Six Inch Edge Line Project on Minnesota's Rural 2-lane/2-way Roads

The edge lines on rural 2-lane/2-way roadways are typically four inches wide. In 2009 MnDOT solicited wider edge line stripping projects for rural 2-lane/2-way roads. The six inch edge lines were installed with standard edge line paint. In other words this project did not include the use of high retro-reflectivity material. The six inch edge lines are intended to provide additional guidance and help drivers avoid leaving the roadway to the right.

This two-phase evaluation of six-inch edge lines includes 1,501 road segments installed in 2010 and 1,680 road segments installed in 2011.

Figure 1: Minnesota's Six Inch Edge Lines on a Rural 2-lane/2-way Road

Total miles for comparison group 1,727. In order to ensure that comparison segments were similar to the treatment segments, the following selection criteria were used: undivided, rural, 2-lane/2-way roadways in a non-metro county that was not part of the six-inch edge line project in 2010 or 2011.

Hypotheses

H_1: Six-inch edge lines will reduce crashes.
$H0_1$: Six-inch edge lines will not change crashes.

H_2: Six-inch edge lines will reduce fatal and serious injury crashes (severe).
$H0_2$: Six-inch edge lines will not change fatal and serious injury crashes (severe).

H_3: Six-inch edge lines will reduce target, run-off-road right crashes.
$H0_3$: Six-inch edge lines will not change target, run-off-road right crashes.

H_4: Six-inch edge lines will reduce severe, target, run-off-road right crashes.
$H0_4$: Six-inch edge lines will not change severe, target, run-off-road right crashes.

Method

These analyses compare two time points – two years before six-inch edge lines installation and a two years following six-inch edgeline installation. Six-inch edgeline installations occurred at two time points – 2010 and 2011. Phase 1 of these analyses represents comparisons for segments installed in 2010. Phase II of these analyses represent comparison for segments installed in 2011. The final analyses combine the pre and post-treatment data for Phase I and Phase II.

- **Pre-treatment**: Phase I: 2008-2009 Phase II: 2009-2010; Phase I and Phase II
- **Post-treatment:** Phase I: 2011-2012; Phase II: 2012-2013; Phase I and Phase II

In order to control for regression to the mean, crash data for treatment segments we compared to the similar, randomly selected segments.

- ***Treatment segments*:** indicates locations with six-inch edge lines
- ***Comparison segments*:** indicates locations with-out six-inch edge lines

In order to test our hypotheses, the research team used 2x2 crosstabulation with a Chi-square test. A crosstab analysis is a relatively simple analysis that is suitable to compare four possible groups, as is the case here; the Chi-square yields the linear-by-linear association test.

Total Crashes

The following three tables show the total number of crashes for the treatment and comparison group before and after treatment. These comparisons include all crash types and crash severities. For each analysis phase, crashes reductions for the treatment segments are dramatically greater than crash reductions observed on the comparison segments.

Table 1 shows the analysis of the Phase I installations. On treatment segments, total crashes decreased by 23%. On comparison segments total crashes decreased by 14%. While the treatment locations show noticeably greater crash reduction, this change is not statistically significant. Crash reductions are promising.

Table 1: Crosstab Comparison of Total Crashes Phase I

	Pre-Treatment (2008-09)	Post Treatment (2011-12)	Total
Comparison Segments	402	344	746
Treatment Segments	622	477	1,099
Total	1,024	821	1,845

X^2=1.32, *p*=0.25.

Table 2 shows the analysis of the Phase II installations. On treatment segments, total crashes decreased by 39%. On comparison segments total crashes decreased by 1%. The treatment locations show noticeably greater crash reduction, this change is not statistically significant. Crash reductions are promising.

Table 2: Crosstab Comparison of Total Crashes Phase II

	Pre-Treatment (2009-10)	Post Treatment (2021-13)	Total
Comparison Segments	357	352	709
Treatment Segments	28	17	45
Total	385	369	754

X^2=2.386, p=0.12.

Table 3 shows the analysis of the combined Phase I and II installations. On treatment segments, total crashes decreased by 24%. On comparison segments total crashes decreased by 8%. Treatment locations show statistically significant (p=.02) crash reduction. Crash reductions on treatment locations are statistically different from those reductions of comparison segments.

Table 3: Crosstab Comparison of Total Crashes Phase I and II

	Pre-Treatment	Post Treatment	Total
Comparison Segments	759	696	1,455
Treatment Segments	650	494	1,144
Total	1,409	1,190	2,599

X^2=5.587, p=0.02.

The combined Phase I and II analyses support hypothesis one:

H_1: Six-inch edge lines will reduce crashes.

We reject the null hypothesis:

$H0_1$: Six-inch edge lines will not change crashes.

Severe Crashes

A severe crash includes crashes in which one or more fatalities and or serious injuries. The following three tables show the total number of fatal and serious injury, severe, crashes for the treatment and comparison group before and after treatment. These comparisons include all crash types. For each analysis phase, crashes reductions for the treatment segments severe crashes reduced; however, these reductions are not dramatic. Small sample size fettered these analyses.

Table 4 shows the Phase I analysis of severe crashes. The comparison segments showed greater reductions in the number of severe crashes in the post treatment period; however, the comparison and treatment segments are statistically similar.

Table 4: Crosstab Comparison of Severe Crashes Phase I

	Pre-Treatment (2008-09)	Post Treatment (2011-12)	Total
Comparison Segments	38	28	66
Treatment Segments	42	41	83
Total	80	69	149

X^2=0.72, p=0.40.

Table 5 shows the Phase II analysis of severe crashes. On comparison segments, severe crashes increased by 92%. On treatment segments, severe crashes decreased by 100%. While these differences appear notable, due to small sample size, the differences are not statistically significant.

Table 5: Crosstab Comparison of Severe Crashes Phase II

	Pre-Treatment (2009-10)	Post Treatment (2021-13)	Total
Comparison Segments	14	27	41
Treatment Segments	1	0	1
Total	15	27	42

X^2=1.84, *p*=0.17.

Table 6 shows the Phase I and Phase II analysis of severe crashes. On comparison segments, severe crashes increased by 6%. On treatment segments, severe crashes decreased by 5%. The differences are not statistically significant. Comparison and treatment segments are statistically similar.

Table 6: Crosstab Comparison of severe Crashes Phase I and II

	Pre-Treatment	Post Treatment	Total
Comparison Segments	52	55	107
Treatment Segments	43	41	84
Total	95	96	191

X^2=0.13, *p*=0.72.

The preceding analyses do not support hypothesis two.

H_2: Six-inch edge lines will reduce fatal and serious injury crashes (severe).

We fail to reject the null hypothesis.

$H0_2$: Six-inch edge lines will not change fatal and serious injury crashes (severe).

Run-off-Road Crashes

In order to prevent run-off-road to the right crashes, six-inch edge lines provide high visibility delineation to drivers. The following three tables show the total number of run-off-road-right crashes for treatment and comparison group before and after treatment. These comparisons include run-off-road to the right crashes of all severities. For each analysis phase, crashes reductions for the treatment segments are dramatically greater than crash reductions observed on the comparison segments.

Table 7 shows the total number of run-off-road right crashes for the treatment and comparison segments before and after the six-inch edge lines installation. On comparison segments, run-off-road right crashes increased by 2%. On treatment segments, run-off-road right crashes decreased by 30%. The difference between the pre and post, installation treatment segments is statistically significant (*p*=0.057).

Table 7: Crosstab Comparison of Total Run-Off-Road Right Crashes Phase I

	Pre-Treatment (2008-09)	Post Treatment (2011-12)	Total
Comparison Segments	96	98	194
Treatment Segments	130	91	221
Total	226	189	415

X^2=3.633, *p*=0.06.

Table 8 shows the total number of run-off-road right crashes for the treatment and comparison segments before and after the six-inch edge lines installation. On comparison segments, run-off-road right crashes increased by 3%. On treatment segments, run-off-road right crashes decreased by 67%. The difference between the pre and post, installation treatment segments is not statistically significant (*p*=0.15), but the change is promising.

Table 8: Crosstab Comparison of Total Run-Off-Road Right Crashes Phase II

	Pre-Treatment (2009-10)	Post Treatment (2012-13)	Total
Comparison Segments	100	103	203
Treatment Segments	6	2	8
Total	106	105	211

X^2=2.04, *p*=0.15.

Table 9 shows the total number of run-off-road right crashes for the treatment and comparison segments before and after the six-inch edge lines installation. On comparison segments, run-off-road right crashes increased by 3%. On treatment segments, run-off-road right crashes decreased by 32%. The difference between the pre and post, installation treatment segments is statistically significant (*p*=0.02).

Table 9: Crosstab Comparison of Total Run-Off-Road Right Crashes Phase I and II

	Pre-Treatment	Post Treatment	Total
Comparison Segments	196	201	397
Treatment Segments	136	93	229
Total	332	294	626

X^2=5.85, *p*=0.02.

The Phase II and combined Phase I and II analyses support hypothesis three.

H_3: Six-inch edge lines will reduce target, run-off-road right crashes.

We reject the null hypothesis:

$H0_3$: Six-inch edge lines will not change target, run-off-road right crashes.

Severe Run-off-Road Crashes

The following three tables show the total number of fatal and serious injury (severe), run-off-road-right crashes for treatment and comparison group before and after treatment. For each analysis phase, crashes reductions for the treatment segments are greater than crash reductions observed on the comparison segments.

Table 10 shows the total number of severe run-off-road right crashes for the treatment and comparison segments before and after the six-inch edge lines installation. On comparison segments, severe run-off-road right crashes remained constant. On treatment segments, severe run-off-road right crashes decreased by 36%. The difference between the pre and post, installation treatment segments is not statistically significant.

Table 10: Crosstab Comparison of Severe Run-Off-Road Right Crashes Phase I

	Pre-Treatment (2008-09)	Post Treatment (2011-12)	Total
Comparison Segments	9	9	18
Treatment Segments	14	9	23
Total	23	18	41

X^2=0.48, p=0.486.

Table 11 shows the total number of severe run-off-road right crashes for the treatment and comparison segments before and after the six-inch edge lines installation. On comparison segments, severe run-off-road right crashes increased 200%. On treatment segments, severe run-off-road right crashes remained the same. The difference between the pre and post, installation treatment segments is not statistically significant.

Table 11: Crosstab Comparison of Severe Run-Off-Road Right Crashes Phase II

	Pre-Treatment (2009-10)	Post Treatment (2012-13)	Total
Comparison Segments	3	9	12
Treatment Segments	0	0	0
Total	3	9	12

Unable to calculate X^2.

Table 12 shows the total number of severe run-off-road right crashes for the treatment and comparison segments before and after the six-inch edge lines installation. On comparison segments, severe run-off-road right crashes increased 50%. On treatment segments, severe run-off-road right crashes decreased 35%. The difference between the pre and post, installation treatment segments is not statistically significant (p=0.13), but the difference is promising.

Table 12: Crosstab Comparison of Severe Run-Off-Road Right Crashes Phase I and II

	Pre-Treatment	Post Treatment	Total
Comparison Segments	12	18	30
Treatment Segments	14	9	23
Total	26	27	53

X^2=2.27, p=0.13.

Small sample size fettered the rigor of these analyses. The analyses do not support the hypothesis, but the direction of change is promising.

The preceding analyses do not support hypothesis four.

H_4: Six-inch edge lines will reduce severe, target, run-off-road right crashes.

We fail to reject the null hypothesis.

$H0_4$: Six-inch edge lines will not change severe, target, run-off-road right crashes.

Discussion

On roads with six-inch edge lines, total crashes, severe crashes, run-off-road right, and severe run-off-road right crashes decreased. On locations with six-inch edge lines:

- Adjusting for overall crash reductions within the analyses periods, total crashes decreased by 15.7%.
- Total crash reductions are statistically significant.
- Adjusting for the overall crash fluctuation of crashes within the analyses periods, severe crashes decreased 10.4%.
- Severe crash reduction is not statistically significant, but is promising.
- Adjusting for the overall fluctuations of crashes within the analyses periods, run-off-road right crashes decreased 34.2%.
- Total run-off-road right crash reductions are statistically significant.
- Adjusting for overall crash fluctuation of crashes within the analysis period, severe run-off-road crash decreased 85.7%.
- Severe, run-off-road right crash reduction is not statistically significant, but is promising.

Conclusion

Six-inch edge lines are an effective countermeasure for overall crashes and run-off-road right crashes. While crashes decreased across all four hypotheses tested, larger sample sizes may lead to more conclusive findings for severe crashes and severe run-off-road right crashes.

These analyses do not account for driver adaptation to six-inch edge lines. Future research should consider possible driver adaptation to well delineated roads – such as increased travel speeds.