



2019 Toward Zero Deaths Safety Treatments – How are they working?

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Richard Storm, PE, PTOE
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Background and Overview

Derek Leuer, PE.
State Traffic Safety Engineer

Which Safety Strategies for today?

- Three types of engineering countermeasures evaluated
 - Rumble/Mumble Strips
 - Speed Limit Changes (55 to 60 MPH)
 - Rural Intersection Conflict Warning System (RICWS)

Which Safety Strategies for today?

- Format for the presentation
 - Discuss WHAT and WHY we did these strategies (Derek)
 - Discuss WHAT was evaluated, HOW, and Results
 - Rumbles/Mumbles – Richard
 - Speed – Taha
 - RICWS – Derek
 - What does this mean (Derek)?

Rumbles and Mumbles

- Why Rumbles and going to Mumbles



- Cut-in grooves in the pavement
- Lane Departure crashes make up 46% of Severe Crashes (3,199 crashes)
- Rumble Strips are consistently shown to reduce Lane Departure Crashes
- Rumble Strips make noise.... Lots of noise...

Rumbles and Mumbles

WEST METRO

Rumble strips are raising grumbles

MnDOT removing road rumble strips on North Shore after complaints

By LaReesa Sandretsky on Jun 17, 2014 at 8:34 a.m.

Highway 5 rumble strips have
Victoria, MN residents grumbling

By Jane Friedmann | JUNE 17, 2013 – 11:55AM

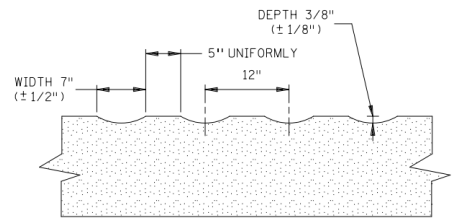
Mumbles

- Why Rumbles and going to Mumbles
 - Produce a design that minimizes external noise
 - Still provides tactile feedback to MOST drivers
 - Effective at reducing crashes?



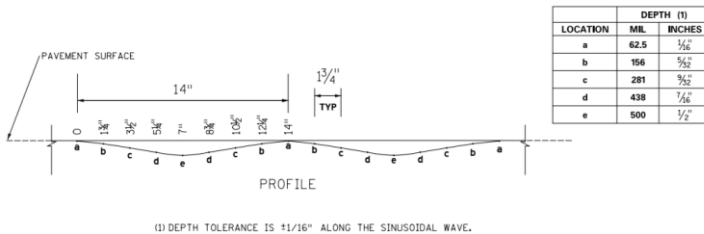
Mumbles

- Why Rumbles and going to Mumbles
 - A few different patterns used
 - ~2,000 miles installed since 2017
 - Still no complaints statewide regarding noise



SECTION A-A

FIGURE 1B - SINUSOIDAL RUMBLE STRIP



Speed Limits – 55 MPH to 60 MPH

Brief History on Rural 2-Lane 2-Way Roadways

1. Prior to 1974, most 2-lane roads were 60mph day/50mph night, some were 65/55
2. 1996: National 55 Act fully repealed, MnDOT did not change back to 60 or 65. Some other speed limits (freeways, etc.) were modified
3. Per statute, nothing prevents MnDOT from raising speed limits based on engineering and traffic investigations
4. 2006: Highway Enforcement of Aggressive Traffic (HEAT) MnDOT raises speed limits on many types of roads to 60mph, no significant changes in travel speeds or crashes
5. 2012: MnDOT raises all of US-59 and US-71 from Iowa to Canada to 60mph, no significant changes in travel speeds or crashes

Speed Limits – 55 MPH to 60 MPH

Brief History on Rural 2-Lane 2-Way Roadways

6. 2014: Legislature plans to raise all 55mph roads to 60mph, MnDOT says that “we already have a process for this”
7. Weeks later: STATUTE Chapter 312, Article 11, Section 36. EVALUATION OF CERTAIN TRUNK HIGHWAY SPEED LIMITS.
Subdivision 1. Engineering and traffic investigations.

The commissioner of transportation shall perform engineering and traffic investigations on trunk highway segments that are two-lane, two-way roadways with a posted speed limit of 55 miles per hour. On determining upon the basis of the investigation that the 55 miles per hour speed limit can be reasonably and safely increased under the conditions....
8. 2019: ~\$1.2 million in combined DOT and consultant costs. 7,000 miles studied. 75% raised to 60mph, many tweaks to transition zones and other zones not changed in decades. Largest single speed zoning study ever conducted by MnDOT.

Early “after samples” showed no signs of changes to travel speeds or crashes.

Speed Limits – 55 MPH to 60 MPH

Brief History on Rural 2-Lane 2-Way Roadways

9. Rudimentary scoring system based on the following criteria:
- Access Points per Mile
 - Shoulder Widths
 - Vertical Grades
 - Clear Zones
 - Crash Rates
 - KA Rates
 - Critical Crash Rates
 - Passing Zones
 - 85th Percentile, 10mph Pace

Rural Intersection Conflict Warning Systems



Rural Intersection Conflict Warning Systems

- Why RICWS

- 878 Severe Crashes on Rural Intersections on 2 Lane Roads in 5 years (2014 SHSP)
- Rural thru-stop intersections are vexing
- Few Tools in the Toolbox
 - Especially moderate price
- Give drivers real time information
- Goal to reduce Crashes



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Rumble Strip Evaluation

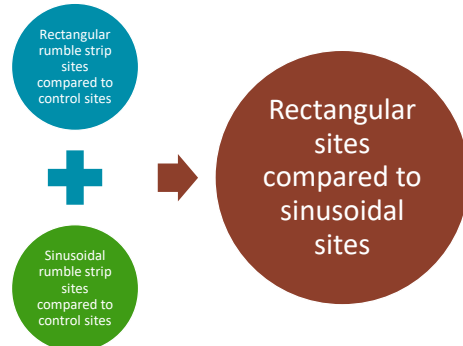
Richard Storm, PE, PTOE

HDR

Purpose of the Study

How do sinusoidal rumble strips compare in safety performance to rectangular rumble strips?

- To answer, two sub-questions are investigated:
 - How do rectangular rumble strip test sites compare in safety to control sites (roads without rumble strips)?
 - How do sinusoidal rumble strip test sites compare in safety to control sites?
 - Differences in crash reductions between the two investigations will indicate safety performance



Rumble Strip Location / Rumble Strip Shape	Rectangular	Sinusoidal
Centerline Only	X	X
Shoulder Only	X	
Centerline and Shoulder	X	

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Literature Review

- No safety/crash research available on sinusoidal rumble strips
- CMF Clearinghouse – 704 CMFs available after searching “rumble strips”
- Filter for 4 stars or better, remove CMFs for angle and rear-end crashes, and remove transverse rumble strips – 232 CMFs are available
- NCHRP Report 641:
 - Shoulder rumble strips on rural two-lane highways: 0.87 (total, SVROR), 0.82 (fatal and all injury, SVROR) (Minnesota study sites)
 - Centerline rumble strips on rural two-lane highways: 0.58 (total, all crash types), 0.27 (fatal and serious injury, all crash types)

CMFs on Rural 2-Lane Undivided Highways

Countermeasure Description	Number of CMFs (Total Crashes)	Average CMF and Range (Total Crashes)	Number of CMFs (Fatal and All Injury)	Average CMF and Range (Fatal and All Injury)
Install Centerline and Shoulder Rumble Strips	28	0.72 [0.44 - 1.02]	4	0.79 [0.56 - 1.02]
Install Shoulder Rumble Strips	23	0.84 [0.53 - 1.40]	8	0.74 [0.53 - 1.05]
Install Centerline Rumble Strips	34	0.75 [0.33 - 1.04]	9	0.76 [0.55 - 1.04]

CMFs on Rural 2-Lane Undivided Highways, Minnesota Sites Included in Study

Countermeasure Description	Number of CMFs (Total Crashes)	Average CMF and Range (Total Crashes)	Number of CMFs (Fatal and All Injury)	Average CMF and Range (Fatal and All Injury)
Install Shoulder Rumble Strips	15	0.86 [0.53 - 1.18]	6	0.74 [0.53 - 1.05]
Install Centerline Rumble Strips	11	0.75 [0.51 - 0.96]	5	0.73 [0.55 - 0.91]

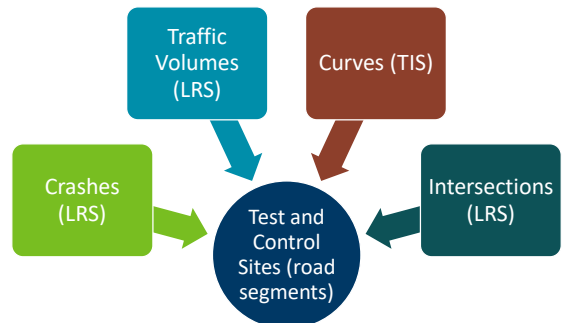
Data Compilation - Data Sources Used

Data Source	Example Data	File Type	Years Available	Referencing System
Rumble Strip Projects	State project number, bid item, installation route	Excel (.xlsx)	2012-2018	TIS
Roadway	Shoulder width, lane width, area type	GIS (.shp) & Text File for attributes (.txt)	2012-2014 & 2016-2018	TIS (2009-2014) & LRS (2016-2018)
Rumble Strip LiDAR	Location of rumble strips	Excel (.xlsx)	2017-2018	Latitude/Longitude
Crashes	Crash severity, crash date	GIS (.shp)	2012-2018	LRS
Traffic Volumes (AADT)	AADT, year	GIS (.shp) & Excel for 2012-2017 (.xlsx)	2012-2018	LRS
Curves	Curve radius, length	GIS (.shp)	Assumed to be constant 2012-2018	TIS
Intersections	Number of approaches, traffic control type	GIS (.shp)	2014 (Assumed to be constant for 2012-2018)	TIS

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Data Compilation

- Validate Project Data
 - Compare to the LiDAR for RS location and type
 - Sinusoidal required additional manual validation
- Related crashes, traffic volumes, curves and intersections to test sites and control sites



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Overview of Statistical Evaluation

- Cross-sectional negative binomial regression analysis
 - Developed **negative binomial regression models** to estimate safety performance on **TEST** sites (sites with rumble strips) and **CONTROL** sites (sites without rumble strips)
 - Rectangular Rumble Strips: 40 test and control segments over years 2012 to 2018
 - Sinusoidal Rumble Strips: 5 test and control segments over years 2015 to 2018 and 10 test and control segments over years 2016 to 2018
 - Attribute the difference in safety performance to the rumble strip
- CMF is estimated from the regression models
 - CMF = 1.0 → No effect on crashes
 - CMF < 1.0 → Fewer crashes due to the treatment
 - CMF > 1.0 → More crashes due to the treatment

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DRAFT Results: Rectangular Rumble Strips

Location	CMF (Total Crashes)	CMF (Fatal and Serious Injury Crashes)
Centerline and Shoulder	0.689 (0.540 – 0.880)	0.640 (0.410 – 0.998)
Shoulder Only	0.767 (0.637 – 0.924)	No statistical effect on crashes
Centerline Only	No statistical effect on crashes	No statistical effect on crashes

- **Shoulder** rumble strips accompanied with **centerline** rumble strips provide the greatest benefit in reducing total crashes (31%) and fatal and serious injury crashes (36%).
- **Shoulder only rumble strips** provide a benefit in reducing total crashes by 23%.
- Including **only centerline rumble strips** has no statistical benefit.

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DRAFT Results: Sinusoidal Rumble Strips

- Not seeing statistically significant results
- At this time, rectangular rumble strips are recommended if you can; especially for sites with lane departure crashes
- Undertaking a refined analysis of sinusoidal rumble strips
 - Different type of analysis (Before/After Analysis)
 - Grow sample size by adding segments in 2017
 - Recognizing sinusoidal rumble strip design change in 2017
 - Investigate how segments were prioritized for sinusoidal treatment
 - Verify if chip sealants were installed on sinusoidal segments

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Next Steps

- Expand Rectangular Rumble Strip Evaluation
 - Incorporate 2013-2016 projects into database
 - Evaluate safety performance related to specific crash types
 - Assess safety performance of rumble strips on Expressways
- Conduct a before-and-after analysis for sinusoidal rumble strips
 - Contacting District Traffic Engineers for information

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Evaluation of 55 to 60 Speed Limit Change

Taha Saleem, PhD

UNC Highway Safety Research Center

Background and Objective

- Evaluate the safety effects of increase in the speed limit from 55 mph to 60 mph
- Focus is on rural two-lane roads
- Relationship between speed-zone setting criteria and safety performance

Overview of Approach

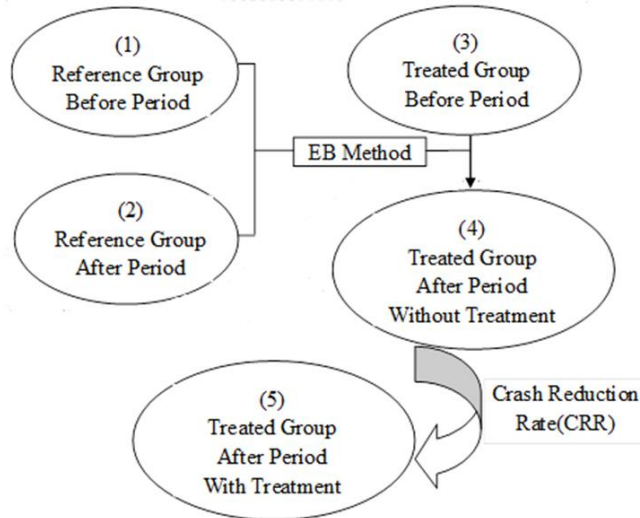
- Identify roadway segments and intersections for evaluation
 - Sites where the speed limit was increased from 55 mph to 60 mph
 - Sites where the speed limit remained at 55 mph
- Compile data
 - Roadway
 - Crash
 - Traffic volume
 - Speed study locations

Data Compilation - Data Types

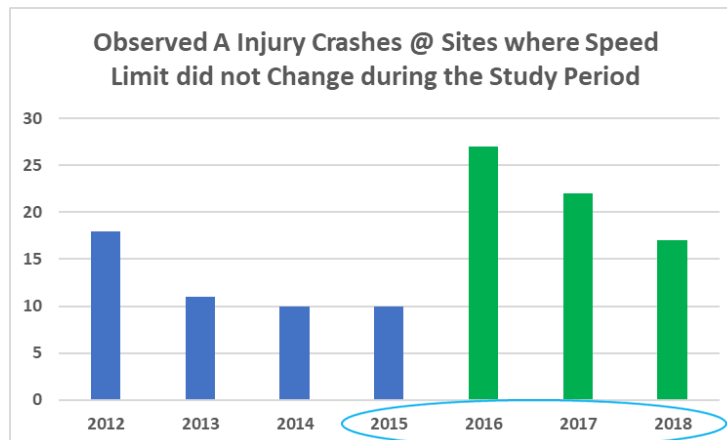
- Roadway Data
 - Lane Widths
 - Shoulder Widths
 - Curves
 - Intersections
- Traffic Volumes
- Crash Data
- Speed Study Locations



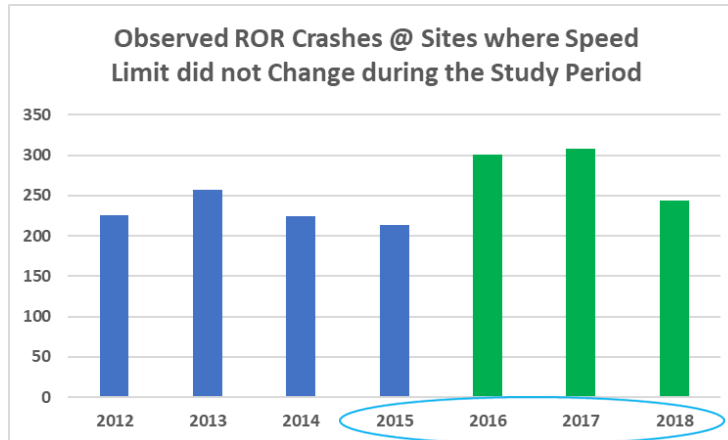
Framework for Before-After Evaluations



Varying Yearly Crash Trends



Varying Yearly Crash Trends (cont.)



Analysis Approach

- Before-after evaluation using empirical Bayes (EB) method
 - Account for changes in traffic volume
 - Possible bias due to regression to the mean (RTM)
 - If high-crash locations are selected with a short before period
 - Other changes over time
- Overall intent
 - Estimate the expected number of crashes in the after period had the treatment not been implemented, and compare that with the actual crashes in the after period
 - Segments and intersections separately
 - Curves and tangents

Analysis Approach (cont.)

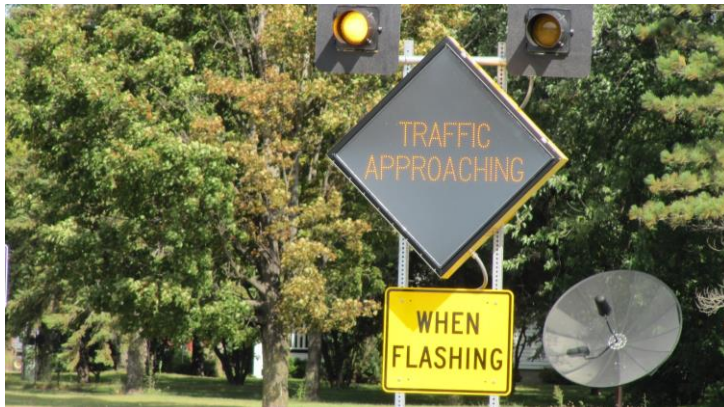
- Speed limit evaluation
 - Large number of sites selected for change in speed limit
 - Unlikely to have bias due to RTM
- Estimated SPFs using AADT and roadway data
 - Before data of sites where speed limit changed during the study period **plus** data from sites where speed limit did not change during the study period.

Initial CMFs for Roadway Segments

Crash Type	Crashes in the After Period	Expected Crashes in the After Period without Treatment	Crash Modification Factor (CMF)	Standard Error of CMF
Total	1191	1111.69	1.071	0.035
Injury (KABC)	456	435.62	1.046	0.052
Injury (KAB)	279	288.22	0.968	0.059
Run Off Road	588	565.96	1.039	0.047

Conclusions

- Speed limit had a modest effect on Total, KABC, and ROR crashes
- Speed limit did not seem to have affected KAB crashes
- Currently investigating:
 - Effect on intersection crashes
 - Effect on curved segments versus tangents
 - Effect on individual corridors
 - Compare changes in speed with changes in crashes



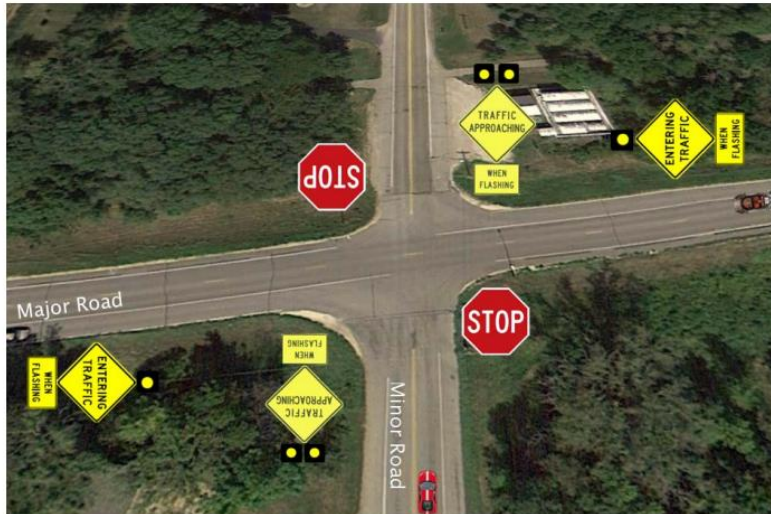
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RICWS Evaluation

Derek Leuer, PE.

State Traffic Safety Engineer

Rural Intersection Conflict Warning Systems



Rural Intersection Conflict Warning Systems

66 Treatment Sites

- 3 years of before data
- All after turn on crash data
- State and County
- Traffic Volume
- Maintenance Logs
- Turn On (2013-2017)
- Majority in 2014/15

76 Control Sites

- Custom to each RICWS Site
- 3 years “before” data
- Match “After” Crash Data
- State and County
- Traffic Volumes

Rural Intersection Conflict Warning Systems

• 66 Treatment Sites

- 11% Reduction in Fatal
- 86% Increase in A crashes
- 7% Decrease in Angle
- **24% Increase in K+A/Angle Crashes**

• 76 Control Sites

- 149% increase in Fatal
- 43% decrease in A crashes
- 33% increase in Angle
- **40% Increase in K+A/Angle Crashes**

Rural Intersection Conflict Warning Systems

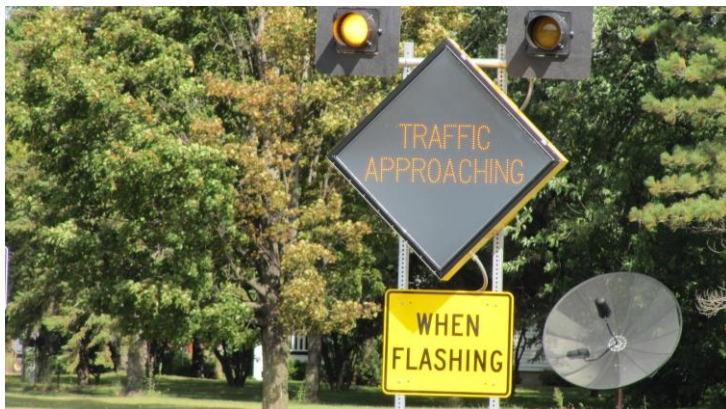
Intersection Type	Crash Rate Type	P-value	Significant?
RICWS	Total Crash	0.925	<i>No</i>
	K+A Right Angle Crash	0.530	<i>No</i>
	K+A Crash	0.276	<i>No</i>
	K Crash	0.807	<i>No</i>
	A Crash	0.306	<i>No</i>
	Right Angle Crash	0.648	<i>No</i>
Control	Total Crash	0.989	<i>No</i>
	K+A Right Angle Crash	0.975	<i>No</i>
	K+A Crash	0.865	<i>No</i>
	K Crash	0.110	<i>No</i>
	A Crash	0.260	<i>No</i>
	Right Angle Crash	0.672	<i>No</i>

Rural Intersection Conflict Warning Systems

The before and after study yielded no indication that the crash rate at RICWS sites significantly increased or decreased after the implantation of the system.

In addition, the comparison test also produced no indication that a difference in crash rate exists between RICWS and control sites.

While this study did not produce the expected results, the two tests did not indicate that the installation of RICWS significantly increased crash rates at rural intersections.



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What does this all mean?

Derek Leuer, PE.

State Traffic Safety Engineer

What does this all mean?

Many of these studies show an array of results...

So what does this all mean?

What does this all mean?

Rumble Strips

- Edgeline Rumbles are an effective tool!
- More investigation is needed on mumbles
 - No standard until 2017
 - Mix of maintenance, other issues
- If in doubt, use the standard!

What does this all mean?

Speed Limits

- Changing the sign will have a small impact
 - Small increase in total crashes
 - Small decrease in injury crashes
 - 1 mph increase in the 50% speed
 - No changes in the 85% speed
- Don't take a blanket approach
- Use engineering judgement and study the road

Speed Limits – 55 MPH to 60 MPH

Items Reviewed before authorizing Change from 55mph to 60 mph

- Access Points per Mile
- Shoulder Widths
- Vertical Grades
- Clear Zones
- Crash Rates
- KA Rates
- Critical Crash Rates
- Passing Zones
- 85th Percentile, 10mph Pace

What does this all mean?

RICWS

- No positive reduction in crashes at RICWS Sites
- No negative impact either....
- Continue to monitor and observe
- Not jumping to any large removals
- Funding is “influx”
- MnDOT is deciding how to maintain, remove, and/or modify the systems over the long term....

What does this all mean?

Many of these studies show an array of results...

So what does this all mean?

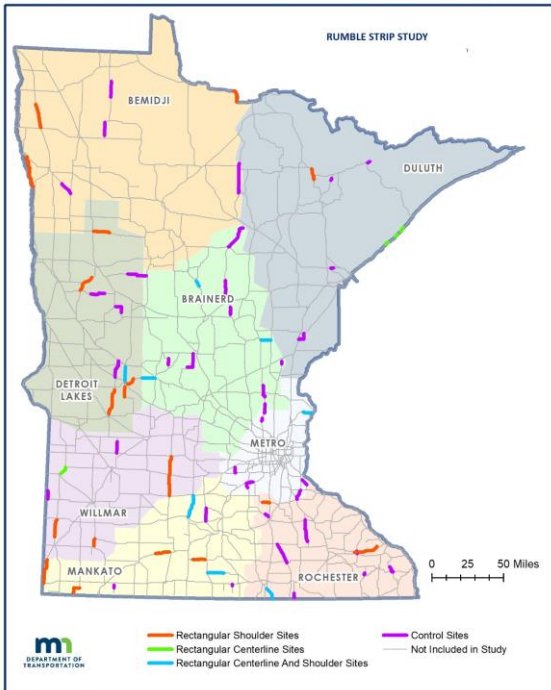
We may need to dig deeper and find where they work versus where they do not, and try to understand WHY!

“There is no failure; only feedback!” – Wise Sage

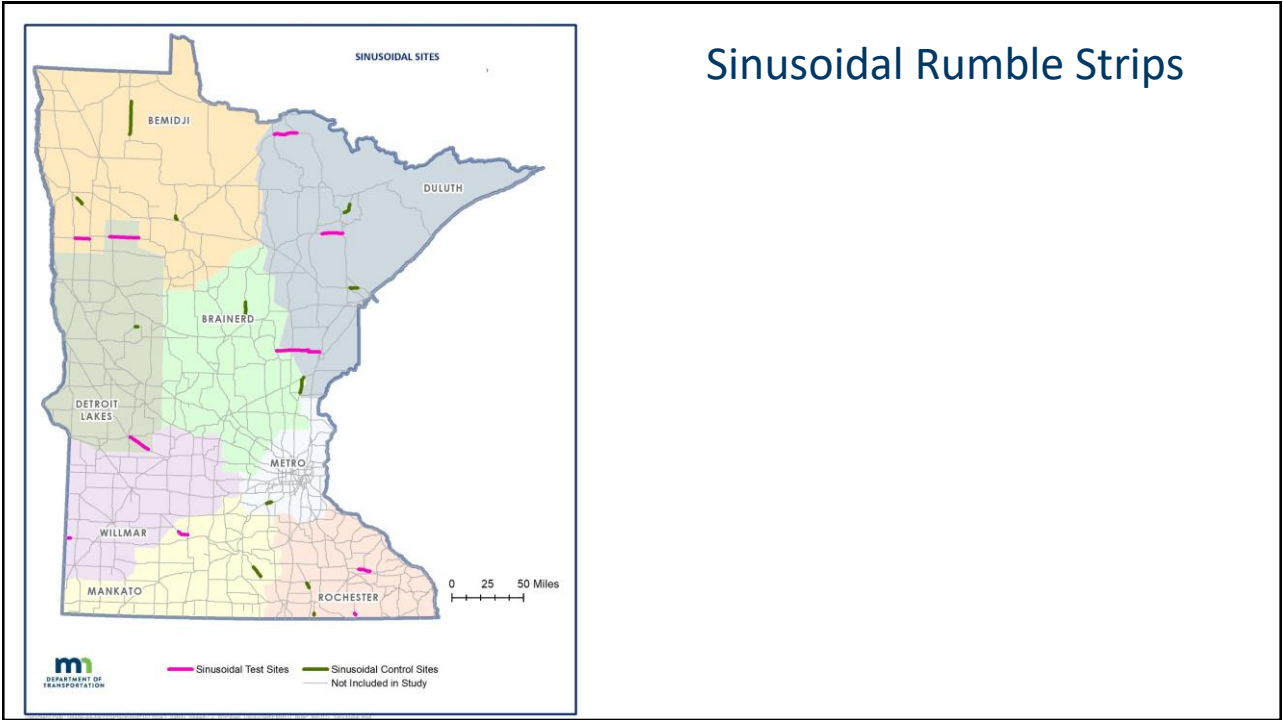
Questions?

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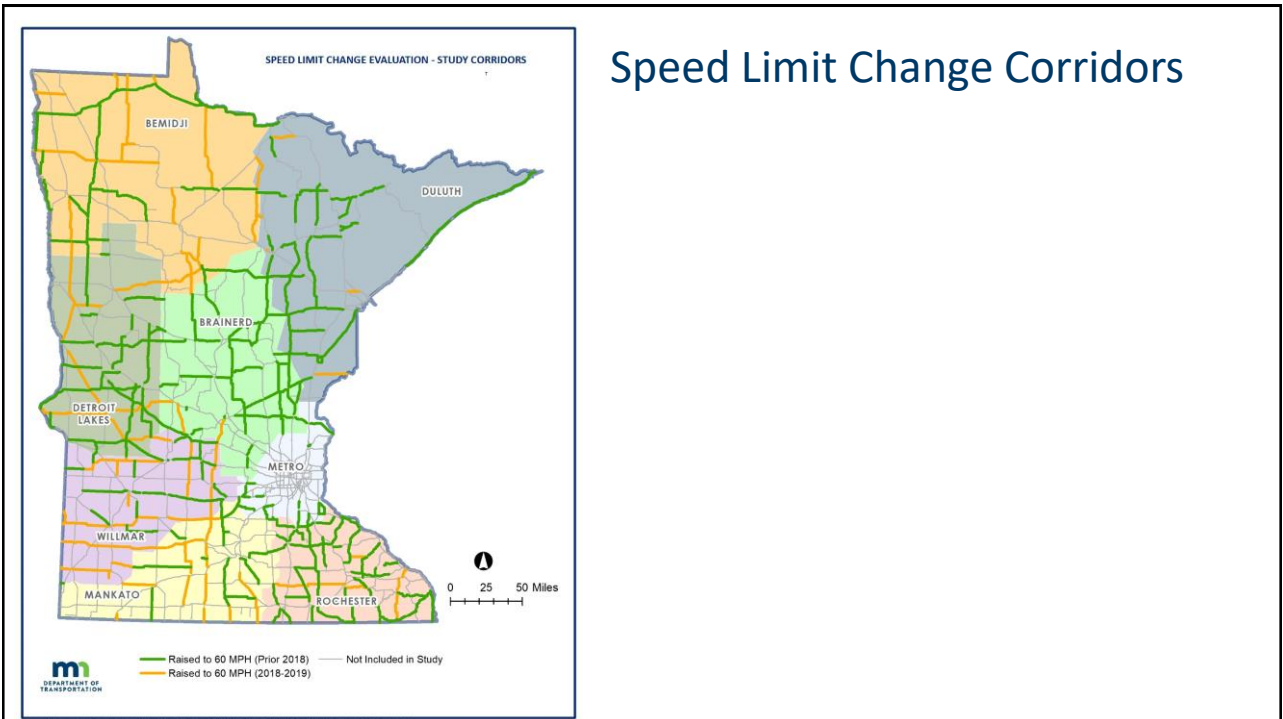
Rectangular Rumble Strips



Sinusoidal Rumble Strips



Speed Limit Change Corridors



RICWS Locations

