Research Report
KTC-01-01/SPR219-00-1I

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SAFETY IMPACTS OF RURAL ROAD CONSTRUCTION

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SAFETY IMPACTS OF RURAL ROAD CONSTRUCTION

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in cooperation with

Kentucky Transportation Cabinet
Commonwealth of Kentucky

and

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EXECUTIVE SUMMARY

Crash data in Kentucky show that the fatal crash rate on two-lane rural roads is substantially higher than on any other type of road. Improvements have been proposed at some locations on this type of road which involve either upgrading the existing two-lane road or adding lanes resulting in a four-lane road. As part of the public information process, highway officials have been asked to document the previous results of this type of construction. The objectives of this study were to: 1) identify sections of two-lane rural roadways where either the two-lane road had been realigned and reconstructed or additional lanes had been added and 2) conduct a before-and-after analysis to determine how these changes affected traffic crashes.

Of the 49 locations included in the study, 25 involved adding lanes and converting to a four-lane road while the two-lane road was upgraded (realignment with wider lanes and shoulders) at 24 locations. Before the construction, the average traffic volume was almost three times higher on the roads where additional lanes were added than where the two-lane road was upgraded. The average daily traffic increased dramatically after the construction was completed with a slightly higher increase for roads where lanes were added.

When all the locations are considered, there was a 51 percent reduction in the crash rate when the road was upgraded and a 56 percent reduction in the crash rate when lanes were added. The rate was reduced from 250 to 122 crashes/100 million vehicle miles (MVM) when the road was upgraded and from 258 to 114 crashes/100 MVM when lanes were added. When only the number of crashes is considered, the number of crashes per mile decreased by 39 percent when the road was upgraded and by 45 percent when lanes were added. The rate of injury or fatal crashes was reduced by 54 percent for upgrading the road and 55 percent by adding lanes while the number of crashes per mile decreased by 43 percent both when the road was upgraded and when lanes were added.

The overall conclusion of the study is that both upgrading two-lane rural roads and converting the road to four lanes are effective methods of reducing total crashes and injury or fatal crashes. The traffic volume would determine the appropriate alternative.

1.0 INTRODUCTION

Traffic volumes have increased on all types of roads. On many two-lane rural roads, the combination of the increase in traffic volumes and less than optimum roadway alignment and cross-section have led to increased congestion and crashes. Crash data in Kentucky show that the fatal crash rate on two-lane rural roads is substantially higher than on any other type of road (1). Data for Kentucky for 1995 through 1999 showed a rate of 3.1 fatal crashes per 100 million vehicle miles (100 MVM) for state maintained two-lane rural roads. The next highest rate for any highway type was 1.7 fatal crashes per 100 MVM for four-lane divided (non-interstate and parkway) rural roadways. Also, the total crash rate on four-lane divided (non-interstate and parkway) rural roads was approximately 50 percent lower than for two-lane rural roads (1).

Highway agencies have proposed improvements to some of these two-lane rural roads with the objective of reducing crashes and congestion. The possible improvements typically involve either: a) major revisions to the existing two-lane roadway (usually involving realignment with wider lanes and shoulders and wider clear zones) or b) adding lanes making a four-lane road. However, in some cases, residents have questioned realignments and adding lanes with the argument that the changes may increase traffic volumes and travel speeds and result in more crashes. Highway officials have been asked to document the previous results of these types of construction.

Recent work in this area noted the lack of before-and-after studies documenting the results of conversions of two-lane rural roads to a four-lane roadway (2). Computer models have been used which resulted in estimates of a 40 to 60 percent crash reduction for conversion of a two-lane highway to a four-lane divided highway. Previous research has estimated reduction factors to apply for various types of countermeasures. A 50 percent reduction in crashes was estimated for construction or reconstruction which involved modifying the roadway's horizontal and vertical alignment (3).

The objectives of this study were to: 1) identify sections of two-lane rural roadways where the two-lane road had either been realigned and reconstructed or additional lanes had been constructed resulting in a four-lane road and 2) conduct before-and-after studies to determine the effects of these changes on the number and rate of crashes.

2.0 PROCEDURE

The first phase of the study was to identify reconstructed sections of rural highway which could be used in the analysis. Kentucky is divided into 12 highway districts. A survey was sent to each district asking for a list of sections of roadway in their area which could be included as case studies. The information requested included: the location of the construction (county, route, beginning and ending milepoints), the year the construction began and ended, and the number of lanes before and after construction. A statewide list of all major construction projects started since about 1990 was also obtained and used along with the district surveys.

After the surveys were returned, each district was visited and/or contacted to determine specific information about each project. For example, the length of the section was typically changed by a small amount as a result of the construction. Beginning and ending milepoints both before and after construction had to be determined for use in the analysis. The dates the construction started and when traffic started to use the road were also verified. The information from the central file containing all construction projects in the state was used along with information obtained from each district.

Computer records of statewide crash data were available for 1987 through 1999. Therefore, the starting and ending dates of the construction had to fall within certain time periods to allow for the collection of before-and-after data. In most cases, three years of before-and-after crash data were used. Two years were used in several instances with only one year before and after construction used in a very few cases.

Traffic volumes had to be determined to calculate rates. Volume data were obtained from a file which contained volumes for several years. The volume data were defined by county, route, and milepoint. The volume along a section of roadway would generally vary. An average volume for the section was obtained by factoring the volumes and the length of roadway to which it applied.

The before-and-after analysis included a comparison of total crashes, injury and fatal crashes, and other characteristics such as accident type and contributing factors. Crash rates were calculated to determine the change resulting from the reconstruction.

3.0 RESULTS

Contacts with the districts resulted in identifying 49 case studies which could be used in the analysis. Data relating to the 49 sections of road at which construction projects were identified are presented in Table 1. The data include the county, route, before-and-after milepoints, construction time period, number of years of before-and-after crash data, and before-and-after traffic volumes.

The sites were divided into the categories of: a) converting a two-lane to a four-lane roadway and b) upgrading the two-lane roadway. Changing to a four-lane road would involve a divided roadway. Upgrading the road would typically involve revising the grade and curvature and providing 12-foot lanes and full-width shoulders and a wider clear zone. Of the 49 locations, 25 involved adding lanes while 24 involved upgrading the two-lane road. The locations were either isolated sections where improvements were made or portions of an larger construction project which extended over a long length of road.

It was necessary to determine, as accurately as possible: a) the dates when construction began and when the road was opened to traffic and b) the start and end locations of each project. In many instances, the beginning and ending milepoints changed slightly after construction. Since crash data are located using milepoints, accurate milepoint data were necessary. The total length of these sections was about 86 miles where the two-lane road was changed to a four-lane road and about 80 miles where the two-lane road was upgraded. Considering all the locations, the data represent 131 years of before-and-after crash history (as shown by the time period data given in Table 1).

A summary of the total number of crashes before and after the construction is given in Table 2. For each location, the length (specified by the milepoint range), average traffic volume, vehicle miles traveled (100 MVM) over the section, total crashes, and rate (crashes/100 MVM) are given for the before-and-after time periods. The lengths of these time periods are given. The percent change in the crash rate in the after period, compared to the before period, is given. When all the locations are considered, there was a 51 percent reduction in the crash rate when the road was upgraded and a 56 percent reduction in the crash rate when lanes were added. The crash rate was reduced after construction at all but three of the 49 locations. The numbers of crashes were low at these locations. There were a few other locations where the number of crashes was higher after construction but the rate was generally lower after construction so the increase in crashes typically would be related to an increase in traffic volume. There was a small increase in crashes at a few locations which typically only had a very low number of crashes.

The rate was reduced from 250 to 122 crashes/100 MVM when the two-lane road was upgraded and from 258 to 114 crashes/100 MVM when lanes were added. This compares to statewide rates of 252 crashes/100 MVM for two-lane rural roads and 119 crashes/100 MVM for four-lane divided (non-interstate or parkway) rural roads (1). The data show that, before construction, the rates for the two-lane rural roads in this study were very similar to the average statewide rate for that type of road. When the road was changed to a four-lane facility, the overall rate was lowered to a level very close to the statewide rate for this type of road. The rate for the roads which were upgraded, but remained two lanes, was reduced to a level only seven percent above that for the roads which were changed to four lanes which is about one-half the statewide rate for two-lane rural roads.

Before the construction, the average traffic volume was almost three times higher on the roads where additional lanes were added than where the two-lane road was upgraded. The average daily traffic increased dramatically after the construction was completed with a slightly higher increase for roads where lanes were added. The large increase in average daily traffic after the improvements was due to the number of years between the before-and-after volume data. There was usually five to six years between the middle of the before and after time periods. When the number of years between the time periods was considered, the annual increase in traffic volume was about five percent.

The decrease in crash rates was due to a combination of a reduction in number of crashes and an increase in traffic volume. When only the number of crashes is considered, the number of crashes per mile decreased by 39 percent when the road was upgraded and by 45 percent when lanes were added.

The improvements involved both isolated locations and connecting onto longer sections of road where construction had previously been completed. An example of an isolated location is a section of US 119 in Pike County where an approximate three-mile section of two-lane road over a mountain was replaced with a four-lane road. The two-lane road had very sharp curves and steep grades with a large amount of coal truck traffic. The number of crashes in the three years before and after construction was reduced from 72 before to 11 after with the rate reduced 86 percent. An example of extending a four-lane section of road is US 27 south of Nicholasville where almost five miles of road was changed from two to four lanes and connected to the existing four-lane bypass. The number of crashes in the two years before and after construction was reduced from 130 to 85 with the rate reduced 52 percent.

A summary of the total number of injury and fatal crashes before and after construction is given in Table 3. The same types of data are given as for Table 2 with the difference that the crashes involve those in which there was an injury or fatality. When all the locations are considered, there was a 54 percent reduction in the injury/fatal crash rate when the two-lane road was upgraded and a 55 percent reduction in the injury/fatal crash rate when lanes were added.

The percent of crashes involving an injury or fatality changed from 42 percent before to 39 percent after for the upgraded sites and from 36 percent before to 37 percent after for the sites with lanes added. This shows the percentage of crashes involving an injury or fatality did not substantially change as a result of the construction. Considering all data, 34 percent of the crashes involved an injury while 0.9 percent involved a fatality.

There was a decrease of from 19 to 13 fatal crashes at the locations where lanes were added and a decrease of from 4 to 2 fatal crashes at the locations where the road was upgraded. The fatal rate at all locations decreased from 2.23 crashes/100MVM before to 1.16 crashes /100MVM after construction for a decrease of 48 percent.

The injury/fatal rate was reduced from 104 to 48 crashes/100 MVM when the two-lane road was upgraded and from 93 to 42 crashes/100 MVM when lanes were added. This compares to statewide injury/fatal rates of 93 crashes/100 MVM for two-lane rural roads and 44 crashes/100 MVM for four-lane divided (non-interstate or parkway) rural roads (1). The data show that, before construction, the rates for the roads in this study were very similar to the statewide average rate. When the roads were changed to a four-lane facility, the overall rate was lowered to a level very close to the statewide rate for this type of road. When the road was upgraded, this rate was reduced to about one-half the statewide rate for two-lane rural roads.

Injury/fatal crash rates increased at 6 of the 49 locations after the construction. The rate for the roads which were upgraded but remained two lanes was reduced to a level only 14 percent above that for the roads which were changed to four lanes. As previously noted, the decrease in rates was due to a combination of a reduction in number of crashes and an increase in traffic volume. When only the number of crashes is considered, the number of crashes per mile decreased by 43 percent both when the road was upgraded and when lanes were added.

An analysis of the characteristics of the crashes is presented in Table 4. Data concerning the type of crash, directional analysis (which is a more detailed description the type of crash), light condition, road surface condition, human contributing factors, and environmental contributing factors are given. The most common type of crash involved a collision with another motor vehicle with the rates decreasing for all types of crashes. The distribution of the crashes by general type of crash did not change substantially. While the rates for crashes at intersections decreased after the construction projects, the percentage of crashes which occurred at an intersection increased due primarily to the increase in the percentage of angle collisions.

The decrease in the rate of crashes during darkness was similar with that for all crashes with a larger decrease in the rate when the road surface was wet or snow covered. The rate and percentage of crashes involving unsafe speed decreased dramatically. This contradicts the theory that the improved roadway geometrics would result in higher speeds which would then cause crashes. While speeds would logically increase on the new roads, the design of the road would allow for the road to be driven safely at higher speeds. The percentage of crashes in which a driver failed to yield the right of way increased when lanes were added. Considering all the types of factors included in the environmental area, the percentage of crashes involving an environmental factor decreased (due primarily to a decrease in crashes involving a slippery surface) but crashes involving an animal action (primarily deer collisions) increased.

4.0 CONCLUSIONS

The comparisons of crash data before and after reconstruction of two-lane rural roadways showed that a substantial reduction in the number and rate of crashes resulted from the construction. When all the locations are considered, there was a 51 percent reduction in the crash rate when the two-lane road was upgraded (realignment with wider lanes and shoulders and a wider clear zone) and a 56 percent reduction in the crash rate when the two-lane road was converted to four lanes. The rate was reduced from 250 to 122 crashes/100 MVM when the two-lane road was upgraded and from 258 to 114 crashes/100 MVM when lanes were added. When only the number of crashes was considered, the number of crashes per mile decreased by 39 percent when the road was upgraded and by 45 percent when lanes were added. The rate of injury or fatal crashes was reduced by 54 percent when upgrading the road and 55 percent when adding lanes with the number of crashes per mile decreased by 43 percent both when the road was upgraded and when lanes were added.

The overall conclusion of the study is that both: a) upgrading two-lane rural roads through realignment and wider lanes, shoulders, and clear zones and b) converting the road to four lanes are effective methods of reducing the number and rate of total crashes as well as injury or fatal crashes. The traffic volume would determine the appropriate alternative with four lanes necessary as traffic volumes increase. Before the construction at the case study locations, the average traffic volume was almost three times higher on the roads where additional lanes were added than where the two-lane road was upgraded.

5.0 REFERENCES

1. Agent, K.R. and Pigman, J.G.; "Analysis of Traffic Accident Data in Kentucky (1995-1999)," Kentucky Transportation Center, University of Kentucky, KTC-00-17, September 2000.

2. Council, F.M. and Stewart, J.R.; "Safety Effects of the Conversion of Rural Two-Lane to Four-Lane Roadways Based on Cross-Sectional Models," Transportation Research Board Record 1665, October 1999.

3. Agent, K.R.; Stamatiadis, N.; and Jones, S.; "Development of Accident Reduction Factors," University of Kentucky, KTC-96-13, June 1996.

Table 1. Summary of Highway Construction Locations

County	Route	Milepoint Range Before	Milepoint Range After	Construction Period	Time Before/ After Data (Yrs)	Average Daily Traffic Before	Average Daily Traffic After
Converting from two to four lanes							
Anderson	US 127 B	0.0-6.831	0.0-6.656	1990-1992	3	8,838	14,041
Anderson	US 127	9.161-11.789	8.9-11.12	1990-1992	3	6,410	5,790
Bell	US 25 E	14.481-19.473	14.481-18.711	1992-1995	3	7,540	9,500
Boyle	US 127	0.0-2.972	0.314-3.443	1992-1994	3	9,369	12,546
Bullitt	US 31 E	3.2-5.465	3.2-5.185	1992-1996	3	10,200	13,580
Christian	US 68	7.3-8.75	7.3-8.75	1995-1997	2	5,900	6,900
Daviess	US 60	19.332-23.558	19.326-23.842	1994-1997	2	10,219	15,539
Floyd	US 23	21.297-23.801	20.445-21.878	1991-1994	3	10,200	12,600
Floyd	US 23	18.153-21.296	17.489-20.444	1991-1993	3	14,500	15,700
Franklin	US 127	0.0-3.881	0.0-3.881	1990-1993	3	9,958	15,304
Hardin	US 62	10.8-14.56	10.8-14.56	1991-1992	3	5,001	7,000
Hardin	US 62	14.57-17.5	14.57-17.5	1991-1992	3	10,572	15,539
Hardin	KY 3005	5.926-8.674	5.926-8.674	1995-1996	3	7,380	11,600
Jefferson	US 31 E	0.0-4.325	0.0-4.325	1995-1998	1	18,453	22,244
Jessamine	US 27	1.179-5.803	1.179-6.008	1995-1997	2	15,985	20,869
Johnson	US 23	4.322-8.7	2.508-7.095	1993-1996	3	11,297	12,164
Johnson	US 23	0.0-4.321	0.0-2.507	1992-1996	3	9,233	13,000
Knox	US 25 E	0.0-5.1	0.0-4.9	1991-1995	3	6,475	9,198
Logan	US 68	19.139-22.159	19.139-22.091	1991-1995	3	5,740	8,133
Logan	US 68	22.16-26.567	22.092-26.733	1992-1996	3	5,538	8,084
Pike	US 23	16.267-21.56	16.267-20.295	1989-1992	3	8,300	12,150
Pike	US 119	12.0-15.0	11.965-14.86	1993-1997	3	6,430	7,530
Trigg	US 68	20.506-24.266	20.74-24.5	1993-1994	3	5,821	8,559
Trigg	US 68	24.267-26.266	24.501-26.5	1995-1997	2	4,882	5,191
Warren	US 68	0.0-5.0	0.0-5.0	1993-1996	3	5,734	6,544

Table 1. Summary of Highway Construction Locations (continued)

County	Route	Milepoint Range Before	Milepoint Range After	Construction Period	Time Before/ After Data (Yrs)	Average Daily Traffic Before	Average Daily Traffic After
Upgrading Two-Lane Roadway							
Bath	KY 11	11-12.749	11-12.783	1993-1994	3	1,100	1,560
Boone	KY 338	4.613-7.961	4.613-7.961	1995-1997	2	1,680	1,850
Boyle	KY 34	16.117-17.274	16.117-17.77	1991-1992	3	6,412	6,618
Bracken	KY 19	10.9-12.3	10.9-12.3	1992-1993	3	846	1,170
Bullitt	US 31 E	0-3.1	0-3.1	1997-1998	1	6,645	6,852
Casey	US 127	0-3.452	0-3.452	1991-1993	3	2,220	2,582
Casey	US 127	6.266-7.478	6.266-7.478	1991-1992	3	2,037	3,375
Casey	US 127	9.957-11.898	9.957-11.898	1991-1993	3	2,770	3,600
Fleming	KY 11	0-2.8	0-2.6	1993-1994	3	1,120	1,310
Franklin	US 127	10.979-22.452	10.979-21.507	1992-1997	2	3,075	3,521
Garrard	KY 34	0-2.724	0-1.610	1991-1992	3	5,040	6,550
Green	US 68	16.3-18.411	16.3-18.411	1995-1997	2	5,150	6,960
Green	US 68	8.194-9.796	8.194-9.796	1991-1993	3	2,610	3,370
Green	US 68	9.796-11.344	9.796-11.344	1994-1995	3	2,610	3,370
Harlan	KY 38	4.733-6.658	4.233-6.658	1993-1994	3	6,680	8,610
Harrison	US 62	1.3-5.5	1.3-5.5	1992-1993	3	2,020	3,830
Lincoln	US 127	3.208-11.61	3.208-10.847	1991-1993	3	4,127	5,197
Marion	US 68	20.6-22.4	20.6-22.4	1993-1994	3	1,520	1,770
Marion	US 68	16.8-18.4	16.8-18.4	1992-1993	3	1,520	1,770
Owen	US 127	0-3.4	0-3.4	1996-1998	1	2,500	2,680
Rowan	KY 801	11.671-14.768	11.6-14.583	1995-1997	2	1,151	2,868
Russell	US 127	19.967-26.998	19.8-26.927	1993-1994	3	2,860	3,133
Taylor	US 68	0-3.475	0-3.475	1995-1997	2	6,101	7,242
Washington	US 150	12.738-19.797	12.738-19.797	1995-1997	2	1,955	2,204

Table 2. Before and After Crash Data

County	Route	Milepoint Range Before	Milepoint Range After	Average Daily Traffic Before	Average Daily Traffic After	100MVM * Before	100MVM * After	Before/After Time (yrs)	Total Crashes Before	Total Crashes After	Rate(/100MVM) Before	Rate(/100MVM) After	Percent Reduction
Converting from two to four lanes													
Anderson	US 127 B	0.0-6.831	0.0-6.656	8,838	14,041	0.6611	1.0234	3	136	86	206	84	59
Anderson	US 127	9.161-11.789	8.9-11.12	6,410	5,790	0.1845	0.1407	3	18	18	98	128	-31
Bell	US 25 E	14.481-19.473	14.481-18.711	7,540	9,500	0.4122	0.4400	3	42	34	102	77	24
Boyle	US 127	0.0-2.972	0.314-3.443	9,369	12,546	0.3049	0.4299	3	163	184	535	428	20
Bullitt	US 31 E	3.2-5.465	3.2-5.185	10,200	13,580	0.2530	0.2952	3	165	47	652	159	76
Christian	US 68	7.3-8.75	7.3-8.75	5,900	6,900	0.0625	0.0730	2	12	12	192	164	14
Daviess	US 60	19.332-23.558	19.326-23.842	10,219	15,539	0.3153	0.5123	2	41	32	130	62	52
Floyd	US 23	21.297-23.801	20.445-21.878	10,200	12,600	0.2797	0.1977	3	79	38	282	192	32
Floyd	US 23	18.153-21.296	17.489-20.444	14,500	15,700	0.4990	0.5080	3	81	35	162	69	58
Franklin	US 127	0.0-3.881	0.0-3.881	9,958	15,304	0.4232	0.6504	3	200	76	473	117	75
Hardin	US 62	10.8-14.56	10.8-14.56	5,001	7,000	0.2059	0.2882	3	47	26	228	90	60
Hardin	US 62	14.57-17.5	14.57-17.5	10,572	15,539	0.3392	0.4985	3	122	126	360	253	30
Hardin	KY 3005	5.926-8.674	5.926-8.674	7,380	11,600	0.2221	0.3491	3	68	51	306	146	52
Jefferson	US 31 E	0.0-4.325	0.0-4.325	18,453	22,244	0.2913	0.3511	1	60	17	206	48	76
Jessamine	US 27	1.179-5.803	1.179-6.008	15,985	20,869	0.5396	0.7357	2	130	85	241	116	52
Johnson	US 23	4.322-8.7	2.508-7.095	11,297	12,164	0.5416	0.6110	3	96	25	177	41	77
Johnson	US 23	0.0-4.321	0.0-2.507	9,233	13,000	0.4369	0.3569	3	77	13	176	36	79
Knox	US 25 E	0.0-5.1	0.0-4.9	6,475	9,198	0.3616	0.4935	3	79	41	218	83	62
Logan	US 68	19.139-22.159	19.139-22.091	5,740	8,133	0.1898	0.2629	3	39	44	205	167	19
Logan	US 68	22.16-26.567	22.092-26.733	5,538	8,084	0.2672	0.4108	3	36	31	135	75	44
Pike	US 23	16.267-21.56	16.267-20.295	8,300	12,150	0.4811	0.5359	3	180	35	374	65	83
Pike	US 119	12.0-15.0	11.965-14.86	6,430	7,530	0.2112	0.2387	3	72	11	341	46	86
Trigg	US 68	20.506-24.266	20.74-24.5	5,821	8,559	0.2397	0.3524	3	67	51	280	145	48
Trigg	US 68	24.267-26.266	24.501-26.5	4,882	5,191	0.0712	0.0758	2	6	3	84	40	53
Warren	US 68	0.0-5.0	0.0-5.0	5,734	6,544	0.3139	0.3583	3	78	37	248	103	58
All				8,799	11,572	8.1074	10.1893		2094	1158	258	114	56

***** 100 million vehicle miles traveled over milepoint range in before or after time period

Table 2. Before and After Crash Data (continued)

County	Route	Milepoint Range Before	Milepoint Range After	Average Daily Traffic Before	Average Daily Traffic After	100MVM * Before	100MVM * After	Before/After Time (yrs)	Total Crashes Before	Total Crashes After	Rate(/100MVM) Before	Rate(/100MVM) After	Percent Reduction
Upgrading two-lane roadway													
Bath	KY 11	11-12.749	11-12.783	1,100	1,560	0.0211	0.0305	3	10	3	475	98	79
Boone	KY 338	4.613-7.961	4.613-7.961	1,680	1,850	0.0411	0.0452	2	8	16	195	354	-82
Boyle	KY 34	16.117-17.274	16.117-17.77	6,412	6,618	0.0812	0.1198	3	16	11	197	92	53
Bracken	KY 19	10.9-12.3	10.9-12.3	846	1,170	0.0130	0.0179	3	4	6	308	335	-8
Bullitt	US 31 E	0-3.1	0-3.1	6,645	6,852	0.0752	0.0775	1	22	9	293	116	60
Casey	US 127	0-3.452	0-3.452	2,220	2,582	0.0839	0.0976	3	22	7	262	72	73
Casey	US 127	6.266-7.478	6.266-7.478	2,037	3,375	0.0270	0.0448	3	10	1	370	22	94
Casey	US 127	9.957-11.898	9.957-11.898	2,770	3,600	0.0589	0.0765	3	8	0	136	0	100
Fleming	KY 11	0-2.8	0-2.6	1,120	1,310	0.0343	0.0373	3	25	26	728	697	4
Franklin	US 127	10.979-22.452	10.979-21.507	3,075	3,521	0.2575	0.2706	2	83	39	322	144	55
Garrard	KY 34	0-2.724	0-1.610	5,040	6,550	0.1503	0.1155	3	27	2	180	17	90
Green	US 68	16.3-18.411	16.3-18.411	5,150	6,960	0.0794	0.1073	2	17	10	214	93	56
Green	US 68	8.194-9.796	8.194-9.796	2,610	3,370	0.0458	0.0591	3	8	9	175	152	13
Green	US 68	9.796-11.344	9.796-11.344	2,610	3,370	0.0442	0.0571	3	16	8	362	140	61
Harlan	KY 38	4.733-6.658	4.233-6.658	6,680	8,610	0.1408	0.2286	3	41	55	291	241	17
Harrison	US 62	1.3-5.5	1.3-5.5	2,020	3,830	0.0929	0.1761	3	40	12	431	68	84
Lincoln	US 127	3.208-11.61	3.208-10.847	4,127	5,197	0.3797	0.4347	3	106	40	279	92	67
Marion	US 68	20.6-22.4	20.6-22.4	1,520	1,770	0.0300	0.0349	3	4	4	134	115	14
Marion	US 68	16.8-18.4	16.8-18.4	1,520	1,770	0.0266	0.0310	3	5	7	188	226	-20
Owen	US 127	0-3.4	0-3.4	2,500	2,680	0.0310	0.0333	1	1	0	32	0	100
Rowan	KY 801	11.671-14.768	11.6-14.583	1,151	2,868	0.0260	0.0625	2	8	17	307	272	11
Russell	US 127	19.967-26.998	19.8-26.927	2,860	3,133	0.2202	0.2445	3	42	25	191	102	46
Taylor	US 68	0-3.475	0-3.475	6,101	7,242	0.1548	0.1837	2	21	13	136	71	48
Washington	US 150	12.738-19.797	12.738-19.797	1,955	2,204	0.1007	0.1136	2	10	10	99	88	11
All				3,073	3,833	2.2157	2.6996		554	330	250	122	51

***** 100 million vehicle miles traveled over milepoint range in before or after time period

Table 3. Before and After Injury and Fatal Crash Data

County	Route	Milepoint Range		Average Daily Traffic		100MVM *		Before/After	Fatal/Injury Crashes		Rate(/100MVM)		Percent
		Before	After	Before	After	Before	After	Time (yrs)	Before	After	Before	After	Reduction
Converting from two to four lanes													
Anderson	US 127 B	0.0-6.831	0.0-6.656	8,838	14,041	0.6611	1.0234	3	50	38	76	37	51
Anderson	US 127	9.161-11.789	8.9-11.12	6,410	5,790	0.1845	0.1407	3	5	8	27	57	-110
Bell	US 25 E	14.481-19.473	14.481-18.711	7,540	9,500	0.4122	0.4400	3	15	13	36	30	19
Boyle	US 127	0.0-2.972	0.314-3.443	9,369	12,546	0.3049	0.4299	3	51	54	167	126	25
Bullitt	US 31 E	3.2-5.465	3.2-5.185	10,200	13,580	0.2530	0.2952	3	48	15	190	51	73
Christian	US 68	7.3-8.75	7.3-8.75	5,900	6,900	0.0625	0.0730	2	4	6	64	82	-28
Daviess	US 60	19.332-23.558	19.326-23.842	10,219	15,539	0.3153	0.5123	2	16	15	51	29	42
Floyd	US 23	21.297-23.801	20.445-21.878	10,200	12,600	0.2797	0.1977	3	41	24	147	121	17
Floyd	US 23	18.153-21.296	17.489-20.444	14,500	15,700	0.4990	0.5080	3	32	22	64	43	32
Franklin	US 127	0.0-3.881	0.0-3.881	9,958	15,304	0.4232	0.6504	3	64	33	151	51	66
Hardin	US 62	10.8-14.56	10.8-14.56	5,001	7,000	0.2059	0.2882	3	19	8	92	28	70
Hardin	US 62	14.57-17.5	14.57-17.5	10,572	15,539	0.3392	0.4985	3	31	39	91	78	14
Hardin	KY 3005	5.926-8.674	5.926-8.674	7,380	11,600	0.2221	0.3491	3	18	9	81	26	68
Jefferson	US 31 E	0.0-4.325	0.0-4.325	18,453	22,244	0.2913	0.3511	1	20	5	69	14	79
Jessamine	US 27	1.179-5.803	1.179-6.008	15,985	20,869	0.5396	0.7357	2	49	19	91	26	72
Johnson	US 23	4.322-8.7	2.508-7.095	11,297	12,164	0.5416	0.6110	3	40	14	74	23	69
Johnson	US 23	0.0-4.321	0.0-2.507	9,233	13,000	0.4369	0.3569	3	41	7	94	20	79
Knox	US 25 E	0.0-5.1	0.0-4.9	6,475	9,198	0.3616	0.4935	3	23	15	64	30	52
Logan	US 68	19.139-22.159	19.139-22.091	5,740	8,133	0.1898	0.2629	3	10	20	53	76	-44
Logan	US 68	22.16-26.567	22.092-26.733	5,538	8,084	0.2672	0.4108	3	16	5	60	12	80
Pike	US 23	16.267-21.56	16.267-20.295	8,300	12,150	0.4811	0.5359	3	75	21	156	39	75
Pike	US 119	12.0-15.0	11.965-14.86	6,430	7,530	0.2112	0.2387	3	24	8	114	34	71
Trigg	US 68	20.506-24.266	20.74-24.5	5,821	8,559	0.2397	0.3524	3	23	20	96	57	41
Trigg	US 68	24.267-26.266	24.501-26.5	4,882	5,191	0.0712	0.0758	2	4	3	56	40	29
Warren	US 68	0.0-5.0	0.0-5.0	5,734	6,544	0.3139	0.3583	3	34	9	108	25	77
All				8,799	11,572	8.1074	10.1893		753	430	93	42	55

* 100 million vehicle miles traveled over milepoint range in before or after time period

Table 3. Before and After Injury and Fatal Crash Data (continued)

County	Route	Milepoint Range Before	Milepoint Range After	Average Daily Traffic Before	Average Daily Traffic After	100MVM * Before	100MVM * After	Before/After Time (yrs)	Fatal/Injury Crashes Before	Fatal/Injury Crashes After	Rate(/100MVM) Before	Rate(/100MVM) After	Percent Reduction
Upgrading two-lane roadway													
Bath	KY 11	11-12.749	11-12.783	1,100	1,560	0.0211	0.0305	3	6	1	285	33	88
Boone	KY 338	4.613-7.961	4.613-7.961	1,680	1,850	0.0411	0.0452	2	6	9	146	199	-36
Boyle	KY 34	16.117-17.274	16.117-17.77	6,412	6,618	0.0812	0.1198	3	6	4	74	33	55
Bracken	KY 19	10.9-12.3	10.9-12.3	846	1,170	0.0130	0.0179	3	2	3	154	167	-8
Bullitt	US 31 E	0-3.1	0-3.1	6,645	6,852	0.0752	0.0775	1	7	3	93	39	58
Casey	US 127	0-3.452	0-3.452	2,220	2,582	0.0839	0.0976	3	11	6	131	61	53
Casey	US 127	6.266-7.478	6.266-7.478	2,037	3,375	0.0270	0.0448	3	5	1	185	22	88
Casey	US 127	9.957-11.898	9.957-11.898	2,770	3,600	0.0589	0.0765	3	6	0	102	0	100
Fleming	KY 11	0-2.8	0-2.6	1,120	1,310	0.0343	0.0373	3	9	8	262	215	18
Franklin	US 127	10.979-22.452	10.979-21.507	3,075	3,521	0.2575	0.2706	2	31	11	120	41	66
Garrard	KY 34	0-2.724	0-1.610	5,040	6,550	0.1503	0.1155	3	8	2	53	17	67
Green	US 68	16.3-18.411	16.3-18.411	5,150	6,960	0.0794	0.1073	2	6	4	76	37	51
Green	US 68	8.194-9.796	8.194-9.796	2,610	3,370	0.0458	0.0591	3	5	1	109	17	85
Green	US 68	9.796-11.344	9.796-11.344	2,610	3,370	0.0442	0.0571	3	5	4	113	70	38
Harlan	KY 38	4.733-6.658	4.233-6.658	6,680	8,610	0.1408	0.2286	3	19	24	135	105	22
Harrison	US 62	1.3-5.5	1.3-5.5	2,020	3,830	0.0929	0.1761	3	17	3	183	17	91
Lincoln	US 127	3.208-11.61	3.208-10.847	4,127	5,197	0.3797	0.4347	3	43	19	113	44	61
Marion	US 68	20.6-22.4	20.6-22.4	1,520	1,770	0.0300	0.0349	3	3	1	100	29	71
Marion	US 68	16.8-18.4	16.8-18.4	1,520	1,770	0.0266	0.0310	3	1	3	38	97	-158
Owen	US 127	0-3.4	0-3.4	2,500	2,680	0.0310	0.0333	1	1	0	32	0	100
Rowan	KY 801	11.671-14.768	11.6-14.583	1,151	2,868	0.0260	0.0625	2	5	6	192	96	50
Russell	US 127	19.967-26.998	19.8-26.927	2,860	3,133	0.2202	0.2445	3	16	8	73	33	55
Taylor	US 68	0-3.475	0-3.475	6,101	7,242	0.1548	0.1837	2	8	5	52	27	47
Washington	US 150	12.738-19.797	12.738-19.797	1,955	2,204	0.1007	0.1136	2	5	3	50	26	47
All				3,073	3,833	2.2157	2.6996		231	129	104	48	54

* 100 million vehicle miles traveled over milepoint range in before or after time period

Table 4. Detailed Analysis of Accident Charateristics

Construction Type	Characteristic	Description	Rate (100 MVM) Before	Rate (100 MVM) After	Percent Reduction	Percent Before	Percent After	Percent Reduction
Converting from Two- to Four-Lane								
Roadway	Type of Crash	Other motor vehicle	191	84	56	74	74	0
		Other collision (not-fixed)	4	2	54	2	2	-5
		Fixed object	55	23	58	21	20	5
		Non-collision	8	5	42	3	4	-31
	Directional Analysis	Intersection						
		Angle	30	27	10	12	24	-104
		Rear-end	24	12	53	9	10	-8
		All	71	47	33	27	42	-52
		Non-intersection						
		Rear-end	58	16	72	23	15	36
		Sideswipe	36	12	67	14	10	26
		Fixed object	26	7	74	10	6	40
		Ran off road	19	5	77	8	4	47
	Light Condition	Darkness	71	33	53	27	29	-7
	Road Surface	Wet	75	23	70	29	20	31
		Snow/ice/slush	9	3	61	3	3	11
		Unsafe Speed	31	8	74	12	7	41
	Human Contributing Factor	Failed to yield	49	30	39	19	26	-38
		Following too closely	19	6	71	7	5	34
		Improper passing	8	1	90	3	1	76
		Alcohol	14	4	74	5	3	40
		Driver inattention	75	38	49	29	34	-16
	Environmental Contributing Factor	All	78	28	64	30	25	17
		Animal action	11	10	11	4	9	-100
		View limited	9	5	50	4	4	-14
		Slippery surface	42	8	81	16	7	55
		Waterpooling	7	2	78	3	1	40

Table 4. Detailed Analysis of Accident Charateristics (continued)

Construction Type	Characteristic	Description	Rate (100 MVM) Before	Rate (100 MVM) After	Percent Reduction	Percent Before	Percent After	Percent Reduction
Upgrading Two-Lane Roadway	Type of Crash	Other motor vehicle	131	74	44	52	60	-15
		Other collision (not-fixed)	7	1	85	3	1	69
		Fixed object	96	38	60	38	31	18
		Non-collision	16	9	43	6	8	-17
	Directional Analysis	Intersection						
		Angle	16	15	4	6	12	-97
		Rear-end	14	6	55	6	5	8
		All	49	29	41	19	24	-21
		Non-intersection						
		Rear-end	32	17	46	13	14	-10
		Sideswipe	31	18	42	12	15	-19
		Fixed object	57	15	74	23	12	47
		Ran off road	28	11	60	11	9	17
	Light Condition	Darkness	96	41	57	38	34	13
	Road Surface	Wet	75	22	71	30	18	40
		Snow/ice/slush	15	6	59	6	5	16
	Human Contributing Factor	Unsafe Speed	34	11	67	14	9	32
		Failed to yield	38	19	51	15	15	0
		Following too closely	11	5	52	4	4	2
		Improper passing	9	4	48	3	4	-6
		Alcohol	18	8	57	7	6	12
		Driver inattention	70	34	51	28	28	-1
	Environmental Contributing Factor	All	88	37	58	35	30	14
		Animal action	14	16	-16	5	13	-135
		View limited	8	4	47	3	3	-6
		Slippery surface	43	12	72	17	10	44
		Waterpooling	2	1	52	1	1	0