



Helpful Tools for Benefit-Cost Analysis

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TEAM Conference
March 15, 2019

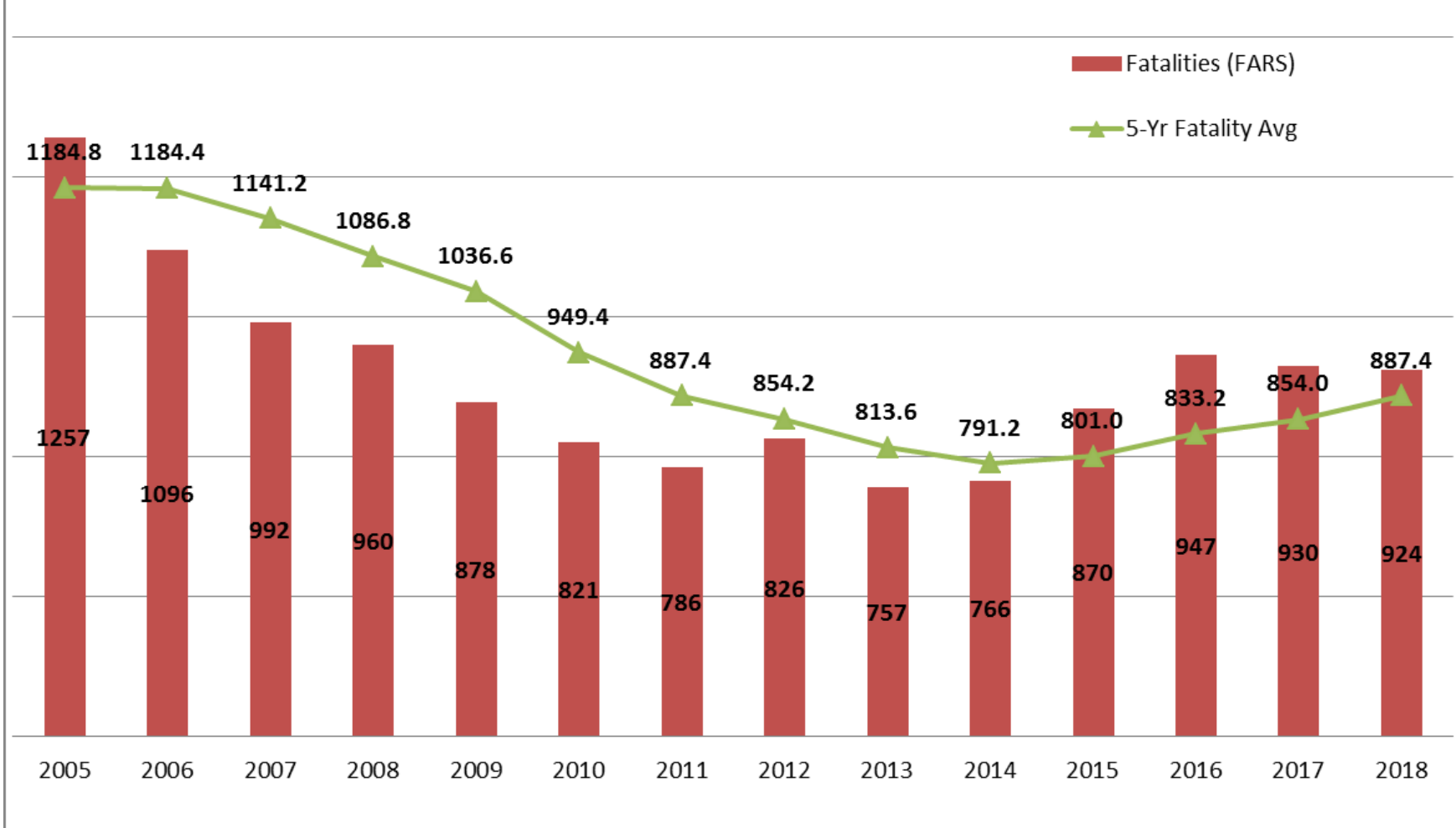
What If Overnight...



- 18,000 more miles of shoulders and rumbles
- 1,000 curves improved
- 20 new J-turns



Annual Fatalities and 5-Year Average Fatalities



Major Road Example



- 34,000+ miles of state-maintained roads
 - 5,600 miles considered major roads

| | Major | Minor |
|----------------|-------|--------|
| Roadway Miles | 5,600 | 27,000 |
| Miles Traveled | 80% | 20% |
| Fatalities | 53% | 47% |

- Over half of state-system fatalities were occurring on less than 20% of the system.
 - Focus on major roads.

Source: Missouri DOT – Based on 2005 Data

Systemic Improvements



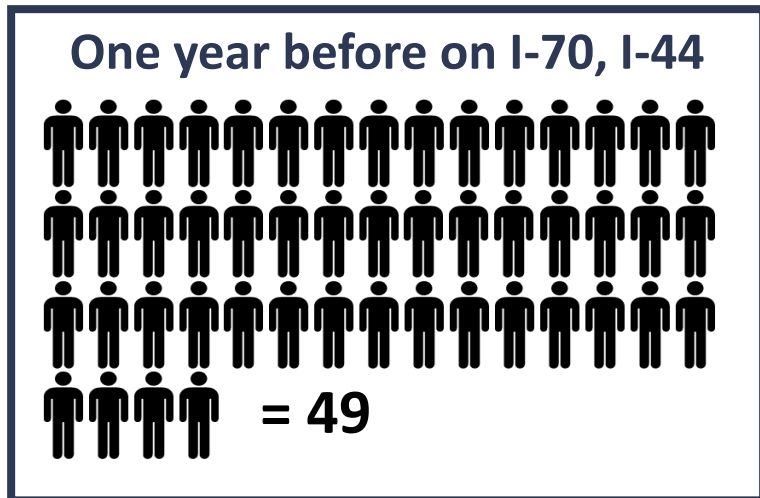
- ▶ Paved shoulders
- ▶ Rumble stripes
- ▶ Bigger, brighter signs
- ▶ Increased pavement marking
- ▶ Delineation



Guard Cable



- I-70 and I-44 accounted for over 80% of cross-median fatalities

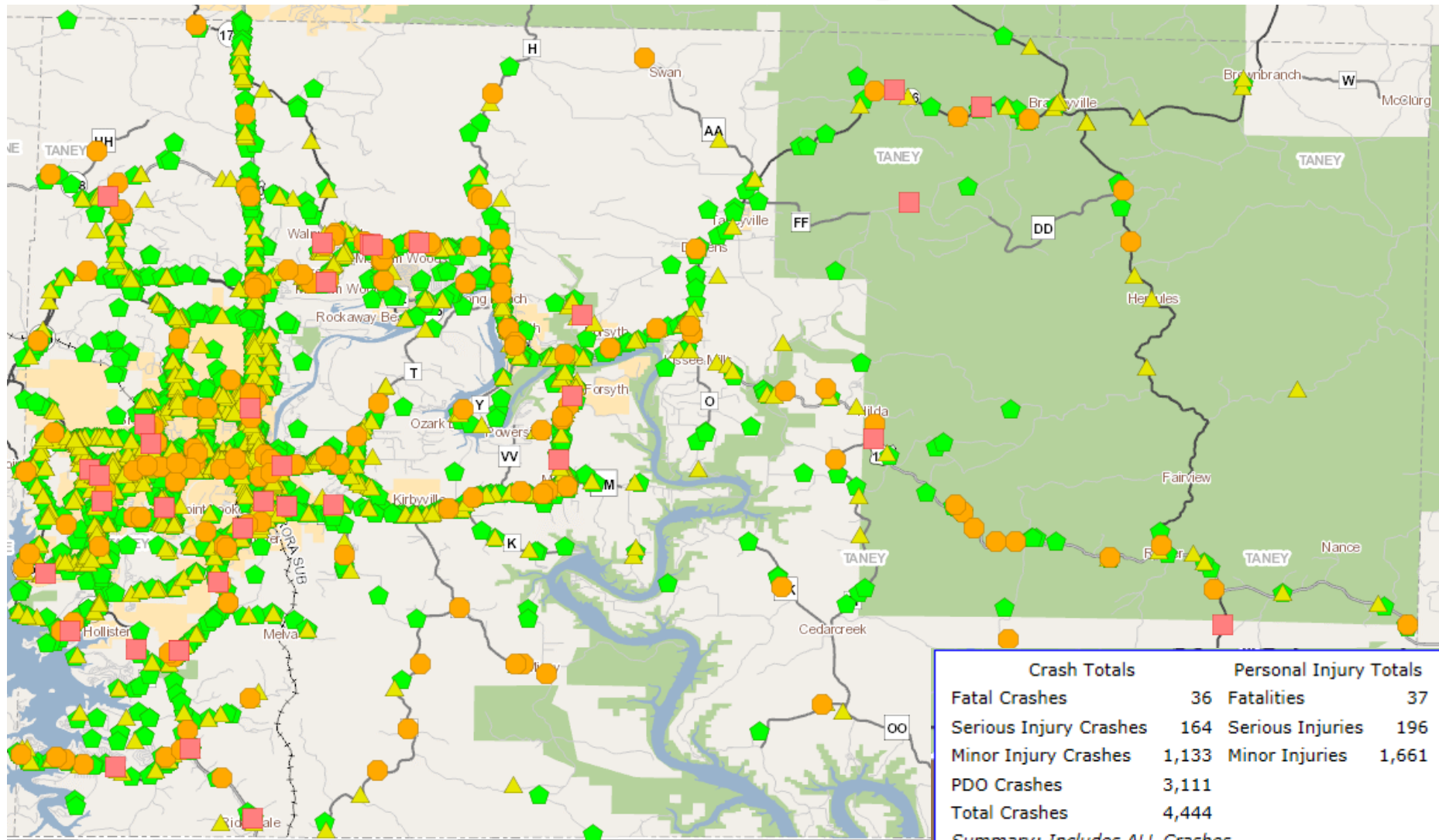


Data Driven Safety Analysis



Source: FHWA

Crash Statistics Map



| Crash Totals | | Personal Injury Totals | |
|------------------------|--------------|------------------------|-------|
| Fatal Crashes | 36 | Fatalities | 37 |
| Serious Injury Crashes | 164 | Serious Injuries | 196 |
| Minor Injury Crashes | 1,133 | Minor Injuries | 1,661 |
| PDO Crashes | 3,111 | | |
| Total Crashes | 4,444 | | |

Summary: Includes ALL Crashes
Map: Includes only LOCATED crashes.

Traffic Safety Lists



**Horizontal Curve
Analysis**



**Shoulder
Analysis**



**Expressway Intersection
Analysis**



**Wet Crash
Analysis**



**Crossed Centerline
Analysis**



**High Severity
Analysis**



**Unrestrained
Analysis**



**Impaired
Analysis**

Highway Safety Manual Spreadsheets



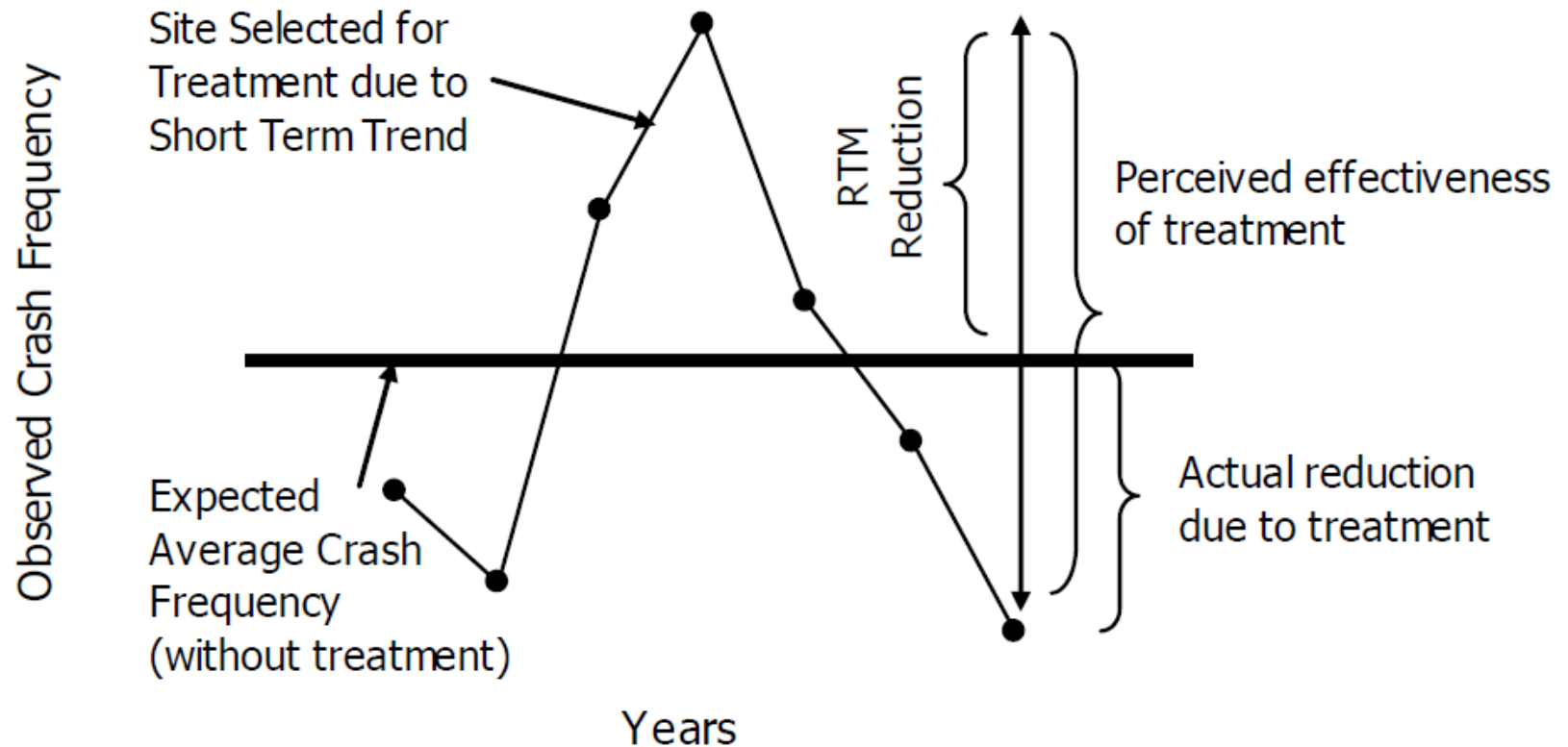
Worksheet 1A (a) -- General Information and Input Data for Rural Multilane Roadway Segments

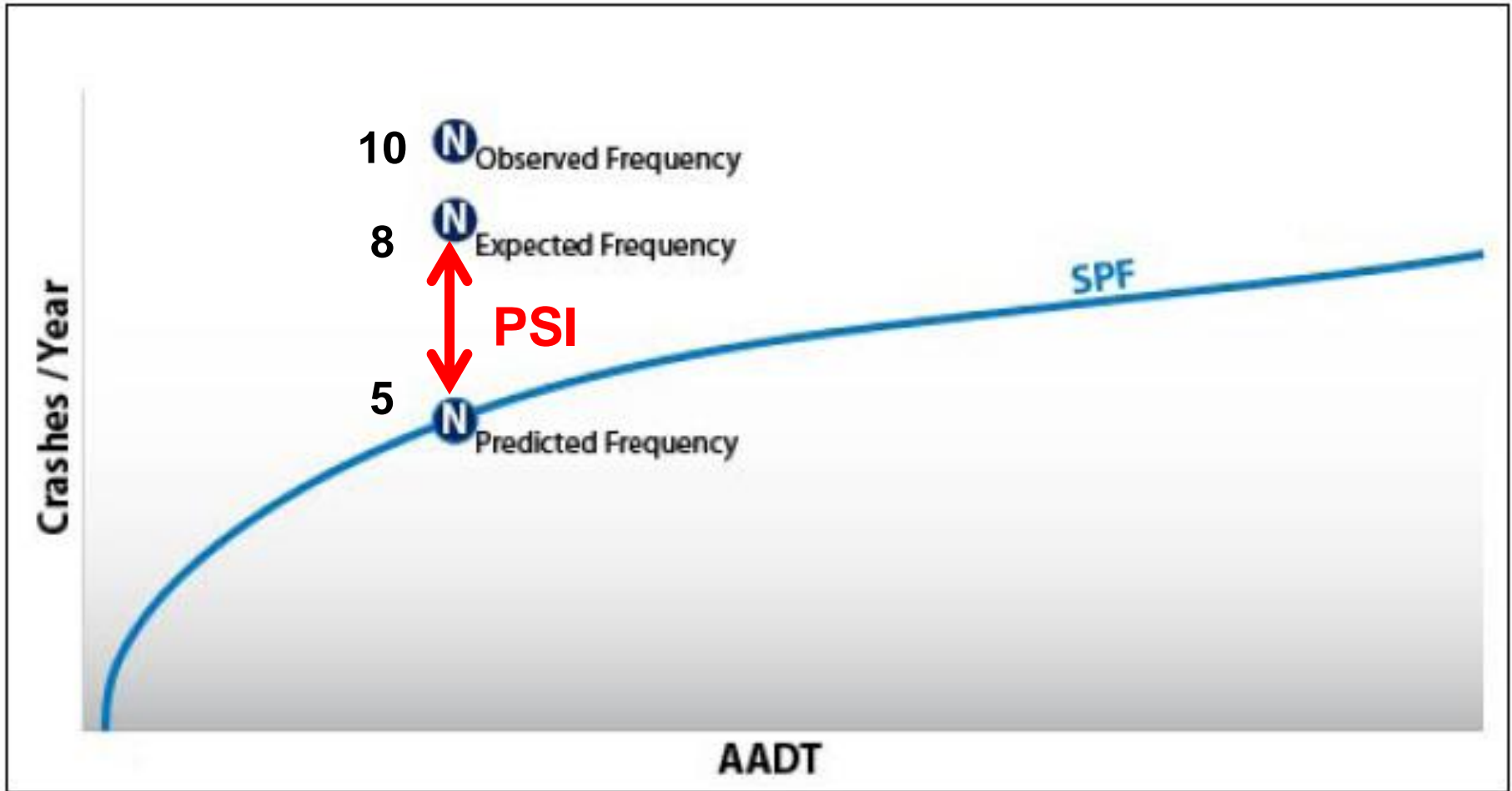
| General Information | | Location Information | |
|--|--|----------------------------|-----------------|
| Analyst | John Smith | Roadway | 0 |
| Agency or Company | ABC Company | Roadway Section | 0 |
| Date Performed | 05/12/11 | Jurisdiction | 0 |
| Segment for Analysis | Segment 1 | Analysis Year | 2011 |
| Input Data | | Site Conditions | Base Conditions |
| Roadway type (divided / undivided) | | Divided | Undivided |
| Length of segment, L (mi) | | | -- |
| AADT (veh/day) | AADT _{MAX} = 89,300 (veh/day) | | -- |
| Lane width (ft) | | | 12 |
| Shoulder width (ft) - right shoulder width for divided [if differ for directions of travel, use average width] | | | 8 |
| Shoulder type - right shoulder type for divided | | | Paved |
| Median width (ft) - for divided only | | | 30 |
| Side Slopes - for undivided only | | Not Applicable | 1:7 or flatter |
| Lighting (present/not present) | | Not Present | Not Present |
| Auto speed enforcement (present/not present) | | Not Present | Not Present |
| Calibration Factor, Cr | | 1.00 | 1.00 |
| Average Annual Crash History (3 or 5-yr average) | | | |
| Segment crashes | | KABC Fatal and Injury Only | 0.0 |
| | | PDO Property Damage Only | 0.0 |

NOTES: * AADT: It is important to remember that the AADT(major) = AADT(major approach1) + AADT(minor approach2) (refer to p.11-6 in Part C of the HSM)

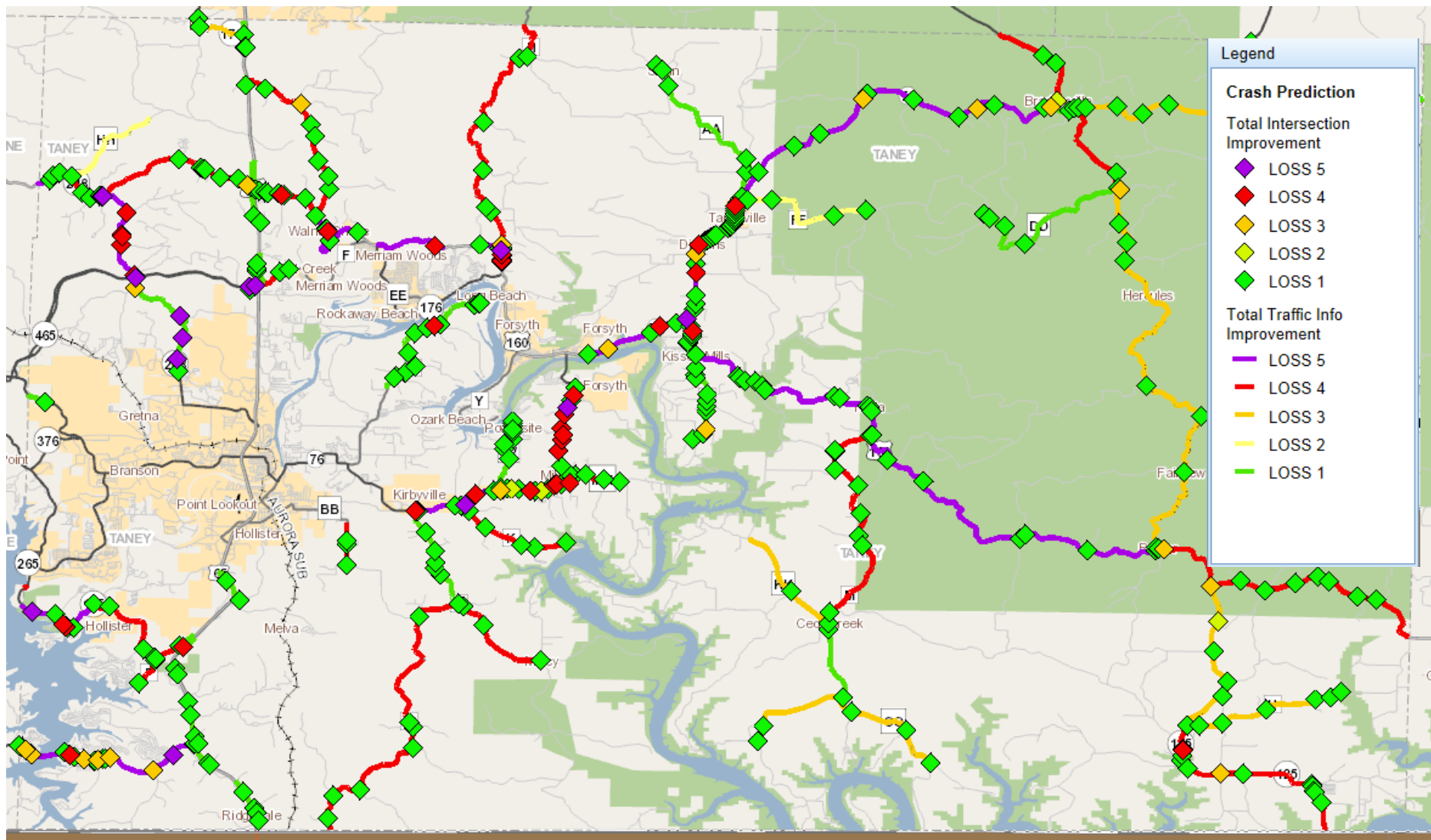


Regression-to-the-mean





Crash Prediction Tool



Crash Prediction Tool



Predicted

Total: 77.78
 Fatal/Injury: 25.35
 Property Damage: 52.43

Expected

Total: 95.73
 Fatal/Injury: 32.18
 Property Damage: 63.55

Potential for Safety Improvement

Total: 17.948
 Fatal/Injury: 6.829
 Property Damage: 11.119

Crash Data Analysis: 2014 - 2016

Segments

Export To Csv

| Raw | | Traffic Info Seg Id | | | | | | Curve Id | | | | |
|---|----------|---------------------|--------|-----------|---------|-----------------|------------------------|-------------|--|---|--|--|
| Drag a column header here to group by that column | | | | | | | | | | | | |
| # | County | Traffic Info Seg ID | Route | Begin Log | End Log | Predicted Total | Predicted Fatal/Injury | P P C | Total Potential for Safety Improvement | Fatal/Injury Potential for Safety Improvement | Property Damage Potential for Safety Improvement | |
| <input type="checkbox"/> | COLE | 729858 | RT B | 2.134 | 4.743 | 6.2812124 | 2.3240486 | | 8.171 | 3.023 | 5.148 | |
| <input type="checkbox"/> | COLE | 729860 | RT B | 4.778 | 8.565 | 4.5993727 | 1.7017684 | | 3.835 | 1.419 | 2.416 | |
| <input type="checkbox"/> | COLE | 729996 | MO 179 | 31.444 | 36.51 | 4.3713115 | 1.6173849 | | 2.756 | 1.020 | 1.737 | |
| <input type="checkbox"/> | COLE | 729904 | RT M | 5.032 | 8.003 | 5.36789 | 1.9861193 | | 2.650 | 0.981 | 1.670 | |
| <input type="checkbox"/> | CALLAWAY | 727485 | RT AA | 1.197 | 2.741 | 1.9206468 | 0.7106396 | | 2.553 | 0.945 | 1.609 | |
| <input type="checkbox"/> | COLE | 729920 | RT W | 0 | 2.715 | 1.9303944 | 0.7142459 | | 1.862 | 0.689 | 1.173 | |
| <input type="checkbox"/> | COLE | 729902 | RT M | 0 | 5.032 | 3.3875169 | 1.2533806 | | 1.380 | 0.511 | 0.870 | |
| <input type="checkbox"/> | CALLAWAY | 727527 | RT OO | 0 | 1.619 | 0.8017882 | 0.2966617 | | 0.821 | 0.304 | 0.517 | |
| <input type="checkbox"/> | CALLAWAY | 727699 | MO 94 | 2.477 | 3.617 | 0.6760556 | 0.2501406 | | 0.395 | 0.146 | 0.249 | |
| <input type="checkbox"/> | COLE | 729862 | RT B | 8.565 | 8.677 | 0.1261511 | 0.0466759 | | 0.383 | 0.142 | 0.241 | |
| | | | | | | Sum=40 | Sum=14.8 | | Sum=24.240 | Sum=8.969 | Sum=15.271 | |

Crash Prediction Tool



Intersections

Raw

Drag a column header here to group by that column

| # | County | Intersection ID | Tway ID | Route | Log | Predicted Total | Predicted Fatal/Injury | Total Potential for Safety Improvement | Fatal/Injury Potential for Safety Improvement | Property Damage Potential for Safety Improvement |
|--------------------------|--------|-----------------|---------|--------|--------|-----------------|------------------------|--|---|--|
| <input type="checkbox"/> | COLE | 323006 | 7379 | RT B | 4.134 | 0.5557835 | 0.133 | 1.158 | 0.279 | 0.879 |
| <input type="checkbox"/> | COLE | 994049 | 7379 | RT B | 2.774 | 0.5434723 | 0.130 | 1.150 | 0.277 | 0.873 |
| <input type="checkbox"/> | COLE | 322769 | 7379 | RT B | 4.021 | 0.5613692 | 0.1 | 0.685 | 0.165 | 0.520 |
| <input type="checkbox"/> | COLE | 324542 | 7379 | RT B | 4.708 | 0.5408699 | 0.130 | 0.681 | 0.164 | 0.517 |
| <input type="checkbox"/> | COLE | 317784 | 7079 | RT J | 3.313 | 0.3212604 | 0.077 | 0.575 | 0.138 | 0.436 |
| <input type="checkbox"/> | COLE | 325582 | 7379 | RT B | 6.11 | 0.1575732 | 0.037 | 0.375 | 0.090 | 0.284 |
| <input type="checkbox"/> | COLE | 325280 | 7083 | RT M | 1.753 | 0.0782088 | 0.018 | 0.329 | 0.079 | 0.249 |
| <input type="checkbox"/> | COLE | 285398 | 3580 | MO 179 | 34.103 | 0.1158613 | 0.027 | 0.298 | 0.072 | 0.226 |
| <input type="checkbox"/> | COLE | 323788 | 7083 | RT M | 5.032 | 0.4090743 | 0.098 | 0.236 | 0.057 | 0.179 |
| <input type="checkbox"/> | COLE | 323063 | 7083 | RT M | 5.236 | 0.2965329 | 0.071 | 0.228 | 0.055 | 0.173 |

Sum=37.78 Sum=1 Sum=-6.291 Sum=-2.140 Sum=-4.152

Selected count: 0

Map Selection

Additional Features



- Edit Existing Roadway Data
 - Shoulder Width / Type
 - AADT
- Scenario Analysis



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CMF Clearinghouse



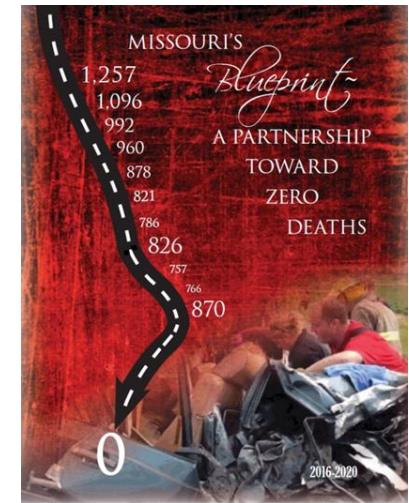
▼ Countermeasure: Install chevron signs on horizontal curves

| <input type="checkbox"/> Compare | CMF | CRF (%) | Quality | Crash Type | Crash Severity | Area Type | Reference | Comments |
|----------------------------------|------|---------|---------|---|----------------|---------------|-------------------------|----------|
| <input type="checkbox"/> | 0.96 | 4 | ★★★★★ | Non-intersection | All | Rural | Srinivasan et al., 2009 | |
| <input type="checkbox"/> | 0.94 | 6 | ★★★★★ | Head on, Non-intersection, Run off road, Sideswipe | All | Rural | Srinivasan et al., 2009 | |
| <input type="checkbox"/> | 0.84 | 16 | ★★★★★ | Non-intersection | K,A,B,C | Rural | Srinivasan et al., 2009 | |
| <input type="checkbox"/> | 0.75 | 25 | ★★★★★ | Nighttime, Non-intersection | All | Rural | Srinivasan et al., 2009 | |
| <input type="checkbox"/> | 0.78 | 22 | ★★★★★ | Head on, Nighttime, Non-intersection, Run off road, Sideswipe | All | Rural | Srinivasan et al., 2009 | |
| <input type="checkbox"/> | 0.63 | 37 | ★★★★ | All | All | Not specified | Montella, 2009 | |

Available Tools



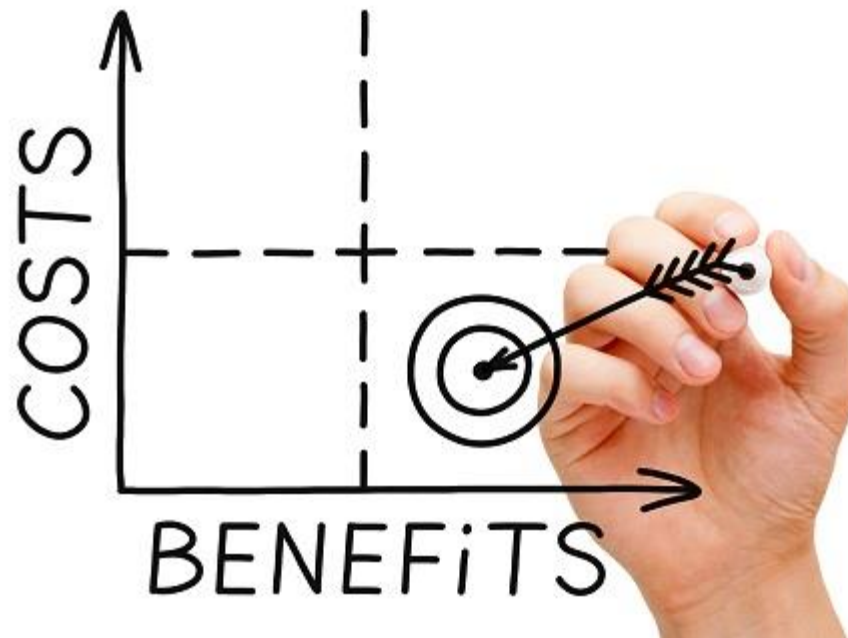
- MoDOT Traffic Safety Lists
- Highway Safety Manual spreadsheets
- Road Safety Assessments
- Crash Modification Factors Clearinghouse
 - www.cmfclearinghouse.org
- TMS Data Zone
 - Crash Statistics Map
 - Crash Prediction Tool



Measuring Value



- How many lives saved and serious injuries prevented?
- What is a good benefit-cost? Anything better than 1:1?





Crash Costs for Highway Safety Analysis



| Severity | Comprehensive Crash Unit Cost (2016 dollars) |
|----------|--|
| K | \$11,295,400 |
| A | \$655,000 |
| B | \$198,500 |
| C | \$125,600 |
| O | \$11,900 |

FHWA Safety Program



U.S. Department of Transportation
Federal Highway Administration






<http://safety.fhwa.dot.gov>

Measuring Value



- What can a Million Dollars in Safety Investment do?

| 2' Paved Shoulder w/Rumbles | Chevron Signing | Install Median Guard Cable |
|---|--|---|
|  |  |  |
| <p>\$100,000 per mile</p> <p>Improve 10 miles</p> <p>45% fewer fatal crashes. 25% fewer disabling injury crashes.</p> <p>10-year project life</p> <p>Saves 1 life</p> <p>Prevents 4 serious injuries</p> <p>Benefit Cost of 11:1</p> | <p>\$2,500 per curve</p> <p>Improve 400 curves</p> <p>Serious crash reduction of 16%</p> <p>10-year project life</p> <p>Saves 7 lives</p> <p>Prevents 27 serious injuries</p> <p>Benefit Cost of 77:1</p> | <p>\$130,000/mile + (\$10K/yr/mi)</p> <p>Improve 7.7 miles</p> <p>Reduction of fatal and serious injury crashes depends on median width and traffic volume.</p> <p>20-year project life</p> <p>Saves 2 lives</p> <p>Prevents 3 serious injuries</p> <p>Benefit Cost of 6:1</p> |



In-Service Performance Evaluation of Median Cable Barriers in Iowa

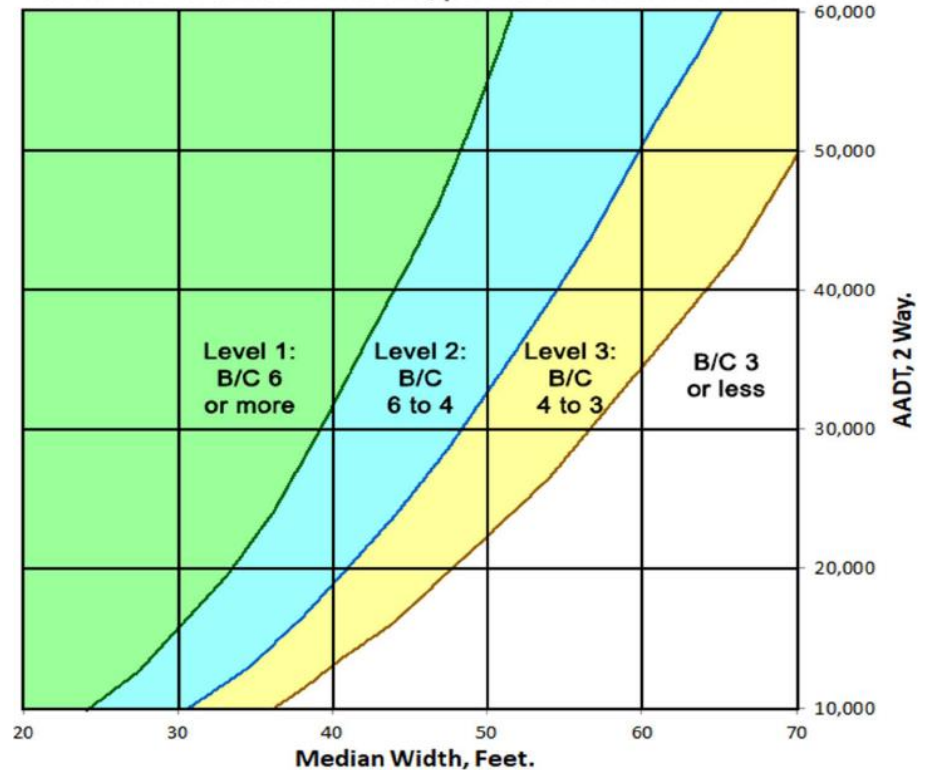
Final Report
May 2018



IOWA STATE UNIVERSITY
Institute for Transportation

Sponsored by
Iowa Department of Transportation
(InTrans Project 15-546)

B/C for Guard Cables in Medians, per Median Width and AADT:



Spot Improvements

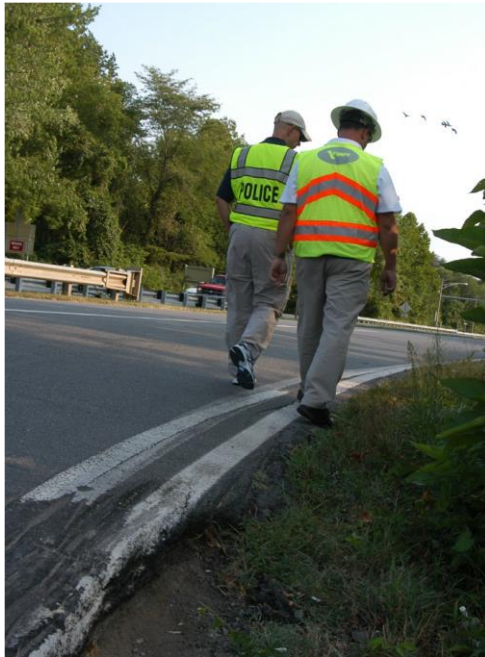


- Still a valid approach; should be balanced with systemic improvements
- Example applications: J-Turns or HFST in a curve

J-Turn Crash Results (per year basis; 19 locations)

| | Total Crashes | Right-Angle Crashes | Fatal Crashes | Serious Injury Crashes | Total Fatalities | Total Serious Injuries |
|-----------|---------------|---------------------|---------------|------------------------|------------------|------------------------|
| Before | 72.8 | 33.6 | 2.6 | 9.0 | 3.4 | 16.8 |
| After | 54.4 | 3.9 | 0.3 | 2.0 | 0.3 | 2.3 |
| Reduction | 25% | 88% | 88% | 78% | 91% | 86% |

Road Safety Assessments



A road safety audit is a proactive, formal safety performance examination of an existing or future road or intersection by an independent and multi-disciplinary team.

SAFETY BENEFIT:

10-60%

Reduction in total crashes

Source: Road Safety Audits: An Evaluation of RSA Programs and Projects, FHWA-SA-12-037; and FHWA Road Safety Audit Guidelines, FHWA-SA-06-06.

CONDUCTING AN RSA



The Right Solution



- Be diligent. Let data lead you to the answer.
- Goal: *Maximum* reduction in fatalities and serious injuries



Considerations



- You only have so much money.
- Data driven analysis doesn't have to be complicated.
- Data driven analysis isn't a promise.
- Traffic and roadway data matters (not just crash data).
- What's best for one region may not be best for another.
- Be critical of a B/C less than 6:1 (using updated crash costs).
- Consider maintenance costs

Access to TMS



- TMS DataZone Website:
- Available to external customers: <http://datazone.modot.org/>
- Contact Information:
 - Ray Shank
 - (573) 526-4293
 - raymond.shank@modot.mo.gov

FHWA Proven Safety Countermeasures



ROADWAY DEPARTURE.....



1. Enhanced Delineation and Friction for Horizontal Curves



2. Longitudinal Rumble Strips and Stripes



3. SafetyEdge_{sm}



4. Roadside Design Improvements at Curves



5. Median Barriers

PEDESTRIANS/BICYCLES.....



13. Leading Pedestrian Intervals



14. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas



15. Pedestrian Hybrid Beacons



16. Road Diets/Reconfigurations



17. Walkways

Source: FHWA

FHWA Proven Safety Countermeasures



INTERSECTIONS



6. Backplates with Retroreflective Borders



7. Corridor Access Management



8. Left- and Right-Turn Lanes at Two-Way Stop-Controlled Intersections



9. Reduced Left-Turn Conflict Intersections



10. Roundabouts



11. Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections



12. Yellow Change Intervals

CROSSCUTTING



18. Local Road Safety Plans



19. Road Safety Audits



20. USLIMITS2

Source: FHWA