Research Laboratory



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.

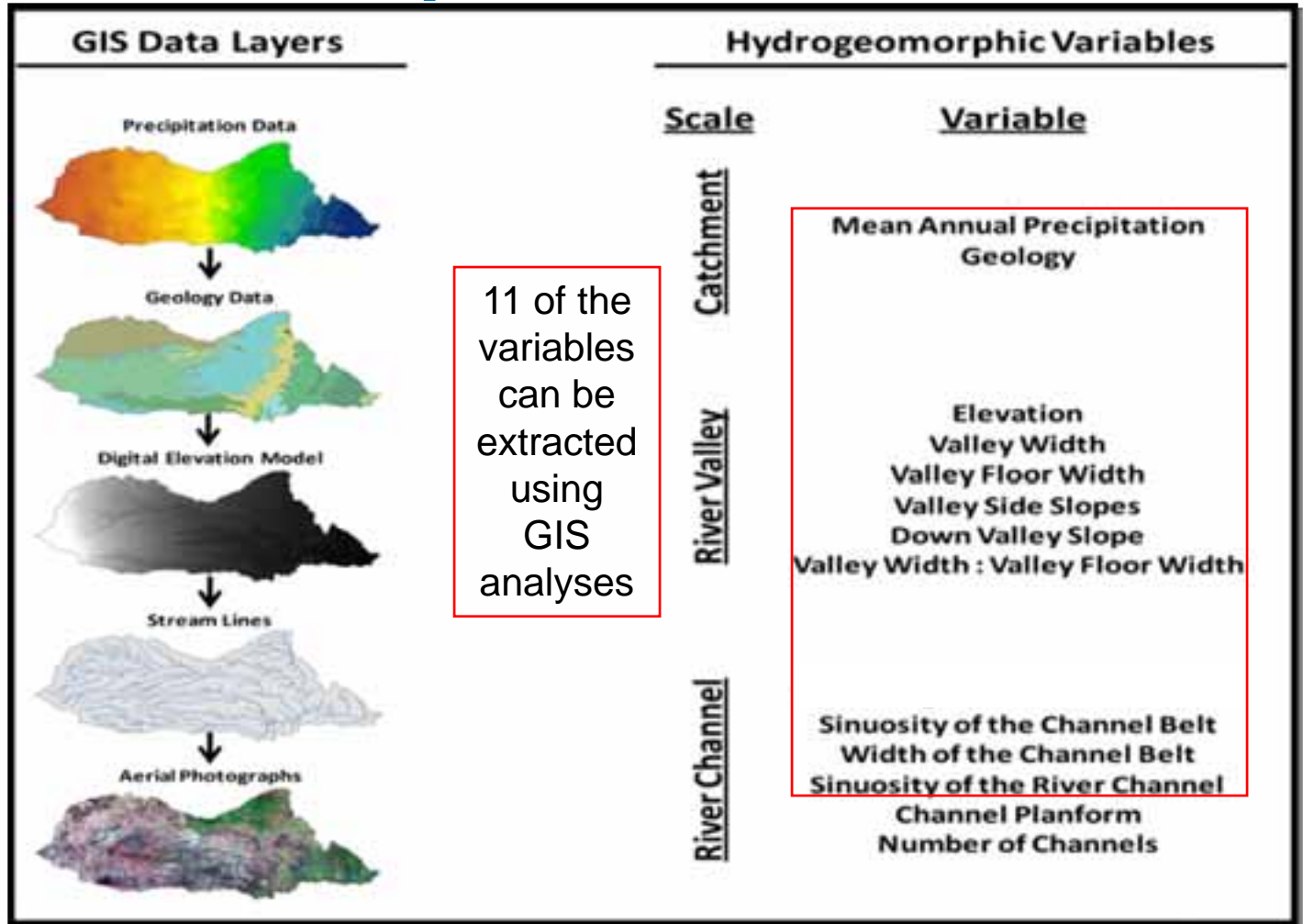
Functional Process Zones

- 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

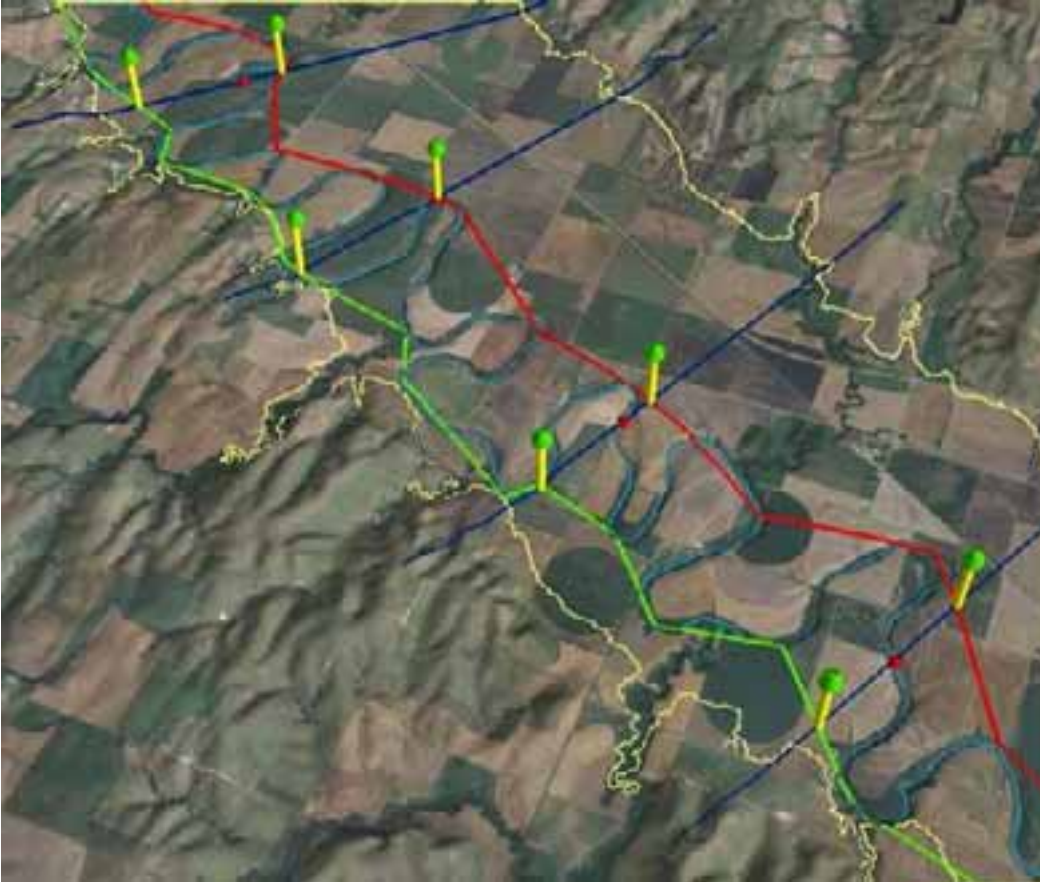
Requires the Calculation of 13 Dependent and Independent Variables



Seven Required Input Datasets

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

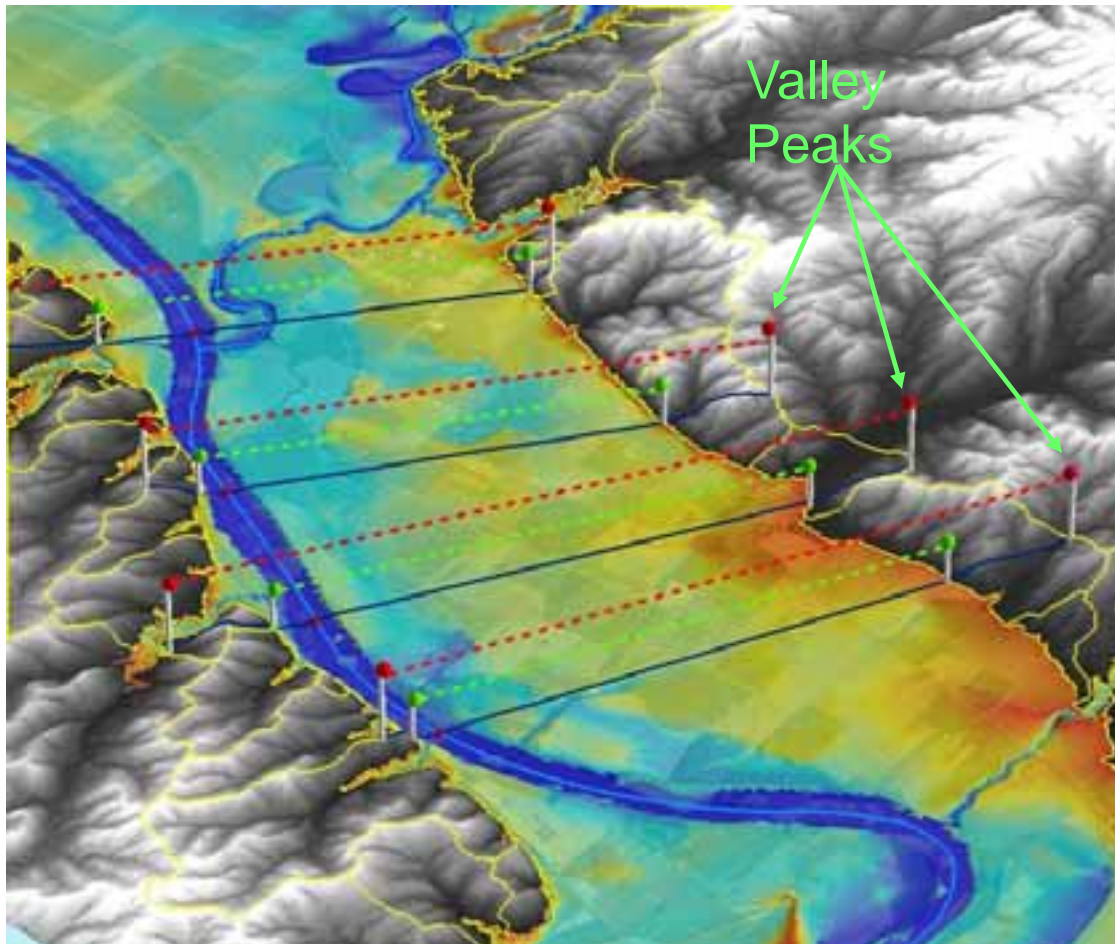
Channel Belt



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

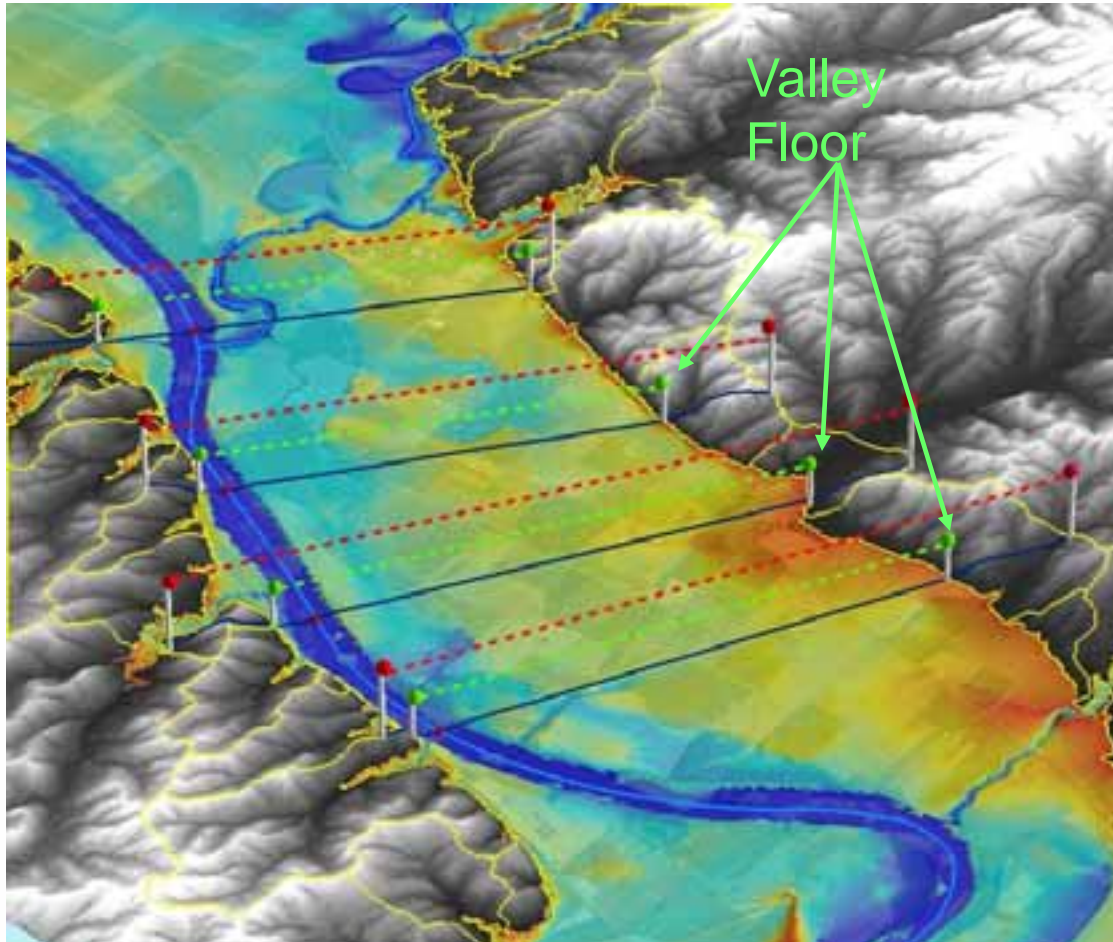
Kansas River, KS

Microsheds



- Created using ArcHydro to help identify the valley peaks.

Floodplain



- 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.

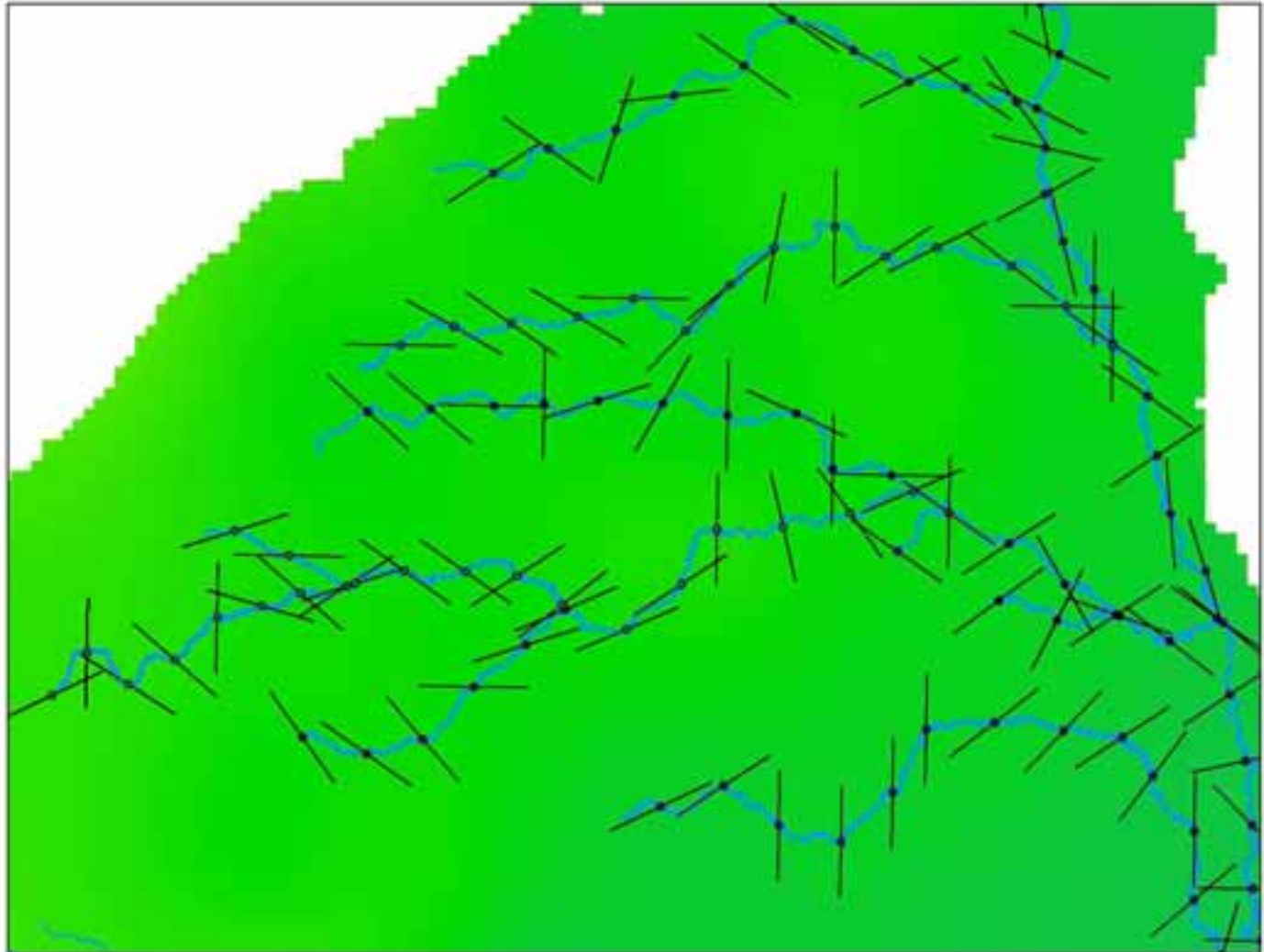
Sampling Points

- 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.

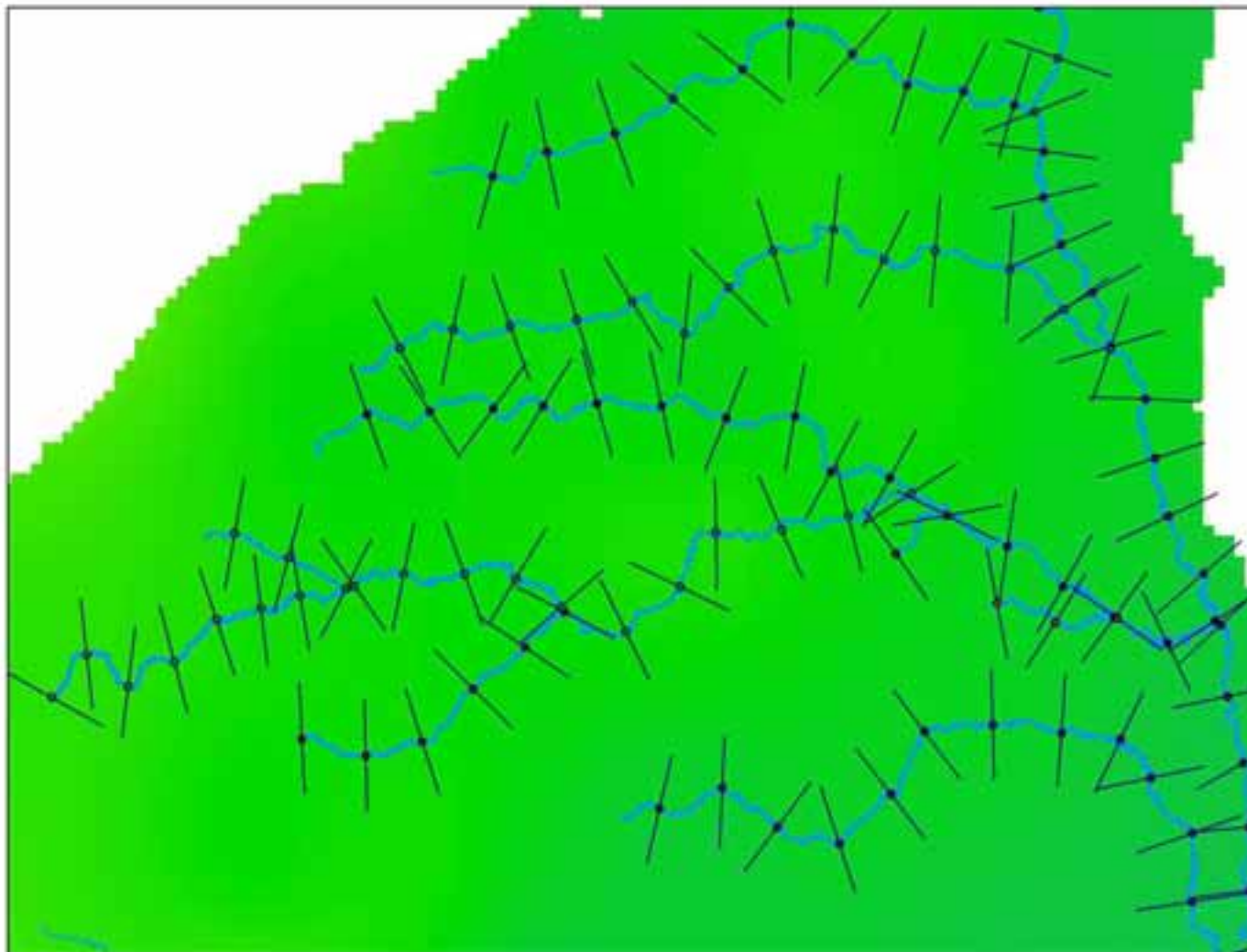
Transects

- 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.



Layers

- Kanawha_streams_final_10k
- Kanawha_microshed_lines
- Kanawha_flood_layer
- USGS_Kanawha_Geology
- PRISM_rsm_Kanawha_Clip.mxd
Value
High: 1850
Low: 910
- Kanawha_dem
Value
High: 1746.19
Low: 162.395

FPZTools



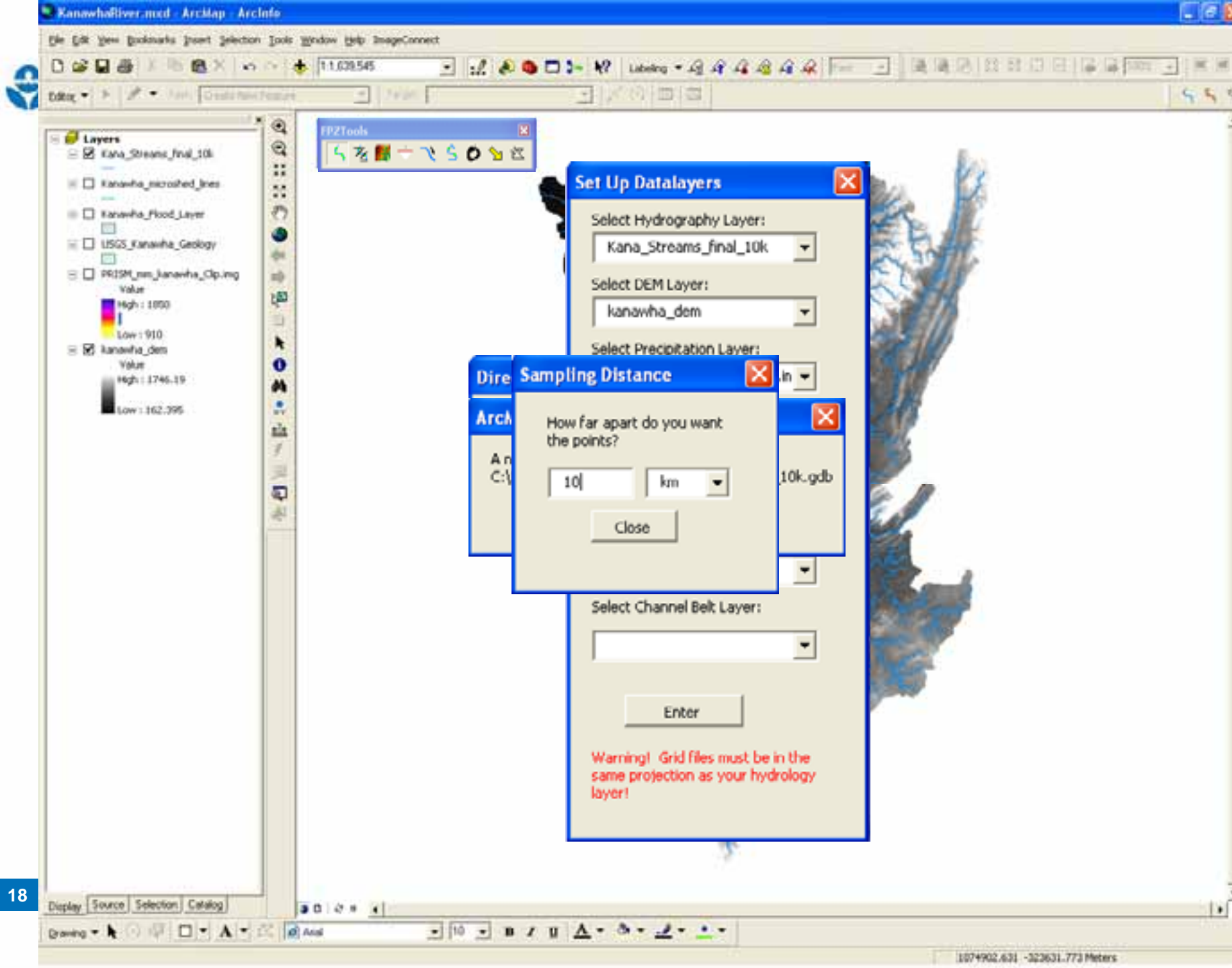
Welcome

*Welcome to the
Functional Process Zone
Analysis Tool*

Let the fun begin

Exit

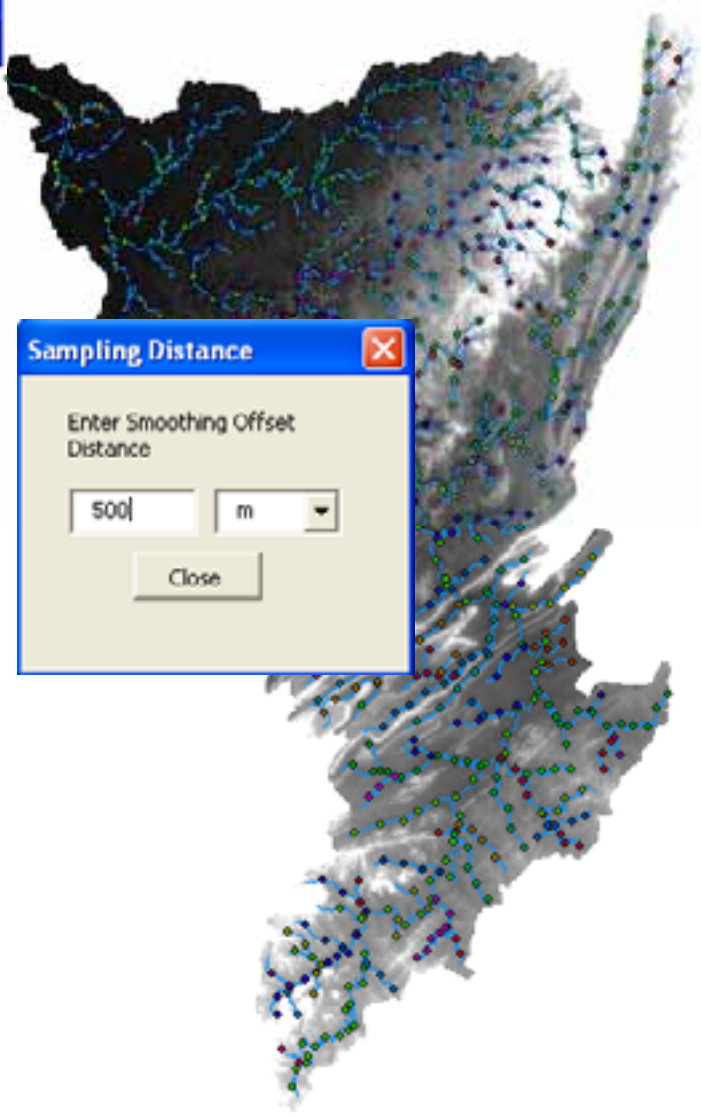




- EastRiver_10km_Layer
- BluestoneRiver_10km_Layer
- GladeCreek1_10km_Layer
- PineyCreek_10km_Layer
- LoopCreek_10km_Layer
- PaintCreek_10km_Layer
- CabinCreek_10km_Layer
- FourCreek_10km_Layer
- WilsonCreek_10km_Layer
- PocatalcoRiver_10km_Layer
- EightmileCreek_10km_Layer
- HurricaneCreek2_10km_Layer
- ThirteenMileCreek_10km_Layer
- SpruceFork_10km_Layer
- LittleCoalCreek_10km_Layer
- CoalRiver_10km_Layer
- HellonCreek_10km_Layer
- LittlehorseCreek_10km_Layer
- BighorseCreek1_10km_Layer
- MeatCampCreek_10km_Layer
- ThreeTopCreek_10km_Layer
- BigLaurelCreek2_10km_Layer
- NorthForkNewRiver_10km_Layer
- KanawhaNewRiver_10km_Layer

FPZTools

Create Transects



Sampling Distance

Enter Smoothing Offset Distance

500 m

Close

- Layers
 - Kana_Streams_Final_10k_Mast
 - traverses
 - 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
 - GloverCreek_10km_Layer
 - EPGreenbrierRiver_10km_Laye
 - NoName9_10km_Layer
 - NoName8_10km_Layer
 - MuddyCreek_10km_Layer
 - LaurelCreek8_10km_Layer
 - MuddyCreek2_10km_Layer

FPZTools



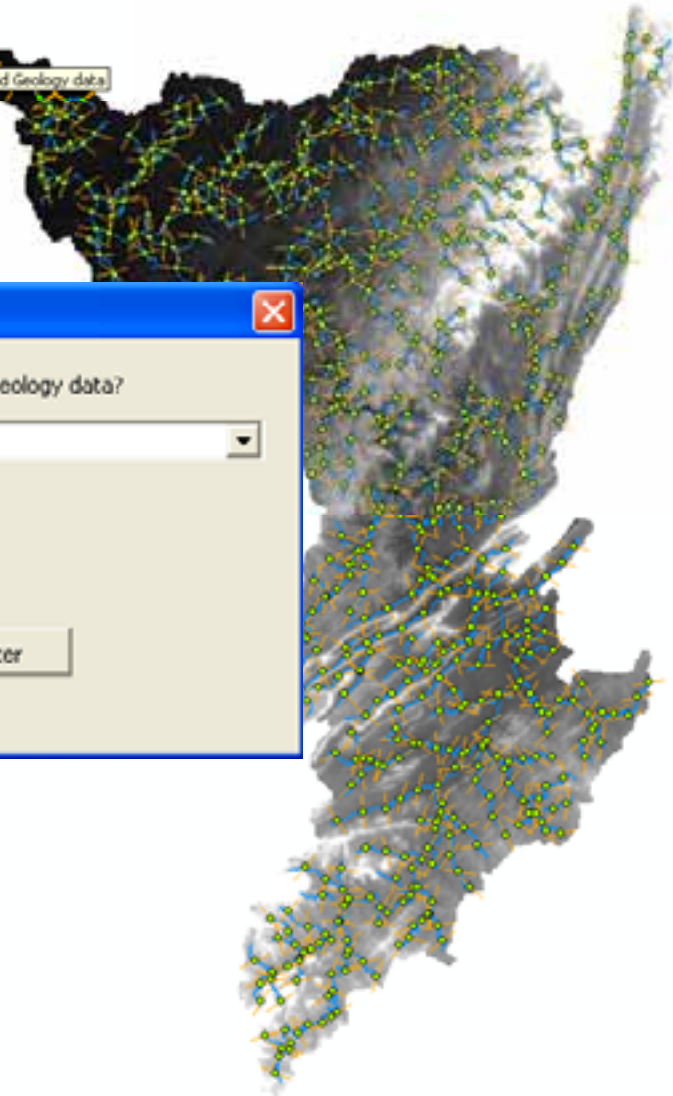
Generate Elevation, Precipitation, and Geology data

Geology Field

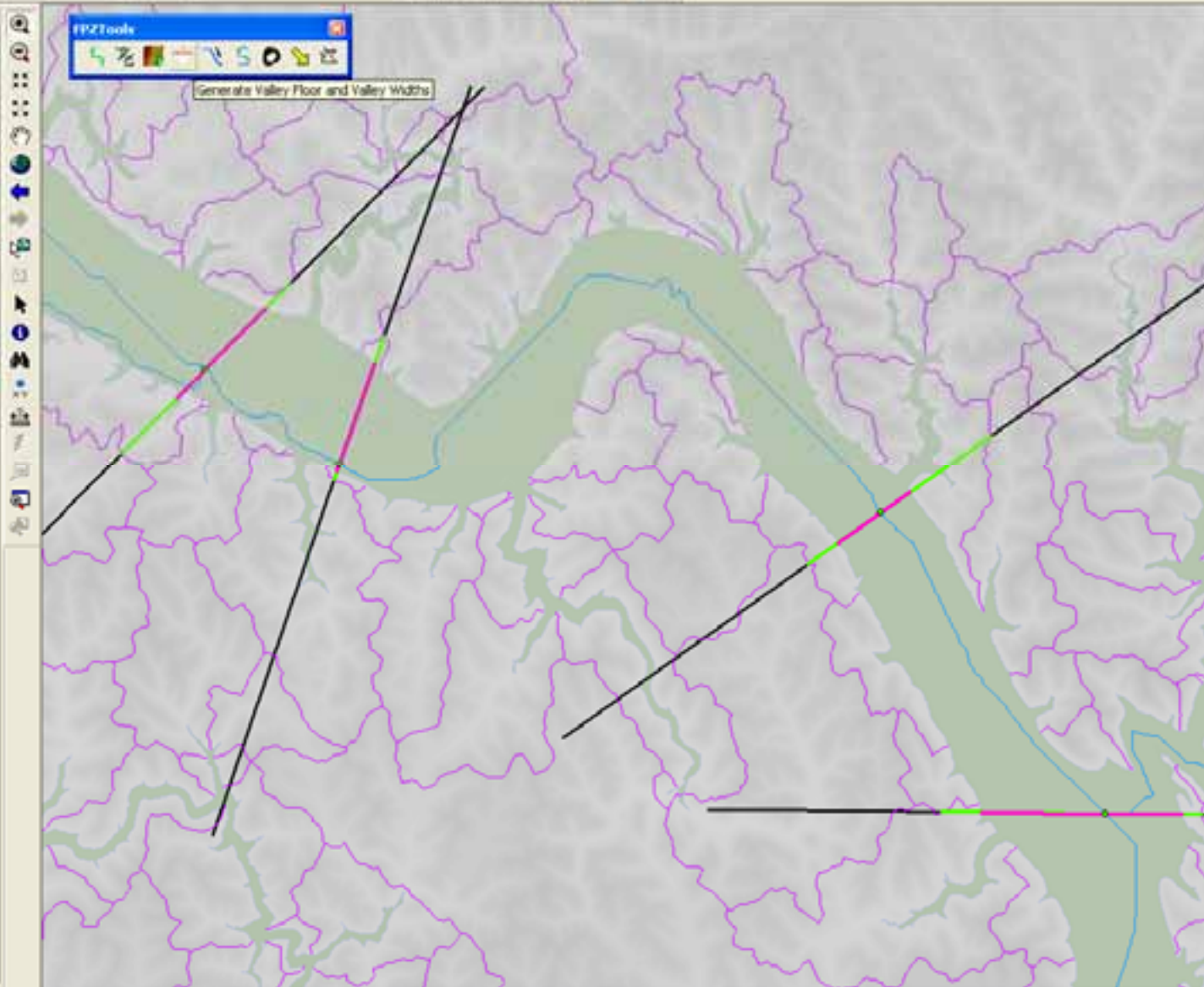
Which field has the geology data?

ROCKTYPE1

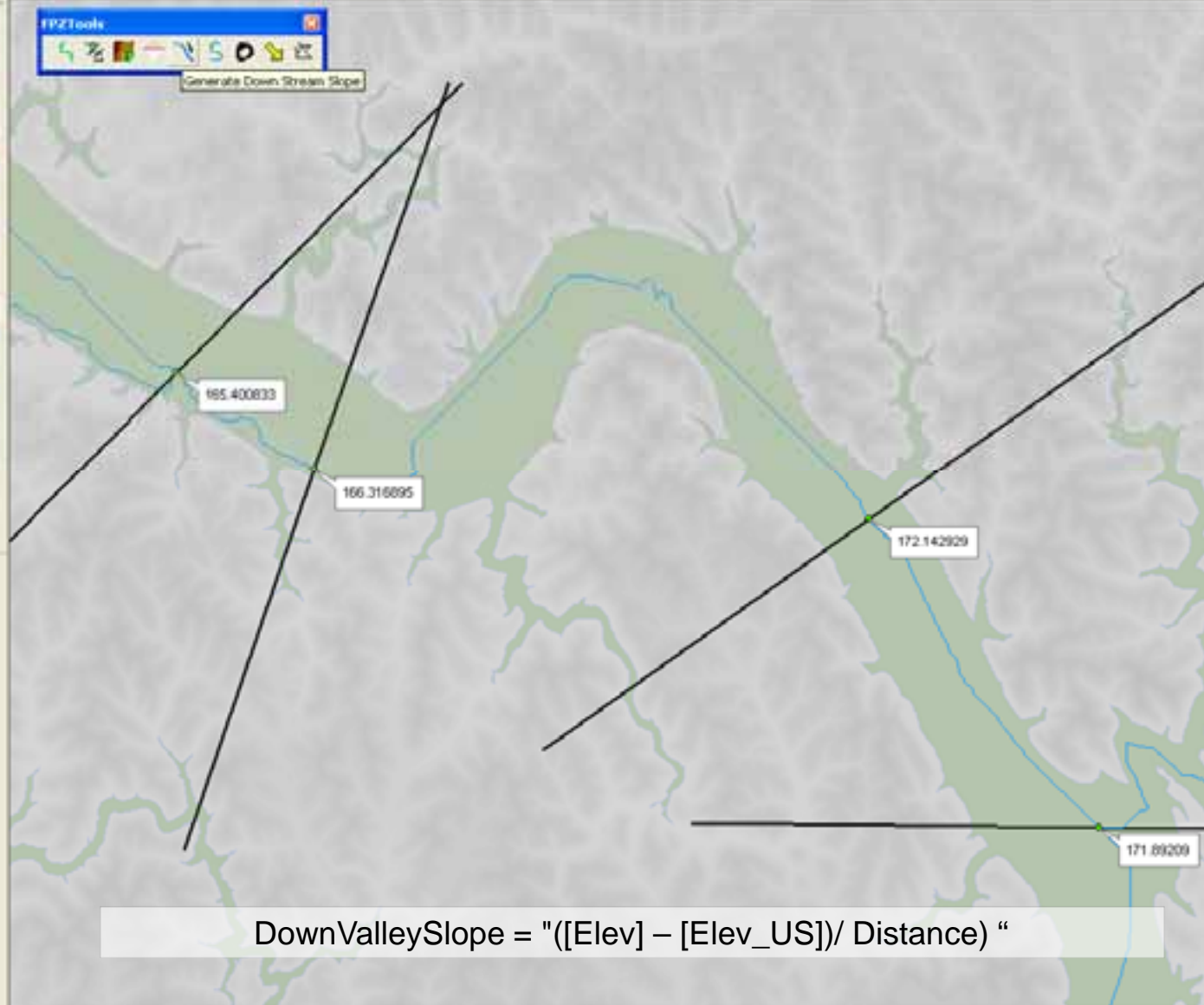
Enter



- Layers
 - Kana_Streams_Final_10k_Mark
 - ValleyWidth
 - ValleyWidth
 - Kanawha_nacashed_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
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 - OneMileRun_10km_Layer
 - SpringCreek2_10km_Layer
 - SpringCreek1_10km_Layer
 - LaurelCreek9_10km_Layer
 - KnappCreek_10km_Layer
 - ThornyCreek_10km_Layer
 - StingtonCreek_10km_Layer
 - CloverCreek_10km_Layer



- Layers
 - ☑ Kanawha_streams_final_10k_Mast
 - ☐ ValleyWidth
 - ☐ ValleyWidth
 - ☐ Kanawha_nacrosched_lines
 - ☑ Kanawha_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



DownValleySlope = "([Elev] – [Elev_US])/ Distance) “

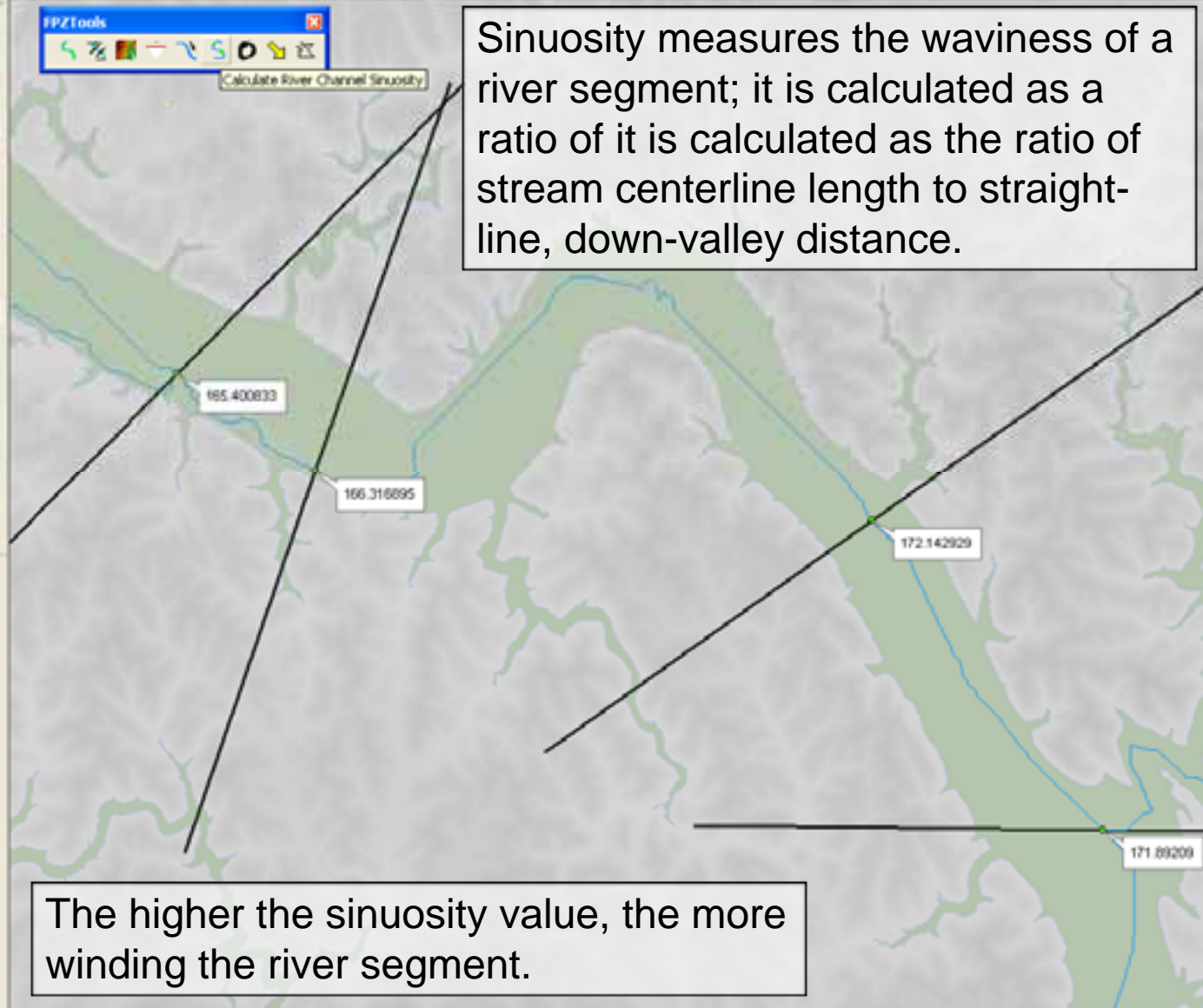
- Layers
- [-] Kana_Streams_Final_10k_Mart
- [-] ValleyWidth
- [-] ValleyWidth
- [-] Kanawha_nacrosched_lines
- [-] Kana_Streams_Final_10k
- [-] Kanawha_Flood_Layer
- [-] transects
- [-] SparrowCreek_10km_Layer
- [-] RichCreek2_10km_Layer
- [-] CoveCreek_10km_Layer
- [-] NoName12_10km_Layer
- [-] LeatherwoodCreek1_10km_La
- [-] 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
- [-] ...

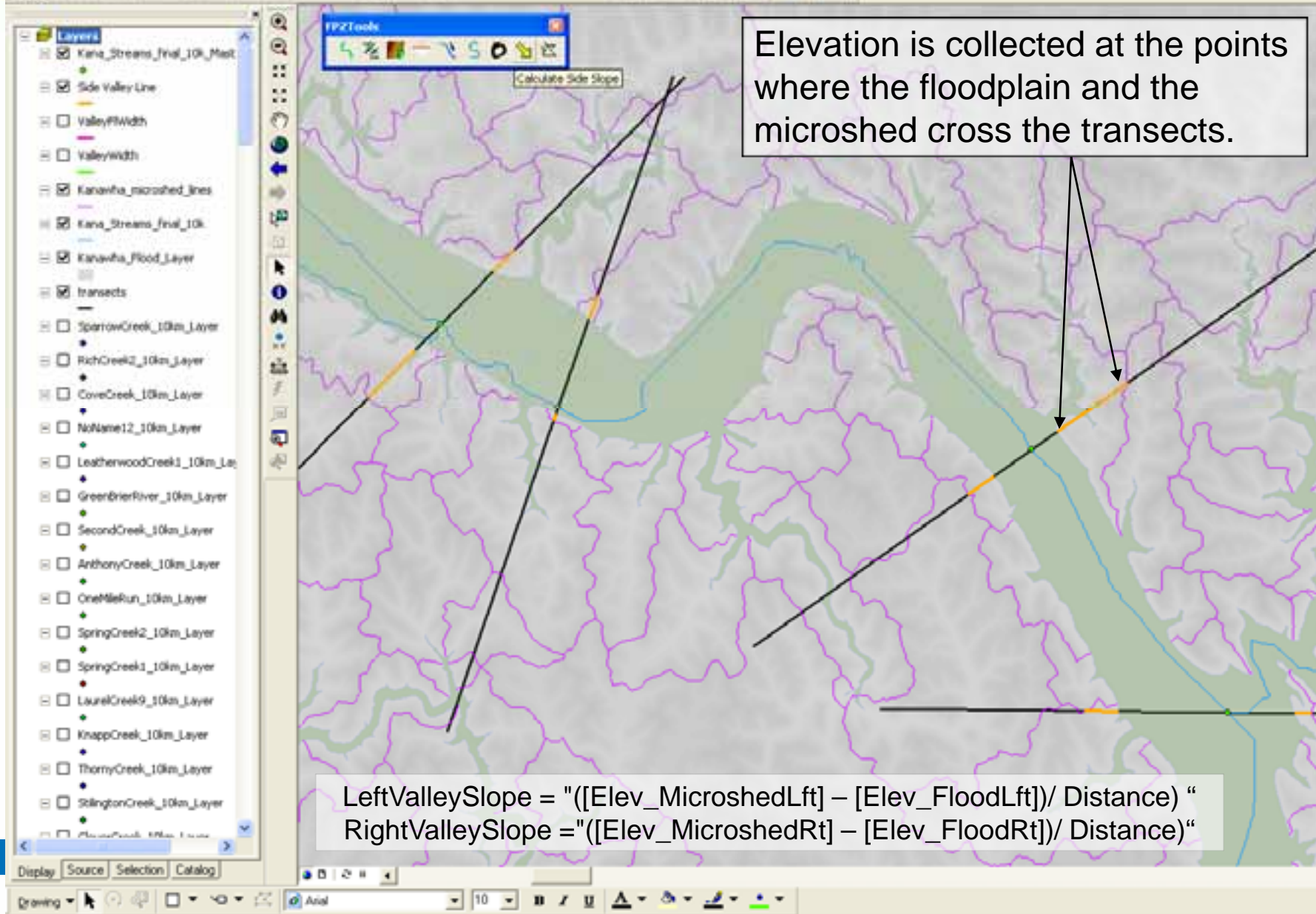
FPZTools

Calculate River Channel Sinuosity

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.

The higher the sinuosity value, the more winding the river segment.





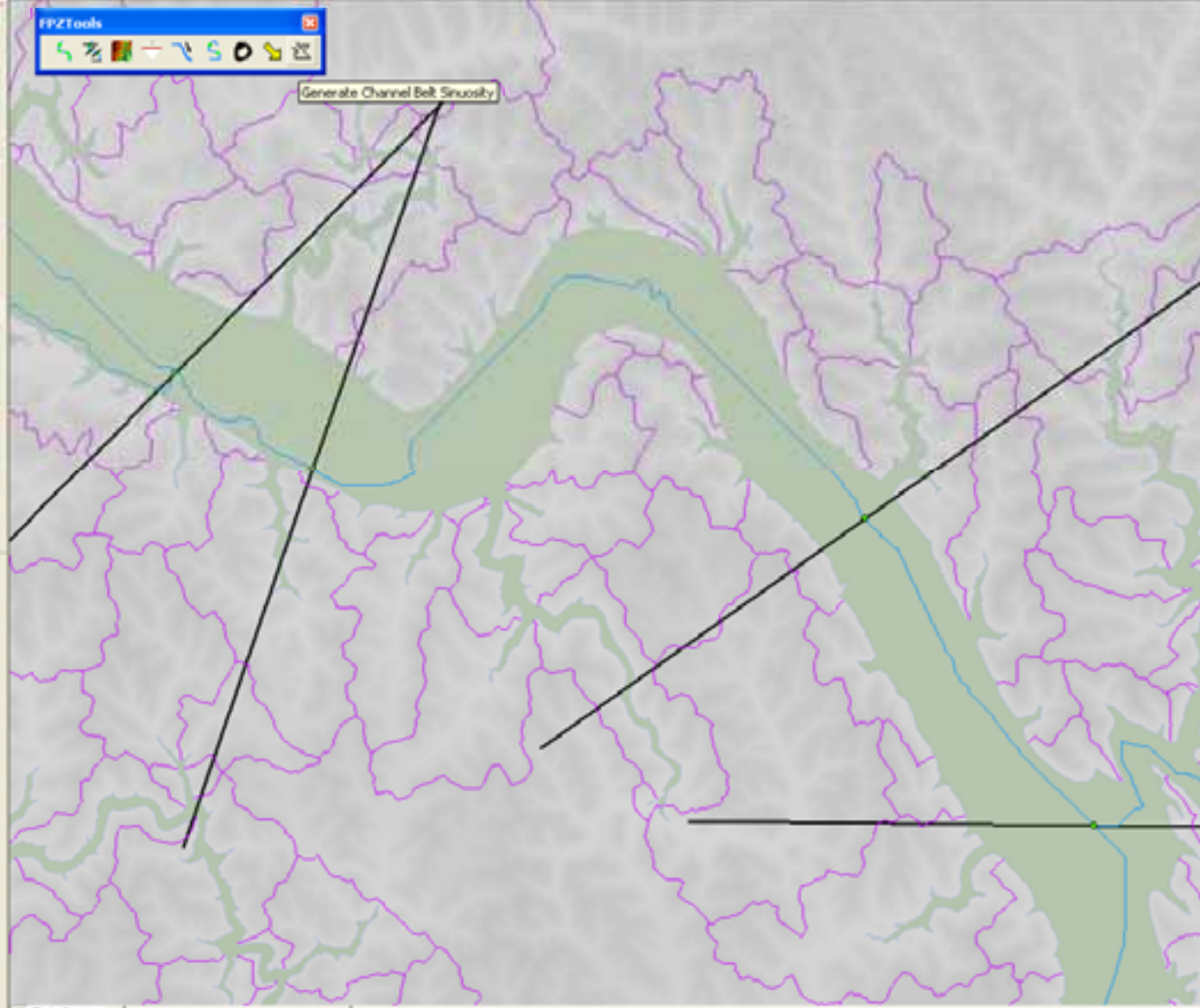
Layers

- ☑ Kanwa_streams_final_10k_Mark
- ☐ Side Valley Line
- ☐ ValleyFWidth
- ☐ ValleyWdth
- ☑ Kanawha_nacashed_lines
- ☑ Kanwa_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
- ☐ StingtonCreek_10km_Layer
- ☐ ...

Display Source Selection Catalog

FPZTools

Generate Channel Belt Suroosity



Final Master Table

Attributes of Kans. Streams_Final_10k

Seg_ID	Units	MeanAnnPre	Geology	Elev	ValWidth	ValFWid	RatioVW/W	LRVSI	RVSIS	RWVSI	SessCB	SessCB	CRWth	SessCB	Platform	X Coord	Y Coord
Kanshaleoffiver_0	km	1061	alluvium	164.157166	3004.916217	1101.22027	7.269134	0	0.01373	0	0	0	0	0	0	1129960.1858	-54415.3158
Kanshaleoffiver_10	km	1063.848175	alluvium	164.399974	3133.826058	1967.529172	1.882777	0.041128	0.00803	0.000138	0	0	0	0	0	1136952.36741	-57985.801858
Kanshaleoffiver_20	km	1069.3081	alluvium	165.911293	3788.380194	1791.103113	2.113818	0.04623	0.01701	-0.000229	0	0	0	0	0	1140546.9375	-63187.587795
Kanshaleoffiver_30	km	1073.357136	alluvium	165.183496	2620.448962	1683.080657	1.598837	0.026493	0.00967	-0.000218	0	0	0	0	0	1148195.81223	-72583.863775
Kanshaleoffiver_40	km	1080.126304	alluvium	164.331571	1985.982002	1448.811982	1.372581	0.410881	0.03995	-0.001185	0	0	0	0	0	1146520.91767	-81829.883201
Kanshaleoffiver_50	km	1080	alluvium	166.316895	1911.783266	1444.568256	1.323445	0.718378	0.06688	-0.000562	0	0	0	0	0	1152683.62167	-87964.416421
Kanshaleoffiver_60	km	1088.537876	alluvium	172.142029	2811.878348	1107.091541	2.838898	0.210909	0.04487	-0.000122	0	0	0	0	0	1159405.0698	-89668.188923
Kanshaleoffiver_70	km	1086.094456	alluvium	171.882029	2152.086628	1481.509483	1.452634	0.031141	0.00259	-0.000058	0	0	0	0	0	1160721.10901	-96627.486723
Kanshaleoffiver_80	km	1112.231751	alluvium	172.571595	2527.267366	1602.006439	1.677576	0.088395	0.05205	-0.000234	0	0	0	0	0	1168806.40445	-102136.121131
Kanshaleoffiver_90	km	1118.042781	alluvium	172.595123	2476.800891	1688.802838	1.466457	0.093537	0.00861	-0.000892	0	0	0	0	0	1173829.36887	-102147.343236
Kanshaleoffiver_100	km	1131.178985	alluvium	172.761988	1570.858874	1103.148489	1.788223	0.291308	0.09085	-0.000867	0	0	0	0	0	1182439.63967	-108607.294
Kanshaleoffiver_110	km	1151.530197	alluvium	173.574483	1319.280155	850.804899	1.550638	0.667028	0.09409	-0.001524	0	0	0	0	0	1185207.3609	-112543.191613
Kanshaleoffiver_120	km	1155.230299	alluvium	179.888894	2775.47726	1105.78882	2.510205	0.300408	0.10804	0.000141	0	0	0	0	0	1182320.46057	-120516.194789
Kanshaleoffiver_130	km	1155.124379	alluvium	180.505207	2609.250891	803.250042	4.320519	0.530836	0.13738	-0.000322	0	0	0	0	0	1198303.82527	-119047.9409
Kanshaleoffiver_140	km	1160	alluvium	187.080138	1084.763713	417.271883	2.998857	0.37312	0.08033	-0.000681	0	0	0	0	0	1193028	-126606.3302
Kanshaleoffiver_150	km	1153.848882	sandstone	187.219167	1815.389406	607.381677	2.658934	0.391582	0.24758	-0.000008	0	0	0	0	0	1194307	-125883.811038
Kanshaleoffiver_160	km	1148.508125	sandstone	197.449434	3498.087273	958.850576	3.848118	0.439582	0.0207	-0.000147	0	0	0	0	0	1218982.81419	-121543.3839
Kanshaleoffiver_170	km	1133.106798	sandstone	227.018642	829.26643	278.458883	3.258849	0.670125	0.20647	-0.002872	0	0	0	0	0	1177278	-122388.80035
Kanshaleoffiver_180	km	1140.052713	sandstone	253.633362	1763.844831	122.884368	14.378184	0.98371	0.20221	-0.00188	0	0	0	0	0	1193426	-122986.8844
Kanshaleoffiver_190	km	1142.264483	sandstone	268.815112	1918.196278	168.170008	11.348972	0.38882	0.32294	-0.000002	0	0	0	0	0	1238160.187	-125482.530686
Kanshaleoffiver_200	km	1150.91243	sandstone	305.77536	1480.578678	222.150494	6.384631	0.37244	0.38734	-0.000027	0	0	0	0	0	1194426	-123818.89127
Kanshaleoffiver_210	km	1167.873463	shale	321.271863	1112.381082	226.817887	4.891087	0.688629	0.29757	-0.001941	0	0	0	0	0	1234386.0483	-147025.018803
Kanshaleoffiver_220	km	1148.448133	shale	337.286007	424.888807	245.818389	1.727157	0.008824	0.28888	-0.001883	0	0	0	0	0	1193443	-151820.860746
Kanshaleoffiver_230	km	1063.786642	shale	363.019378	1381.288038	230.819598	6.032788	0.388307	0.23828	-0.00136	0	0	0	0	0	1234395.58724	-150383.8319
Kanshaleoffiver_240	km	1125.416583	shale	388.167808	3029.074118	475.537977	8.388784	0.058134	0.25348	-0.00189	0	0	0	0	0	1209120	-167358.856121
Kanshaleoffiver_250	km	1108.058764	shale	381.959187	955.934207	404.142732	2.385487	0.897395	0.19613	-0.000524	0	0	0	0	0	12075533	-169620.195303
Kanshaleoffiver_260	km	894.438612	shale	397.481221	1514.888583	415.058891	3.848315	0.374828	0.27611	0.000037	0	0	0	0	0	1248947.73478	-186275.488534
Kanshaleoffiver_270	km	875.714851	shale	412.424886	2650.095037	388.742464	8.848107	0.500623	0.15328	-0.001524	0	0	0	0	0	1221108	-173683.21667
Kanshaleoffiver_280	km	972.01835	water	433.272568	2385.326875	521.257828	4.422792	0.875339	0.14723	0.000083	0	0	0	0	0	1252257.4834	-188861.847681
Kanshaleoffiver_290	km	975.87528	water	432.816386	1886.537713	431.058807	4.330142	0.32713	0.15439	0.001648	0	0	0	0	0	1253760.0375	-188758.481580
Kanshaleoffiver_300	km	952.420856	water	436.787581	1181.510504	262.720425	3.20222	0.085424	0.26895	0.000008	0	0	0	0	0	1353013	-193382.813274
Kanshaleoffiver_310	km	950.871814	water	440.972471	2175.888727	549.482269	3.994488	0.143588	0.17773	-0.00126	0	0	0	0	0	1258888.26281	-195887.848093
Kanshaleoffiver_320	km	947.548234	water	447.00382	1686.822289	385.118882	4.846798	0.091884	0.08783	-0.000801	0	0	0	0	0	1194881	-204584.838257
Kanshaleoffiver_330	km	942.327882	shale	457.888	2944.899332	891.228028	4.322588	0.05135	0.20173	-0.00015	0	0	0	0	0	1272112	-206391.648986
Kanshaleoffiver_340	km	969.449192	dolomite (dolomite)	483.182388	2423.812012	378.464388	8.404334	0.100828	0.20588	0.000001	0	0	0	0	0	1267730.82229	-210878.857588
Kanshaleoffiver_350	km	987.772241	dolomite (dolomite)	475.472278	1318.381082	295.222215	6.888342	0.157442	0.13288	-0.00004	0	0	0	0	0	1242208.7638	-207831.028844
Kanshaleoffiver_360	km	968.899188	dolomite (dolomite)	487.572021	2087.898877	355.589178	8.988777	0.284483	0.08388	-0.00081	0	0	0	0	0	1208483	-212288.7244
Kanshaleoffiver_370	km	970.492888	dolomite (dolomite)	493.798898	716.848436	286.587832	1.747428	0.098388	0.28091	-0.000867	0	0	0	0	0	1262882.8648	-215288.981108
Kanshaleoffiver_380	km	958.288806	shale	505.878807	1488.784441	498.863847	2.83801	0.178788	0.08228	0	0	0	0	0	0	1284748.80664	-223882.232273

Record: 11 | 1 | 3 | 11 | Show: All Selected | Records (1 out of 725 Selected) | Options: -

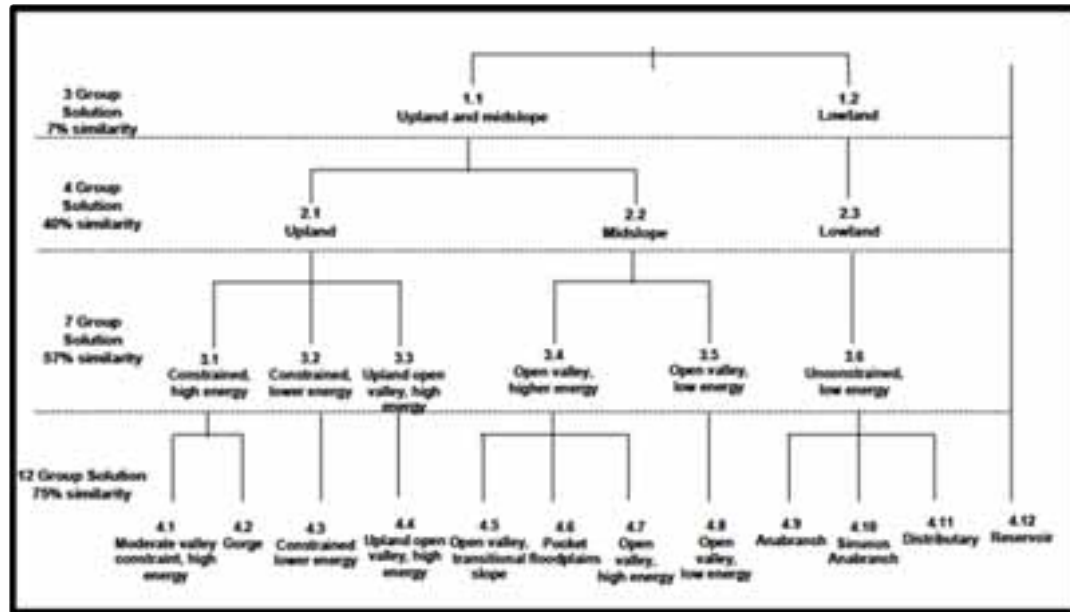
Preliminary Study of the Kanawha River Basin

- ~ 32,000 km²
- 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)

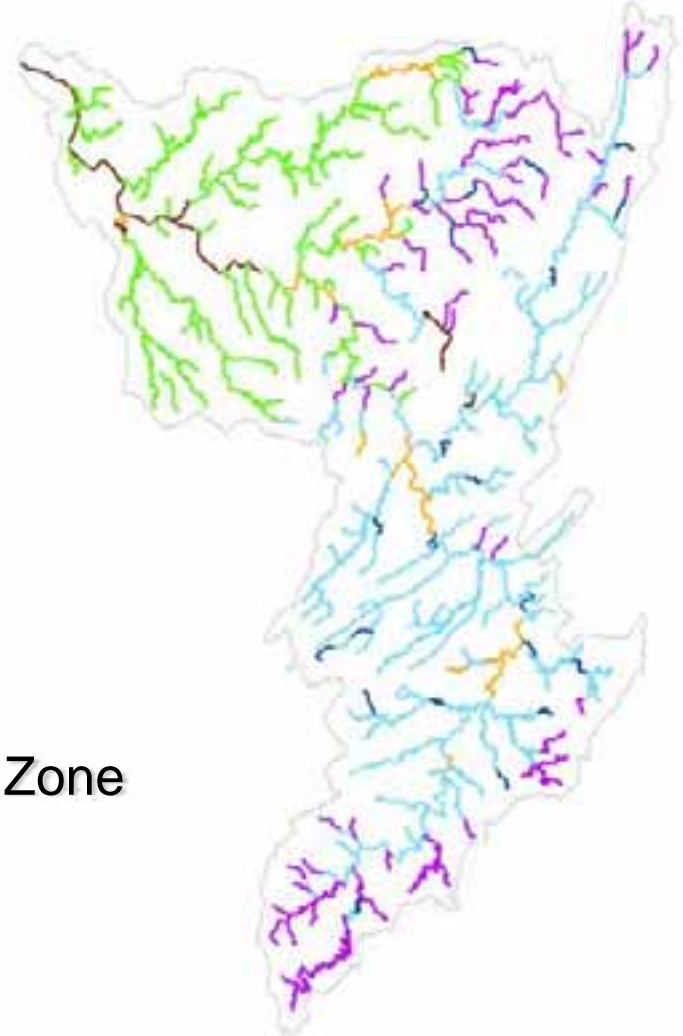


- The validity of the groups is then assessed with Multidimensional Scaling.

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:

**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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