

Network Screening for Safety on State- Maintained Roads in Kentucky

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Goals

- Develop a metric to score the safety performance of all state-maintained roads
- Provide a tool for transportation organizations to use to identify locations with poor safety performance
- Tool must be suitable for all users, regardless of GIS expertise



Kentucky's SHIFT Initiative

- Strategic Highway Investment Formula for Tomorrow (SHIFT)
- Provide a data driven methodology to select projects for funding
- Potential projects on state-maintained roads with a need (safety, congestion, development) are sponsored and added to a statewide list
- Score projects based on the following criteria:
 - Safety
 - Congestion
 - Economic Development
 - Asset Management
 - Benefit/Cost
- Top projects are included in the Statewide Transportation Plan (2 year cycle)
- Efforts focused solely on scoring and screening for safety



Old SHIFT Safety Process

Segment ($L > 0.2$): $CHSM = 0.25 * ((CD * L)_{\dagger \text{scaled}}) + 0.25 * (CRF_{\dagger \text{scaled}}) + 0.50 * (CF_{\dagger \text{scaled}})$

Intersection ($L \leq 0.2$): $CHSM = 0.5 * (CF_{\dagger \text{scaled}}) + 0.5 * (CRF_{\dagger \text{scaled}})$

Measure	Description	Summary Method All crash data summarized over 5 yrs. 2011-2015
CD*L	CD: Crash Density L: Project Length	Total # crashes 5 yr / cumulative length of roadway for facility type statewide Ending mile point minus beginning mile point
CRF	Critical Rate Factor	Length Weighted Avg
CF	Crash Frequency	# of crashes over 5 yr period

\dagger Scaled - The percentile rank of the value. Converts value to score of 0 to 100.



Limitations of Previous Approach

- CRF is outdated
 - Crashes and AADT are not linear
 - Sites with low AADTs tend to move to the top
 - No accounting for sites with zero crashes
 - Crash rates may be misleading
- Arbitrary weighting between the three components
- Crash reductions at different facility types should count the same (a life is a life)
- Length of a project should not (totally) drive the decision
- Segments and intersections should be modeled differently



Highway Safety Manual (HSM) Methodologies

- Safety Performance Function (SPF): regression equation modeling crashes based on AADT and length (for homogenous sections)
 - $\text{Crashes} = L * f(\text{AADT})$
 - Volume only for intersections
- If a project section or intersection is not similar to the reference group used to develop the SPF, must adjust
 - Adjustment Factors (AF): Account for differences in crashes when a segment varies from base conditions
 - $\text{Crashes} = L * f(\text{AADT}) * \text{AF}$
- Empirical Bayes (EB) Method: Combines adjusted SPF crash predictions with historical crash data to combat **regression to the mean**



• Safety Performance Function (SPF)

$$\text{Crashes} = L * e^a * \text{AADT}^b * AF$$

Crashes = SPF crash prediction

L = Length of segment

AADT = annual average daily traffic

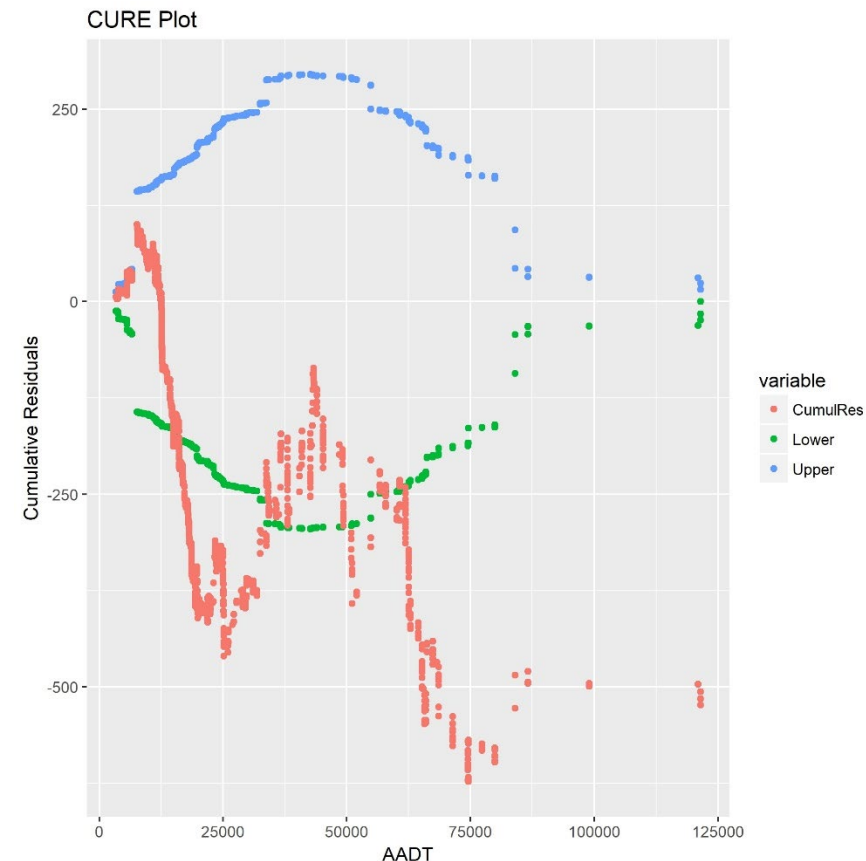
a & b = regression coefficients

AF = adjustment factor



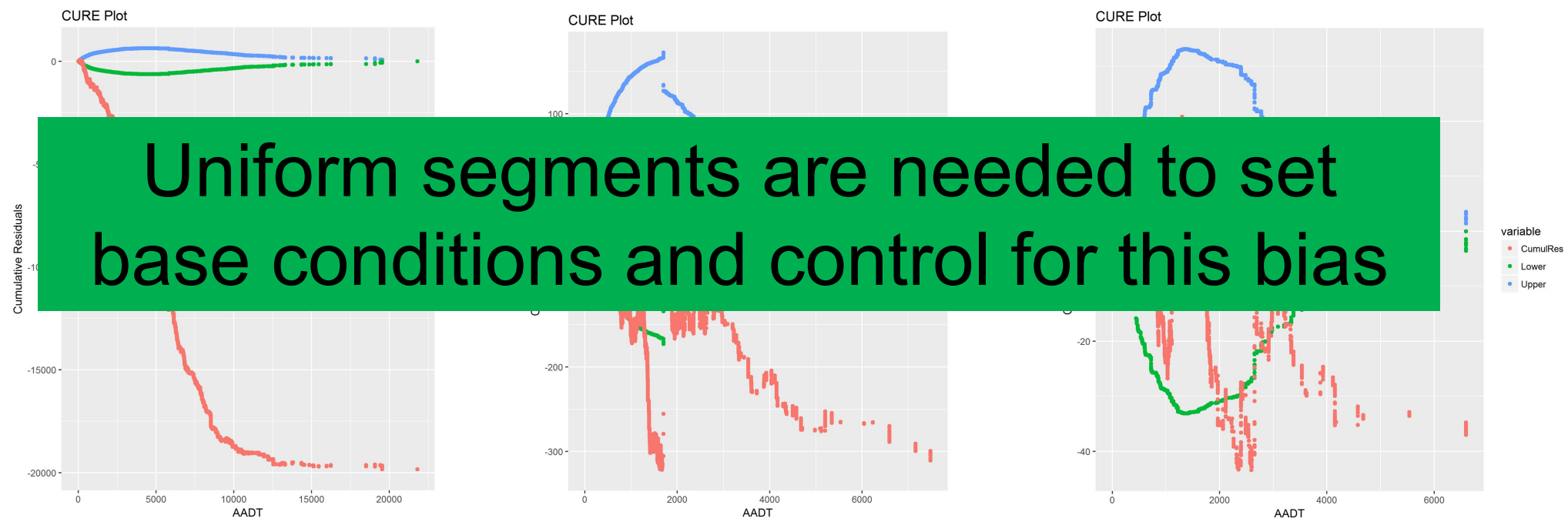
Safety Performance Function (SPF)

- Base conditions to account for roadway characteristics
- Adjustment factors to handle roadways outside of base conditions
- Judge fit of SPFs based on CURE plots



Omitted-variable Bias: CURE Plot Example

- All Rural two lanes roads
- Rural two lane with 9' lanes and 3' shoulders
- Rural two lane with 9' lanes, 3' shoulders, no curvature, and no grades,



Empirical Bayes (EB) Method

- $$\text{Expected Crashes} = w * \text{SPF Crashes} + (1 - w) * \text{Actual Crashes}$$

w = weight (based on overdispersion parameter from calibrated SPF)

SPF Crashes = predicted crashes on a segment from SPF

Actual Crashes = total historic crashes on a segment

*For SPFs with poor correlation, the weight parameter is lower, which places greater emphasis on historic crash data

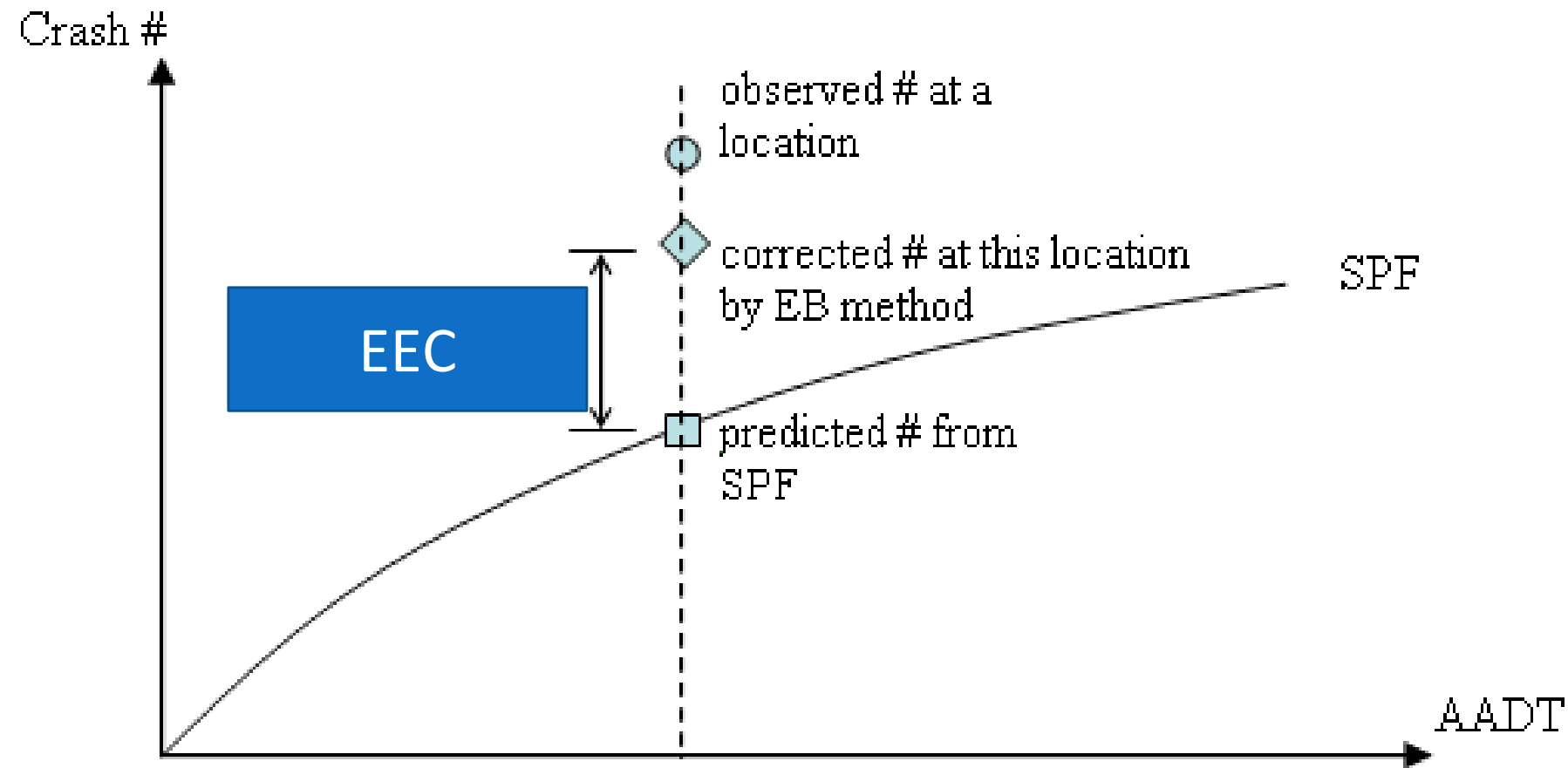


Excess Expected Crashes (EEC)

- $EEC = EB \text{ Expected Crashes} - SPF \text{ Predicted Crashes}$
- Compares crashes on a segment to crashes that would be expected on that segment
- Positive EEC = more crashes **than would be expected**
- Negative EEC = Fewer crashes **than would be expected**
- Locations with negative EEC can still benefit from a safety improvement, however these locations are already performing better than other locations of similar characteristic, so money is being focused in locations with higher than expected crashes.



Putting it all Together



Creating Uniform Segments

- Used roadway characteristic shapefiles from Kentucky's Highway Information System (HIS)
 - Traffic flow
 - Functional class
 - Horizontal Curves
 - Vertical Curves
 - Lanes
 - Shoulders
 - Medians
 - Intersections
- Save all DBFs to a geodatabase



Overlay Route Events

Overlay Route Events

Input Event Table

Input Event Table Properties

Route Identifier Field

Event Type
POINT

Measure Field

To-Measure Field

Overlay Event Table

Overlay Event Table Properties

Route Identifier Field

Event Type
POINT

Measure Field

To-Measure Field

Type of Overlay
UNION

Output Event Table

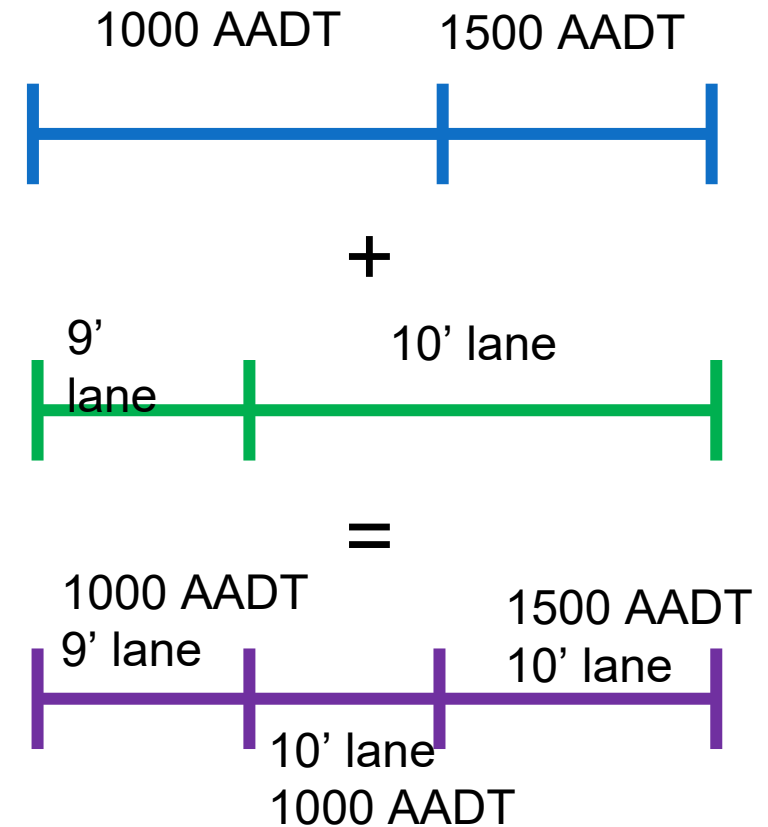
Output Event Table Properties

Type of Overlay

The type of overlay to be performed.

- INTERSECT—Writes only overlapping events to the output event table. This is the default.
- UNION—Writes all events to the output table. Linear events are split at their intersections.

OK Cancel Environments... << Hide Help Tool Help



Roadway Types for SPF development

- Rural two-lanes
- Rural multilane divided
- Rural multilane undivided
- Urban two-lanes
- Urban multilane divided
- Urban multilane undivided
- Rural Interstate/Parkway
- Urban Interstate/Parkway
- Ramps
- 36 Intersections Types



SPF-R Tool

- R-Studio tool to develop SPFs for any dataset
- Available in the FHWA Roadway Safety Data Program Toolbox
- Provides CURE plots and other metrics to evaluate SPFs



Final SPFs and Adjustment Factors

- Developed SPF with the best CURE plot using the least amount of base conditions for each roadway type

Roadway Type	Base Conditions
Rural 2 Lane	Lane Width = 9 ft Shoulder Width = 3 ft Horizontal Curve = Class A Grade = Class A
Non Rural 2 Lane	---
Rural Multilane (Divided)	Shoulder Width = 10 ft
Rural Multilane (Undivided)	Lane Width = 12 ft
Urban Multilane (Divided)	Median Width over 20
Urban Multilane (Undivided)	Lane Width = 12 ft
Rural Interstate and Parkways	---
Urban Interstate and Parkways	---



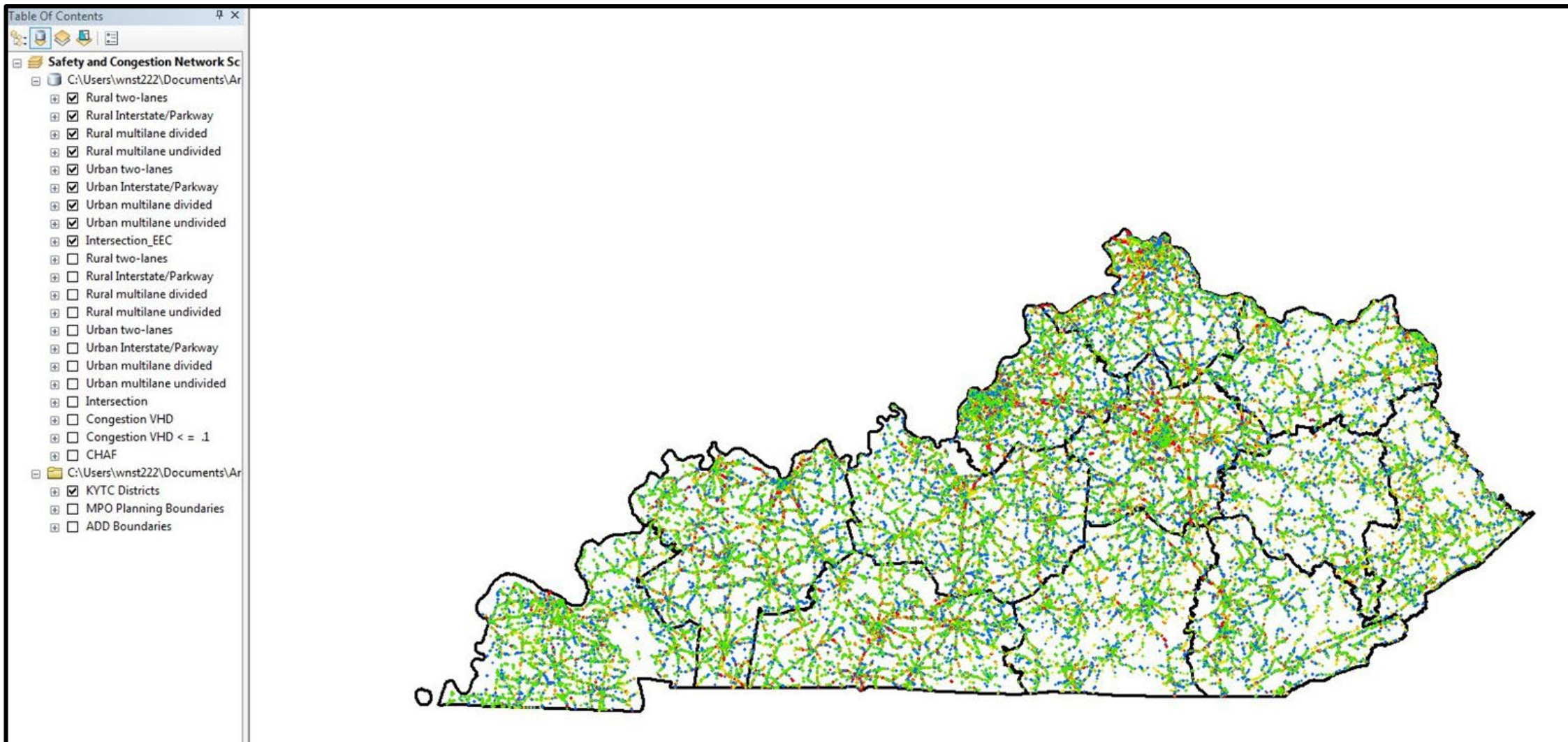
SHIFT Network Screening Tool

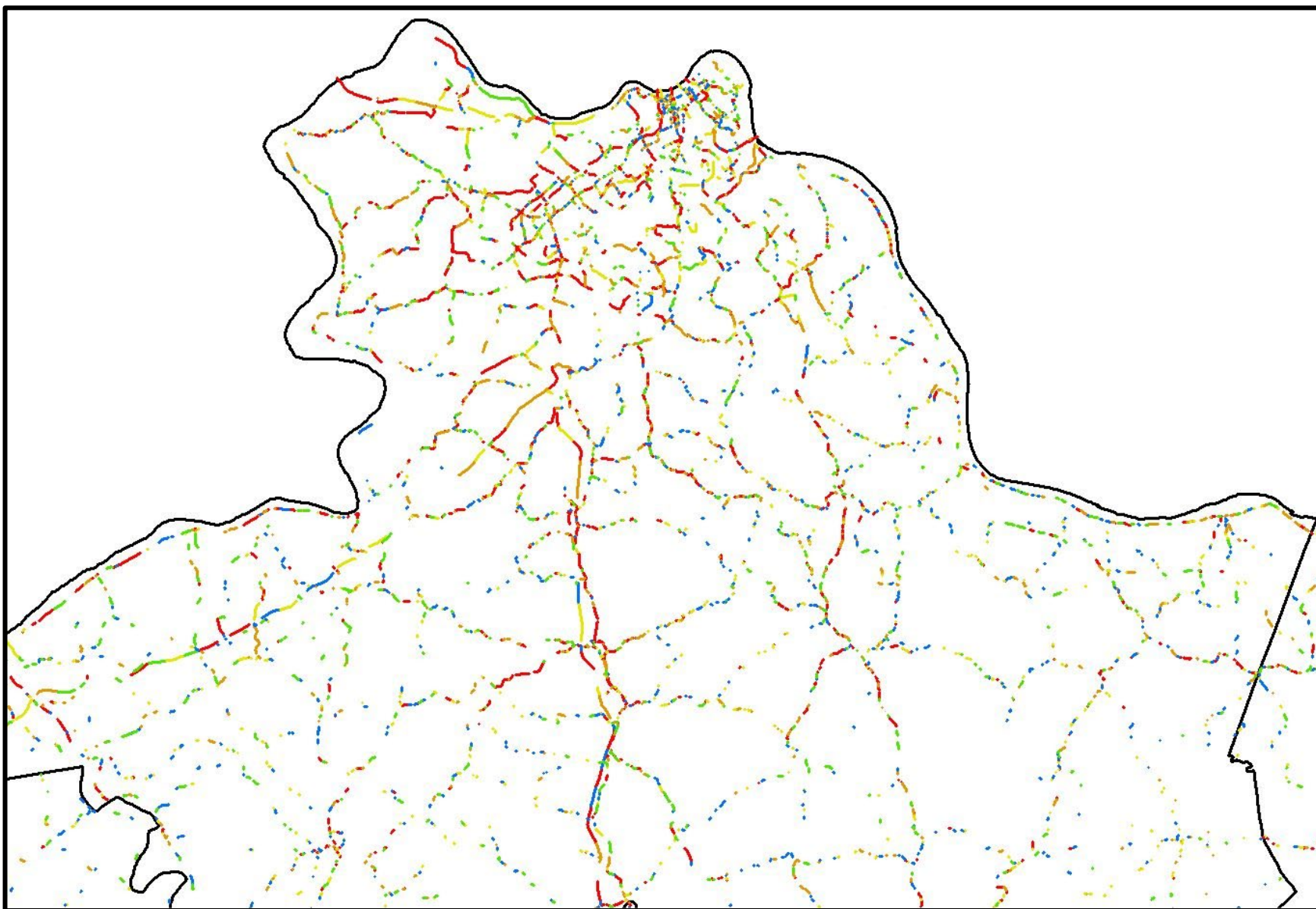
- Created an ArcGIS Map Package to distribute to highway districts, area development districts, and metropolitan planning organizations
- User friendly interface prepopulated with symbology for those less experienced with GIS
- Shows only road segments with positive EEC; color coded by quantiles based on roadway type
- Includes previous project locations for reference

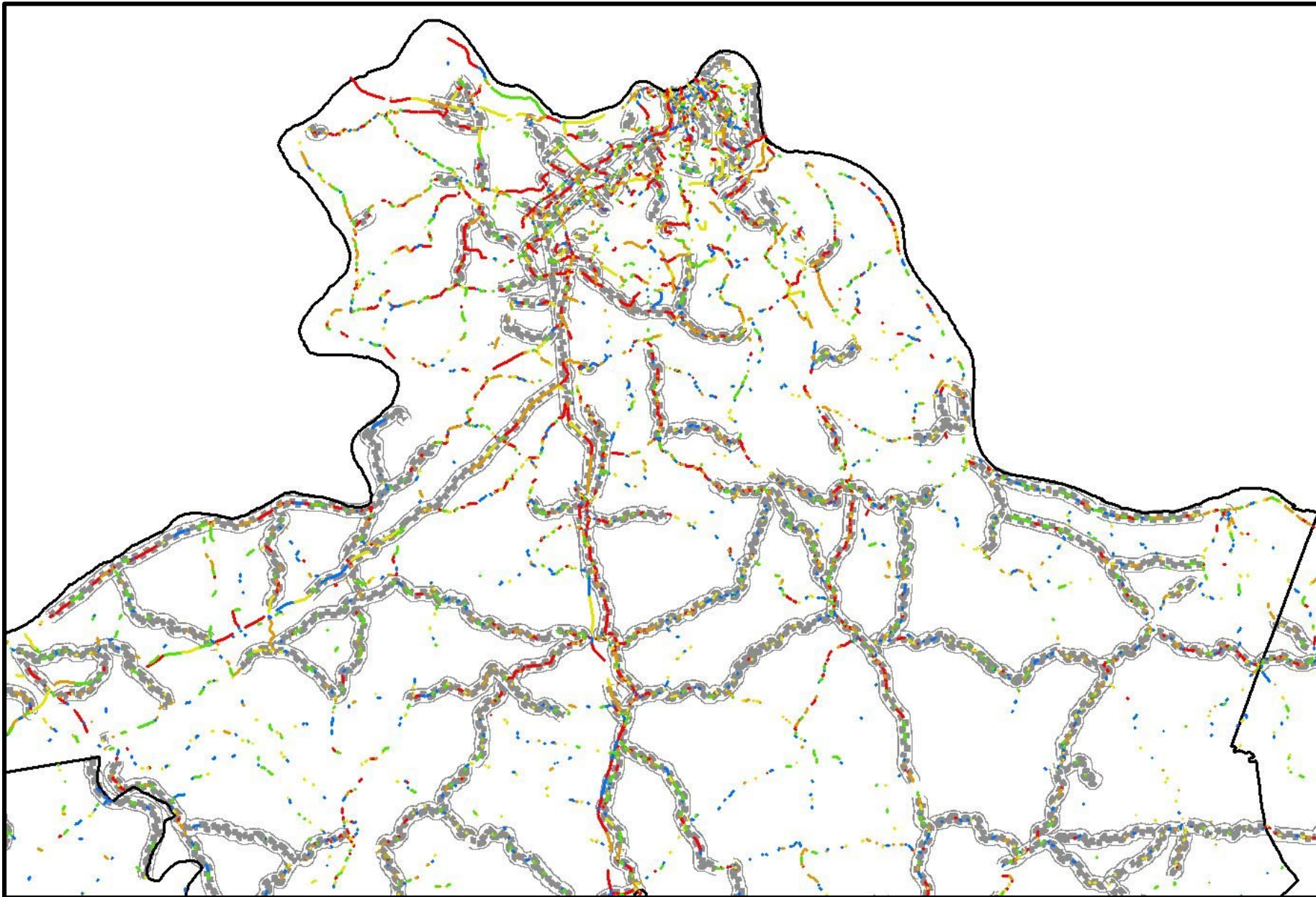


Simple Interface

Name	Date modified	Type	Size
 Safety and Congestion Network Screening	4/18/2019 10:50 AM	ArcGIS Map Package	166,804 KB







Thank You

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