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<td>In order to use the cost-optimization procedure of dynamic programming to rank safety improvements, improvement costs and benefits must be input. The benefits are in terms of accident reductions resulting from specific safety improvements. In this study a comprehensive list of accident reduction factors were developed to use in the cost-optimization program. The development of the list of reduction factors was based mainly on a review of literature and survey of states, with limited input from a before-and-after accident analysis.</td>
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Form DOT F 1700.7 (8-72) Reproduction of completed page authorized
DEVELOPMENT OF ACCIDENT REDUCTION FACTORS

by

Tom Creasey
Transportation Research Engineer

and

Kenneth R. Agent
Senior Transportation Research Engineer

Kentucky Transportation Research Program
College of Engineering
University of Kentucky
Lexington, Kentucky

in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the University of Kentucky, the Kentucky Transportation Cabinet, nor the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

March 1985
ACKNOWLEDGEMENTS

Appreciation is expressed to the following members of the Study Advisory Committee for their guidance in performing the research and preparing this report.

Lance Gorman, Chairman, Division of Traffic, Kentucky Department of Highways

Ron George, Federal Highway Administration

Joe Ann O’Hara, Highway Safety Standards Branch, Kentucky State Police
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
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<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>PROCEDURE</td>
<td>1</td>
</tr>
<tr>
<td>RESULTS</td>
<td>2</td>
</tr>
<tr>
<td>Review of Literature</td>
<td>2</td>
</tr>
<tr>
<td>Survey of States</td>
<td>3</td>
</tr>
<tr>
<td>Before and After Analysis in Kentucky</td>
<td>4</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>4</td>
</tr>
<tr>
<td>Development of Reduction Factors</td>
<td>5</td>
</tr>
<tr>
<td>IMPLEMENTATION</td>
<td>5</td>
</tr>
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<td>APPENDIX</td>
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INTRODUCTION

As part of its highway safety improvement program, the Kentucky Transportation Cabinet utilizes the cost-optimization procedure of dynamic programming to rank highway safety improvements. The accuracy of the improvement costs and benefits (in the form of accident reductions) determines the effectiveness of this program. The procedure presently assumes a 100-percent reduction in accidents for any given safety improvement, but this generally does not occur in reality. The objective of this study is to develop a listing of factors that may be used to reasonably predict the reduction (or increase) in accidents expected upon implementation of a given safety improvement.

PROCEDURE

A review of literature pertaining to past and current studies related to benefits associated with safety improvements was conducted. Information from those sources was compiled to form a list of accident reduction factors for various highway safety improvements.

A survey of states was performed to determine what is being used currently by individual states. A letter was sent to all states to obtain information concerning accident reduction estimates used to rank highway safety improvements and the basis for those percentages (Appendix). The states were asked whether the percent reductions in accidents, if used, were based on before-and-after analysis related to implementation of the improvement, a review of relevant literature, or engineering judgment.

A before-and-after accident analysis of safety improvement projects in Kentucky was performed and a list of reduction factors was compiled for those safety improvements. Accident data for one or two years before implementation of the improvement and one or two years after implementation were obtained from the Accident Surveillance Section of the Division of Traffic. Average annual accidents before and after
implementation of safety improvements were compared to obtain the estimated percent reduction in all accidents related to implementation.

RESULTS

An attempt was made to compile a comprehensive list of all types of safety improvements from current literature and from other states. Although some safety improvements may have been excluded from the literature sources or returned survey responses, a large number of safety improvements and associated accident reduction factors was collected. Those safety improvements were grouped into the general categories listed in Table 1. Subsequent tables were based on all or part of those categories. All categories having characteristics in common, such as signs, were placed in the same category. Subdivisions by type of improvement within each category were made to provide clarity and organization. For example, the category "Signs" was subdivided by type of sign: Warning Signs, Regulatory Signs, Guidance Signs, Other.

REVIEW OF LITERATURE

From the review of literature pertaining to past and present studies, 42 sources relating to accident reductions from highway safety improvements were obtained and are listed in the "References" section of this report. The majority of the sources described the effects of highway safety improvements in terms of percentage reductions in accidents. These are listed in Table 2. The remaining references related highway safety improvements to percentage reductions in accident rates and are listed in Table 3.

Some of the references listed reductions in accidents or accident rates by severity of accident -- fatal, injury, fatal and injury, and property damage only -- as well as reductions in total accidents or accident rates for a given safety improvement. Others listed only a total reduction in all accidents or rates for a given safety
improvement. Reductions for specific types of accidents such as wet pavement or nighttime accidents were listed by some of the references. Reductions in accidents or accident rates for some types of safety improvements varied widely among sources. For example, in the safety improvement category for signals in Table 2, the percentage reduction in all accidents corresponding to new signal installation ranged from 10 to 80 percent.

The source of the information given in Tables 2 and 3 is identified by the reference number as given in the listing of references. Some references were based upon findings of several previous studies and contained more than one list of reduction factors. Additional lists of reduction factors by the same reference are denoted by a lower case letter. For example, Reference 6, a 1966 report by Roy Jorgensen & Associates, contains three separate lists of accident reduction factors: a summary of before-and-after-results from a previous study, a list of forecasted reductions from the same study, and a list of reduction factors based on the Jorgensen study itself. These three lists are designated in Table 2 as References 6, 6a, and 6b, respectively.

SURVEY OF STATES

Table 4 summarizes the origin of reduction factors obtained from the survey of states. At the time of the survey, 22 states replied they did not use reduction factors in ranking highway safety improvements. Eleven states reported they developed their own factors through before-and-after studies, review of literature, engineering judgment, or a combination of the three. Twelve states adopted factors either from current literature or factors developed by other states. Five states — Kansas, New Jersey, New York, Texas, and Utah — used a combination of adopted factors and factors developed from their own studies. The expected percentage reductions in accidents for highway safety improvements according to reduction factors used by states are given in
Table 5, while percentage reductions in accident rates corresponding to highway safety improvements expected by states are given in Table 6.

The reduction factors listed in Tables 5 and 6 were either developed by the states listed or have been adopted from other sources. The source shown in these tables is either the state (noted by the state abbreviation) or the literature source from which the state adopted its factors (as noted in Table 4). Review of Tables 4, 5, and 6 reveals that Minnesota has developed its own reduction factors, but those factors are not listed in Table 5 or Table 6. Minnesota does not have a set of statewide reduction factors. Instead, individual highway districts are responsible for developing their own reduction factors. Two districts listed accident reduction factors for highway safety improvements. Those factors were given by type of accident (e.g. rear end, angle, head-on, right turn, etc.) and were incompatible with factors submitted by other states. Thus, they were not included in the tables.

BEFORE-AND-AFTER ANALYSIS IN KENTUCKY

A before-and-after accident analysis of highway safety improvements in Kentucky was performed. Accident data were obtained for one-year or two-year periods before and after implementation of safety improvements. Average annual accidents before and after implementation were compared to determine the percentage reductions in total accidents for various types of safety improvements. Those results are given in Table 7.

CONCLUSION

Through a review of current literature and a survey of states, it was concluded that there is no commonly accepted list of factors that may be used to predict the percentage reduction in accidents corresponding to implementation of different types of highway safety improvements. Some states utilized developed or adopted factors for the
purpose of ranking safety improvements, while others preferred alternative methods. Nearly all states expressed an interest in such a set of factors.

DEVELOPMENT OF REDUCTION FACTORS

It was the objective of this study to derive a comprehensive list of accident reduction factors for the purpose of optimizing the priority ranking procedure of highway safety improvements in Kentucky. The development of a list of these reduction factors was based mainly on the review of literature and survey of states, with limited input from the before-and-after accident analysis in Kentucky.

Table 8 lists a set of recommended accident reduction factors for highway safety improvements. Some of those factors are based on before-and-after studies, others are based solely on engineering judgment, and some entail a combination of both. While many of these factors are judgmental, a step has been made toward developing a set of commonly accepted accident reduction factors. It is hopeful that this list will be continually improved and upgraded through before-and-after accident analyses so that in the future a reliable prediction of accident reductions associated with highway safety improvements may be utilized by all agencies.

IMPLEMENTATION

The Division of Traffic of the Kentucky Transportation Cabinet uses a dynamic programming procedure as a means to priority rank safety improvements. To use this program, the user must provide certain vital information that includes expected reductions in accidents for each safety improvement. The accident reduction factors developed in this report (given in Table 8) can be used to provide that information.
REFERENCES


8. "Cost-Effectiveness Program for Roadside Safety Improvements on Texas Highways," Volumes 1, 2, &3; Weaver, Post, et. al., Texas Transportation Institute, Research Report 15-1; August 1974.


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<tr>
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<td>A. Warning Signs</td>
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<tr>
<td>B. Regulatory Signs</td>
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<tr>
<td>C. Guidance Signs</td>
</tr>
<tr>
<td>D. Other</td>
</tr>
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<td>II. SIGNALS</td>
</tr>
<tr>
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<td>B. Signal Modernization, Modification or Upgrading</td>
</tr>
<tr>
<td>C. Warning Signal/Flashing Beacons</td>
</tr>
<tr>
<td>D. Signal Phasing</td>
</tr>
<tr>
<td>E. Other</td>
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<tr>
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<tr>
<td>B. Delineators</td>
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<tr>
<td>C. Other Delineation</td>
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<td>B. Other Pavement Marking</td>
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<td>B. Left-Turn Channelization</td>
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<td>B. Lane/Shoulder Widening</td>
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<td>C. Alignment</td>
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<td>D. Curve Reconstruction</td>
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<td>F. Bridges</td>
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<td>G. General Reconstruction and Miscellaneous</td>
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<td>H. Other</td>
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<td>C. Other</td>
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<td>D. Bridge-Underpass Locations</td>
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<td>4 leg</td>
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<td>b. Stop ahead</td>
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<td>c. Prepare for sudden stop</td>
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<td>b. Stop control, minor leg</td>
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<td>c. Change from 2-way to 4-way stop</td>
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<td>d. Install yield sign</td>
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<td>D. OTHER</td>
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II. SIGNALS
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1. General
<p>| | | | | | |
| | | | | | |
| 5 | | | | 19 |
| 6 | | | | 32 |
| 6a | | | | 25 |
| 7,11 | | | | 15 |
| 6b,7a,10,14 | | | 50 | 29 |
| 10a | | | | 80 |
| 10b | | | | 27 |
| 15 | | | | 14 |
| 16 | | | | 18 |
| 18 | | | 43 | 26 | 30 |
| 39 | | | 8 | 10 |
| 2. With channelization | 5,7,11 | | | | 20 |
| 6 | | | | 27 |
| 18 | | | 53 | 39 | 42 |
| 39 | | 21 | 6 | | |</p>
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<td>2+ lanes</td>
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<td>2+ lanes, T-int.</td>
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<td>Rural, 2+ lanes</td>
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<tr>
<td>C. WARNING SIGNALS/FLASHING BEACONS</td>
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<td>2+ lanes</td>
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### III. DELINEATION

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<td>16</td>
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#### B. DELINEATORS

1. Raised pavement markers | 5,7,10b,11 |
2. Install delineators | 12 |

2b. At horizontal curves | 5,7,7a,10b,11 |
2. At bridge approaches | 1 |
2. Rural, 2 lanes | 10 |
2+ lanes | 16 |
3. At bridge underpass | 5,6b,10,14 |
2 lanes | -8 |
2+ lanes | 62 |
4. Reflectorized traffic buttons | 5 |
4. Curve delineation | 18 |
5. Install posts where none present | 4 |
5. Replace and upgrade posts and lenses | 1 |

#### C. OTHER DELINEATION

1. Delineation for wrong-way accidents | 1,2 |

---

*References:
5
6
b
10
14
6a
7a
16
12
10a
12
10a,12
41
1, 2
6
15
5,6 b,10,14
10
2
5
5
1
2
5
5
60
30
25
18
25
13
5
15
40
40
25
25
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## TABLE 2. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<td>c. 36-40'</td>
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TABLE 2. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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B. LEFT-TURN CHANNELIZATION

1. At signalized intersections

a. Left-turn phase
   7a,10b
   12
   36
   30

b. No left-turn phase
   7a,10b
   12
   15
   20

2. At non-signalized intersections

a. W/curbs and/or raised bars
   7,7a,11
   15
   65

b. Painted channelization
   7,7a,11
   30
   15
   50

VI. CONSTRUCTION/RECONSTRUCTION

A. LANE ADDITION

1. Left-Turn lane

a. Without signal

   Urban:
   2 lanes
   2+ lanes
   2+ lanes, T-int.
   2+ lanes, T-int.
   5
   30
   54
   79
   62
   5
   15
   25

   Rural:
   2+ lanes
   2+ lanes, Y-int.
   5
   -1
   5
   -15
   33

   Urban, 2 lanes
   6b,10
   2+ lanes
   2+ lanes, T-int.
   2+ lanes, T-int.
   6b,10
   80
   54
   79
   62
   5
   -1
   6

   Rural, 2+ lanes
   2+ lanes, Y-int.
   2+ lanes
   7a
   19

   Rural, 2+ lanes
   2+ lanes
   -6

b. With signal

   Urban
   5,6b,7,10,11,14
   1
   -7
   27

   Rural, T-int.
   58
   43
   42

   Rural, -+int.
   -28

c. Two-way left-turn lanes

   5
   30

2. Add Acc./Decel. lanes

   5
   10

3. Add right-turn lanes and decel. lane

   12
   15

4. Add passing lane

   12
   30

17
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<td>8. Add climbing lane</td>
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**B. LANE/SHOULDER WIDENING**

1. Pavement & shoulder widening                                  | 5         | -13          | 32           | 26    |
|                                                               | 7a        |              |              | 18    | 21    |
|                                                               | 39        |              |              |       | 22    |
| 2. Passing lane                                                 | 5         |              |              |       |
| a. Widen to 36'                                                 |          |              |              |       |
| Widen to 46'                                                   |          |              |              |       |
| Widen to 42-44'                                                |          |              |              |       |
| b. 2 lane highways                                             | 17        |              |              |       |
| widen to 40'                                                   |          |              |              |       |
| widen to 42-44'                                                |          |              |              |       |
| c. 2 lane highways                                             | 17        |              |              |       |
| AADT <3000, widened to 28'                                    |          |              |              |       |
| AADT <5000, widened to 32'                                    |          |              |              |       |
| AADT >5000, widened to 40'                                    |          |              |              |       |
| 3. Shoulder stabilization                                     | 5,6b,10,14|              |              |       |
| 4. Shoulder improvement                                        | 3         |              |              |       |
|                                                               | 5         |              |              |       |
|                                                               | 16        |              |              |       |
| 5. Shoulder widening                                           | 6b,10,14  |              |              |       |
| a. No dimensions                                               | 12        |              |              |       |
|                                                               | 16        |              |              |       |
| b. To 28' road width                                           | 5         | 69           | 30           | 16    |
| 32' road width                                                 |          | 53           | 17           | 44    |
| 40' road width                                                 |          | -29          | 29           | 31    |
| 6. Shoulder widening or improvement                            | 41        |              |              |       |
| 7. Widen travelled way                                         | 6b,7a,10,14|              |              |       |
| a. No dimensions, rural 2 lane                                 | 12,16     |              |              |       |
| b. From 9-ft. lanes                                            | 6b,10,14  |              |              |       |
| c. From 10-ft. lanes                                           | 6b,10,14  | -65          | -37          | 5     |
| 8. Pavement widening                                           | 39        |              | -2           | 8     |
|                                                               | 41        |              |              | 25    |

*TABLE 2. REVIEW OF LITERATURE - PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)*

**FATAL INJURY**

**F&I**

**PDO***

**TOTAL**
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TABLE 2. REVIEW OF LITERATURE - PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<td>10. Widening, correct superelevation, etc.</td>
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<td>11. Flatten side slope</td>
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<td>13. Grade separated interchange (replace at-grade)</td>
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VII. PAVEMENT TREATMENT

A. RESURFACING

1. Urban, 2+ lanes                                      | 5,6b,7a,10,14 | 46 42|
2. Rural, 2 lanes                                       | 21 12         | 59 44|
3. Overall resurfacing                                 | 12           | 10   |
4. ACP                                                   | 5 17 19       | 21(42W) 42W |
5. Overlay                                               | 5 16 39 41    | 13 24 21 17|

B. SKID RESISTANCE

1. Deslicking                                           | 1           | 50 50 50 |
   a. Urban, 2 lanes                                     | 5,6b,10,14  | 15 20 |
   b. Rural                                              | 5 10a 12    | 37 50 13 |
      12(67W) 91W 9(30W) 10(75W) 48 48 48 |
2. Pavement grooving                                    | 5 16 41      | 7 75W |
   a. Length < 0.5 Mile                                  | 7           | 75W |
   b. Length > 0.5 Mile                                  |             |
3. Grooving or resurfacing                              | 5 15         | 80W 76W 67W 70W |
4. Pavement anti-skid treatment                         | 5,7a        | 21 -8 16 |
5. Asphalt seal coat                                    | 5 17 19      | 21(42W) 42W |
6. Saw concrete/rural                                   | 5           | 20   |
<table>
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<tr>
<th>SAFETY IMPROVEMENT</th>
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<th>FATAL INJURY</th>
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C. OTHER

1. Rumble strips
   a. Rural, 2 lanes | 5,6b,10,14 |

VIII. SAFETY BARRIERS

A. MEDIAN BARRIERS

1. Cable barrier
   >2 lanes | 5,6b,7a,10,14 |
   | 36 | -20 | -40 | -31 |

2. Beam barrier
   >2 lanes | 5,6b,7a,10,14 |
   | 15 | -30 | -10 | -20 |

3. Add painted/raised median | 5,6b,10,14 |
   | 26 | 24 | 27 |

4. Concrete barrier
   1-12' (median width) | 5,7a |
   | 90 | 10 | -10 |
   | 85 | 5 | -25 |

5. CMB replacing barrels | 5 |
   | 50 | 50 | -50 |

6. Install type barrier
   >2 lanes | 6b,10,14 |
   | 11 | -44 |

7. Install center barrier
   4-lane, median width 0-5' | 6b,10,14 |
   | 61 | -53 |

8. Installation or improvement of median barrier | 7a,41 |
   | 18 | -9 | -36 |

9. Double-faced guardrail
   1-12' (median width) | 5 |
   | 75 | 2 | -28 |
   | 85 | 5 | -30 |
   | 85 | 5 | -30 |

10. Antiglare screen | 5 |
    | 0 | 20 | -50 | -14 |

11. CMB w/end treatment | 5 |
    | 60 | 40 | -150 |

12. Add median & median barrier | 12 |
    | 75 | 75 | 40 |

13. Retrofit curbs w/New Jersey barrier @ bridges | 75,75 |
    | 50 | 50 | -20 |

B. CRASH CUSHIONS

1. General | 5 |
   | 75 | 50 | -100 |

2. Water-filled cushion | 5 |
   | 75 | 60 | -300 |

3. Sand-filled cell | 5 |
   | 75 | 60 | -300 |

4. Steel barrel | 5 |
   | 75 | 60 | -300 |
### TABLE 2. REVIEW OF LITERATURE - PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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*PERCENTAGE REDUCTION* in accidents
### TABLE 2. REVIEW OF LITERATURE - PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<td>B. OTHER</td>
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### XII. REMOVAL/RELOCATION OF ROADSIDE OBJECTS

**A. REMOVAL**
1. Remove utility poles
   - Reference: 5,7a
   - Percentage: 35, -2, 0
2. Remove trees
   - Reference: 50
   - Percentage: 25, -20
3. Remove obstacles from:
   a. existing steep slope
      - Reference: 5
      - Percentage: 14, 10, -18
   b. existing gentle slope
      - Reference: 5
      - Percentage: 73, 23, -40
   c. cut slopes
      - Reference: 5
      - Percentage: 35, 15, -30
4. Remove rock outcroppings
   - Percentage: 100, 100, 50
   - Reference: 1
   - Percentage: 65, 25, 5
5. Fixed object
   - Percentage: 80
   - Reference: 12
   - Percentage: 64

**B. RELOCATION**
1. Fixed objects
   - Reference: 10a
   - Percentage: 60
2. Utility poles - 30 ft. from pavement edge
   - Reference: 5,7a
   - Percentage: 32, -2, 0

**C. OTHER**
1. Clear gore area
   - Reference: 1
   - Percentage: 75, 50, 25
   - Reference: 2
   - Percentage: 50, 50, 0
2. Shield rock cuts
   - Reference: 1
   - Percentage: 90, 60, -60

### XIII. OTHER

**A. FENCING**
1. Deer fencing
   - Reference: 1
   - Percentage: 100, 100, 100
2. Fencing, livestock
   - Reference: 5,6b,10,14
   - Rural, Interstate: -36, -9, 0, -3
   - Rural, divided: 100, 63, 57, 61
   - Rural, undivided, <4 lanes: 100, 100, 55, 74

**B. MISCELLANEOUS**
1. Ramp metering
   - Reference: 2
   - Percentage: 75, 75, 75
2. Culvert/headwall improvements
   - Reference: 1
   - Percentage: 90, 60, 0
   - Reference: 18
   - Percentage: 30
3. Eliminate parking
   - Reference: 5,6b,10,14
   - Percentage: 3
   - Reference: 12
   - Percentage: 32
   - Reference: 30

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25
TABLE 2. REVIEW OF LITERATURE - PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<tr>
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<td>5. Curtail turning movements</td>
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<td>8. Revise driveways</td>
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<td>9. Prohibit left turns</td>
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C. OTHER COMBINATION IMPROVEMENTS

1. Delineators, Markings, Signs, Maintenance
   General
   Curve
   5
   22
   24

2. Resurfacing, Patching, Drainage, Desilch, Culvert
   General
   Curve & guardrail
   5
   16
   33

3. Marking & Delineation
   5
   39
   10
   -5
   -9
   -12
   -11

4. Signs, Markings & Delineation at Narrow Bridges
   39
   5
   15

5. Marking, Maintenance & Signing (intersection)
   5
   35

6. Marking & Signs
   General
   Intersection
   5
   36
   24

7. Rumble Strips & Beacon
   5
   32

8. Rumble Strips & Lighting
   5
   17

9. Warning Signs, Installment and Delineators
   Urban, 2+ lanes
   5
   -27
   41
   20

10. Intersection directional & warning signs
    12
    14

11. Signs/striping
    16
    24

12. Signs/striping & breakaway signs or supports
    16
    24

13. Improve drainage structures
    39
    0
    8

* - Negative value indicates an increase in accidents
** - F&I - Fatal and Injury Accidents
*** - PDO - Property Damage only Accidents
w - wet pavement accidents
n - nighttime accidents
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TABLE 3. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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TABLE 3. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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### TABLE 3. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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**E. OTHER**

1. Improve Sight Distance  
   a. At intersections  
      Rural areas:  
      2 lanes  
      4 lanes, divided  
      All rural  
   b. Urban areas:  
      4 lanes, undivided  
      4 lanes, divided  
      All urban  

2. New median  
   a. Rural areas:  
      4 lanes, divided  
      All rural  
   b. Urban areas:  
      4 lanes, undivided  
      4 lanes, divided  
      All urban  

3. Flatten side slopes  
4. Upgrade bridge/guardrail transition

**VI. PAVEMENT TREATMENT**

**A. RESURFACING**

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**B. SKID RESISTANCE**

1. Pavement grooving  
   a. Rural areas:  
      2 lanes  
      4 lanes, divided  
      All rural  
   b. Urban areas:  
      4 lanes, divided  
      All urban  

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30
TABLE 3. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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<thead>
<tr>
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VII. SAFETY BARRIERS

A. MEDIAN BARRIERS

1. Rural areas:
   4 lanes, divided
   All rural
2. Urban areas:
   4 lanes, undivided
   >4 lanes, divided
   All urban

B. GUARDRAILS

1. General
2. New and/or improved

   a. Rural areas:
      2 lanes
      4 lanes, undivided
      4 lanes, divided
      All rural
   b. Urban areas:
      2 lanes
      4 lanes, divided
      All urban
3. Upgrade guardrails
4. Impact attenuators

VIII. SAFETY LIGHTING

A. GENERAL

   a. New flashing beacons

IX. RAILROAD CROSSING

A. AT-GRADE

   1. New flashing beacons
TABLE 3. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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X. OTHER

A. COMBINATION IMPROVEMENTS

1. Channelization, Turning Lanes and/or Traffic Signals
(22)(24) 17 17 9 12
(24) 64 25 26 24 25

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TABLE 3. REVIEW OF LITERATURE -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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w = wet pavement accidents
TABLE 4. ORIGIN OF ACCIDENT REDUCTION FACTORS USED IN VARIOUS STATES

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* Combination of before and after studies, review of literature, and engineering judgment.

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### TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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### C. WARNING SIGNALS/FLASHING BEACONS

1. New Installation
   1a. Intersection
      a. Red-yellow
      b. 4-leg
      c. 3-leg
         - HRR 332, NCHRP 162
      d. 4-way red
         - MT, HRR 332, NCHRP 162
   1b. Advance warning
      a. Intersection
      b. Curve
      c. School curve and intersection
      d. Urban, 2+ lanes
      e. Rural, 2 lanes
         - 2+ lanes
      f. RR Crossing
      g. Pedestrian signals
         a. Urban, 2 lanes
         b. 2+ lanes

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38
### TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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**Notes:**
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- MO, NCHRP 162
- Handbook
- AK, NJ, Handbook
- LA, NCHRP 162
- HSS
- TX
- MT
- OK, NCHRP 162
- Jorgensen
- MT
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TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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IV. PAVEMENT MARKING

A. PAINT STRIPES

1. Install/improve edge marking AK | 25 |       |       |       |       |       |
|                      | KS     |       |       |       |       |       |
|                      | WA     |       |       |       |       |       |
|                      | Jorgensen | 15  | 15 | 14 |       |       |
|                      |        |       |       |       |        |       |
| 2. Right edgelines | KS, MO, MT, OK, HRR 332, NCHRP 162 | 2 |       |       |       |       |
| 3. Edgeline striping | CA, KS | 18 | 11 | 25 |       |       |
|                      | TX     |       |       |       |       |       |
|                      |        |       |       |       |        |       |
| a. 22-26° | KS | 7 |       |       |       |       |
|                      | MT     |       |       |       |       |       |
|                      | NY     |       |       |       |       | 15   |
| b. 28-34° | KS | 13 |       |       |       |       |
| c. 36-40° | KS | 14 |       |       |       |       |
| 4. Centerline striping | AK, TX | 65 |       |       |       |       |
|                      | KS, NY | -12 |      | 5 | 60 | 60   |
|                      |        |       |       |       |        |       |
| a. Rural, crest curve | Jorgensen | 64 |       |       |       |       |
| b. Tangent sections | KS | 40 |       |       |       |       |
| c. Winding sections | KS | 28 |       |       |       |       |
| d. Improve striping | KS | -25 |       |       |       | 2     |

40
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<td>V. CHANNELIZATION</td>
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<td>A. GENERAL INTERSECTION</td>
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<td>b. W/signs</td>
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<td>c. W/left turn bay</td>
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* Percentages are based on before and after studies.
** F&I = Fatal or Injury
*** PDO = Property Damage Only
### TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<tr>
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<th>INJURY</th>
<th>F&amp;I**</th>
<th>PDO***</th>
<th>TOTAL</th>
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<td>d. With right turn bay</td>
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#### B. LEFT-TURN CHANNELIZATION

1. At signalized intersections
   - a. Left-turn phase
     - CA
     - KS, MO, NCHRP 162
   - b. No left-turn phase
     - CA, MO, NCHRP 162
     - KS

2. At non-signalized intersections
   - a. W/curbs and/or raised bars
     - KS, HRR 332
     - MO
     - NY
     - urban areas
       - KS, HRR 332
       - NCHRP 162
     - suburban areas
       - KS, NCHRP 162
     - rural areas
       - KS, HRR 332
       - NCHRP 162
   - b. Painted channelization:
     - KS
     - MO
     - NY
     - HRR 332
     - KS, HRR 332
     - NCHRP 162
     - urban areas
       - KS, NCHRP 162
     - suburban areas
       - KS, HRR 332
     - rural areas
       - KS

   3. Continuous left-turn lane
      - CA
      - KS
      - LA
      - MO
      - MT
      - PA

#### VI. CONSTRUCTION/RECONSTRUCTION

A. LANE ADDITION

1. General
   - NY
   - OK
   - Handbook

   a. Lane and Shoulder
      - OK

   b. Turning lane
      - TX

2. Left-Turn lane
   a. Without signal:
      - Urban: 2 lanes
        - MO
        - PA
        - KS
        - MO
        - KS
        - LA
        - WA
      - Jorgensen
      - 80
      - 80
      - 80

---

42
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<td>2 lanes, T-int.</td>
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<td>62</td>
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<tr>
<td></td>
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<tr>
<td>Rural:</td>
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<tr>
<td>2 lanes</td>
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<tr>
<td>2+ lanes</td>
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<td>-1</td>
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<tr>
<td>2+ lanes, Y-int.</td>
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<tr>
<td>b. With signal:</td>
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<tr>
<td>Urban</td>
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<td>c. Two-way left-turn lanes</td>
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<tr>
<td>d. Without signal turn phase</td>
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<td>4. Add right-turn lane</td>
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<td></td>
<td>WA</td>
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<td>5. Add passing lane</td>
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<td>6. Add shoulder</td>
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<td>7. Extend lane drop and add</td>
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<td>b. Urban areas:</td>
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TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<tr>
<td>b. Urban areas:</td>
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*Percentage reduction in accidents
**F&I: Fatal and Injury
***PDO: Property Damage Only

SOURCE
- KS
- CA
- PA
- HSS
- NJ, Handbook
- AK, LA, TX
- Jorgensen
- NY
- MT
- TX
- WA

44
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

<table>
<thead>
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<td>C. ALIGNMENT</td>
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<td>4. Widen intersection</td>
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<tr>
<td>a. Urban: signalized unsignalized</td>
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<td>5. Relocate intersection</td>
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<td>6. Widen intersection approach</td>
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<td>7. Pave shoulder (for right turns)</td>
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<td>F. BRIDGES</td>
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<tr>
<td>1. Widen existing bridge or other major structure</td>
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<td>18</td>
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<tr>
<td></td>
<td>NJ, Handbook</td>
<td>18</td>
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<tr>
<td></td>
<td>OH</td>
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</tr>
<tr>
<td></td>
<td>OK</td>
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<td></td>
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<td></td>
<td>TX</td>
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<tr>
<td></td>
<td>WA</td>
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45
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<td>2. Replace bridge or other major structure</td>
<td>AK,NJ, Handbook</td>
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<td>KS</td>
<td>25        48     52     36     41</td>
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<td></td>
<td>MT</td>
<td>47        39     23     10f    62</td>
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<tr>
<td></td>
<td>NY</td>
<td>10        10     5      3      15f</td>
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<tr>
<td></td>
<td>OH</td>
<td>5         3       3      30</td>
</tr>
<tr>
<td></td>
<td>OK</td>
<td>5         3       3      30</td>
</tr>
<tr>
<td></td>
<td>PA</td>
<td>5         3       3      30</td>
</tr>
<tr>
<td></td>
<td>TX</td>
<td>78        29     31</td>
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<tr>
<td></td>
<td>HSS</td>
<td>78        29     31</td>
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<tr>
<td>3. Widen small structure</td>
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<tr>
<td>G. GENERAL RECONSTRUCTION AND MISCELLANEOUS</td>
<td>MT</td>
<td>26</td>
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<td>1. Reconstruction</td>
<td>LA</td>
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<td>20</td>
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<td>NCHRP 162</td>
<td>18</td>
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<tr>
<td>a. Road &amp; shoulders</td>
<td>WA</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>TX</td>
<td>40</td>
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<tr>
<td>b. Reconstruct intersection</td>
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<td>H. OTHER</td>
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<tr>
<td>1. Improve sight distance</td>
<td>AK,NJ</td>
<td>57        20     21     26     31</td>
</tr>
<tr>
<td></td>
<td>KS</td>
<td>68        33     24     32     30</td>
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<td></td>
<td>MT</td>
<td>68        33     24     32     30</td>
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<tr>
<td></td>
<td>NY</td>
<td>30</td>
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<tr>
<td>a. At intersections:</td>
<td>PA</td>
<td>27</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>b. At horizontal curves</td>
<td>PA</td>
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<tr>
<td>2. New median</td>
<td>KS</td>
<td>19        2       11     1</td>
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<td>HSS</td>
<td>72        -13     11     1</td>
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<tr>
<td>With left-turn lanes</td>
<td>NY</td>
<td>24</td>
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<tr>
<td>3. Correct/improve superelevation</td>
<td>KS, PA</td>
<td>42</td>
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<td></td>
<td>MO, OH, NCHRP 162</td>
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<td>4. Widen culvert</td>
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<td>5. Replace culvert</td>
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<td>6. Increase turning radii at intersections</td>
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<td>25</td>
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<tr>
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<tr>
<td>7. Frontage road, new construction</td>
<td>AK, KS, TX</td>
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<td>15</td>
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<td>8. Ramp modification</td>
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<tr>
<td>a. Entrance</td>
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</tr>
<tr>
<td>b. Exit</td>
<td>AK, KS, TX</td>
<td>20</td>
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<tr>
<td>9. Widening, correct superelevation, etc.</td>
<td>KS</td>
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<tr>
<td>10. Flatten side slope</td>
<td>AK, LA, TX</td>
<td>46</td>
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<tr>
<td></td>
<td>KS</td>
<td>10</td>
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<tr>
<td></td>
<td>WA</td>
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<td>-3</td>
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- *Percentages are based on the reduction in accidents before and after the improvement is implemented.
- **F&I**: Fatal and Injury
- ***PDO***: Property Damage Only
- Numbers in italics indicate a percentage reduction.
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<thead>
<tr>
<th>SAFETY IMPROVEMENT</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>11. Construct pedestrian crossover</td>
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<td>12. Construct pedestrian walkway</td>
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<td>60</td>
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<td>13. Construct turn-arounds</td>
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<td>14. Construct emergency truck deceleration beds/escape ramps or lanes</td>
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<td>15. Stabilize berms--rural section</td>
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VII. PAVEMENT TREATMENT

A. RESURFACING

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<td>KS</td>
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<td>27</td>
<td>26</td>
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<td>MO</td>
<td>36</td>
<td>42</td>
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<tr>
<td>NY</td>
<td>15</td>
<td>21</td>
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<tr>
<td>PA</td>
<td>21</td>
<td></td>
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1. Urban, 2+ lanes

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<td>OH,Jorgensen</td>
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2. Rural, 2 lanes

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3. ACP

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4. Overlay

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<td>NJ,Handbook</td>
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a. Rural areas:

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b. Urban areas:

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C. Intersection, urban

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<tbody>
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B. SKID RESISTANCE

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1. Deslicking

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<td>OH</td>
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<td>OH,NCHRP 162</td>
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a. Urban

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<tbody>
<tr>
<td>KS</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jorgensen.J</td>
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b. Rural

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47
### TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<tr>
<td></td>
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<tr>
<td>2. Pavement grooving</td>
<td>KS</td>
<td>12(%)</td>
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<tr>
<td></td>
<td>LA</td>
<td>42(%)</td>
</tr>
<tr>
<td></td>
<td>NJ, Handbook</td>
<td>21(%)</td>
</tr>
<tr>
<td></td>
<td>NY</td>
<td>15(%)</td>
</tr>
<tr>
<td></td>
<td>PA</td>
<td>27(%)</td>
</tr>
<tr>
<td></td>
<td>TX</td>
<td>11(%)</td>
</tr>
<tr>
<td>a. Length &lt; 0.5 Mile</td>
<td>KS, Jorgensen</td>
<td>75(%)</td>
</tr>
<tr>
<td>b. Length &gt; 0.5 Mile</td>
<td>KS, Jorgensen</td>
<td>75(%)</td>
</tr>
<tr>
<td>c. Rural areas: 2 lanes</td>
<td>WA</td>
<td>15</td>
</tr>
<tr>
<td>d. Urban areas: 4 lanes, divided</td>
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<td>15</td>
</tr>
<tr>
<td>3. Grooving or resurfacing</td>
<td>KS</td>
<td>80</td>
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<tr>
<td>4. Pavement anti-skid treatment</td>
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<tr>
<td>5. Planer</td>
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<tr>
<td>6. Asphalt seal coat</td>
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</tr>
<tr>
<td>7. Saw concrete/rural</td>
<td>KS</td>
<td>20</td>
</tr>
<tr>
<td>8. Treated with resin/bauxite</td>
<td>KS</td>
<td>40</td>
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</tbody>
</table>

**C. OTHER**

1. Rumble strips | LA, OK, TX | 2 |    |    |    |        |
| a. Rural, 2 lanes | KS, Jorgensen | 26 | 24 | 27 | 25 |        |
|                  | PA          |    |    |    |    |        |
|                  | WA          | 25 | 25 |    |    |        |

### VIII. SAFETY BARRIERS

#### A. MEDIAN BARRIERS

1. Median barriers | MT | 69 | 11 | 14 | 14 | 14 |
|                   | MT |    |    | 15 |    | 15 |
|                   | NY |    |    | 13 |    | 13 |
|                   | PA |    |    | 36 |    | 36 |
|                   | TX |    |    | 75 |    | 75 |
|                   | Handbook |    |    |    |    |    |
|                   | HSS | 67 | -1 |    |    | 67 |
| 2. Cable barrier >2 lanes | KS, Jorgensen | 36 | -20 | -40 | -31 | -31 |
| 3. Beam barrier >2 lanes | KS | 15 | -30 | -22 | -10 | -20 |
| 4. Add painted/raised median | AK, TX | 8 |    |    |    |    |
|                            | KS |    |    |    |    |    |
|                            | WA |    |    |    |    |    |
| 5. Concrete barrier | KS | -3 |    |    |    |    |
|                            | OH |    | -26 | -26 | -26 | -26 |
|                            | OK |    |    |    |    |    |
|                            | WA | 60 | 60 |    |    |    |
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

<table>
<thead>
<tr>
<th>SAFETY IMPROVEMENT</th>
<th>SOURCE</th>
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<th>F&amp;I**</th>
<th>PDO***</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>a. 1-12' (median width)</td>
<td>KS</td>
<td>90</td>
<td>10</td>
<td>-10</td>
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<tr>
<td>b. 13-30' (median width)</td>
<td>KS</td>
<td>85</td>
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<tr>
<td>c. with end treatment</td>
<td>KS</td>
<td>60</td>
<td>40</td>
<td>-150</td>
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<td>6. Install type barrier &gt;2 lanes</td>
<td>Jorgensen</td>
<td>-11</td>
<td>-44</td>
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<tr>
<td>7. Install center barrier 4-lane, median width 0-5'</td>
<td>Jorgensen</td>
<td>-61</td>
<td>-53</td>
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<tr>
<td>8. Installation or improvement of median barrier</td>
<td>NJ, Handbook</td>
<td>-3</td>
<td>3</td>
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<tr>
<td>9. Double-faced guardrail</td>
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<td>a. 1-12' (median width)</td>
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<td>75</td>
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<td>b. 13-30' (median width)</td>
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<tr>
<td>c. 31-60' (median width)</td>
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*Note: F&I = Fatal and Injury, PDO = Percentage Decrease Over Total.*

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51
TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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2. Breakaway all KS -20

3. Safety treat sign support KS -5 12 25

B. UTILITY POLES

1. Make utility poles breakaway KS OH 30 -1 0

XI. RAILROAD CROSSING

A. AT-GRADE CROSSING

1. New flashing beacons KS NCHRP 162 81t 80

   a. Rural crossings WA 50 80
   b. Urban crossings WA 50 80

2. Cantilever flashing beacons OK 22t

3. Post mounted flashing beacons OK 90t

4. Replace signs with:

   a. Flashing beacons AK,NJ,Handbook KS HSS 93 83 83t 73t 70t 74

   b. Automatic gates AK,NJ,Handbook KS NY HSS 96 86

5. Automatic gates and new flashing lights OK (replacing passive devices) 94t

   a. Rural crossings 2 lanes All rural
   b. Urban crossings 2 lanes All urban

6. Replace active device:

   a. With automatic gates KS NJ,Handbook NY 100t
   b. With grade separation KS 100t
   c. With flashing lights HSS 48 36

---

52
### TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

<table>
<thead>
<tr>
<th>SAFETY IMPROVEMENT</th>
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<th>SOURCE</th>
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<th>F&amp;I **</th>
<th>PDO ***</th>
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### XII. REMOVAL/RELOCATION OF ROADSIDE OBJECTS

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TABLE 5. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENTS (Cont.)

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<tr>
<td></td>
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<tr>
<td>1. Remove utility poles</td>
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<td>2. Remove trees</td>
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<tr>
<td>3. Remove obstacles from:</td>
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<tr>
<td>a. existing steep slope</td>
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<td>14</td>
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<tr>
<td>b. existing gentle slope</td>
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<td>c. cut slopes</td>
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<tr>
<td>4. Remove curb and/or riprap</td>
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<tr>
<td>5. Fixed objects</td>
<td>AK,TX</td>
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B. RELOCATION

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<tr>
<td>1. Fixed objects</td>
<td>AK</td>
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<tr>
<td>2. Signs</td>
<td>KS</td>
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<tr>
<td>3. Utility poles - 30 ft. from pavement edge</td>
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<td>4. Relocate signs behind guardrail</td>
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<td>C. OTHER</td>
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XIII. OTHER

A. FENCING

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<tbody>
<tr>
<td>1. Fencing, livestock</td>
<td>AK,KS,TX,Jorgensen</td>
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</tr>
<tr>
<td>a. Rural, interstate</td>
<td>KS</td>
<td>-36</td>
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<tr>
<td>b. Rural, divided</td>
<td>KS</td>
<td>100</td>
</tr>
<tr>
<td>c. Rural, undivided, &lt;4 lanes</td>
<td>KS</td>
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<td>2. General fencing</td>
<td>MT</td>
<td>-52</td>
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B. MISCELLANEOUS

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<tr>
<td>1. Close median openings</td>
<td>LA, MO,NCHRP 162</td>
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<tr>
<td>2. Eliminate parking</td>
<td>AK,OK,TX, MO,Jorgensen, NY</td>
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<tr>
<td>3. Remove signal</td>
<td>MO</td>
<td>90r</td>
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<td>4. Modernize to design standards</td>
<td>LA</td>
<td>15</td>
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<td>a. Rural, 2 lanes 2+ lanes</td>
<td>Jorgensen</td>
<td>-6</td>
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<tr>
<td></td>
<td>Jorgensen</td>
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<td>5. Curtail turning movements</td>
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<td>MO</td>
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<td>a. Urban, 2+ lanes</td>
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<td>Jorgensen</td>
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<td>6. Revise driveways</td>
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<tr>
<td>7. Relocate driveways</td>
<td>OH, NCHRP 162</td>
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<tr>
<td>8. Prohibit turns (general)</td>
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<td>9. Modernize drainage</td>
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<td>NY</td>
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<td>10. Improve drainage structures</td>
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<td>HSS</td>
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<tr>
<td>11. Change 2-way streets to 1-way</td>
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C. OTHER COMBINATION IMPROVEMENTS

1. Flashing Beacons & 4-way stop signs (rural) | OK | 88 |
2. Channelization, Turning Lanes and/or Traffic Signals (any combination) | AK, NJ, Handbook | 31 |
<p>|                      | MT | 62 | 34 | 30 |
|                      | NY | 30 | 50 |
|                      | OK | 50 | 21 |
| 3. Delineators, Markings, Signs, Maintenance | KS | 22 |
| a. General | KS | 22 |
| b. Curve | KS | 24 |
| 4. Resurfacing, Patching, Drainage, Deslick, Culvert | KS | 16 |
| a. General | KS | 16 |
| b. Curve &amp; guardrail | KS | 33 |
| 5. Pavement Marking and Delineation | KS | 10 | -5 | -9 | -12 | -11 |
|                      | NY | 50 |
| 7. Marking, Maintenance and Signing (intersection) | KS | 35 |</p>
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<thead>
<tr>
<th>SAFETY IMPROVEMENT</th>
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<td>b. Intersection</td>
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<td>9. Rumble Strips &amp; Beacon</td>
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<td>15. Add turn lane, signal and illumination</td>
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<td>16. New signal and new safety lighting</td>
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<td>17. New signal and improve safety lighting</td>
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<td>18. Improve signals and safety lighting</td>
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<tr>
<td>19. Lighting, signals, and reflectorized traffic buttons</td>
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* - Negative value indicates an increase in accidents
** - F&I - Fatal and Injury Accidents
*** - PDO - Property Damage only Accidents
s - Rear-end and sideswipe accidents
r - Run-off road accidents
f - Fatal accidents
t - Train accidents
w - Wet pavement accidents
m - Median and cross-median accidents
n - Nighttime accidents
a - Angle accidents
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<th>F&amp;I**</th>
<th>PDO***</th>
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TABLE 6. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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V. CONSTRUCTION/RECONSTRUCTION

A. LANE ADDITION

1. General
   a. Rural, 4 lanes, undivided
   b. Urban, 4 lanes, undivided
      4 lanes, divided
      >4 lanes, undivided
      All urban

2. Left-Turn lane
   a. Rural areas:
   b. Urban areas:
      2 lanes
      4 lanes, undivided
      4 lanes, divided
      All urban

3. Add climbing lane

B. LANE/SHOULDER WIDENING

1. Pavement & shoulder widening
   a. Rural areas:
      4 lanes, divided
   b. Urban areas:
      2 lanes
      4 lanes, undivided
      4 lanes, divided
      All urban

2. Passing lane
   a. Rural areas:
      2 lanes
      All rural
   b. Urban areas:
      2 lanes
      4 lanes, undivided
      All urban

3. Shoulder widening or improvement
   a. Rural areas:
   b. Urban areas:

4. Pavement widening
   a. Rural areas:
   b. Urban areas:

58
TABLE 6. SURVEY OF STATES -- PERCENTAGE REDUCTION IN ACCIDENT RATES (Cont.)

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<tr>
<th>SAFETY IMPROVEMENT</th>
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### Table 6. Survey of States -- Percentage Reduction in Accident Rates (Cont.)

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### VI. Pavement Treatment

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<td>Urban (wet pavement accidents)</td>
<td></td>
<td>56</td>
<td>64</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>

#### B. Skid Resistance

1. Pavement grooving | Memo | 12-15 | 13-30 | 15   | 14-40 |
| a. Rural areas:     | Memo | 43    | 43    | 30   | 37    |
| 2 lanes |       | 26    | 29    |      |       |
| 4 lanes, divided    |        | 31    | 33    |      |       |
| All rural           |        |       |        |      |       |
| b. Urban areas:     | Memo | 37    | 38    | 59   | 52    |
| 4 lanes, divided    |        | 9     |       |      |       |
| All urban           |        |       |        |      |       |

#### C. Other

<table>
<thead>
<tr>
<th>Source</th>
<th>FATAL</th>
<th>INJURY</th>
<th>FSI **</th>
<th>PDO***</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumble strips</td>
<td>Memo</td>
<td>94</td>
<td>43</td>
<td>33</td>
<td>44</td>
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</tbody>
</table>

### VII. Median Barriers

#### A. Median Barriers

<table>
<thead>
<tr>
<th>Source</th>
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<th>PDO***</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>Median barriers</td>
<td>Memo</td>
<td>75</td>
<td>17</td>
<td>11</td>
<td></td>
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<tr>
<td>a. Rural areas:</td>
<td>Memo</td>
<td>93</td>
<td></td>
<td>75</td>
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<tr>
<td>SAFETY IMPROVEMENT</td>
<td>SOURCE</td>
<td>FATAL</td>
<td>INJURY</td>
<td>F&amp;I</td>
<td>PDO</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>b. Urban areas:</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4 lanes undivided</td>
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<td>63</td>
<td>65</td>
<td>32</td>
<td>46</td>
</tr>
<tr>
<td>4 lanes, divided</td>
<td>84</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>&gt;4 lanes, divided</td>
<td>28</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All urban</td>
<td>72</td>
<td>22</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. GUARDRAILS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. General</td>
<td>Memo</td>
<td>6-16</td>
<td>6-16</td>
<td>7-61</td>
<td>6-42</td>
</tr>
<tr>
<td>2. New and/or improved</td>
<td>Memo</td>
<td>35</td>
<td>4-23</td>
<td>6-16</td>
<td>7-61</td>
</tr>
</tbody>
</table>
| a. New              | AZ     | 100   | 100   | 100 | 76  | 88(87\%)
| b. Improved         | AZ     |       |       |     |     |       |
| c. New and improved |        | 50    | 12    | 14  | 18  | 16    |
| d. Rural areas:     | Memo   | 50    | 12    | 14  | 18  | 16    |
| 2 lanes             |         | 44    | 23    | 25  | 44  | 37    |
| 4 lanes, undivided  |         | 46    | 13    | 15  | 6   |       |
| 4 lanes, divided    |         | 43    | 12    | 14  | 14  | 14    |
| All rural           |         |       |       |     |     |       |
| e. Urban areas:     | Memo   |       |       |     |     |       |
| 2 lanes             |         |       |       |     |     |       |
| 4 lanes, divided    |         |       |       |     |     |       |
| All urban           |         | 32    | 23    |     |     |       |

VIII. SAFETY LIGHTING

A. GENERAL LIGHTING

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FATAL</th>
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<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memo</td>
<td>40</td>
<td>10</td>
<td>6</td>
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</table>

B. INTERSECTIONS

<table>
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<tr>
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<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>Memo</td>
<td>11</td>
<td>14</td>
<td>23</td>
<td>20</td>
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C. RAILROAD CROSSINGS

<table>
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<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memo</td>
<td>49</td>
<td>66</td>
<td>62</td>
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<td></td>
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IX. RAILROAD CROSSING

A. AT-GRADE CROSSING

1. New flashing beacons

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FATAL</th>
<th>INJURY</th>
<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
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</thead>
<tbody>
<tr>
<td>Memo</td>
<td>80</td>
<td>82</td>
<td>82</td>
<td>59</td>
<td>70</td>
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<tr>
<td>a. Rural crossings</td>
<td>Memo</td>
<td>76</td>
<td>72</td>
<td>42</td>
<td>54</td>
</tr>
<tr>
<td>2 lanes</td>
<td></td>
<td>75</td>
<td>66</td>
<td>38</td>
<td>50</td>
</tr>
<tr>
<td>All rural</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Urban crossings</td>
<td>Memo</td>
<td>81</td>
<td>85</td>
<td>69</td>
<td>76</td>
</tr>
<tr>
<td>2 lanes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All urban</td>
<td></td>
<td>61</td>
<td>70</td>
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<td></td>
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</tbody>
</table>

2. Upgraded flashing beacons

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FATAL</th>
<th>INJURY</th>
<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td>100</td>
<td>15</td>
<td>15</td>
<td>15</td>
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</tr>
</tbody>
</table>

3. Automatic gates and new flashing lights (replacing passive devices)

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FATAL</th>
<th>INJURY</th>
<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memo</td>
<td>95-98</td>
<td>81-96</td>
<td>84</td>
<td>67-87</td>
<td>72-91</td>
</tr>
<tr>
<td>a. Rural crossings</td>
<td>AZ</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>86</td>
</tr>
<tr>
<td>2 lanes</td>
<td>Memo</td>
<td>47</td>
<td>55</td>
<td>36</td>
<td>44</td>
</tr>
<tr>
<td>All rural</td>
<td>Memo</td>
<td>51</td>
<td>61</td>
<td>43</td>
<td>50</td>
</tr>
<tr>
<td>b. Urban crossings</td>
<td>AZ</td>
<td>100</td>
<td>100</td>
<td>83</td>
<td>86</td>
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<tr>
<td>2 lanes</td>
<td>Memo</td>
<td>67</td>
<td>72</td>
<td>55</td>
<td>62</td>
</tr>
</tbody>
</table>

4. Automatic gates only (replacing passive devices and flashing lights)

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FATAL</th>
<th>INJURY</th>
<th>F&amp;I</th>
<th>PDO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memo</td>
<td>89</td>
<td>70</td>
<td>74</td>
<td>38</td>
<td>55</td>
</tr>
<tr>
<td>SAFETY IMPROVEMENT</td>
<td>SOURCE</td>
<td>FATAL</td>
<td>INJURY</td>
<td>F&amp;I**</td>
<td>PDO***</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>a. Rural crossings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lanes</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All rural</td>
<td></td>
<td>57</td>
<td>60</td>
<td>46</td>
<td>34</td>
</tr>
<tr>
<td>b. Urban crossings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lanes</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All urban</td>
<td></td>
<td>59</td>
<td>64</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>5. Signs &amp; markings at crossings</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Surface improvements at crossings</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Grade separation structures</td>
<td>Memo</td>
<td>41</td>
<td>43</td>
<td>37</td>
<td>39</td>
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<tr>
<td>to eliminate existing crossings</td>
<td></td>
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<tr>
<td>X. OTHER</td>
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</tr>
<tr>
<td>A. FENCING</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fencing, livestock</td>
<td>AZ</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>B. OTHER COMBINATION IMPROVEMENTS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. Flashing beacons &amp; 4-way stop signs (rural)</td>
<td>Memo</td>
<td>64</td>
<td>17-25</td>
<td>17-26</td>
<td>9-24</td>
</tr>
<tr>
<td>2. Channelization, Turning Lanes and/or Traffic Signals (any combination)</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Rural areas:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lanes</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 lanes, undivided</td>
<td></td>
<td>26</td>
<td>27</td>
<td>51</td>
<td>44</td>
</tr>
<tr>
<td>All rural</td>
<td></td>
<td>33</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>b. Urban areas:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lanes</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 lanes, undivided</td>
<td></td>
<td>19</td>
<td>21</td>
<td>31</td>
<td>28</td>
</tr>
<tr>
<td>4 lanes, divided</td>
<td></td>
<td>30</td>
<td>30</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>&gt;4 lanes, divided</td>
<td></td>
<td>18</td>
<td>19</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>All urban</td>
<td></td>
<td>64</td>
<td>22</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>c. With new signals</td>
<td>AZ</td>
<td>66</td>
<td>53</td>
<td>54</td>
<td>32</td>
</tr>
<tr>
<td>d. With improved signals</td>
<td>AZ</td>
<td>-30</td>
<td>51</td>
<td>50</td>
<td>46</td>
</tr>
<tr>
<td>3. Pavement Marking &amp; Delineation</td>
<td>Memo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Centerline</td>
<td>AZ</td>
<td>-33</td>
<td>-34</td>
<td>-12</td>
<td>-21</td>
</tr>
<tr>
<td>b. Centerline &amp; Edgeline</td>
<td>AZ</td>
<td>69</td>
<td>69</td>
<td>18</td>
<td>46</td>
</tr>
<tr>
<td>4. Signs, Markings &amp; Delineation at Narrow Bridges</td>
<td>Memo</td>
<td>49</td>
<td>42</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>5. Marking &amp; Signs at Curves</td>
<td>AZ</td>
<td>86</td>
<td>86</td>
<td>27</td>
<td>65</td>
</tr>
</tbody>
</table>

** Negative value indicates an increase in accidents
*** Fatal and injury accidents
a - Property damage only accidents
l - Angle accidents
r - Left-turn accidents
s - Run-off-road accidents

62
### TABLE 7. PERCENT REDUCTION IN ACCIDENTS FROM BEFORE AND AFTER ANALYSIS OF SAFETY IMPROVEMENTS IN KENTUCKY.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>SAFETY IMPROVEMENT</th>
<th>LOCATIONS</th>
<th>ANNUAL AVG BEFORE</th>
<th>ANNUAL AVG AFTER</th>
<th>PERCENT REDUCTION</th>
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<tbody>
<tr>
<td>I. SIGNS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. General</td>
<td></td>
<td>9</td>
<td>58</td>
<td>28.5</td>
<td>51</td>
</tr>
<tr>
<td>2. Chevrons and curve signs</td>
<td></td>
<td>1</td>
<td>3.5</td>
<td>5</td>
<td>-43</td>
</tr>
<tr>
<td>3. Chevrons, advisory speed, bridge panels</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2.5</td>
<td>-150</td>
</tr>
<tr>
<td>4. Slippery when wet signs</td>
<td></td>
<td>1</td>
<td>37(16²)</td>
<td>31.5(9.5³)</td>
<td>15(41⁴)</td>
</tr>
<tr>
<td>II. SIGNALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Modernization, Modification or Upgrading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Increase clearance interval</td>
<td></td>
<td>11</td>
<td>122</td>
<td>50.5</td>
<td>59</td>
</tr>
<tr>
<td>b. Add left-turn phase (Ref. 42)</td>
<td></td>
<td>24</td>
<td>480(116¹)</td>
<td>409(17¹)</td>
<td>15(85¹)</td>
</tr>
<tr>
<td>c. Upgrading</td>
<td></td>
<td>5</td>
<td>71</td>
<td>59</td>
<td>17</td>
</tr>
<tr>
<td>2. Warning Signals</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>a. Add flashing beacons</td>
<td></td>
<td>2</td>
<td>21</td>
<td>22</td>
<td>-5</td>
</tr>
<tr>
<td>III. PAVEMENT MARKING</td>
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<td></td>
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<tr>
<td>Lane use pavement arrows</td>
<td></td>
<td>8</td>
<td>48.5</td>
<td>32.5</td>
<td>33</td>
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<tr>
<td>IV. CONSTRUCTION/RECONSTRUCTION</td>
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<td></td>
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<tr>
<td>1. Construct acceleration lane</td>
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<td>1</td>
<td>2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>2. Vertical realignment</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3. Left-turn lane, median reconstruction</td>
<td></td>
<td>1</td>
<td>15</td>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>4. Raised median and markings</td>
<td></td>
<td>1</td>
<td>11</td>
<td>2</td>
<td>82</td>
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<tr>
<td>V. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Combination improvements</td>
<td></td>
<td>3</td>
<td>34</td>
<td>18.5</td>
<td>46</td>
</tr>
<tr>
<td>a. Pavement marking and signal improvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Pavement marking and signing</td>
<td></td>
<td>2</td>
<td>29</td>
<td>25.5</td>
<td>12</td>
</tr>
<tr>
<td>c. Signing and signal improvement</td>
<td></td>
<td>2</td>
<td>27</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>2. Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Trim vegetation</td>
<td></td>
<td>2</td>
<td>13</td>
<td>9</td>
<td>31</td>
</tr>
</tbody>
</table>

¹ - Left-turn accidents
² - Train accidents
³ - Wet pavement accidents
<table>
<thead>
<tr>
<th>TABLE 8. RECOMMENDED REDUCTION FACTORS FOR SAFETY IMPROVEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. SIGNS</td>
</tr>
<tr>
<td>A. WARNING SIGNS</td>
</tr>
<tr>
<td>1. Intersections</td>
</tr>
<tr>
<td>a. Urban Area</td>
</tr>
<tr>
<td>b. Rural Area</td>
</tr>
<tr>
<td>2. Sections</td>
</tr>
<tr>
<td>a. Urban Area</td>
</tr>
<tr>
<td>b. Rural Area</td>
</tr>
<tr>
<td>3. Curves</td>
</tr>
<tr>
<td>B. REGULATORY SIGNS</td>
</tr>
<tr>
<td>1. Intersections</td>
</tr>
<tr>
<td>2. Other</td>
</tr>
<tr>
<td>C. GUIDANCE SIGNS</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>D. OTHER</td>
</tr>
<tr>
<td>1. Variable Message Signs</td>
</tr>
<tr>
<td>2. Upgrade Signing</td>
</tr>
<tr>
<td>II. SIGNALS</td>
</tr>
<tr>
<td>A. NEW SIGNAL INSTALLATION</td>
</tr>
<tr>
<td>B. SIGNAL MODERNIZATION, MODIFICATION, OR UPGRADEING</td>
</tr>
<tr>
<td>C. WARNING SIGNALS/FLASHING Beacons</td>
</tr>
<tr>
<td>1. Intersections</td>
</tr>
<tr>
<td>a. Red-yellow</td>
</tr>
<tr>
<td>b. 4-way red</td>
</tr>
<tr>
<td>c. Advance</td>
</tr>
<tr>
<td>2. Curves</td>
</tr>
<tr>
<td>3. RR Crossing</td>
</tr>
<tr>
<td>4. Pedestrian Signal</td>
</tr>
<tr>
<td>D. SIGNAL PHASING</td>
</tr>
<tr>
<td>1. Add protected left-turn phase</td>
</tr>
<tr>
<td>2. Add permissive left-turn phase</td>
</tr>
<tr>
<td>3. Improve timing</td>
</tr>
<tr>
<td>4. Add pedestrian phase</td>
</tr>
</tbody>
</table>
**TABLE 8. RECOMMENDED REDUCTION FACTORS FOR SAFETY IMPROVEMENTS (Cont.)**

<table>
<thead>
<tr>
<th>E. OTHER</th>
<th>PERCENTAGE REDUCTION IN TOTAL ACCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pretimed to actuated</td>
<td>20</td>
</tr>
<tr>
<td>2. 12-inch lens</td>
<td>10</td>
</tr>
</tbody>
</table>

| III. DELINEATION | 5(20\(^{\text{wn}}\))(10\(^{\text{dn}}\)) |
| A. POST DELINEATORS | 20 |
| B. RAISED PAVEMENT MARKERS | |

| IV. PAVEMENT MARKING |  |
| A. ADD CENTERLINE | 30 |
| B. ADD EDGELINE | 15 |
| C. ADD NO PASSING STRIPING | 40 |
| D. TRANSVERSE STRIPING | 15 |

| E. LANE USE/PAVEMENT ARROWS | 30 |

| V. CHANNELIZATION |  |
| A. GENERAL INTERSECTION | 20 |

| B. LEFT-TURN CHANNELIZATION |  |
| 1. Signalized Intersection |  |
| a. Left-turn phase | 30 |
| b. No left-turn phase | 15 |
| 2. Non-Signalized Intersection |  |
| a. With curb | 60 |
| b. Painted | 30 |

| C. CONTINUOUS LEFT-TURN LANE | 30 |

<p>| VI. CONSTRUCTION/RECONSTRUCTION |  |
| A. LANE ADDITION |  |
| 1. Left-Turn Lane |  |
| a. Without signal | 25 |
| b. With signal | 30 |
| c. Two-way left-turn lane | 30 |
| 2. Acceleration/Deceleration Lane | 10 |</p>
<table>
<thead>
<tr>
<th>B. LANE/SHOULDER WIDENING</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. ALIGNMENT</td>
<td></td>
</tr>
<tr>
<td>1. Change horizontal alignment</td>
<td>30</td>
</tr>
<tr>
<td>2. Change Vertical alignment</td>
<td>45</td>
</tr>
<tr>
<td>3. Change horizontal and vertical alignment</td>
<td>50</td>
</tr>
<tr>
<td>D. CURVE RECONSTRUCTION</td>
<td>50</td>
</tr>
<tr>
<td>E. BRIDGES</td>
<td></td>
</tr>
<tr>
<td>1. Widen Bridge</td>
<td>40</td>
</tr>
<tr>
<td>2. Replace Bridge</td>
<td>40</td>
</tr>
<tr>
<td>F. INTERSECTION/INTERCHANGE</td>
<td></td>
</tr>
<tr>
<td>1. Construct Interchange</td>
<td>50</td>
</tr>
<tr>
<td>2. Reconstruct Intersection</td>
<td>40</td>
</tr>
<tr>
<td>G. OTHER</td>
<td></td>
</tr>
<tr>
<td>1. Improve sight distance</td>
<td>30</td>
</tr>
<tr>
<td>2. Correct/improve superelevation</td>
<td>40</td>
</tr>
<tr>
<td>3. Close median openings</td>
<td>30</td>
</tr>
<tr>
<td>4. Increase turning radii at intersections</td>
<td>15</td>
</tr>
<tr>
<td>5. Frontage road</td>
<td>40</td>
</tr>
<tr>
<td>6. Ramp modification</td>
<td>25</td>
</tr>
<tr>
<td>7. Flatten side slope</td>
<td>15</td>
</tr>
<tr>
<td>8. Construct pedestrian crossover</td>
<td>95P</td>
</tr>
</tbody>
</table>

VII. PAVEMENT TREATMENT
A. RESURFACING 20\(40^\circ\)W

B. SKID RESISTANCE
1. Deslicking 20\(40^\circ\)W
2. Pavement grooving 15\(55^\circ\)W

C. RUMBLE STRIPS 25
<table>
<thead>
<tr>
<th>VIII. SAFETY BARRIERS</th>
<th>PERCENTAGE REDUCTION IN TOTAL ACCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. MEDIAN BARRIERS</td>
<td>(0(60^f)(10^i))</td>
</tr>
<tr>
<td>B. CRASH CUSHION</td>
<td>(0(75^f)(50^i))</td>
</tr>
<tr>
<td>C. GUARDRAIL</td>
<td>(0(55^f)(35^i))</td>
</tr>
</tbody>
</table>

| IX. SAFETY LIGHTING  |                                          |
| A. GENERAL           | \(25(50^n)\)                            |
| B. INTERSECTIONS     | \(25(55^n)\)                            |
| C. SECTIONS          | \(25(50^n)\)                            |
| D. RAILROAD CROSSINGS| \(30(60^n)\)                            |
| E. INTERCHANGES      | \(25(50^n)\)                            |

| X. SAFETY POLES AND POSTS |                                          |
| A. BREAKAWAY SIGNS       | \(0(60^f)(30^i)\)                       |
| B. Breakaway Utility Poles| \(0(40^f)(30^i)\)                       |

| XI. RAILROAD CROSSING   |                                          |
| A. FLASHING BEACONS     | \(65^t\)                               |
| B. AUTOMATIC GATES      | \(75^t\)                               |
| C. RR PAVEMENT MARKINGS | \(10\)                                 |

| XII. REMOVAL/RELOCATION OF ROADSIDE OBJECTS |                                          |
| A. REMOVE FIXED OBJECTS     | \(0(50^f)(15^i)\)                      |
| B. RELOCATE FIXED OBJECTS   | \(0(40^f)(15^i)\)                      |

| XIII. OTHER              |                                          |
| A. FENCING               | \(90^d\)                               |
| B. ELIMINATE PARKING     | \(30\)                                 |

| C. PROHIBIT TURNING MOVEMENTS |                                          |
| C. PROHIBIT TURNING MOVEMENTS | \(40\)                                 |

- p = pedestrian accidents
- l = left-turn accidents
- wn = wet-nighttime accidents
- dn = dry-nighttime accidents
- w = wet pavement accidents
- f = fatal accidents
- i = injury accidents
- n = nighttime accidents
- t = train accidents
- d = animal accidents
APPENDIX

Survey Letter
Dear

The Kentucky Department of Highways utilizes a cost-optimization procedure (called dynamic programming) to priority rank improvements in its highway safety improvement program. The effectiveness of this program is greatly dependent on the accuracy of the improvement costs and benefits (accident reductions) input into the computer program.

The University of Kentucky Transportation Research Program is performing a study for the Kentucky DOH with the objective of developing a state-of-the-art listing of accident reduction percentages or factors associated with various types of safety improvements. While it is difficult to assign accurate accident reduction factors for specific safety improvements, our objective is to develop a listing which can be used to reasonably predict the consequences of implementing a given safety improvement.

One phase of this study involves a survey of states to determine what is currently being used across the country. We would appreciate any information your office could provide concerning the accident reduction estimates your state used to rank improvements proposed as part of your safety improvement program. We also wish to know the basis for these percentages, that is, whether they are based on studies conducted before and after the installation of safety improvements, a review of relevant literature, or engineering judgment. We will provide you with a summary of the findings of our survey if you so indicate. We appreciate your assistance.

Sincerely,

Kenneth R. Agent, P.E.
Research Engineer