



KENTUCKY TRANSPORTATION CENTER

CRASH HISTORY AFTER INSTALLATION OF TRAFFIC SIGNALS (WARRANTED VS. UNWARRANTED)





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products and services.

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In all that we do.

**CRASH HISTORY AFTER INSTALLATION OF TRAFFIC SIGNALS
(WARRANTED VS. UNWARRANTED)**

by

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in cooperation with

Kentucky Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
U.S. Department of Transportation

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16. Abstract The objective of this study was to determine the change in crash history at intersections after installation of a traffic signal. Signals installed based on the warrants from an engineering study resulted in a decrease in angle collisions with an increase in the less severe rear end collisions. At intersections where signal warrants were not met, there was a smaller decrease in angle collisions and a larger increase in rear end collisions. The removal of unwarranted traffic signals did not result in a crash problem. The analysis shows that the warrants given in the MUTCD should be followed when determining the need for a traffic signal installation with the installation based on an engineering study.					
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TABLE OF CONTENTS

	Page
Executive Summary	i
1.0 Introduction	1
2.0 Procedure	2
2.1 Selection of Intersections	2
2.2 Crash Data	2
3.0 Results	3
3.1 Intersections	3
3.2 Before and After Crash Data	3
3.3 Effect of Removal of Signals	4
4.0 Conclusions	5
5.0 Recommendation	6
Tables	7
Appendix A. List of Intersections and Warrants	9
Appendix B. Before and After Crash Data	12

EXECUTIVE SUMMARY

The objective of this study was to determine the change in crash history at intersections after installation of a traffic signal. The change in crash history was also analyzed relative to whether the signal was warranted based on MUTCD guidelines. The effect of removing signals at locations where they were no longer warranted was reviewed at a few locations.

The analysis resulted in the following conclusions relating to the change in crash history at intersections after the installation or removal of a traffic signal.

1. Most signal installations met one or more MUTCD warrant with volume warrants the most common type of warrant met.
2. Total crashes per year decreased slightly after installation of a signal (10.9 percent) with injury or fatal crashes per year decreasing more substantially (42.0 percent).
3. The decrease in total crashes was the result of the large decrease at intersections (42.9 percent) where the signal was installed based on a crash warrant. Total crashes increased slightly (11.5 percent) at locations where the signal was installed based on another type of warrant (not the crash warrant).
4. Angle crashes per year decreased by 63.0 percent while rear end crashes increased by 74.3 percent after installation of a traffic signal.
5. The number of crashes per year increased at intersections after installation of an unwarranted traffic signal (28.3 percent). This was a result of the dramatic increase in rear end crashes (222 percent). Angle crashes per year decreased by 40.2 percent at unwarranted signal locations.
6. Angle crashes per year decreased by 74.5 percent at intersections which met the crash warrant prior to the signal installation.
7. Traffic signals installed on the basis of an engineering study resulted in a decrease in angle collisions with an increase in the less severe rear end collisions. At intersections where the signal warrants were not met, there was a smaller decrease in angle collisions and a larger increase in rear end collisions.
8. The removal of unwarranted traffic signals did not result in a crash problem.

The analysis shows that the warrants given in the MUTCD should be followed when determining the need for a traffic signal installation. Therefore, installation of a traffic signal should be the result of an engineering study.

1.0 INTRODUCTION

Traffic signs, signals, and markings are traffic control devices used to regulate traffic flow through an intersection. Guidelines for the use of these devices are given in the Manual on Uniform Traffic Control Devices (MUTCD).

The MUTCD states that “an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location.” The following eight warrants are provided in Chapter 4C of the MUTCD to consider when determining whether a traffic signal should be installed at an intersection.

- | | |
|------------|-----------------------------|
| Warrant 1. | Eight-Hour Vehicular Volume |
| Warrant 2. | Four-Hour Vehicular Volume |
| Warrant 3. | Peak Hour |
| Warrant 4. | Pedestrian Volume |
| Warrant 5. | School Crossing |
| Warrant 6. | Coordinated Signal System |
| Warrant 7. | Crash Experience |
| Warrant 8. | Roadway Network |

The MUTCD notes that satisfaction of a traffic signal warrant or warrants shall not itself require the installation of a traffic control signal. However, it is stated that a traffic control signal should not be installed unless one or more of the relevant factors are met. Specifically, the MUTCD states that “a traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.”

Problems can be created when an unwarranted signal is installed. The MUTCD states that improper or unjustified traffic control signals can result in one or more of the following disadvantages.

- excessive delay
- excessive disobedience of the signal indications
- increased use of less adequate routes as road users attempt to avoid the traffic control signals
- significant increases in the frequency of collisions (especially rear-end collisions)

The MUTCD also discusses the removal of traffic signals. It notes that a traffic signal can be removed if justified by an engineering study.

The objective of this study was to determine the change in crash history at intersections after installation of a traffic signal. The change in crash history was also analyzed relative to whether the signal met MUTCD warrants. The effect of removing signals at locations where they were no longer warranted was reviewed at a few locations.

2.0 PROCEDURE

2.1 Selection of Intersections

Files maintained by the Kentucky Transportation Cabinet, which provided information for intersections where traffic signals have been installed, were searched. Specifically, the Traffic Signal Checklist was reviewed for each location. A list of intersections where traffic signals had been installed in recent years was obtained. The installation date had to be within a range of dates that would allow sufficient before and after crash data to provide meaningful results. The installation could not be used in the analysis if it was installed as part of a new development where there was no crash data before the installation.

The files were also reviewed to obtain information describing the basis for the signal installation. The specific warrants under which the signal was installed were determined. Signal installations which did not meet MUTCD warrants were identified.

A list of a few intersections where a traffic signal had been removed was also obtained. The date of removal was determined with available crash data summarized.

2.2 Crash Data

The Collision Report Analysis for Safer Highways (CRASH) database was searched to obtain crash data before and after the signal installation or removal. Crash reports in this database were available starting January 1, 2000. In some instances, crash data prior to that date were contained in the intersection files and included in the analysis.

The date of installation (or removal) was obtained from the intersection file. The number of years of available before and after crash data was determined. Analyzing the crashes to determine whether a crash occurred at a specific intersection required a combination of a computer summary and a manual inspection of the police reports.

The milepoint for each intersection (using all available state routes) was obtained. Crash data for a milepoint range for several tenths of a mile on either side of the intersection were obtained using the CRASH database. The intersecting road was listed in the CRASH data for some cases along with the type of crash. In many instances the crash report had to be reviewed to determine if the crash occurred at the specific intersection.

3.0 RESULTS

3.1 Intersections

A total of 89 intersections were identified where a traffic signal had been installed and the relevant warrants could be determined. A list of all of the intersections and the type of warrants met are given in Appendix A. Before and after crash data were available at 67 of these intersections.

A summary of the general type of warrant met at each intersection is given in Table 1. The large majority (79 percent) of the signal installations met one or more warrant (70 of the 89 installations). Some intersections met several warrants. Almost all of the warranted signals (67 of 70) met one or more of the various volume-related warrants. Twenty percent of the warranted signals (14 of 70) met the crash warrant.

It should be noted that all of the eight warrants given in the MUTCD are not typically reviewed in the analysis for every possible signal installation. Also, some of the warrants are considered more in the analysis at a specific intersection based on the circumstances at that location. The data show that the warrants based on traffic volume and crash history are considered most often in the analysis.

3.2 Before and After Crash Data

A summary of the before and after crash data is shown in Table 2. Crashes per year were used in the comparisons. Crash rates were not used because of the lack of intersection volume data for the time periods both before and after the signal installations. A logical assumption would be that any change in volume for the period after installation would involve an increase. If the number of crashes decrease after installation of a signal, the percent decrease in numbers would provide a conservative estimate compared to rates (since volumes would increase).

Considering all crashes, the number of crashes per year decreased by 10.9 percent. There was a dramatic difference in the change in crashes at warranted versus unwarranted signal installations. There was an 18.0 percent reduction in crashes per year at locations where the signal was warranted compared to a 28.3 percent increase in crashes per year at locations where the signal was not warranted. The reduction in total crashes at warranted locations was primarily the result of the large decrease at locations which met the crash warrant (42.9 percent). Crashes increased (11.5 percent) where the signal was installed due to a non-crash warrant.

Considering all crashes, the crashes per year increased at 29 intersections and decreased at 38 intersections after the signal installations. Crashes increased at 10 of the 15 unwarranted locations. Crashes decreased at 12 of the 14 locations meeting the crash warrant and 21 of the 38 intersections meeting a non-crash warrant.

Another analysis was conducted using crashes which involved either an injury or fatality (Table 3). The reduction in crashes per year increased to 42 percent. The decrease was higher for warranted locations (43.8 percent) compared to unwarranted installations (32.0 percent). The decrease was higher for locations meeting the crash warrant (54.3 percent) compared to those meeting another type of warrant (28.9 percent).

The differences in the crash history at warranted versus unwarranted intersections are further explained when the type of crash is considered. The changes in rear end and angle crashes are given in Table 4. The large majority of all the intersection crashes involved either a rear end or angle collision. Considering all crashes, the number of rear end crashes per year increased by 74.3 percent while the number of angle crashes per year decreased by 63.0 percent.

The overall increase in total crashes at unwarranted installations was related to the dramatic increase in rear end collisions (222 percent). Rear end collisions increased by 49 percent at warranted collisions. The number of angle crashes per year decreased by 66.9 percent at warranted installations compared to a decrease of 40.2 percent at unwarranted locations. Angle crashes decreased by 74.5 percent at intersections which met the crash warrant.

3.3 Effect of Removal of Signals

Data were obtained at a limited number of intersections where a traffic signal had been removed after a study showed the signal was no longer warranted. The sample was small and the type of data available varied so the data for these intersections were not combined. The data were summarized separately for each intersection with the new traffic control provided if known.

The signal at the intersection of KY 80 and Guardian Street in Columbia in Adair County was removed and replaced with a two-way stop. No crashes could be located at the intersection in four years before and two years after the removal. There was a reference in the file to a crash which resulted in the signal being placed on flash with the signal then removed.

The signal at the intersection of US 60 and Innovative Way in Daviess County was removed after studies found it was not warranted. The crash records showed no crashes in the four years prior to removal and only one angle crash in the three years after removal.

The signal at the intersection of KY 3035 and Richardson Road in Kenton County was removed and replaced with a four-way stop. The crash records revealed no crashes in the four years prior to removal with only one opposing left turn crash in the two years after removal of the signal.

The signal at the intersection of KY 1460 and KY 1384 (Loraine Street) in Pike County was removed after a study showed it did not meet warrants. Crash records showed one opposing left turn crash in the two years before removal and three crashes (two opposing left turn and one single vehicle) in the five years after removal.

The signal at the KY 53 and the Interstate 64 westbound off-ramp in Shelby County was removed with a signal then installed at the adjacent Interstate 64 eastbound off-ramp. The signal was in operation for only about one year before being placed on flash and then removed. The number of crashes decreased from six in the year of operation to 3.2 in the four years after removal of the signal.

Traffic signals were removed and replaced with four-way stops at three intersections in Cynthiana in Harrison County since they did not meet volume warrants. The changes occurred in 2000, and there was no data available before removal with seven years of after data available. Data after removal of the signals showed 1.86 crashes per year at the intersection of KY 32 and Walnut Street, 2.14 crashes per year at the intersection of KY 982 and KY 2358, and 0.86 crashes per year at the intersection of KY 2358 and Walnut Street. Most of the crashes were angle.

4.0 CONCLUSIONS

The analysis resulted in the following conclusions relating to the change in crash history at intersections after the installation or removal of a traffic signal.

1. Most signal installations met one or more MUTCD warrant with volume warrants the most common type of warrant met.
2. Total crashes per year decreased slightly after installation of a signal (10.9 percent) with injury or fatal crashes per year decreasing more substantially (42.0 percent).
3. The decrease in total crashes was the result of the large decrease at intersections (42.9 percent) where the signal was installed based on a crash warrant. Total crashes increased slightly (11.5 percent) at locations where the signal was installed based on another type of warrant (not the crash warrant).
4. Angle crashes per year decreased by 63.0 percent while rear end crashes increased by 74.3 percent after installation of a traffic signal.
5. The number of crashes per year increased at intersections after installation of an unwarranted traffic signal (28.3 percent). This was a result of the dramatic increase in rear end crashes (222 percent). Angle crashes per year decreased by 40.2 percent at unwarranted signal locations.
6. Angle crashes per year decreased by 74.5 percent at intersections which met the crash warrant prior to the signal installation.

7. Traffic signals installed on the basis of an engineering study resulted in a decrease in angle collisions with an increase in the less severe rear end collisions. At intersections where the signal warrants were not met, there was a smaller decrease in angle collisions and a larger increase in rear end collisions.
8. The removal of unwarranted traffic signals did not result in a crash problem.

5.0 RECOMMENDATION

The analysis shows that the warrants given in the MUTCD should be followed when determining the need for a traffic signal installation. Therefore, installation of a traffic signal should be the result of an engineering study.

Table 1. Number of Sites by Warrant Type

Type	Number of Intersections
<i>Warranted</i>	70
<i>Crash</i>	14
<i>Volume</i>	67
<i>Unwarranted</i>	19
<i>All</i>	89

Table 2. Percent Change in Crashes per Year (Before to After Installing Signal)

Type	Number of Intersections	All Crashes/Year		Percent Change
		Before	After	
<i>Warranted</i>	52	3.62	2.97	-18.0
<i>Crash</i>	14	6.13	3.50	-42.9
<i>Non-Crash</i>	38	1.87	2.09	11.5
<i>Unwarranted</i>	15	2.29	2.94	28.3
<i>All</i>	67	3.33	2.96	-10.9

**Table 3. Percent Change in Fatal and Injury Crashes per Year
(Before to After Installing Signal)**

Type	Fatal or Injury Crashes/Year		Percent Change
	Before	After	
<i>Warranted</i>	1.25	0.70	-43.8
<i>Crash</i>	2.13	0.98	-54.3
<i>Non-Crash</i>	0.65	0.46	-28.9
<i>Unwarranted</i>	0.84	0.57	-32.0
<i>All</i>	1.16	0.67	-42.0

Table 4. Percent Change in Rear End and Angle Crashes per Year (Before to After Installing Signal)

Type	Rear End Crashes/Year		Percent Change	Angle Crashes/Year		Percent Change
	Before	After		Before	After	
<i>Warranted</i>	0.94	1.40	49.1	2.11	0.70	-66.9
<i>Crash</i>	1.11	1.15	3.5	4.31	1.10	-74.5
<i>Non-Crash</i>	0.62	1.11	78.5	0.88	0.42	-52.1
<i>Unwarranted</i>	0.56	1.79	221.7	1.24	0.74	-40.2
<i>All</i>	0.85	1.49	74.3	1.92	0.71	-63.0

Appendix A. List of Intersections and Warrants

APPENDIX A. LIST OF MUTCD WARRANTS BY SIGNAL LOCATION

ID	County	Intersection	MUTCD WARRANT NUMBER										Warranted
			1A	1B	Combo	2	3	4	5	6	7	8	
1*	Anderson	US 127 B @Bellerive	Y	Y		Y	Y						Yes
2	Anderson	US 62 @ Robert B. Turner/Westwood											No
3	Barren	US 68 @ Scottie Drive	Y										Yes
4	Bell	KY 74 @ 21st Street											No
5	Boone	KY 237 @ I275 Eastbound Ramps	Y	Y	Y								Yes
6	Boone	KY 237 @ Rogers Lane	Y	Y	Y								Yes
7	Boone	KY 842 @ Merchants St.											No
8	Boyle	US 150B @ Daniel Drive		Y	Y								Yes
9	Breathitt	KY 1812/ KY3068 @ Washington Avenue	Y	Y	Y	Y	Y						Yes
10	Calloway	KY 121 @ KY 774	Y	Y									Yes
11*	Calloway	US 641 @ Murray State University Stadium	Y		Y							Y	Yes
12	Carroll	KY 227 @ KY 36		Y		Y	Y						Yes
13	Christian	KY 1682 @ KY 109 (Dawson Springs Road)											No
14	Christian	US 41 @ Murray State Ext. Campus Ent.											No
15	Christian	US 41A @ Bradford Square Mall North Entrance	Y	Y									Yes
16	Christian	US 41A @ Gate 7 (Cole Road)		Y	Y								Yes
17*	Christian	US 41A @ Lowes Entrance/Sisk Auto Mall		Y	Y	Y	Y						Yes
18*	Christian	US 41A @ WALMART DIST. CENTER				Y	Y						Yes
19	Daviess	KY 2698 (Carter Rd.) @ Unifirst Drive											No
20	Daviess	KY 2698 (Carter Road) @ Tamarck Road	Y	Y									Yes
21*	Daviess	US 431 (Fredrica St) @ Home Depot Entrance	Y	Y	Y	Y	Y						Yes
22	Fayette	KY 1927 @ Fortune Drive	Y	Y	Y								Yes
23	Fayette	US 25 @ Sandersville Road		Y	Y								Yes
24	Fayette	US 27 @ Old Paris Pike	Y	Y	Y						Y		Yes
25	Fayette	US 421 @ Ruffian Way/McConnells Trace				Y	Y						Yes
26	Fayette	US 60 @ KY 1425	Y	Y	Y								Yes
27	Fayette	US 68 @ 1267 (Military Pike)		Y							Y		Yes
29*	Grant	KY 491 @ I-75 N. B. Ramp											No
30*	Grant	KY 491 @ I-75 S. B. Ramp											No
31*	Graves	KY 121 @ Graves County High School											No
32*	Grayson	US 62 @ Wal-Mart Entrance	Y	Y	Y	Y	Y						Yes
33	Greenup	KY 207 @ Wilkerson Street/Riddle Street		Y	Y								Yes
34	Hardin	KY 251 @ Panther Lane/St James Street		Y							Y		Yes
35*	Hardin	KY 3005 @ Home Depot Entrance	Y			Y	Y						Yes
36	Hardin	KY 3005 @ Nightingale Drive		Y	Y								Yes
38	Henderson	KY 425 @ US 41A									Y		Yes
40*	Jefferson	KY 1065 @ Vaughn Mill Road	Y	Y									Yes
41	Jefferson	KY 1230 @ KY 1934		Y							Y		Yes
43*	Jefferson	KY 1747 @ Home Depot/Target Entrance		Y	Y								Yes
44*	Jefferson	KY 1819 @ Gaudet Road/Walmart	Y	Y	Y								Yes
45	Jefferson	KY 3084 (Old Henry Rd.) @ Nelson Miller Pkwy.	Y				Y						Yes
46*	Jefferson	KY 61 (Preston Hwy) @ Interchange Dr.	Y										Yes
47*	Jefferson	KY 864 (Poplar Level) @ Jefferson Blvd.	Y										Yes
48	Jefferson	KY 913 (Blankenbaker) @ Plantside Drive		Y	Y						Y		Yes
49	Jefferson	US 42 @ KY 329		Y	Y								Yes

APPENDIX A. LIST OF MUTCD WARRANTS BY SIGNAL LOCATION

ID	County	Intersection	MUTCD WARRANT NUMBER										Warranted
			1A	1B	Combo	2	3	4	5	6	7	8	
50	Jessamine	US 27 @ Commerce Drive											No
51	Jessamine	US 68 @ Windhaven Dr/Bellerive Blvd.											No
52	Johnson	KY 321 @ Federal Drive/Johnson Central High		Y									Yes
53*	Johnson	KY 321 @ Wal-Mart Entrance	Y	Y	Y	Y	Y						Yes
54*	Kenton	KY 1072 B @ Z Development	Y	Y									Yes
55*	Kenton	KY 17 @ Old KY 17	Y	Y	Y								Yes
56	Kenton	KY 17 @ Rolling Ridge		Y									Yes
57	Knox	US 25E @ Kroger/Goody's Entrance		Y									Yes
58	Lawrence	US 23 @ KY 2565									Y		Yes
59	Madison	KY 52 @ KY 977		Y									Yes
60	Madison	US 25 (Richmond Bypass) @ KY 1986	Y	Y									Yes
61	Madison	US 25X @ Boggs Lane/Morrow Drive		Y									Yes
62	Marion	US 68 @ Warehouse Drive											No
63	McCracken	KY 1954 @ I-24 EB Ramp				Y	Y				Y		Yes
65	McCracken	US 62 & HOLT ROAD	Y	Y	Y						Y		Yes
66	Meade	US 60 @ KY 144					Y				Y		No
67	Montgomery	KY 686 (Mt. Sterling Bp) @ Old Owingsville Rd	Y			Y	Y				Y		Yes
68	Muhlenburg	KY 189 @ KY 1380/Cleaton Road	Y	Y	Y	Y							Yes
69*	Nelson	KY 245 @ Filatreau Lane/Culpeper St.(Wal-Mart)	Y	Y									Yes
70	Oldham	US 42 @ Ridgemoor/High Meadows Pike		Y							Y		Yes
71	Pike	KY 1426 @ Pikeville Methodist Hospital		Y	Y								Yes
72	Pike	US 119 @ KY 308		Y									Yes
73	Pike	US 23 @ BB&T entrance								Y			Yes
74	Pike	US 23 @ KY 2061 (Cowpen Rd)								Y			Yes
75	Pike	US 23 @ Power Drive											Yes
77	Shelby	KY 53 & I-64 EB Ramp	Y										Yes
78	Shelby	KY 55 @ KY 43/KY 2268	Y										Yes
79	Shelby	US 60 @ KY 1848	Y	Y	Y						Y		Yes
80	Shelby	US 60 @ KY 1871 (Rocket Lane)											No
81	Spencer	KY 55/KY155 @ KY 55/KY 1633	Y										Yes
82	Taylor	KY 210 @ KY 3350		Y	Y								Yes
83	Taylor	KY 210 @ Lori West Drive/Jefra Avenue		Y									Yes
84	Taylor	KY 3350 @ KY 527											No
85	Trigg	US 68 @ Broadbent Boulevard	Y	Y	Y								Yes
86*	Union	US 60 West @ US 60 Bypass											No
87	Warren	US 231 @ McIntosh St.		Y							Y		Yes
88*	Warren	US 231X @ New Wal-Mart		Y									Yes
89	Warren	US 31W @ Modern Way				Y	Y						Yes
90	Warren	US 31W @ W.H. Natcher NB Off Ramp	Y	Y	Y								Yes
91	Washington	KY 555 @ KY 528											No
92*	Woodford	KY 1964 @ KY 2113					Y						Yes
93	Woodford	KY 33 @ KY 2113											No
94	Woodford	US 62 @ KY 2113											No
95	Boyd	US 60 @ KY 1012		Y		Y	Y						Yes

*These sites were not included in Appendix B as they were new installations that did not have before crash data.

Appendix B. Before and After Crash Data

APPENDIX B-1. ALL CRASHES BEFORE AND AFTER SIGNALS WERE ADDED (BY LOCATION)

ID	District	County	Intersection	Years	Years	Number of Crashes	
				Before	After	Before	After
2	7	Anderson	US 62 @ Robert B. Turner/Westwood	3	3	0	1
3	3	Barren	US 68 @ Scottie Drive	4	2	5	1
4	11	Bell	KY 74 @ 21st Street	4	2	17	3
5	6	Boone	KY 237 @ I275 Eastbound Ramps	3	3	17	44
6	6	Boone	KY 237 @ Rogers Lane	2	4	7	18
7	6	Boone	KY 842 @ Merchants St.	3	3	1	17
8	7	Boyle	US 150B @ Daniel Drive	2	4	2	7
9	10	Breathitt	KY 1812/ KY3068 @ Washington Avenue	4	3	5	2
10	1	Calloway	KY 121 @ KY 774	2	4	12	13
12	6	Carroll	KY 227 @ KY 36	4	2	15	4
13	2	Christian	KY 1682 @ KY 109 (Dawson Springs Road)	2	4	5	5
14	2	Christian	US 41 @ Murray State Ext. Campus Ent.	3	3	1	3
15	2	Christian	US 41A @ Bradford Square Mall North Entrance	4	2	16	6
16	2	Christian	US 41A @ Gate 7 (Cole Road)	4	2	9	4
19	2	Daviess	KY 2698 (Carter Rd.) @ Unifirst Drive	3	2	9	7
20	2	Daviess	KY 2698 (Carter Road) @ Tamarck Road	4	3	2	6
22	7	Fayette	KY 1927 @ Fortune Drive	2	4	5	3
23	7	Fayette	US 25 @ Sandersville Road	2	4	4	9
24	7	Fayette	US 27 @ Old Paris Pike	3	3		22
25	7	Fayette	US 421 @ Ruffian Way/McConnells Trace	2	4	2	3
26	7	Fayette	US 60 @ KY 1425	2	4	2	11
27	7	Fayette	US 68 @ 1267 (Military Pike)	3	3	40	14
33	9	Greenup	KY 207 @ Wilkerson Street/Riddle Street	2	4	1	0
34	4	Hardin	KY 251 @ Panther Lane/St James Street	2	5	11	15
36	4	Hardin	KY 3005 @ Nightingale Drive	3	3	27	7
38	2	Henderson	KY 425 @ US 41A	4	2	26	10
41	5	Jefferson	KY 1230 @ KY 1934	4	2	17	1
45	5	Jefferson	KY 3084 (Old Henry Rd.) @ Nelson Miller Pkwy.	4	4	0	0
48	5	Jefferson	KY 913 (Blankenbaker) @ Plantside Drive	2	4	13	16
49	5	Jefferson	US 42 @ KY 329	4	3	17	7
50	7	Jessamine	US 27 @ Commerce Drive	3	3	14	49
51	7	Jessamine	US 68 @ Windhaven Dr/Bellerive Blvd.	4	3	12	3
52	12	Johnson	KY 321 @ Federal Drive/Johnson Central High	3	3	16	12
56	6	Kenton	KY 17 @ Rolling Ridge	4	2	5	17
57	11	Knox	US 25E @ Kroger/Goody's Entrance	3	3	32	13
58	12	Lawrence	US 23 @ KY 2565	4	2	16	1
59	7	Madison	KY 52 @ KY 977	2	4	7	11
60	7	Madison	US 25 (Richmond Bypass) @ KY 1986	3	3	9	20
61	7	Madison	US 25X @ Boggs Lane/Morrow Drive	2	3	8	9
62	4	Marion	US 68 @ Warehouse Drive	4	2	0	5
63	1	McCracken	KY 1954 @ I-24 EB Ramp	4	2	22	7
65	1	McCracken	US 62 & HOLT ROAD	3	2	17	9
66	4	Meade	US 60 @ KY 144	4	2	29	9
67	7	Montgomery	KY 686 (Mt. Sterling Bp) @ Old Owingsville Rd	3	3	21	9
68	2	Muhlenburg	KY 189 @ KY 1380/Cleaton Road	3	2	3	0
70	5	Oldham	US 42 @ Ridgemoor/High Meadows Pike	3	3	6	11
71	12	Pike	KY 1426 @ Pikeville Methodist Hospital	3	3	8	9
72	12	Pike	US 119 @ KY 308	4	2	1	3
73	12	Pike	US 23 @ BB&T entrance	3	3	3	8
74	12	Pike	US 23 @ KY 2061 (Cowpen Rd)	3	3	5	13
75	12	Pike	US 23 @ Power Drive	3	3	3	5
77	5	Shelby	KY 53 & I-64 EB Ramp	4	2	8	2
78	5	Shelby	KY 55 @ KY 43/KY 2268	4	2	14	10
79	5	Shelby	US 60 @ KY 1848	2	5	11	9
80	5	Shelby	US 60 @ KY 1871 (Rocket Lane)	2	5	7	13
81	5	Spencer	KY 55/KY155 @ KYY 55/KY 1633	4	2	13	1
82	4	Taylor	KY 210 @ KY 3350	2	4	2	20
83	4	Taylor	KY 210 @ Lori West Drive/Jefra Avenue	3	3	4	1
84	4	Taylor	KY 3350 @ KY 527	2	4	1	3
85	1	Trigg	US 68 @ Broadbent Boulevard	2	4	7	6
87	3	Warren	US 231 @ McIntosh St.	4	2	21	7
89	3	Warren	US 31W @ Modern Way	3	3	5	13
90	3	Warren	US 31W @ W.H. Natcher NB Off Ramp	2	5	9	17
91	4	Washington	KY 555 @ KY 528	2	5	7	18
93	7	Woodford	KY 33 @ KY 2113	3	3	0	1
94	7	Woodford	US 62 @ KY 2113	3	3	0	1
95	9	Boyd	US 60 @ KY 1012	3	3	15	6

APPENDIX B-2. ANGLE CRASHES BEFORE AND AFTER SIGNALS WERE ADDED (BY LOCATION)

ID	District	County	Intersection	Years	Years	Number of Crashes	
				Before	After	Before	After
2	7	Anderson	US 62 @ Robert B. Turner/Westwood	3	3	0	0
3	3	Barren	US 68 @ Scottie Drive	4	2	0	1
4	11	Bell	KY 74 @ 21st Street	4	2	8	2
5	6	Boone	KY 237 @ I275 Eastbound Ramps	3	3	5	2
6	6	Boone	KY 237 @ Rogers Lane	2	4	1	2
7	6	Boone	KY 842 @ Merchants St.	3	3	0	2
8	7	Boyle	US 150B @ Daniel Drive	2	4	1	1
9	10	Breathitt	KY 1812/ KY3068 @ Washington Avenue	4	3	5	0
10	1	Calloway	KY 121 @ KY 774	2	4	3	3
12	6	Carroll	KY 227 @ KY 36	4	2	2	0
13	2	Christian	KY 1682 @ KY 109 (Dawson Springs Road)	2	4	4	0
14	2	Christian	US 41 @ Murray State Ext. Campus Ent.	3	3	0	1
15	2	Christian	US 41A @ Bradford Square Mall North Entrance	4	2	5	0
16	2	Christian	US 41A @ Gate 7 (Cole Road)	4	2	6	1
19	2	Daviess	KY 2698 (Carter Rd.) @ Unifirst Drive	3	2	2	5
20	2	Daviess	KY 2698 (Carter Road) @ Tamarck Road	4	3	2	4
22	7	Fayette	KY 1927 @ Fortune Drive	2	4	2	1
23	7	Fayette	US 25 @ Sandersville Road	2	4	1	4
24	7	Fayette	US 27 @ Old Paris Pike	3	3		8
25	7	Fayette	US 421 @ Ruffian Way/McConnells Trace	2	4	2	1
26	7	Fayette	US 60 @ KY 1425	2	4	0	3
27	7	Fayette	US 68 @ 1267 (Military Pike)	3	3	22	0
33	9	Greenup	KY 207 @ Wilkerson Street/Riddle Street	2	4	0	0
34	4	Hardin	KY 251 @ Panther Lane/St James Street	2	5	10	7
36	4	Hardin	KY 3005 @ Nightingale Drive	3	3	6	0
38	2	Henderson	KY 425 @ US 41A	4	2	16	5
41	5	Jefferson	KY 1230 @ KY 1934	4	2	11	0
45	5	Jefferson	KY 3084 (Old Henry Rd.) @ Nelson Miller Pkwy.	4	4	0	0
48	5	Jefferson	KY 913 (Blankenbaker) @ Plantside Drive	2	4	7	3
49	5	Jefferson	US 42 @ KY 329	4	3	8	1
50	7	Jessamine	US 27 @ Commerce Drive	3	3	3	4
51	7	Jessamine	US 68 @ Windhaven Dr/Bellerive Blvd.	4	3	3	2
52	12	Johnson	KY 321 @ Federal Drive/Johnson Central High	3	3	12	0
56	6	Kenton	KY 17 @ Rolling Ridge	4	2	3	2
57	11	Knox	US 25E @ Kroger/Goody's Entrance	3	3	28	7
58	12	Lawrence	US 23 @ KY 2565	4	2	9	0
59	7	Madison	KY 52 @ KY 977	2	4	5	5
60	7	Madison	US 25 (Richmond Bypass) @ KY 1986	3	3	6	7
61	7	Madison	US 25X @ Boggs Lane/Morrow Drive	2	3	6	1
62	4	Marion	US 68 @ Warehouse Drive	4	2	0	1
63	1	McCracken	KY 1954 @ I-24 EB Ramp	4	2	19	1
65	1	McCracken	US 62 & HOLT ROAD	3	2	14	5
66	4	Meade	US 60 @ KY 144	4	2	26	6
67	7	Montgomery	KY 686 (Mt. Sterling Bp) @ Old Owingsville Rd	3	3	20	3
68	2	Muhlenburg	KY 189 @ KY 1380/Cleaton Road	3	2	3	0
70	5	Oldham	US 42 @ Ridgemoor/High Meadows Pike	3	3	4	2
71	12	Pike	KY 1426 @ Pikeville Methodist Hospital	3	3	4	2
72	12	Pike	US 119 @ KY 308	4	2	1	0
73	12	Pike	US 23 @ BB&T entrance	3	3	2	1
74	12	Pike	US 23 @ KY 2061 (Cowpen Rd)	3	3	1	4
75	12	Pike	US 23 @ Power Drive	3	3	2	2
77	5	Shelby	KY 53 & I-64 EB Ramp	4	2	6	0
78	5	Shelby	KY 55 @ KY 43/KY 2268	4	2	7	4
79	5	Shelby	US 60 @ KY 1848	2	5	11	3
80	5	Shelby	US 60 @ KY 1871 (Rocket Lane)	2	5	5	3
81	5	Spencer	KY 55/KY155 @ KYY 55/KY 1633	4	2	9	0
82	4	Taylor	KY 210 @ KY 3350	2	4	2	4
83	4	Taylor	KY 210 @ Lori West Drive/Jefra Avenue	3	3	1	1
84	4	Taylor	KY 3350 @ KY 527	2	4	0	0
85	1	Trigg	US 68 @ Broadbent Boulevard	2	4	2	1
87	3	Warren	US 231 @ McIntosh St.	4	2	18	1
89	3	Warren	US 31W @ Modern Way	3	3	2	1
90	3	Warren	US 31W @ W.H. Natcher NB Off Ramp	2	5	5	6
91	4	Washington	KY 555 @ KY 528	2	5	5	9
93	7	Woodford	KY 33 @ KY 2113	3	3	0	0
94	7	Woodford	US 62 @ KY 2113	3	3	0	0
95	9	Boyd	US 60 @ KY 1012	3	3	9	1

APPENDIX B-3. REAR END CRASHES BEFORE AND AFTER SIGNALS WERE ADDED (BY LOCATION)

ID	District	County	Intersection	Years	Years	Number of Crashes	
				Before	After	Before	After
2	7	Anderson	US 62 @ Robert B. Turner/Westwood	3	3	0	0
3	3	Barren	US 68 @ Scottie Drive	4	2	5	0
4	11	Bell	KY 74 @ 21st Street	4	2	4	0
5	6	Boone	KY 237 @ I275 Eastbound Ramps	3	3	4	24
6	6	Boone	KY 237 @ Rogers Lane	2	4	6	10
7	6	Boone	KY 842 @ Merchants St.	3	3	1	12
8	7	Boyle	US 150B @ Daniel Drive	2	4	1	2
9	10	Breathitt	KY 1812/ KY3068 @ Washington Avenue	4	3	0	1
10	1	Calloway	KY 121 @ KY 774	2	4	7	4
12	6	Carroll	KY 227 @ KY 36	4	2	10	4
13	2	Christian	KY 1682 @ KY 109 (Dawson Springs Road)	2	4	1	1
14	2	Christian	US 41 @ Murray State Ext. Campus Ent.	3	3	1	2
15	2	Christian	US 41A @ Bradford Square Mall North Entrance	4	2	1	2
16	2	Christian	US 41A @ Gate 7 (Cole Road)	4	2	3	1
19	2	Daviess	KY 2698 (Carter Rd.) @ Unifirst Drive	3	2	4	2
20	2	Daviess	KY 2698 (Carter Road) @ Tamarck Road	4	3	0	1
22	7	Fayette	KY 1927 @ Fortune Drive	2	4	0	2
23	7	Fayette	US 25 @ Sandersville Road	2	4	1	3
24	7	Fayette	US 27 @ Old Paris Pike	3	3		4
25	7	Fayette	US 421 @ Ruffian Way/McConnells Trace	2	4	0	0
26	7	Fayette	US 60 @ KY 1425	2	4	2	5
27	7	Fayette	US 68 @ 1267 (Military Pike)	3	3	13	11
33	9	Greenup	KY 207 @ Wilkerson Street/Riddle Street	2	4	1	0
34	4	Hardin	KY 251 @ Panther Lane/St James Street	2	5	1	1
36	4	Hardin	KY 3005 @ Nightingale Drive	3	3	19	5
38	2	Henderson	KY 425 @ US 41A	4	2	5	3
41	5	Jefferson	KY 1230 @ KY 1934	4	2	1	0
45	5	Jefferson	KY 3084 (Old Henry Rd.) @ Nelson Miller Pkwy.	4	4	0	0
48	5	Jefferson	KY 913 (Blankenbaker) @ Plantside Drive	2	4	1	5
49	5	Jefferson	US 42 @ KY 329	4	3	4	4
50	7	Jessamine	US 27 @ Commerce Drive	3	3	8	45
51	7	Jessamine	US 68 @ Windhaven Dr/Bellerive Blvd.	4	3	3	1
52	12	Johnson	KY 321 @ Federal Drive/Johnson Central High	3	3	4	11
56	6	Kenton	KY 17 @ Rolling Ridge	4	2	0	14
57	11	Knox	US 25E @ Kroger/Goody's Entrance	3	3	4	4
58	12	Lawrence	US 23 @ KY 2565	4	2	2	0
59	7	Madison	KY 52 @ KY 977	2	4	0	5
60	7	Madison	US 25 (Richmond Bypass) @ KY 1986	3	3	2	12
61	7	Madison	US 25X @ Boggs Lane/Morrow Drive	2	3	2	5
62	4	Marion	US 68 @ Warehouse Drive	4	2	0	3
63	1	McCracken	KY 1954 @ I-24 EB Ramp	4	2	2	2
65	1	McCracken	US 62 & HOLT ROAD	3	2	2	1
66	4	Meade	US 60 @ KY 144	4	2	1	3
67	7	Montgomery	KY 686 (Mt. Sterling Bp) @ Old Owingsville Rd	3	3	0	2
68	2	Muhlenburg	KY 189 @ KY 1380/Cleaton Road	3	2	0	0
70	5	Oldham	US 42 @ Ridgemoor/High Meadows Pike	3	3	2	7
71	12	Pike	KY 1426 @ Pikeville Methodist Hospital	3	3	2	5
72	12	Pike	US 119 @ KY 308	4	2	0	3
73	12	Pike	US 23 @ BB&T entrance	3	3	1	6
74	12	Pike	US 23 @ KY 2061 (Cowpen Rd)	3	3	3	8
75	12	Pike	US 23 @ Power Drive	3	3	1	2
77	5	Shelby	KY 53 & I-64 EB Ramp	4	2	2	2
78	5	Shelby	KY 55 @ KY 43/KY 2268	4	2	3	1
79	5	Shelby	US 60 @ KY 1848	2	5	0	2
80	5	Shelby	US 60 @ KY 1871 (Rocket Lane)	2	5	1	7
81	5	Spencer	KY 55/KY155 @ KYY 55/KY 1633	4	2	2	0
82	4	Taylor	KY 210 @ KY 3350	2	4	0	11
83	4	Taylor	KY 210 @ Lori West Drive/Jefra Avenue	3	3	2	0
84	4	Taylor	KY 3350 @ KY 527	2	4	0	1
85	1	Trigg	US 68 @ Broadbent Boulevard	2	4	0	1
87	3	Warren	US 231 @ McIntosh St.	4	2	3	5
89	3	Warren	US 31W @ Modern Way	3	3	3	11
90	3	Warren	US 31W @ W.H. Natcher NB Off Ramp	2	5	1	5
91	4	Washington	KY 555 @ KY 528	2	5	1	6
93	7	Woodford	KY 33 @ KY 2113	3	3	0	1
94	7	Woodford	US 62 @ KY 2113	3	3	0	0
95	9	Boyd	US 60 @ KY 1012	3	3	3	5

APPENDIX B-4. FATAL AND INJURY CRASHES BEFORE AND AFTER SIGNALS WERE ADDED (BY LOCATION)

ID	District	County	Intersection	Years	Years	Number of Crashes	
				Before	After	Before	After
2	7	Anderson	US 62 @ Robert B. Turner/Westwood	3	3	0	0
3	3	Barren	US 68 @ Scottie Drive	4	2	3	0
4	11	Bell	KY 74 @ 21st Street	4	2	4	0
5	6	Boone	KY 237 @ I275 Eastbound Ramps	3	3	1	4
6	6	Boone	KY 237 @ Rogers Lane	2	4	2	2
7	6	Boone	KY 842 @ Merchants St.	3	3	1	4
8	7	Boyle	US 150B @ Daniel Drive	2	4	1	0
9	10	Breathitt	KY 1812/ KY3068 @ Washington Avenue	4	3	1	1
10	1	Calloway	KY 121 @ KY 774	2	4	7	1
12	6	Carroll	KY 227 @ KY 36	4	2	6	0
13	2	Christian	KY 1682 @ KY 109 (Dawson Springs Road)	2	4	1	0
14	2	Christian	US 41 @ Murray State Ext. Campus Ent.	3	3	0	1
15	2	Christian	US 41A @ Bradford Square Mall North Entrance	4	2	1	0
16	2	Christian	US 41A @ Gate 7 (Cole Road)	4	2	7	2
19	2	Daviess	KY 2698 (Carter Rd.) @ Unifirst Drive	3	2	2	1
20	2	Daviess	KY 2698 (Carter Road) @ Tamarck Road	4	3	0	1
22	7	Fayette	KY 1927 @ Fortune Drive	2	4	4	1
23	7	Fayette	US 25 @ Sandersville Road	2	4	1	3
24	7	Fayette	US 27 @ Old Paris Pike	3	3		12
25	7	Fayette	US 421 @ Ruffian Way/McConnells Trace	2	4	1	1
26	7	Fayette	US 60 @ KY 1425	2	4	0	3
27	7	Fayette	US 68 @ 1267 (Military Pike)	3	3	11	1
33	9	Greenup	KY 207 @ Wilkerson Street/Riddle Street	2	4	0	0
34	4	Hardin	KY 251 @ Panther Lane/St James Street	2	5	3	1
36	4	Hardin	KY 3005 @ Nightingale Drive	3	3	7	0
38	2	Henderson	KY 425 @ US 41A	4	2	5	1
41	5	Jefferson	KY 1230 @ KY 1934	4	2	9	0
45	5	Jefferson	KY 3084 (Old Henry Rd.) @ Nelson Miller Pkwy.	4	4	0	0
48	5	Jefferson	KY 913 (Blankenbaker) @ Plantside Drive	2	4	4	6
49	5	Jefferson	US 42 @ KY 329	4	3	3	0
50	7	Jessamine	US 27 @ Commerce Drive	3	3	8	13
51	7	Jessamine	US 68 @ Windhaven Dr/Bellerive Blvd.	4	3	1	1
52	12	Johnson	KY 321 @ Federal Drive/Johnson Central High	3	3	4	4
56	6	Kenton	KY 17 @ Rolling Ridge	4	2	2	2
57	11	Knox	US 25E @ Kroger/Goody's Entrance	3	3	12	1
58	12	Lawrence	US 23 @ KY 2565	4	2	8	1
59	7	Madison	KY 52 @ KY 977	2	4	6	3
60	7	Madison	US 25 (Richmond Bypass) @ KY 1986	3	3	3	7
61	7	Madison	US 25X @ Boggs Lane/Morrow Drive	2	3	1	3
62	4	Marion	US 68 @ Warehouse Drive	4	2	0	0
63	1	McCracken	KY 1954 @ I-24 EB Ramp	4	2	10	2
65	1	McCracken	US 62 & HOLT ROAD	3	2	6	4
66	4	Meade	US 60 @ KY 144	4	2	13	1
67	7	Montgomery	KY 686 (Mt. Sterling Bp) @ Old Owingsville Rd	3	3	5	4
68	2	Muhlenburg	KY 189 @ KY 1380/Cleaton Road	3	2	1	0
70	5	Oldham	US 42 @ Ridgemoor/High Meadows Pike	3	3	4	2
71	12	Pike	KY 1426 @ Pikeville Methodist Hospital	3	3	4	3
72	12	Pike	US 119 @ KY 308	4	2	1	2
73	12	Pike	US 23 @ BB&T entrance	3	3	2	4
74	12	Pike	US 23 @ KY 2061 (Cowpen Rd)	3	3	2	3
75	12	Pike	US 23 @ Power Drive	3	3	2	1
77	5	Shelby	KY 53 & I-64 EB Ramp	4	2	5	0
78	5	Shelby	KY 55 @ KY 43/KY 2268	4	2	5	4
79	5	Shelby	US 60 @ KY 1848	2	5	4	4
80	5	Shelby	US 60 @ KY 1871 (Rocket Lane)	2	5	2	3
81	5	Spencer	KY 55/KY155 @ KYY 55/KY 1633	4	2	7	0
82	4	Taylor	KY 210 @ KY 3350	2	4	0	4
83	4	Taylor	KY 210 @ Lori West Drive/Jefra Avenue	3	3	0	1
84	4	Taylor	KY 3350 @ KY 527	2	4	0	0
85	1	Trigg	US 68 @ Broadbent Boulevard	2	4	2	4
87	3	Warren	US 231 @ McIntosh St.	4	2	6	0
89	3	Warren	US 31W @ Modern Way	3	3	2	6
90	3	Warren	US 31W @ W.H. Natcher NB Off Ramp	2	5	3	2
91	4	Washington	KY 555 @ KY 528	2	5	6	2
93	7	Woodford	KY 33 @ KY 2113	3	3	0	1
94	7	Woodford	US 62 @ KY 2113	3	3	0	0
95	9	Boyd	US 60 @ KY 1012	3	3	6	1

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