South Dakota
Department of Transportation
Office of Research

U.S. Department
of Transportation
Federal Highway
Administration

SD2004-06-F

Updating South Dakota Crash Frequencies and Crash Reduction Factors

Study SD2004-06
Final Report

Prepared by
Office of Research Room 122
700 East Broadway
Pierre, South Dakota

August 2004

DISCLAIMER

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 South Dakota Department of Transportation, the State Transportation Commission, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ACKNOWLEDGEMENTS

This work was performed under the supervision of the SD2004-06 Technical Panel:

Cliff Reuer .... Local Government Assistance
John Adler..... Operations Support
Paul Knofczynski.....Project Development
Sharon Johnson.....FHWA
Bruce Potter ..... Office of Research
Hal Rumpca ..... Office of Research

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. SD2004-06-F	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Updating South Dakota Crash Frequencies and Crash Reduction Factors		5. Report Date August 5, 2004
		6. Performing Organization Code
7. Author(s) Rebecca Jungman		8. Performing Organization Report No.
9. Performing Organization Name and Address South Dakota Department of Transportation Office of Research Pierre, South Dakota, 57501-2586		10. Work Unit No.
		11. Contract or Grant No. SDDOT Contract Number
12. Sponsoring Agency Name and Address South Dakota Department of Transportation Office of Research 700 East Broadway Avenue Pierre, SD 57501-2586		13. Type of Report and Period Covered Final Report May 2004 to August 2004
		14. Sponsoring Agency Code
15. Supplementary Notes An executive summary is published separately as SD00-00-X.		

16. Abstract

This report offers the methodology and findings of the updates to the South Dakota Accident Reduction Factors (ARFs) and Severity Reduction Ratios (SRRs). The ARFs and SRRs focused on Roadway Safety Improvement (RSI) projects located in the State of South Dakota.

A literature search was conducted at the beginning of the project. The researcher used accident data gathered from RSI projects from 1994 to 2000 to calculate the ARFs and SRRs. The researcher updated the Severity Reduction Ratio formula with the most recent FHWA accident severity values. A benefit/cost analysis was performed on the RSI locations to determine their cost effectiveness.

Recommendations were made as to the use of the ARFs, SRRs, and the benefit/cost analysis. The recommendations were based on the results of the SDDOT research project, SD2004-06.

17. Keywords customer satisfaction	18. Distribution Statement No restrictions. This document is available to the public from the sponsoring agency.		
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 47	22. Price

Table of Contents

List of Tables

List of Equations

Problem Description

Currently, the federal government requires states to evaluate their Roadway Safety Improvement (RSI) projects and report the findings to the Federal Highway Administration (FHWA). The states have also been encouraged to produce their own Accident Reduction Factors to assist in the evaluation of their RSI projects. In 1998, the South Dakota Department of Transportation (SDDOT) developed Accident Reduction Factors for sixty-two RSI project locations in the State of South Dakota. However, there was not enough data at that time to calculate the Accident Reduction Factors for at least ten accident locations for each improvement type. Therefore, South Dakota continues to rely on information from the University of Kentucky for its Accident Reduction Factors.

In 1998, the SDDOT also developed expected value analysis tables for accident data collected from random intersections located throughout the state. The values provide a standard for identifying abnormal accident characteristics in consideration of local roadways, drivers, and environmental conditions. This information is used to improve identification of serious safety problems at intersections in South Dakota. However, the accident data for the tables has not been updated since the initial study.

Background Information

One method that South Dakota is using to help reduce accident rates is to calculate Accident Reduction Factors (ARF's) and Severity Reduction Ratios (SRR's) for South Dakota RSI projects. Accident Reduction Factors are values used to determine the degree to which accidents decrease after an improvement project. The factors consider driver, weather, road conditions, collision and improvement types, and the time of day/week/month/year. RSI projects from a variety of locations within South Dakota were used. RSI sites from 1986 to 2000 were included in this study; additional years of data can be added as accident information becomes available.

A Severity Reduction Ratio is a ratio of overall accident severity before an improvement project to the overall accident severity after an improvement project. A SRR is used to determine the degree to which accident severity decreases after an improvement project. Accidents involve five severities: fatalities, incapacitating injury, non-incapacitating injury, possible injury, and property-damage-only (PDO). All severity types will be incorporated into the study and used in calculating the Severity Reduction Formula which produces the Severity Reduction Ratio (SRR).

To calculate the SRR, the formula multiplies the number of each severity type by a corresponding factor amount and then sums the results for the three years following an improvement and the three years preceding the improvement. The three years' sum after the improvement is then divided by the sum calculated for the three years before the improvement project. The result is the SRR. An ideal ratio would be less than 1.0. For example, suppose a location had 44 accidents in the three years prior to the improvement and 65 accidents in the three years following the improvement. Next each severity type is multiplied by it's corresponding factor – 1291.67 for a fatality, 87.50 for an incapacitating injury, etc.. Suppose in this situation, doing so yields a value of 461.5 for the three years preceding the improvement and 422.5 for the three year following the improvement. To finally produce the ratio, 422.5 is divided by 461.5 which yields a Severity Reduction Ratio of 0.92. A ratio less than 1.0 means that the severity of the accidents occurring at the given location has decreased. Therefore, although the number of accidents in the example increased, the overall severity has decreased.

As with many other states, South Dakota is continually working on reducing the number of accidents at its roadway intersections. In order to facilitate this, the state must be able to identify intersections that have an abnormally high number of accidents. Currently South Dakota uses a set of expected value analysis tables to identify intersections with an above average number or severity of accidents. An expected value analysis table provides the expected number of accidents for a given intersection type. The

expected values provide a standard for identifying abnormal accident rates in consideration of local roadways, drivers, and environmental conditions.

The 1998 study developed expected value analysis tables for fourteen intersection categories - urban, three leg, signalized intersections; urban, four leg, signalized intersections with volume below 15,000; urban, four leg, signalized intersections with volume above 15,000; rural, divided, four lane to two lane, two way stop intersections; rural, four way stop, four leg intersections; three leg, signalized intersections in Rapid City; four leg, signalized intersections with a volume below 15,000 in Rapid City; four leg, signalized intersections with volume above 15,000 in Rapid City; three leg, signalized intersections in Sioux Falls; four leg, signalized intersections with a volume below 15,000 in Sioux Falls; four leg, signalized intersections with a volume above 15,000 in Sioux Falls; rural, one way stop, three leg intersections; rural , two way stop, four leg intersections; and rural, four way stop, four leg intersections.

The researcher obtained the latest FHWA specified dollar values for fatalities, incapacitating injuries, etc. from the SDDOT Office of Local Government Assistance. The new values were used to create updated formulas for the expected value analysis tables. Accident reports from the past five years will be collected for South Dakota intersections. This data will be arranged according to collision type, severity class, environmental conditions, time of day, and alcohol/drug use.

The “collision type” category is broken down into head on, angle, rear end, sideswipe overtaking, sideswipe opposite direction, overtaking road, ran off road, fixed object, parked vehicles, pedestrian, animal, left turn, and other collisions. Likewise, the “severity class” category is divided into fatality, major injury, and property damage. The third category, environmental conditions, is subdivided into light and surface conditions. Surface conditions can be separated into dry, wet, ice-frost, snow-slush, and other. Light conditions can be separated into light, dawn, dusk, and dark. The “time of day” category is broken down into months of the year, day of the week, and time of the day. Months of the year are grouped into sets of three, which correlate to the seasons: Winter - December, January, and February; Spring - March, April, and May; Summer - June, July, and August; and Fall - September, October, and November. Each day of the week is a separate category while the “time of day” is divided into seven groups. The groups consist of 00:00-06:00, 06:01-09:00, 09:01-11:00, 11:01-13:00, 13:01-15:00, 15:01-18:00, and 18:01-24:00. The final category added was Alcohol-Drugs. This category is subdivided into alcohol, drugs, alcohol-drugs, and other-none. This group uses the number of people in the accidents rather than the number of vehicles.

When all the data is gathered, a random sample is taken. Then the data will be substituted into the formula. The formula for the mean and standard deviation is shown below:

$$\overline{X} = \frac{\sum fx}{n} \qquad (1)$$

and

$$s = \sqrt{\frac{\sum f(\overline{x} - x)^2}{n - 1}} \qquad (2)$$

- $\overline{x}$ = mean accident frequency for the accident type
- f = number of sites with a given frequency for the intersection type
- x = number of accidents for the intersection type for each site
- n = total number of sites included in the analysis
- s = standard deviation of the specific accident characteristic.

The abnormal upper limit is calculated by using the following formula:

$$UL = \overline{x} + Ks \qquad (3)$$

UL = Abnormal upper limit of a specific accident characteristic
K = The probability, 1 – P, of the specific accident characteristic being exceeded by chance. Typical values for K are 1.96 for P = 0.05 (95^{th} percentile) and 1.645 for P = 0.10 (90^{th} percentile).

The formula provides the expected values for every intersection type. The abnormal upper limit provides the designation point for an abnormal number of accidents. If the number of accidents at an intersection exceeds the upper limit, then the frequency of accidents at that intersection will be considered abnormal.

Objectives

The technical panel overseeing the research project, SD2004-06, defined the following objectives for the study:

1) Calculate Accident Reduction Factors and Severity Reduction Ratios for each Roadway Safety Improvement Project completed between 1994 and 2000.

The Office of Accident Records in the SD Department of Public Safety maintains accident records from 1983 to present. The previous ARF study researched RSI projects completed through December 31, 1994. This study continues with projects completed through December 31, 2000. Setting the cut-off date at December 31, 2000 was necessary to allow for a complete three year period following the improvement project for the accident summaries.

2) Calculate average Accident Reduction Factors and Severity Reduction Ratios for each RSI improvement type used by the SDDOT.

To assess the overall improvement generated by an RSI improvement type, RSI projects were grouped by their improvement types, and the total number of accidents before and after the improvements were summed. The total number of following accidents was divided by the total number of previous accidents. The resulting ratios are the average ARFs and SRRs for each RSI improvement type.

3) Recommend Accident Reduction Factors and Severity Reduction Ratios to be used in RSI selections.

Once the ARFs and SRRs were calculated, they were compared with those found from a literature search. If the South Dakota ARF and SRR data was consistent with data found in the literature search and had the recommended ten locations per improvement type, they were recommended for use by the SDDOT and other agencies.

4) Update the South Dakota Expected Value Analysis Tables of accident frequencies at various intersection types.

An updated sample of 275 intersections throughout South Dakota was generated. The Office of Accident Records generated accident summaries for the most recent five year period, 1999 to 2003, for the 275 intersections. Unfortunately, time constraints prevented the researcher from completing the updates to the expected value analysis tables.

Task Description

Task 1 -- Meet with the project's technical panel to review the project scope and work plan.

The researcher met with the panel to review the project scope and the proposed work plan. This meeting was intended to provide an opportunity for the panel to ask any questions and provide additional input on the work plan. Any suggested changes which were approved by the panel were incorporated into the work plan.

Task 2 -- Review and summarize literature pertinent to abnormal accident patterns evaluations, Accident Reduction Factors, and Severity Reduction Ratios.

A literature search was conducted using information that was made available to the SDDOT Office of Research via universities, various state departments of transportation, and the Internet. Literature about accident pattern evaluations, such as the expected value analysis tables, is available from Virginia, Michigan, Texas, Ohio, Utah, and the Federal Highway Administration. Accident Reduction Factor literature is available from Kentucky, New York, California, Oregon, Iowa, North Carolina, and the Federal Highway Administration. The primary method used for calculating ARF's in the literature search was the before-and-after method. This was also the method used in the SD96-13 study. Therefore the researcher decided to continue the use of the method. A comparison of South Dakota's ARFs with those found in the literature search can be found in Table VI of Appendix A.

Task 3 -- Develop a phone survey and contact State DOT's in the Upper-Midwest Region to determine if they have developed and used expected value analysis tables, Accident Reduction Factors, and Severity Reduction Ratios.

A phone survey was planned for the states surrounding South Dakota. However, time constraints prevented the researcher from completing this task.

Task 4 -- Develop a list of South Dakota RSI Projects completed since 1986 including project location boundaries and types of improvements. Generate three-year before-and-after RSI accident summaries for each project completed from 1986 to 2000.

The 1998 study compiled a list of sixty-two RSI projects from 1986 to 1994. With the help of the Office of Local Government Assistance (LGA), the researcher added another fifty-five RSI Projects from 1994 to 2000 to the RSI projects list. For each project, the list included the general location, the type(s) of improvement(s), beginning and ending construction dates, project number and PCEM number.

The researcher worked with LGA to determine the project location boundaries and the type of improvement for each RSI project. In cooperation with the Office of Accident Records, the researcher gathered accident summaries for each RSI project for the three years prior to the project and three years following the project.

Every accident summary covers a three-year period and contains data describing many aspects of an accident. The summary details the totals of the types of collisions, roadway surface conditions, weather conditions, and the relations-to-intersection of the accidents. Road alignment and type of vehicles are also listed. The summary also notes whether the operator(s) of the vehicle(s) involved was (were) under the influence of drugs or alcohol, both, or neither. The hour, day, and month of the accident is included as well. Severity of the accidents is divided into fatality, incapacitating injury, non-incapacitating injury, possible injury and property-damage-only accidents. Finally, a table showing the relationship of the accident-type to accident-severity is given.

All projects were reviewed, sorted, and grouped by their improvement type. A list of the RSI improvement types can be seen in Table 1. If a RSI project had multiple improvement types, the researcher worked with LGA to determine the predominate improvement to be included in the totals and calculations.

Table 1: RSI Improvement Types

Improvement Types	
Addition of Acceleration Lane	Reconst.-General
Addition of Left Turn Lane	Reconst.-Increase Turning Radii
Addition of Pedestrian Walkway	Reconst.-Left Turn Lane
Addition of Right Turn Lane	Reconst.-Realign Intersection
Close Intersection	Remove Fixed Object
Cold Plastic Pavement Marking	Resurface-Addition of Center Turn Lane
Install Signal with Pavement Marking	Roadway Lighting
Install signal with turn radii	Shoulder Widening
Lengthened Left Turn Lane	Signal Upgrade
Pavement Marking-Continuous Center Turn Lane	Signal Upgrade and Pavement Marking
Pavement Marking-Left Turn Lane	Signing
Realignment-Horizontal	Slope flattening of approaches
Realignment-Horizontal and Vertical	Widen for the Addition of a center turn lane
Reconst.-Left Turn Lane with signal phase	Reconst.-Continuus center turn lane

Task 5 -- Using the information from RSI accident summaries from each project and the latest FHWA-specified dollar values for fatalities, injuries, and property-damage-only crashes, update the Accident Reduction Factors (ARF's) and the Severity Reduction Formula, and calculate the Severity Reduction Ratios (SRR's) for each project. Compare the results with the factors, formulas, and ratios identified in the literature search and phone survey.

The researcher used a Microsoft Excel spreadsheet and a Microsoft Access database to compile data, calculate totals for each location, and determine the increase or decrease of each accident type. For each RSI project location, the number of accidents was summed for the three years prior to the improvement project and three years following the improvement project. The totals for each type from the three years before were compared to the totals for each type following the improvement to determine the increase or decrease in accidents per type per location. Then, for each location, the total number of accidents from the three years prior to the improvement was added to the total number of accidents from the three years following the improvement to yield the total number of accidents per location.

For every location, the total number of accidents before and after the project was used to calculate the Accident Reduction Factor. The number of accidents following the improvement project was divided by the number of accidents from the three years prior to the project. This is the calculated Accident Reduction Factor.

Accident Reduction Factor Formula:

$$\text{ARF} = \frac{\text{Total accidents from three years after RSI project}}{\text{Total accidents from three years before RSI project}} \quad (4)$$

Table 2 provides a list of ARFs calculated for the fifty-five RSI locations from 1994 to 2000.

A Severity Reduction Formula is used to calculate the Severity Reduction Ratio. Included in the Severity Reduction Ratio formula are five accident severity types. The five types are: Fatality, Incapacitating Injury, Non-incapacitating Injury, Possible Injury, and Property-Damage-Only (PDO)[1]. A "Fatality" is an injury that results in death. If an injury causes death within 30 days of an accident, it is considered an accident fatality. An "Incapacitating Injury" is an injury such as skull injuries or broken bones that prevents the victim from normally continuing activities she was able to do before the accident. A "Non-Incapacitating Injury" is an injury other than an Incapacitating Injury that is evident to observers at the seen of the accident. Examples are abrasions, bruises, and minor lacerations. A "Possible Injury" is an injury reported or claimed that does not fall within the previous two categories. This includes limping, nausea, complaint of pain, and complaint of injuries not visible to observers. "PDO" results if there was only property damage; no injuries resulted from the accident.

In the formula, each accident severity type is given a factor value. The values are derived from data supplied by the Federal Highway Administration. The Federal data[2] estimates the amount of money that an individual is willing to spend on improved safety in order to prevent each accident severity type. The updated FHWA value for a fatality is estimated at $3,100,000, an incapacitating injury at $210,000, a non-incapacitating injury at $43,000, a possible injury at $23,000, and a property-damage-only accident at $2400. In order to derive the severity type factor amounts, each accident severity type dollar value is divided by the PDO dollar value. The factor values are 1291.67 for a fatality, 87.50 for an incapacitating injury, 17.92 for a non-incapacitating injury, 9.58 for a possible injury, and 1 for a PDO. These factor values are multiplied by the number of each accident severity-type: 1291.67 times each fatality, 87.5 times each incapacitating injury, etc. to produce the severity factors. The resulting values are then added together. To determine the Severity Reduction Ratio, the sum of the severity factors was calculated for the three years preceding and the three years following a project. The three-year total after the project was divided by the preceding three years' total to derive the SRR.

Severity Reduction Ratio Formula:

$$\frac{(F_f * 1291.67) + (I_f * 87.50) + (N_f * 17.92) + (P_f * 9.58) + (PDO_f * 1)}{(F_p * 1291.67) + (I_p * 87.50) + (N_p * 17.92) + (P_p * 9.58) + (PDO_p * 1)} \quad (5)$$

F = Fatality
I = Incapacitating Injury
N = Non-incapacitating Injury
P = Possible Injury
PDO = Property Damage Only

f = Following three years' totals
p = Previous three years' totals

[1] Instruction Manual for us with South Dakota's Motor Vehicle Traffic Accident Report, 1/1/83.
[2] FHWA Technical Advisory T 7570.2; U.S. Department of Transportation, 10/31/1994; values updated as of 6/2/04 from FHWA.

Using the SRR Formula, SRRs were calculated for all fifty-five project locations. These can be seen in Table 2:

Table 2: ARFs and SRRs by Project

PCEM	Previous Three Years' Accident Totals	Following Three Years' Accident Totals	Increase or Decrease by Location*	Accident Reduction Factor	Previous SRF Totals	Following SRF Totals	Severity Reduction Ratio
036M	80	79	-1	0.99	4,539.62	5632.85	1.24
037M	22	10	-12	0.45	412.42	253.92	0.62
038M	5	8	3	1.60	570.42	311.92	0.55
0773	29	44	15	1.52	589.24	881.34	1.50
1277	11	6	-5	0.55	62.00	57.00	0.92
148P, 149P	255	186	-69	0.73	3,044.10	3494.18	1.15
208P, 209P	81	113	32	1.40	4665.57	1433.10	0.31
292H	1	0	-1	0.00	1.0	0.00	0.00
3099	13	12	-1	0.92	46.84	54.66	1.17
3111	85	72	-13	0.85	1,138.62	525.94	0.46
326X	8	9	1	1.13	182.00	115.24	0.63
3622	9	0	-9	0.00	192.58	0.00	0.00
3625	24	1	-23	0.04	557.50	1.00	0.00
3663	22	9	-13	0.41	373.68	113.42	0.30
3828	122	120	-2	0.98	2,342.42	2339.80	1.00
3873	40	40	0	1.00	3638.0	188.66	0.05
3981	510	342	-168	0.67	6,767.86	6623.20	0.98
3982	0	0	0	N/A	0.0	0.00	N/A
3983	24	27	3	1.13	100.50	183.66	1.83
3985	1	0	-1	0.00	1.0	0.00	0.00
3989	127	102	-25	0.80	4109.91	1769.42	0.43
3990	27	8	-19	0.30	576.00	33.50	0.06
4352	0	0	0	N/A	0.00	0.00	N/A
4449	284	189	-95	0.67	3,925.10	5217.18	1.33
4537, 4539	131	87	-44	0.66	1,531.22	960.00	0.63
4538 (1) **	78	57	-21	0.73	4,769.11	505.64	0.11
4538 (2) **	78	57	-21	0.73	4,769.11	505.64	0.11
4540	0	0	0	N/A	0.0	0.00	N/A
4541	24	17	-7	0.71	2,148.93	138.58	0.06
4545	27	22	-5	0.81	539.86	1722.35	3.19
4547, 412R	52	32	-20	0.62	1,019.22	1132.16	1.11
4548	118	66	-52	0.56	2,652.82	1212.74	0.46
4549	3	2	-1	0.67	3.00	2.00	0.67
4551 (Dark)***	4	1	-3	0.25	90.5	87.50	0.97

PCEM	Previous Three Years' Accident Totals	Following Three Years' Accident Totals	Increase or Decrease by Location*	Accident Reduction Factor	Previous SRF Totals	Following SRF Totals	Severity Reduction Ratio
4551 (Norm)***	15	15	0	1.00	335.84	658.58	1.96
4554, 4555	49	42	-7	0.86	1470.92	1298.68	0.88
4579, 4546	31	18	-13	0.58	18113.03	21188.73	1.17
4785	28	21	-7	0.75	158.4	297.00	1.88
4878	17	14	-3	0.82	269.26	370.92	1.38
4879	49	31	-18	0.63	238.80	117.32	0.49
4880	152	78	-74	0.51	3,019.32	2261.97	0.75
5182	222	157	-65	0.71	2,660.54	3088.54	1.16
5183, 4799	45	29	-16	0.64	960.98	1091.84	1.14
5184, 5437	105	91	-14	0.87	899.6	621.46	0.69
5185	61	12	-49	0.20	905.72	28.92	0.03
5186	17	16	-1	0.94	42.74	180.24	4.22
5189, 5355	12	14	2	1.17	221.42	100.08	0.45
5440	8	2	-6	0.25	129.82	88.50	0.68
5442	63	43	-20	0.68	1384.1	2148.75	1.55
5591, 5356	41	32	-9	0.78	451.26	773.92	1.72
5672	40	36	-4	0.90	646.72	949.34	1.47
5683	20	4	-16	0.20	246.24	99.08	0.40
606R, 604R	156	96	-60	0.62	3,897.47	1048.88	0.27
660H, 661H	40	13	-27	0.33	832.76	150.26	0.18
A697	24	22	-2	0.92	179.66	142.82	0.79

* Negative denotes decrease

** PCEM 4538 ARF/SRR was calculated twice for two different improvement types.

*** PCEM 4551 ARF/SRR was calculated once using night only accidents and once using all accidents.

To calculate the averages ARFs for each type of improvment, every project-of-same-type ARF was grouped and averaged. The Average ARF's calculated from South Dakota data was then compared to Average ARF's found in the literary search. The projects and their respective Severity Reduction Ratios were sorted and grouped by improvement type. The groups of SRRs for every improvement type was summed and then averaged to produce an Average Severity Reduction Ratio for each type of improvement. The Average SRRs calculated from South Dakota data was then compared to Average SRRs found in the literature search. Table 3 lists the updated Average ARFs and SRRs by improvement type. For a complete list of the ARFs, SRRs, Average ARFs, Average SRRs, and percent reduction by improvement type, consult Table 1 of Appendix A.

Table 3: Average ARFs and Average SRRs by Improvement Type

Improvement Type	Number of Locations	Average ARFs	Average SRRs
Addition of Acceleration Lane	1	0.20	0.40
Addition of Left Turn Lane	4	0.72	0.08
Addition of Pedestrian Walkway	2	N/A	N/A
Addition of Right Turn Lane	2	0.48	0.63
Close Intersection	1	N/A	N/A
Cold Plastic Pavement Marking	10	0.67	0.90
Install signal with Pavement Marking	10	0.71	0.92
Install signal with turn radii	3	0.46	0.23
Lengthened Left Turn Lane	1	0.78	1.72
Pavement Marking-Continuous Center Turn Lane	3	0.90	1.02
Pavement Marking-Left Turn Lane	2	0.65	0.27
Realignment-Horizontal	6	0.21	0.05
Realignment-Horizontal and Vertical	3	1.12	4.12
Reconst.-Continuous Center Turn Lane	8	0.88	0.89
Reconst.-General	1	0.92	0.79
Reconst.-Increase Turning Radii	2	0.66	1.58
Reconst.-Left Turn Lane	3	0.69	0.84
Reconst.-Left Turn Lane with signal phase	4	1.02	0.74
Reconst.-Realign Intersection	7	0.81	0.59
Remove Fixed Object	1	0.00	0.00
Resurface-Addition of Center Turn Lane	2	0.63	1.48
Roadway Lighting	8	0.79	0.25
Shoulder Widening	1	0.80	0.75
Signal Upgrade	9	0.68	0.65
Signal Upgrade and Pavement Marking	8	0.79	0.97
Signing	9	0.96	0.91
Slope flattening of approaches	5	0.92	0.61
Widen for the addition of a center turn lane	1	0.80	0.43

Task 6 -- Calculate the benefit/cost ratios of projects completed with RSI funding only.

Due to the availability of accident severity information and improvement project costs, a benefit/cost analysis was performed on each project location. The researcher used the Bailey Formula[3] in calculating the benefit/cost ratios. This formula is used and recommended by the FHWA. Table 4 shows an example of the form provided by LGA used to calculate the benefit/cost ratios.

[3] FHWA Technical Advisory T 7570.2; U.S. Department of Transportation, 6/30/1988.

Table 4: Benefit Cost Analysis for PCEM 036M

	BENEFIT/COST ANALYSIS			
	PROJECT NAME:	PCEM 036M		
	Variables		Constants	
	Const. Improve. Cost	$224,000	* Fatal Accident Cost	$41,142
	Annual O & M Before	750	* Injury Accident Cost	$41,142
	Annual O & M After	500		
	Number Fatal Accidents	-1		
	Number of Injury Accds.	-1	* Prop. Damage Acc. Cost	$41,142
	Number of Fatalities	-1	Services Life	20
	Number of Injuries	-5	Salvage Value	0
	Number Prop. Damage Acc's	3	Interest Rate	10%
	Accdt. Reduct. Factr	0.15		
	Capital Recovery	0.117	Present Worth Fctr	0.149
	Sinking Fund	0.017	Present Worth Fctr Ser	8.514
	EUAB**	2057.10	PWOB**	17513.25
	EUAC**	26060.96	PWOC**	221871.61
#	B/C = EUAB/EUAC =	0.08	B/C = PWOB/PWOC =	0.08

This analysis is based on accident reports on file in the DOT Office of Accident Records for a six year period from 5/1/97 to 6/30/03.

This analysis is based on Cold Plastic Pavement Marking improvement type.

```
* RATES CALCULATED BY ROADWAY SYSTEM USING 3 YEAR ACCIDENT
   EXPERIENCE AND THE FOLLOWING FORMULA:
```

DEATHS * $3,000,000 +inc-injuries*$209,000+non-inc*$42,000+possible*$22,000+pdo*$2,300
fatal accid + inc-injury accid + non-inc accid + possible injury accid + property damage only acid

** EUAB – Equivalent Uniform Annual Benefit
EUAB – Equivalent Uniform Annual Cost
PWOB – Present Worth of Benefits
PWOC – Present Worth of Costs

To determine the number of fatal accidents to enter into the form, the researcher subtracting the number of accident after the improvement project from the number of accidents before the improvement project. For the example in Table 4, this was 2 fatal accidents before the improvement minus 3 fatal accidents following the improvement to yield a total of -1 accidents to enter into the form. For the example in Table 4, the number fatal and injury accidents actually increased. This lead to the benefit/cost ratio of 0.08. An ideal benefit/cost ratio would be greater than 1.00.

The benefit/cost ratios were also calculated using the ARF provided by the University of Kentucky in order to match those ARFs used in determining the feasibility of the original RSI project. A complete listing of the benefit/cost ratios by location is listed in Appendix A.

Task 7 -- Recommend the Accident Reduction Factors and Severity Reduction Ratios to be used in South Dakota.

The researcher will submit to the technical panel recommendations on Accident Reduction Factors in South Dakota. The recommendations will focus on the most effective type of improvement to be considered for use in the future. South Dakota ARF's based on limited data should be carefully considered. In such a case, the researcher may use data from other states in lieu of South Dakota data.

Task 8 -- Obtain accident, traffic volume, and other data from the SDDOT and local units of government necessary to update the expected value analysis tables for the most current five year period.

The researcher first took a random sample of the population of the intersections in South Dakota. The 1998 study determined that a sample size of 15 or 30 was sufficient depending on the size of the initial population. There were four categories where a sample size was not required: 1) rural, four lane, one way stop, three leg intersections; 2) three leg, signalized intersections in Rapid City; 3) four leg, signalized intersections with a volume below 15,000 in Rapid City; and 4) rural, four way stop, four leg intersections. The population sizes of these four categories (nine, twenty-two, seven, and seven respectively) were all too small to require a sample to be taken.

The coordinates of the sample intersections were obtained from a Microsoft Access database provided by the Office of Accident Records. After determining the coordinates, the researcher contacted the Office of Accident Records and requested accident summaries generated for the years 1999 to 2003 for the selected intersections. A complete list of the sample intersections will be added to the future update of SD98-12 *Identification of Abnormal Accident Patterns at Intersections*.

Task 9 -- Update the expected value analysis tables for South Dakota and compare them to a representative sample of similar tables developed for other states.

Due to time constrains, the researcher was unable to complete this task. However, since the accident summaries were gathered for the intersections, the data is available for entry at a later date.

Task 10 -- Prepare a final report and executive summary of the literature review, findings and conclusions.

The researcher prepared a final report and executive summary of the literature review, research methodology, findings, conclusions, and recommendations. The researcher updated spreadsheets and databases used to calculate the expected value analysis tables, totals, the individual Accident Reduction Factors, and Severity Reduction Ratios. Both the spreadsheets and database were designed to allow the input of new information as it becomes available. Therefore, SDDOT can use and analyze accident data in the future.

Task 11 -- Make an executive presentation to the Research Review Board at the conclusion of the project.

The researcher made an executive presentation to the SDDOT Research Review Board on the results of the Updating South Dakota Crash Frequency and Accident Reduction Factors project at the August 5, 2004 Research Review Board meeting.

Findings and Conclusions

This study included fifty-five Roadway Safety Improvement projects located throughout the State of South Dakota. The fifty-five projects were added to sixty-two projects studied in the 1998 project, Developing South Dakota Accident Reduction Factors. The projects were located on city roads, state and US highways, and Interstate systems. The 117 projects cover twenty-eight improvement types. Seven of the improvement types contain one location, five improvement types included two locations, and sixteen improvement types included any number of locations ranging from three to nine. There were two improvement types, "Cold Plastic Pavement Marking" and "Install Signal with Pavement Marking", included a full ten locations.

Twenty-four of the improvement types show Accident Reduction Factors of less than 1.00, indicating a decrease in the number of accidents. Two improvement types, "Reconst.-Left turn lane with signal phase" and "Realignment Horizontal and Vertical", had ARFs greater than 1.00 showing an increase in accidents, and two improvement types, "Addition of Pedestrian Walkway" and "Close Intersection", had no ARFs. These two improvement types included only one location each and had no accidents before or after the RSI projects, resulting in no ARFs. These two locations underwent RSI projects because they had the potential for dangerous accidents rather than actually having the accidents. The two improvement types showing an increase in accidents had only three or four locations each.

The 1998 study recommended that South Dakota ARFs be based on at least ten project locations per improvement type. The researcher's findings further support this recommendation. The researcher found that improvement types with a higher number of accident locations showed fewer fluctuations in the ARFs when new locations were added. Therefore the ARFs for the "Cold Plastic Pavement Marking" and "Install Signal with Pavement Marking" improvement types should be considered the most accurate. Likewise, those types with only one location should be considered the least accurate.

Along with ARFs, Severity Reduction Ratios were calculated for every project location. Recall that a SRR of less than 1.00 is ideal. This indicates a decrease in the severity of accidents at a location. A SRR of 1.00 shows no difference in the severity while an SRR greater than 1.00 shows an increase in the severity of accidents. There were five improvement types that had SRRs greater than 1.00: "Lengthened Left Turn Lane", "Pavement Marking-Continuous Center Turn Lane", "Realignment-Horizontal and Vertical", "Reconst.-Increase Turning Radii", and "Resurface-Addition of Center Turn Lane". The improvement types showing the increase in severity were all types with less than five locations each. As with the ARF's, the "Addition of Pedestrian Walkway" and "Close Intersection" improvement types did not have SRRs.. There were three improvement types ("Realignment-Horizontal", "Addition of Left Turn Lane", and "Remove Fixed Object") with SRRs at or very near 0.00. These would indicate nearly a 100 % reduction in severity. Once again, these were nearly all types with less than five locations. Generally, improvement types with five or more locations had SRRs that fell between the two extremes.

In addition to calculating ARFs and SRRs, the researcher also performed a benefit/cost analysis on the RSI projects. Unlike the initial study, the benefit/cost analysis was performed on all the RSI projects regardless of their funding sources. This was done because so many of the projects now have multiple funding sources. The total amount spent on the project was used in the analysis. In benefit/cost analysis, a number greater than 1.00 represents a project that was beneficial. Of the fifty-five RSI projects analyzed, twenty-eight yielded a benefit/cost of 1.00 or greater.

When the benefit/cost ratios were compared with the ARFs and SRRs, it was found that they showed corresponding benefit increases or decreases in less than half the projects. For nineteen projects, the ARFs, SRRs, and the benefit/cost analysis all agreed in showing the project was beneficial. The ARFs, SRRs, and benefit cost analysis agreed in showing six projects were not beneficial. For the other thirty projects, there was a conflict between the ARFs/SRRs and the benefit/cost analysis. For example an RSI project may have and ARF and SRR both less then 1.00 showing a benefit resulting from the project, and

yet have a benefit/cost number of less than 1.00. This indicates that while the project decreased the number of accidents and their severity, the decrease was not enough to justify the money spent on the project. However, the benefit/cost analysis only focuses on accidents and does not take into consideration other benefits such as decreased travel time, better ride quality, and a decrease of traffic congestion. The conflicts between the ARFs/SRRs and the benefit cost ratios could be due to the fact that the specific RSI funding could not be separated out from projects with multiple funding sources. A table of the benefit/cost analysis performed by location can be found in Appendix A.

Implementation Recommendations

Based on the results of this research study, the following recommendations are presented to the Research Review Board for their consideration:

1) **Future Roadway Safety Improvement projects should be analyzed and added to the existing data as the projects are completed.** Increasing the number of project locations will increase the accuracy of the South Dakota Accident Reduction Factors and Severity Reduction Ratios.

2) **The SDDOT Office of Local Government Assistance should be responsible for continuing Roadway Safety Improvement analysis.** The Office of Local Government Assistance oversees the Roadway Safety Improvement program and will therefore be able to produce much of the necessary project information. Also, LGA uses Accident Reduction Factors in its determination process for future RSI projects.

3) **South Dakota Accident Reduction Factor averages should be based on at least ten accident locations per improvement type before being considered for use.** The South Dakota Department of Transportation should continue to use Accident Reduction Factors from outside sources until South Dakota Accident Reduction Factors have a minimum of ten locations per improvement project.

4) **The South Dakota Department of Transportation should begin using the South Dakota Accident Reduction Factors for the "Cold Plastic Pavement Marking" and "Install Signal with Pavement Marking" improvement types.** The "Cold Plastic Pavement Marking" and "Install Signal with Pavement Marking" improvement types both have ten project locations and should be implemented for use by the Office of Local Government Assistance.

5) **The South Dakota Department of Transportation should consider ceasing the use of benefit/cost analyses on split funded Roadway Safety Improvement projects.** The increase in the number of projects with multiple funding sources has decreased the reliability of the benefit/cost analysis. Therefore, the SDDOT should reconsider the use of the analysis on projects with multiple funding sources.

6) **The South Dakota Expected Value Analysis Tables should be updated as part of a separate research project.** The South Dakota Expected Value Analysis Tables should be updated as part of their own project due to the extensive data collection and entry required.

References

Agent, Kenneth R., Nikiforos Stamatiadis, and Samantha Jones. *Development of Accident Reduction Factors.* Lexington: University of Kentuck, 1996.

North Carolina Department of Transportation. *W-Project Crash Reduction Information*. (2002). http://www.doh.dot.state.nc.us/preconstruct/traffic/safety/ses/project_guide/regionalfactors.pdf

South Dakota Office of Accident Records. *Instruction Manual for use with South Dakota's Motor Vehicle Accident Report*. Pierre, SD, Office of Accident Records, 1983.

Storsteen, Mary. *Identification of Abnormal Accident Patterns at Intersections.* Pierre, SD, Office of Research, 1998.

Strathman, James G., Kenneth J. Duecker, Jihong Zhang, and Timothy Williams. *Analysis of Design Attributes and Crashes on the Oregon Highway System*. Center for Urban Studies, Portland State University, 2001.

Thomas, Gary B. and Smith, Daniel J. *Effectiveness of Roadway Safety Improvement*. Center for Transportation Research and Education: Iowa State University, 2001.

Tople, Andrew R. *Development of South Dakota Accident Reduction Factors.* Pierre, South Dakota, Office of Research, 1998.

U.S. Dept. of Transportation. *Technical Advisory T 7570.2*. Washington D.C., FHWA, 1994, updated 2004.

U.S. Dept. of Transportation. *Technical Advisory T 7570.2.* Washington D.C., FHWA, 1988.

Appendix A

Supplemental Tables for ARFs and SRRs

Table I

RSI-Accident Reduction Factors Report

Improvement Type				PCEM	Location	Accident Reduction Factor	SRR
Addition of Acceleration Lane							
	Number of Accidents						
Previous	20	**Following**	4	5683	Jct. SD42 & SD11 South of Brandon	0.20	0.40
					Overall averages:	**0.20**	**0.40**
					Overall ARF	**80.00% Decrease**	
Addition of Left Turn Lane							
	Number of Accidents						
Previous	40	**Following**	40	3873	US 85 - from National St south to 0.24 miles	1.00	0.05
Previous	27	**Following**	8	3990	New York & 5th in Rapid City	0.30	0.06
Previous	78	**Following**	57	4538 (2)	US281 - from 4th St. N NW to Fair Grounds	0.73	0.11
Previous	3	**Following**	2	4549	Canyon Lake Dr. & Dakota Dr. in Rapid City	0.67	0.67
					Overall averages:	**0.72**	**0.08**
					Overall ARF	**27.70% Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor		SRR
Addition of Right Turn Lane								
	Number of Accidents							
Previous	61	**Following**	12	5185	Russel & Kiwanis in Sioux Falls	0.20		0.03
Previous	40	**Following**	36	5672	Watertown & Lacrosse in Rapid City	0.90		1.47
					Overall averages:	**0.48**		**0.63**
					Overall ARF	**52.48%**	**Decrease**	
Cold Plastic Pavement Marking								
	Number of Accidents							
Previous	80	**Following**	79	036M	US16A from Keystone Wye to Keystone	0.99		1.24
Previous	22	**Following**	10	037M	US16A from Keystone Wye to Keystone	0.45		0.62
Previous	5	**Following**	8	038M	SD224 from US16A to Mt. Rushmore	1.60		0.55
Previous	510	**Following**	342	3981	SD 115 from Russell St to 17th St. in SF	0.67		0.98
Previous	284	**Following**	189	4449	SD115 from 18th St. to 33rd St.	0.67		1.33
Previous	118	**Following**	66	4548	St Patrick from Elm to St Joseph in Rapid City	0.56		0.46
Previous	49	**Following**	42	4554, 4555	Duster Corner to Main Gate Rd in Box Elder	0.86		0.88
Previous	152	**Following**	78	4880	5th St. from Columbus South to Fairmont Blvd.	0.51		0.75
Previous	222	**Following**	157	5182	Cliff Ave from I-90 S to Benson Road in Sioux	0.71		1.16
Previous	156	**Following**	96	606R, 604R	SD 115 from N of Robur Dr S to Benson road	0.62		0.27
					Overall averages:	**0.67**		**0.90**
					Overall ARF	**33.23%**	**Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor		SRR
Install Signal with Pavement Marking								
Number of Accidents								
Previous	32	**Following**	16	2089	E North St & Spruce	0.50		0.50
Previous	13	**Following**	13	2095	E North St & Milwaukee St	1.00		1.03
Previous	37	**Following**	19	2114	5th St and Kansas City St in Rapid City	0.51		0.96
Previous	29	**Following**	27	305X	Intersection of Cliff Ave & Rice St in Sioux	0.93		4.18
Previous	27	**Following**	9	3114	SD79 & Fairmont Blvd in Rapid City	0.33		0.35
Previous	11	**Following**	24	339X	Jackson and Main in Spearfish	2.18		5.52
Previous	8	**Following**	4	3620	City-intersection of 5th St. S. & Main Ave.	0.50		4.01
Previous	15	**Following**	13	3621	8th St. S & 22nd Ave in Brookings	0.87		1.19
Previous	9	**Following**	0	3622	49th & Kiwanis in Sioux Falls	0.00		0.00
Previous	16	**Following**	14	3980	US16 (8th St) & Cathedral Dr. intersection in	0.88		1.12
					Overall averages:	**0.71**		**0.92**
					Overall ARF	**29.44%**	**Decrease**	
Install signal with turn radii								
Number of Accidents								
Previous	37	**Following**	7	2097	3rd & Dakota S in Aberdeen	0.19		0.06
Previous	14	**Following**	12	343X	US212 & 11th St. SE in Watertown	0.86		0.34
Previous	10	**Following**	9	589X	8th Ave NE & Roosevelt St in Aberdeen	0.90		0.22
					Overall averages:	**0.46**		**0.23**
					Overall ARF	**54.10%**	**Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor		SRR
Lengthened Left Turn Lane								
	Number of Accidents							
Previous	41	**Following**	32	5591, 5356	E. North St. & Campbell (US16B) in Rapid City	0.78		1.72
					Overall averages:	**0.78**		**1.72**
					Overall ARF	**21.95%**	**Decrease**	
Pavement Marking-Continuous Center Turn								
	Number of Accidents							
Previous	58	**Following**	42	3619	SD44(W Omaha St)-Mt View Rd to 11th St in	0.72		1.80
Previous	115	**Following**	117	3853	LaCrosse St.-from Anamosa St. S to E North	1.02		0.92
Previous	105	**Following**	91	5184, 5437	Havens St from Ohlman to Burr in Mitchell	0.87		0.69
					Overall averages:	**0.90**		**1.02**
					Overall ARF	**10.07%**	**Decrease**	
Pavement Marking-Left Turn Lane								
	Number of Accidents							
Previous	10	**Following**	10	3825	City Sts.- intersection of 5th St. & St. Cloud St.	1.00		0.10
Previous	16	**Following**	7	3991	intersection of W Main St. & Cross St. in RC	0.44		0.45
					Overall averages:	**0.65**		**0.27**
					Overall ARF	**34.62%**	**Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor	SRR
Realignment-Horizontal							
	Number of Accidents						
Previous	16	**Following**	0	0083	US385 at MRM 118.8--S. of JCT US85 &	0.00	0.00
Previous	1	**Following**	0	292H	Sturgis - Sly Hill Area	0.00	0.00
Previous	2	**Following**	0	319X	Co. Rd. East of JCT SD11 & Minn Co #115	0.00	0.00
Previous	1	**Following**	0	322X	SD71 MRM 30.5 South of Hot Springs	0.00	0.00
Previous	22	**Following**	9	3663	Terry Peak Rd near Trojan	0.41	0.30
Previous	1	**Following**	0	3985	Vanocker Canyon Rd & Otter Rd in Meade	0.00	0.00
					Overall averages:	**0.21**	**0.05**
					Overall ARF	**79.07% Decrease**	
Realignment-Horizontal and Vertical							
	Number of Accidents						
Previous	9	**Following**	15	2085	SD407 from NE state line to Pine Ridge	1.67	11.09
Previous	6	**Following**	0	325X	Township Rd. from SD11 to Palisades Park	0.00	0.00
Previous	2	**Following**	4	452X	SD1804 From Oahe Dam, North	2.00	0.15
					Overall averages:	**1.12**	**4.12**
					Overall ARF	**11.76% Increase**	

Improvement Type				PCEM	Location	Accident Reduction Factor		SRR
Reconst.-Continuous Center Turn Lane								
Number of Accidents								
Previous	11	**Following**	6	1277	10th St. - Cleveland to Thompson	0.55		0.92
Previous	49	**Following**	62	3093	SD44(3)(Jackson Blvd) from W Main to Mt	1.27		1.00
Previous	112	**Following**	97	3115	Cambell St. from E North St. to SD44	0.87		0.75
Previous	3	**Following**	1	3116	US83-through the town of White River	0.33		0.03
Previous	84	**Following**	68	3641	26th St.- from Big Sioux River St. to Cleveland	0.81		0.77
Previous	27	**Following**	30	3830	SD44-from Campbell St. southeasterly to	1.11		2.79
Previous	23	**Following**	13	450X	Pennington Co #223, Ellsworth AFB Main	0.57		17.79
Previous	24	**Following**	17	4541	SD115 From North of I-90 North thru Res.	0.71		0.06
					Overall averages:	**0.88**		**0.89**
					Overall ARF	**11.71%**	**Decrease**	
Reconst.-General								
Number of Accidents								
Previous	24	**Following**	22	A697	Twilight Dr. from SD44 to Moon St.	0.92		0.79
					Overall averages:	**0.92**		**0.79**
					Overall ARF	**8.33%**	**Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor	SRR
Reconst.-Increase Turning Radii							
Number of Accidents							
Previous	4	**Following**	0	157W	9th & Summit in Yankton to 8th St	0.00	0.00
Previous	28	**Following**	21	4785	Cliff Ave. & 54th St. in Sioux Falls	0.75	1.88
					Overall averages:	**0.66**	**1.58**
					Overall ARF	**34.38%**	**Decrease**
Reconst.-Left Turn Lane							
Number of Accidents							
Previous	9	**Following**	6	3113	SD37 & 23rd St in Mitchell	0.67	1.07
Previous	1	**Following**	0	3120	SD79-east entrances at SDSM&T	0.00	0.00
Previous	3	**Following**	3	334X	Campbell and North St in Rapid City	1.00	0.60
					Overall averages:	**0.69**	**0.84**
					Overall ARF	**30.77%**	**Decrease**
Reconst.-Left Turn Lane with signal phase							
Number of Accidents							
Previous	29	**Following**	44	0773	SD42 & Lyons in Sioux Falls	1.52	1.50
Previous	61	**Following**	37	2087	SD439 intersection of Campbell & St Patrick	0.61	0.48
Previous	40	**Following**	4	335X	Intersection of SD44 & Canyon Lake Dr. in	0.10	0.03
Previous	28	**Following**	76	451X	SD238 from Campbell to SD44	2.71	4.46
					Overall averages:	**1.02**	**0.74**
					Overall ARF	**1.90%**	**Increase**

Improvement Type				PCEM	Location	Accident Reduction Factor	SRR
Reconst.-Realign Intersection							
Number of Accidents							
Previous	6	**Following**	2	1919	US14 & Lincoln Ave in Huron	0.33	0.04
Previous	2	**Following**	5	2096	Hillsview Dr. & W. St. Patrick St.	2.50	2.07
Previous	3	**Following**	3	2113	SD50 and county road at Junction City	1.00	0.38
Previous	8	**Following**	9	326X	US85 Jct of US85 & SD34 & Ziebach St in	1.13	0.63
Previous	18	**Following**	11	344X	US85 and National St in Belle Fourche	0.61	1.06
Previous	24	**Following**	1	3625	Western & Russel in Sioux Falls	0.04	0.00
Previous	19	**Following**	34	588X	City-intersection of Russell St. & Prairie Ave	1.79	2.04
					Overall averages:	**0.81**	**0.59**
					Overall ARF	**18.75% Decrease**	
Remove Fixed Object							
Number of Accidents							
Previous	9	**Following**	0	321X	Burr St from Douglas Ave to 1st Ave in	0.00	0.00
					Overall averages:	**0.00**	**0.00**
					Overall ARF	**100.00% Decrease**	
Resurface-Addition of Center Turn Lane							
Number of Accidents							
Previous	8	**Following**	2	5440	SD 50 WBL from Vermillion East to I29	0.25	0.68
Previous	63	**Following**	43	5442	SD50 from Ferdig Ave in Yankton E to	0.68	1.55
					Overall averages:	**0.63**	**1.48**
					Overall ARF	**36.62%**	**Decrease**

Improvement Type				PCEM	Location	Accident Reduction Factor		SRR
Roadway Lighting								
Number of Accidents								
Previous	2	**Following**	3	2076	US18 through Martin	1.50		0.08
Previous	1	**Following**	1	2574	SD73 from Jct US18 1400ft South	1.00		1.00
Previous	3	**Following**	1	291H	US83-through the town of White River	0.33		0.03
Previous	64	**Following**	53	338X	S Main fro US12 to 12th St South in Aberdeen	0.83		1.20
Previous	2	**Following**	2	4096	SD47-through Ft. Thompson	1.00		0.03
Previous	78	**Following**	57	4538 (1)	US281 - from 4th St. N NW to Fair Grounds	0.73		0.11
Previous	15	**Following**	1	4551 (Dark)	SD79 & US18 East of Hot Springs	0.07		0.97
Previous	4	**Following**	15	4551 (Norm)	SD79 & US18 East of Hot Springs	3.75		1.96
					Overall averages:	**0.79**		**0.25**
					Overall ARF	**21.30%**	**Decrease**	
Shoulder Widening								
Number of Accidents								
Previous	10	**Following**	8	3118	SD46-from jct. SD25 east to the Menno Rd.	0.80		0.75
					Overall averages:	**0.80**		**0.75**
					Overall ARF	**20.00%**	**Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor	SRR
Signal Upgrade							
Number of Accidents							
Previous	165	**Following**	97	3097	SD38-10th & 11th Sts.	0.59	0.65
Previous	13	**Following**	12	3099	SD115 from Russel to I229	0.92	1.17
Previous	11	**Following**	14	330X	SD79 & Douglas in Sturgis	1.27	0.22
Previous	65	**Following**	49	3598	US16 (8th St) and Kansas City St in Rapid City	0.75	1.10
Previous	17	**Following**	8	3832	US81 & SD50 in Yankton	0.47	0.01
Previous	14	**Following**	12	3978	SD37-(Sanborn Blvd) & 7th Ave in Mitchell	0.86	1.48
Previous	52	**Following**	33	4547, 412R	St Patrick & St Joseph, St Patrick & Creek Dr	0.63	1.11
Previous	49	**Following**	31	4879	SD50 Loop Cherry St from Cottage St East to	0.63	0.49
Previous	12	**Following**	14	5189, 5355	Disk Dr. & Lacrosse in Rapid City	1.17	0.45
					Overall averages:	**0.68**	**0.65**
					Overall ARF	**32.16% Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor	SRR
Signal Upgrade and Pavement Marking							
Number of Accidents							
Previous	255	**Following**	186	148P, 149P	Ints. On US212, US81, SD20 and Broadway	0.73	1.15
Previous	85	**Following**	72	3111	41st. & Louise in Sioux Falls	0.85	0.46
Previous	122	**Following**	120	3828	Omaha St. at 5th, 6th, & 8th St. in Rapid City	0.98	1.00
Previous	23	**Following**	27	3983	Euclid & Broadway – Pierre, Euclid & Capitol	1.17	1.83
Previous	131	**Following**	87	4537, 4539	Orchard Dr. & 22nd Ave8th & Medary	0.66	0.63
Previous	17	**Following**	14	4878	14th & Main in Sioux Falls	0.82	1.38
Previous	45	**Following**	29	5183, 4799	St Patrick & St Joseph in Rapid City	0.64	1.14
Previous	17	**Following**	16	5186	12th & Grange in Sioux Falls	0.94	4.22
					Overall averages:	**0.79**	**0.97**
					Overall ARF	**20.72% Decrease**	

Signing							
Number of Accidents							
Previous	81	**Following**	113	208P, 209P,	County Roads in Bon Homme County	1.40	0.31
Previous	37	**Following**	41	264H	County roads throughout Fall River county	1.11	0.88
Previous	759	**Following**	727	310X	County roads throughout Pennington county	0.96	1.11
Previous	57	**Following**	53	353H	County roads throughout Corson county	0.93	0.56
Previous	360	**Following**	348	396W	County roads throughout Meade county	0.97	0.58
Previous	74	**Following**	53	429W	County roads throughout Hughes county	0.72	0.98
Previous	27	**Following**	22	4545	County rds at various locations in Stanely Co.	0.81	3.19
Previous	31	**Following**	18	4579, 4546	County Roads in Todd County	0.58	1.17
Previous	116	**Following**	108	626W	County roads throughout Day county	0.93	0.41
					Overall averages:	**0.96**	**0.91**
					Overall ARF	**3.83% Decrease**	

Improvement Type				PCEM	Location	Accident Reduction Factor		SRR
Slope flattening of approaches								
Number of Accidents								
Previous	44	**Following**	65	1839	US12 from S. JCT US83 E. to Ipswich	1.48		0.92
Previous	110	**Following**	106	1840	US83 from US14 N. to Sully line: from US212	0.96		0.64
Previous	1	**Following**	5	2257	SD253 from US12 N. 9 mi.	5.00		0.01
Previous	105	**Following**	88	2538	SD79 from Maverick JCT to Rapid City	0.84		0.66
Previous	40	**Following**	13	660H, 661H	SD 15/20 from US 212 N. to 1.3 Mi S. of	0.33		0.18
					Overall averages:	**0.92**		**0.61**
					Overall ARF	**7.67%**	**Decrease**	
Widen for the Addition of a center turn lane								
Number of Accidents								
Previous	127	**Following**	102	3989	SD79 from W Chicago to Meade County Line	0.80		0.43
					Overall averages:	**0.80**		**0.43**
					Overall ARF	**19.69%**	**Decrease**	

Table II

RSI-Data by PCEM from 1986 to 2000						
PCEM	**County**	**Improvement Type**	**Begin**	**End**	**Location Description**	**Project**
0083	Lawrence	Realignment-Horizontal	5/4/1987	6/16/1987	US385 at MRM 118.8--S. of JCT US85 & US385	HES0385(23)119
036M	Pennington	Cold Plastic Pavement Marking	5/1/2000	6/8/2000	US16A from Keystone Wye to Keystone	
037M	Pennington	Cold Plastic Pavement Marking	5/1/2000	6/8/2000	US16A from Keystone Wye to Keystone	PH1016(18)50
038M	Pennington	Cold Plastic Pavement Marking	5/1/2000	6/9/2000	SD224 from US16A to Mt. Rushmore	PH0244(00)30
0773	Minnehaha	Reconst.-Left Turn Lane with signal phase	4/14/1997	8/22/1998	SD42 & Lyons in Sioux Falls	P-PH-BRF0042(1)363
1277	Minnehaha	Reconst.-Continuous Center Turn Lane	1/2/1996	7/12/1997	10th St. - Cleveland to Thompson	P-PH0038(14)372
148P, 149P	Codington	Signal Upgrade and Pavement Marking	6/15/1998	2/9/2000	Ints. On US212, US81, SD20 and Broadway Ave.	P-PH0212(02)376
157W	Yankton	Reconst.-Increase Turning Radii	7/16/1991	12/1/1991	9th & Summit in Yankton to 8th St	M-HES4756(2)
1839	Walworth	Slope flattening of approaches	7/9/1986	9/4/1986	US12 from S. JCT US83 E. to Ipswich	HES0012(52)214
1840	Pennington	Slope flattening of approaches	9/8/1986	5/14/1987	US83 from US14 N. to Sully line: from US212 to ND	HES0083(38)138
1919	Beadle	Reconst.-Realign Intersection	6/12/1989	8/26/1989	US14 & Lincoln Ave in Huron	HES0014(95)344
2076	Bennett	Roadway Lighting	10/18/1988	2/17/1989	US18 through Martin	HES0018(87)148
2085	Shannon	Realignment-Horizontal and Vertical	8/14/1989	10/1/1989	SD407 from NE state line to Pine Ridge	HES0407(2)0
2087	Pennington	Reconst.-Left Turn Lane with signal phase	9/22/1988	12/19/1988	SD439 intersection of Campbell & St Patrick in RC	HES0439(8)
2089	Pennington	Install Signal with Pavement Marking	7/23/1990	12/15/1990	E North St & Spruce	HES2090(10)70
208P, 209P, 671H, 4542	Bon Homme	Signing	8/21/1996	10/1/1996	County Roads in Bon Homme County	P000S(145) PH8005(5)
2095	Pennington	Install Signal with Pavement Marking	7/23/1990	12/15/1990	E North St & Milwaukee St	HES2090(11)70

RSI-Data by PCEM from 1986 to 2000						
PCEM	**County**	**Improvement Type**	**Begin**	**End**	**Location Description**	**Project**
2096	Pennington	Reconst.-Realign Intersection	8/7/1989	9/5/1989	Hillsview Dr. & W. St. Patrick St.	HES1883(1)
2097	Brown	Install signal with turn radii	7/13/1987	1/15/1988	3rd & Dakota S in Aberdeen	HES2306(3)
2113	Union	Reconst.-Realign Intersection	4/12/1990	8/1/1990	SD50 and county road at Junction City	F-HES0050(35)417
2114	Pennington	Install Signal with Pavement Marking	7/8/1991	11/1/1991	5th St and Kansas City St in Rapid City	HES1669(27)
2257	Edmunds	Slope flattening of approaches	7/9/1986	9/4/1986	SD253 from US12 N. 9 mi.	HES3253(3)172
2538	Pennington	Slope flattening of approaches	11/4/1987	5/5/1988	SD79 from Maverick JCT to Rapid City	HES0079(31)26
2574	Bennett	Roadway Lighting	10/18/1988	2/17/1989	SD73 from Jct US18 1400ft South	HES0073(33)12
264H	Fall River	Signing	4/18/1994	7/27/1994	County roads throughout Fall River county	P000S(114)
291H	Mellette	Roadway Lighting	7/12/1993	9/2/1993	US83-through the town of White River	PH0083(52)44
292H	Meade	Realignment-Horizontal	2/23/1998	8/1/1998	Sturgis - Sly Hill Area	BRF-P-PH7701(1)
305X	Minnehaha	Install Signal with Pavement Marking	10/30/1987	6/9/1988	Intersection of Cliff Ave & Rice St in Sioux Falls	F-HES1038(8)368
3093	Pennington	Reconst.-Continuous Center Turn Lane	2/4/1992	5/22/1992	SD44(3)(Jackson Blvd) from W Main to Mt View RD	HES1741(1)
3097	Minnehaha	Signal Upgrade	6/15/1992	10/19/1992	SD38-10th & 11th Sts.	PH0038(25)371
3099	Minnehaha	Signal Upgrade	4/6/1999	5/12/2000	SD115 from Russel to I229	PH0115(21)83
310X	Pennington	Signing	4/28/1987	6/24/1987	County roads throughout Pennington county	HES6480(3)
3111	Minnehaha	Signal Upgrade and Pavement Marking	4/16/1997	11/1/1997	41st. & Louise in Sioux Falls	PH1400(9)
3113	Davison	Reconst.-Left Turn Lane	4/1/1991	11/1/1991	SD37 & 23rd St in Mitchell	HES0037(46)76
3114	Pennington	Install Signal with Pavement Marking	7/8/1991	6/16/1992	SD79 & Fairmont Blvd in Rapid City	HES0079(34)75
3115	Pennington	Reconst.-Continuous Center Turn Lane	11/20/1991	9/22/1992	Cambell St. from E North St. to SD44	F-HES2016(4)70
3116	Mellette	Reconst.-Continuous Center Turn Lane	2/14/1993	11/3/1993	US83-through the town of White River	NH-PH0083(42)44
3118	Bon Homme	Shoulder Widening	4/26/1993	11/2/1993	SD46-from jct. SD25 east to the Menno Rd.	P-PH0046(40)318
3120	Pennington	Reconst.-Left Turn Lane	6/18/1991	9/23/1991	SD79-east entrances at SDSM&T	HES0079(35)77
319X	Minnehaha	Realignment-Horizontal	10/23/1986	5/27/1987	Co. Rd. East of JCT SD11 & Minn Co #115	HES8050(13)
321X	Davison	Remove Fixed Object	2/12/1990	11/1/1990	Burr St from Douglas Ave to 1st Ave in	HES3681(1)

RSI-Data by PCEM from 1986 to 2000						
PCEM	**County**	**Improvement Type**	**Begin**	**End**	**Location Description**	**Project**
					Mitchell	
322X	Fall River	Realignment-Horizontal	9/2/1986	6/5/1987	SD71 MRM 30.5 South of Hot Springs	HES3071(6)30
325X	Minnehaha	Realignment-Horizontal and Vertical	6/22/1987	8/11/1987	Township Rd. from SD11 to Palisades Park	HH8050(14)
326X	Butte	Reconst.-Realign Intersection	3/20/1995	10/13/1995	US85 Jct of US85 & SD34 & Ziebach St in Belle Fourche	P-PH0085(31)54
330X	Meade	Signal Upgrade	11/3/1986	6/24/1987	SD79 & Douglas in Sturgis	HES0079(29)107
334X	Pennington	Reconst.-Left Turn Lane	5/5/1988	5/27/1988	Campbell and North St in Rapid City	HES2090(6)71
335X	Pennington	Reconst.-Left Turn Lane with signal phase	4/15/1988	8/15/1988	Intersection of SD44 & Canyon Lake Dr. in RC	HES0044(73)41
338X	Brown	Roadway Lighting	5/11/1988	7/1/1988	S Main fro US12 to 12th St South in Aberdeen	HES2313(2)
339X	Lawrence	Install Signal with Pavement Marking	8/11/1987	12/4/1987	Jackson and Main in Spearfish	HES8300(1)
343X	Codington	Install signal with turn radii	5/1/1987	6/12/1987	US212 & 11th St. SE in Watertown	HES0212(67)377
344X	Butte	Reconst.-Realign intersection	9/16/1988	10/21/1988	US85 and National St in Belle Fourche	HES0085(32)55
353H	Corson	Signing	7/21/1994	10/1/1994	County roads throughout Corson county	P000S(119)
3598	Pennington	Signal Upgrade	7/8/1991	11/1/1991	US16 (8th St) and Kansas City St in Rapid City	HES0016(49)68
3619	Pennington	Pavement Marking-Continuous Center Turn Lane	6/18/1991	7/5/1991	SD44(W Omaha St)-Mt View Rd to 11th St in RC	HES0044(107)43
3620	Brookings	Install Signal with Pavement Marking	1/1/1993	6/1/1993	City-intersection of 5th St. S. & Main Ave.	PH3313(8)
3621	Brookings	Install Signal with Pavement Marking	1/1/1993	6/1/1993	8th St. S & 22nd Ave in Brookings	PH3360(3)
3622	Minnehaha	Install Signal with Pavement Marking	3/22/1999	10/16/1999	49th & Kiwanis in Sioux Falls	PH1416(4) & CIP 132099
3625	Minnehaha	Reconst.-Realign Intersection	10/16/1995	8/15/1996	Western & Russel in Sioux Falls	P-PH1353(5)
3641	Minnehaha	Reconst.-Continuous Center Turn Lane	6/28/1993	9/14/1993	26th St.- from Big Sioux River St. to Cleveland Av	P-PH1368(5)
3663	Lawrence	Realignment-Horizontal	4/8/1996	10/11/1996	Terry Peak Rd near Trojan	P-PH0473(1)92
3825	Pennington	Pavement Marking-Left Turn	6/30/1993	7/15/1993	City Sts.- intersection of 5th St. & St. Cloud	PH1669(28)

RSI-Data by PCEM from 1986 to 2000						
PCEM	**County**	**Improvement Type**	**Begin**	**End**	**Location Description**	**Project**
		Lane			St.	
3828	Pennington	Signal Upgrade and Pavement Marking	10/22/1996	6/5/1997	Omaha St. at 5th, 6th, & 8th St. in Rapid City	PH0044(114)48
3830	Pennington	Reconst.-Continuous Center Turn Lane	6/8/1994	10/27/1994	SD44-from Campbell St. southeasterly to Sedivy Ln	PH0044(115)45
3832	Yankton	Signal Upgrade	4/26/1993	5/3/1993	US81 & SD50 in Yankton	PH0081(64)3
3853	Pennington	Pavement Marking-Continuous Center Turn Lane	6/30/1993	7/15/1993	LaCrosse St.-from Anamosa St. S to E North St.	PH1575
3873	Belle Fourche	Addition of Left Turn Lane	10/13/1994	9/16/1995	US 85 - from National St south to 0.24 miles south of SD 34 in Belle Fourche	NH-PH0085(49)53
396W	Meade	Signing	9/17/1990	10/30/1990	County roads throughout Meade county	HES8047(6)
3978	Davison	Signal Upgrade	9/30/1994	10/21/1994	SD37-(Sanborn Blvd) & 7th Ave in Mitchell	PH0037(67)75
3980	Pennington	Install Signal with Pavement Marking	6/14/1993	9/21/1993	US16 (8th St) & Cathedral Dr. intersection in RC	PH0016(56)67
3981	Minnehaha	Cold Plastic Pavement Marking	6/7/1999	7/1/1999	SD 115 from Russell St to 17th St. in Sioux Falls	PH0115(12)81
3982	Walworth	Close Intersection	6/19/1996	7/23/1996	US 13 & Bangor St intersection in Selby	PH9065(1)
3983	Hughes	Signal Upgrade and Pavement Marking	10/28/1996	6/1/1997	Euclid & Broadway - Pierre Euclid & Capitol Euclid & Elizabeth	P-PH0014(122)229
3985	Meade	Realignment-Horizontal	5/20/1996	6/27/1996	Vanocker Canyon Rd & Otter Rd in Meade Cty	PH7699(02)
3989	Pennington & Meade	Widen for the Addition of a center turn lane	7/13/1999	9/7/2000	SD79 from W Chicago to Meade County Line	PH-P0079(47)81
3990	Pennington	Addition of Left Turn Lane	7/10/1998	11/7/1995	New York & 5th in Rapid City	PH6991(1)
3991	Pennington	Pavement Marking-Left Turn Lane	6/30/1993	7/15/1993	intersection of W Main St. & Cross St. in RC	PH1714(1)
4096	Buffalo	Roadway Lighting	4/11/1994	7/14/1994	SD47-through Ft. Thompson	P-PH0047(34)89
429W	Hughes	Signing	4/12/1994	5/24/1994	County roads throughout Hughes county	P000S(108)
4352	Bennett	Addition of Pedestrian Walkway	7/1/1996	11/1/1996	Jct. SD73 E. to Sunrise Housing Area	P-PHOENH(32)
4449	Minnehaha	Cold Plastic Pavement Marking	7/12/1997	6/27/1998	SD115 from 18th St. to 33rd St.	P-PH0115(33)82

RSI-Data by PCEM from 1986 to 2000						
PCEM	**County**	**Improvement Type**	**Begin**	**End**	**Location Description**	**Project**
450X	Pennington	Reconst.-Continuous Center Turn Lane	6/28/1988	6/29/1988	Pennington Co #223, Ellsworth AFB Main Ent.	HES6549(2)52
451X	Pennington	Reconst.-Left Turn Lane with signal phase	4/4/1988	10/3/1988	SD238 from Campbell to SD44	HES1804(4)
452X	Hughes	Realignment-Horizontal and Vertical	10/18/1990	9/1/1991	SD1804 From Oahe Dam, North	RS-HES3804(26)256
4537, 4539	Brookings	Signal Upgrade and Pavement Marking	9/26/1996	7/1/1997	Orchard Dr. & 22nd Ave 8th & Medary Main E. to 2nd Ave. S	PH8006(26)
4538 (1)	Brown	Roadway Lighting	9/4/1996	8/1/1997	US281 - from 4th St. N NW to Fair Grounds Road	PH0281(58)196
4538 (2)	Brown	Addition of Left Turn Lane	9/4/1996	8/1/1997	US281 - from 4th St. N NW to Fair Grounds Road	PH0281(58)196
4540	Charles Mix	Addition of Pedestrian Walkway	11/5/1997	6/25/1998	US18 from 3rd Ave in Lake Andes East	P-PH0018(125)339
4541	Minnehaha	Reconst.-Continuous Center Turn Lane	4/27/1998	7/1/1998	SD115 From North of I-90 North thru Res. Area	PHO115(28)89
4545	Stanely	Signing	12/4/1995	4/17/1996	County rds at various locations in Stanley Co.	PH8059(1)
4547, 412R	Pennington	Signal Upgrade	12/10/1997	8/28/1999	St Patrick & St Joseph, St Patrick & Creek Dr	PH0238(03)43
4548	Pennington	Cold Plastic Pavement Marking	7/22/1997	8/6/1997	St Patrick from Elm to St Joseph in Rapid City	PH8052(38)
4549	Pennington	Addition of Left Turn Lane	10/11/1995	6/3/1996	Canyon Lake Dr. & Dakota Dr. in Rapid City	PH8052(39)
4551 (Dark)	Fall River	Roadway Lighting	1/21/1997	5/12/1997	SD79 & US18 East of Hot Springs	PH0018(124)44
4551 (Norm)	Fall River	Roadway Lighting	1/21/1997	5/12/1997	SD79 & US18 East of Hot Springs	PH0018(124)44
4554, 4555	Pennington	Cold Plastic Pavement Marking	6/11/1998	7/1/1998	Duster Corner to Main Gate Rd in Box Elder	PH0230(2)47 PH6269(4)
4579, 4546	Todd	Signing	7/2/1997	9/12/1997	County Roads in Todd County	P000S(135) PH8061(4)
4785	Minnehaha	Reconst.-Increase Turning Radii	10/14/1996	5/27/1996	Cliff Ave. & 54th St. in Sioux Falls	P-PH0115(32)88
4878	Minnehaha	Signal Upgrade and Pavement Marking	5/14/1997	11/1/1997	14th & Main in Sioux Falls	PH1332(06)
4879	Clay	Signal Upgrade	5/11/1999	8/27/1999	SD50 Loop Cherry St from Cottage St East to Plum St in Vermillion	PH-P2050(05)409

RSI-Data by PCEM from 1986 to 2000						
PCEM	**County**	**Improvement Type**	**Begin**	**End**	**Location Description**	**Project**
4880	Pennington	Cold Plastic Pavement Marking	7/16/1997	7/31/1997	5th St. from Columbus South to Fairmont Blvd.	PH8052(38)
5182	Minnehaha	Cold Plastic Pavement Marking	4/13/1998	9/3/1998	Cliff Ave from I-90 S to Benson Road in Sioux Falls	PH0115(31)89
5183, 4799	Pennington	Signal Upgrade and Pavement Marking	5/18/1998	7/30/1998	St Patrick & St Joseph in Rapid City	PH1543(1) & SA 0643
5184, 5437	Davison	Pavement Marking-Continuous Center Turn Lane	3/1/2000	9/6/2000	Havens St from Ohlman to Burr in Mitchell	PH2090(20)298 PH3710(01)
5185	Minnehaha	Addition of Right Turn Lane	6/7/2000	12/1/2000	Russel & Kiwanis in Sioux Falls	PH 1282(4)
5186	Minnehaha	Signal Upgrade and Pavement Marking	8/31/1999	11/10/1999	12th & Grange in Sioux Falls	PH-P0042(31)365
5189, 5355	Pennington	Signal Upgrade	8/17/1999	5/26/2000	Disk Dr. & Lacrosse in Rapid City	PH-IM1575(14) IM90-2(13)57
5440	Union	Resurface-Addition of Center Turn Lane	6/5/2000	9/1/2000	SD 50 WBL from Vermillion East to I29	PH0050(70)416
5442	Yankton	Resurface-Addition of Center Turn Lane	5/16/2000	11/9/2000	SD50 from Ferdig Ave in Yankton E to Divided Highway	PH-P0050(63)385
5591, 5356	Pennington	Lengthened Left Turn Lane	3/23/1999	10/1/1999	E. North St. & Campbell (US16B) in Rapid City	IM90-2(101)59 NH-PH2016(08)71
5672	Pennington	Addition of Right Turn Lane	8/17/1999	9/16/1999	Watertown & Lacrosse in Rapid City	PH1774(2)
5683	Minnehaha	Addition of Acceleration Lane	4/26/2000	8/15/2000	Jct. SD42 & SD11 South of Brandon	PH0042(8)373
588X	Minnehaha	Reconst.-Realign Intersection	4/14/1993	11/3/1993	City-intersection of Russell St. & Prairie Ave	P-PH1282(1)
589X	Brown	Install signal with turn radii	10/11/1988	3/13/1989	8th Ave NE & Roosevelt St in Aberdeen	HES8007(25)
606R, 604R	Minnehaha & Lincoln	Cold Plastic Pavement Marking	6/3/1999	6/10/1999	SD 115 from N of Robur Dr S to Benson road in Sioux Falls	PH0115(19)87 0291-271/272
626W	Day	Signing	10/19/1993	5/11/1994	County roads throughout Day county	P000S(111)
660H, 661H	Grant-Deuel	Slope flattening of approaches	7/28/1997	12/1/1997	SD 15/20 from US 212 N. to 1.3 Mi S. of Milbank	P-PH0015(13)155 P-PH0020(76)439
A697	Pennington	Reconst.-General	3/6/1997	10/1/1998	Twilight Dr. from SD44 to Moon St.	P-PH1555(1)

Table III

Previous Severity Factors from 1994 to 2000

PCEM	Fatal	Fatality Factor	Incap.Inj.	Incap. Inj. Factor	Non-incap. Inj.	Non-incap Inj. Factor	Poss. Inj.	Poss. Inj. Factor	PDO	PDO Factor	Previous Combined SRF
036M	2	2583.34	18	1575	15	268.8	6	57.48	55	55	4,539.62
037M	0	0	4	350	2	35.84	1	9.58	17	17	412.42
038M	0	0	6	525	2	35.84	1	9.58	0	0	570.42
0773	0	0	4	350	7	125.44	10	95.8	18	18	589.24
1277	0	0	0	0	2	35.84	2	19.16	7	7	62.00
148P, 149P	0	0	14	1225	62	1111.04	57	546.06	162	162	3,044.10
208P, 209P	3	3875.01	6	525	5	89.6	12	114.96	61	61	4,665.57
292H	0	0	0	0	0	0	0	0	1	1	1.00
3099	0	0	0	0	2	35.84	0	0	11	11	46.84
3111	0	0	8	700	9	161.28	23	220.34	57	57	1,138.62
326X	0	0	2	175	0	0	0	0	7	7	182.00
3622	0	0	2	175	0	0	1	9.58	8	8	192.58
3625	0	0	4	350	7	125.44	7	67.06	15	15	557.50
3663	0	0	2	175	8	143.36	4	38.32	17	17	373.68
3828	0	0	16	1400	32	573.44	31	296.98	72	72	2,342.42
3873	2	2583.34	9	787.5	8	143.36	10	95.8	28	28	3,638.00
3981	0	0	47	4112.5	61	1093.12	128	1226.24	336	336	6,767.86
3982	0	0	0	0	0	0	0	0	0	0	0.00
3983	0	0	0	0	3	53.76	3	28.74	18	18	100.50
3985	0	0	0	0	0	0	0	0	1	1	1.00
3989	1	1291.67	21	1837.5	30	537.6	33	316.14	127	127	4,109.91
3990	0	0	3	262.5	11	197.12	11	105.38	11	11	576.00
4352	0	0	0	0	0	0	0	0	0	0	0.00
4449	0	0	22	1925	59	1057.28	79	756.82	186	186	3,925.10
4537, 4539	0	0	7	612.5	27	483.84	36	344.88	90	90	1,531.22
4538 (1)*	3	3875.01	4	350	11	197.12	31	296.98	50	50	4,769.11
4538 (2)*	3	3875.01	4	350	11	197.12	31	296.98	50	50	4,769.11
4540		0		0		0		0		0	0.00
4541	1	1291.67	9	787.5	3	53.76	0	0	16	16	2,148.93
4545	0	0	4	350	9	161.28	1	9.58	19	19	539.86
4547, 412R	0	0	6	525	14	250.88	23	220.34	23	23	1,019.22
4548	0	0	20	1750	29	519.68	33	316.14	67	67	2,652.82
4549	0	0	0	0	0	0	0	0	3	3	3.00
4551 (Dark)**	0	0	1	87.5	0	0	0	0	3	3	90.50
4551 (Norm)**	0	0	3	262.5	3	53.76	1	9.58	10	10	335.84
4554, 4555	0	0	11	962.5	18	322.56	17	162.86	23	23	1,470.92
4579, 4546	13	16791.7	12	1050	8	143.36	12	114.96	13	13	18,113.03
4785	0	0	1	87.5	0	0	5	47.9	23	23	158.40
4878	0	0	2	175	4	71.68	1	9.58	13	13	269.26

PCEM	Fatal	Fatality Factor	Incap.Inj.	Incap. Inj. Factor	Non-incap. Inj.	Non-incap Inj. Factor	Poss. Inj.	Poss. Inj. Factor	PDO	PDO Factor	Previous Combined SRF
4879	0	0	0	0	4	71.68	14	134.12	33	33	238.80
4880	0	0	21	1837.5	30	537.6	59	565.22	79	79	3,019.32
5182	0	0	16	1400	36	645.12	49	469.42	146	146	2,660.54
5183, 4799	0	0	6	525	13	232.96	19	182.02	21	21	960.98
5184, 5437	0	0	5	437.5	7	125.44	27	258.66	78	78	899.60
5185	0	0	7	612.5	6	107.52	15	143.7	42	42	905.72
5186	0	0	0	0	0	0	3	28.74	14	14	42.74
5189, 5355	0	0	1	87.5	5	89.6	4	38.32	6	6	221.42
5440	0	0	1	87.5	0	0	4	38.32	4	4	129.82
5442	0	0	13	1137.5	9	161.28	4	38.32	47	47	1,384.10
5591, 5356	0	0	2	175	10	179.2	7	67.06	30	30	451.26
5672	0	0	3	262.5	10	179.2	19	182.02	23	23	646.72
5683	0	0	2	175	1	17.92	4	38.32	15	15	246.24
606R, 604R	1	1291.67	20	1750	24	430.08	34	325.72	100	100	3,897.47
660H, 661H	0	0	7	612.5	8	143.36	5	47.9	29	29	832.76
A697	0	0	1	87.5	2	35.84	4	38.32	18	18	179.66

* PCEM 4538 ARF/SRR was calculated twice for two different improvement types.

** PCEM 4551 ARF/SRR was calculated once using night only accidents and once using all accidents.

Table IV

Following Severity Factors from 1994-2000

PCEM	Fatal	Fatality Factor	Incap.Inj.	Incap. Inj. Factor	Non-incap. Inj.	Non-incap Inj. Factor	Poss. Inj.	Poss. Inj. Factor	PDO	PDO Factor	Previous Combined SRF
036M	3	3875.01	15	1312.5	15	268.8	13	124.54	52	52	5632.85
037M	0	0	2	175	3	53.76	2	19.16	6	6	253.92
038M	0	0	3	262.5	2	35.84	1	9.58	4	4	311.92
0773	0	0	5	437.5	16	286.72	14	134.12	23	23	881.34
1277	0	0	0	0	2	35.84	2	19.16	2	2	57.00
148P, 149P	0	0	23	2012.5	43	770.56	64	613.12	98	98	3494.18
208P, 209P	0	0	13	1137.5	9	161.28	4	38.32	96	96	1433.10
292H	0	0	0	0	0	0	0	0	0	0	0.00
3099	0	0	0	0	1	17.92	3	28.74	8	8	54.66
3111	0	0	1	87.5	8	143.36	26	249.08	46	46	525.94
326X	0	0	0	0	3	53.76	6	57.48	4	4	115.24
3622	0	0	0	0	0	0	0	0	0	0	0.00
3625	0	0	0	0	0	0	0	0	1	1	1.00
3663	0	0	1	87.5	1	17.92	0	0	8	8	113.42
3828	0	0	17	1487.5	25	448	35	335.3	69	69	2339.80
3873	0	0	0	0	5	89.6	7	67.06	32	32	188.66
3981	2	2583.34	30	2625	33	591.36	75	718.5	105	105	6623.20
3982	0	0	0	0	0	0	0	0	0	0	0.00
3983	0	0	1	87.5	2	35.84	4	38.32	22	22	183.66
3985	0	0	0	0	0	0	0	0	0	0	0.00
3989	0	0	12	1050	24	430.08	23	220.34	69	69	1769.42
3990	0	0	0	0	1	17.92	1	9.58	6	6	33.50
4352	0	0	0	0	3	53.76	4	38.32	1	1	93.08
4449	2	2583.34	15	1312.5	36	645.12	59	565.22	111	111	5217.18
4537, 4539	0	0	5	437.5	17	304.64	17	162.86	55	55	960.00
4538 (1)*	0	0	1	87.5	11	197.12	19	182.02	39	39	505.64
4538 (2)*	0	0	1	87.5	11	197.12	19	182.02	39	39	505.64
4540	0	0	0	0	0	0	0	0	0	0	0.00
4541	0	0	1	87.5	1	17.92	2	19.16	14	14	138.58
4545	1	1291.67	3	262.5	7	125.44	3	28.74	14	14	1722.35
4547, 412R	0	0	10	875	8	143.36	10	95.8	18	18	1132.16
4548	0	0	9	787.5	13	232.96	16	153.28	39	39	1212.74
4549	0	0	0	0	0	0	0	0	2	2	2.00
4551 (Dark)**	0	0	1	87.5	0	0	0	0	0	0	87.50
4551 (Norm)**	0	0	7	612.5	1	17.92	2	19.16	9	9	658.58
4554, 4555	0	0	10	875	16	286.72	12	114.96	22	22	1298.68
4579, 4546	15	19375.05	18	1575	10	179.2	6	57.48	2	2	21188.73
4785	0	0	2	175	4	71.68	4	38.32	12	12	297.00

PCEM	Fatal	Fatality Factor	Incap.Inj.	Incap. Inj. Factor	Non-incap. Inj.	Non-incap Inj. Factor	Poss. Inj.	Poss. Inj. Factor	PDO	PDO Factor	Previous Combined SRF
4878	0	0	3	262.5	4	71.68	3	28.74	8	8	370.92
4879	0	0	0	0	2	35.84	6	57.48	24	24	117.32
4880	1	1291.67	5	437.5	14	250.88	24	229.92	52	52	2261.97
5182	0	0	24	2100	28	501.76	41	392.78	94	94	3088.54
5183, 4799	0	0	10	875	8	143.36	6	57.48	16	16	1091.84
5184, 5437	0	0	4	350	3	53.76	15	143.7	74	74	621.46
5185	0	0	0	0	1	17.92	0	0	11	11	28.92
5186	0	0	1	87.5	2	35.84	5	47.9	9	9	180.24
5189, 5355	0	0	0	0	3	53.76	4	38.32	8	8	100.08
5440	0	0	1	87.5	0	0	0	0	1	1	88.50
5442	1	1291.67	5	437.5	14	250.88	15	143.7	25	25	2148.75
5591, 5356	0	0	5	437.5	12	215.04	11	105.38	16	16	773.92
5672	0	0	8	700	9	161.28	7	67.06	21	21	949.34
5683	0	0	1	87.5	0	0	1	9.58	2	2	99.08
606R, 604R	0	0	6	525	13	232.96	24	229.92	61	61	1048.88
660H, 661H	0	0	1	87.5	3	53.76	0	0	9	9	150.26
A697	0	0	1	87.5	0	0	4	38.32	17	17	142.82

* PCEM 4538 ARF/SRR was calculated twice for two different improvement types.

** PCEM 4551 ARF/SRR was calculated once using night only accidents and once using all accidents.

Table V

Benefit/cost Analysis by Location

PCEM	Project	Improvement Type	Location Description	Benefit/cost by location
036M	PH0085(09)29	Cold Plastic Pavement Marking	US85 from Deadwood to near I-90	0.08
037M	PH1016(18)50	Cold Plastic Pavement Marking	US16A from Keystone Wye to Keystone	1.91
038M	PH0244(00)30	Cold Plastic Pavement Marking	SD224 from US16A to Mt. Rushmore	-0.77
0773	P-PH-BRF0042(1)363	Reconst. - Left Turn Lane with signal phase	SD42 & Lyons in Sioux Falls	-4.32
1277	P-PH0038(14)372	Reconst. - Continuous Center Turn Lane	10th St. - Cleveland to Thompson	0.02
148P, 149P	P-PH0212(02)376	Signal Upgrade and Pavement Markings	Ints. On US212, US81, SD20 and Broadway Ave.	19.21
208P, 209P	P000S(145) PH8005(5)	Signing	County Roads in Bon Homme County	-12.25
292H	BRF-P-PH7701(1)	Realignment - Horizontal	Sturgis - Sly Hill Area	0.29
3099	PH0115(21)83	Signal Upgrade	SD115 from Russel to I229	0.02
3111	PH1400(9)	Signal Upgrade and Pavement Marking	41st. & Louise in Sioux Falls	2.01
326X	P-PH0085(31)54	Reconst. - Realign Intersection	US85 Jct of US85 & SD34 & Ziebach St in Belle Fourche	0.13
3622	PH1416(4) & CIP 132099	Install Signal with Pavement Marking	49th & Kiwanis in Sioux Falls	0.77
3625	P-PH1353(5)	Reconst. - Realign Intersection	Western & Russel in Sioux Falls	1.38
3663	P-PH0473(1)92	Realignment - Horizontal	Terry Peak Rd near Trojan	1.33
3828	PH0044(114)48	Signal Upgrade and Pavement Marking	Omaha St. at 5th, 6th, & 8th St. in Rapid City	0.28
3873	NH-PH0085(49)53	Addition of Left Turn Lane	US 85 - from National St south to 0.24 miles south of SD 34 in Belle Fourche	0
3981	PH0115(12)81	Cold Plastic Pavement Marking	SD 115 from Russell St to 17th St. in Sioux Falls	25.79
3982	PH9065(1)	Close Intersection	US 13 & Bangor St intersection in Selby	0
3983	P-PH0014(122)229	Signal Upgrade and Pavement Upgrade	Euclid & Broadway - Pierre Euclid & Capitol Euclid & Elizabeth	-0.48
3985	PH7699(02)	Realignment - Horizontal	Vanocker Canyon Rd & Otter Rd in Meade Cty	0.47
3989	PH-P0079(47)81	Widen for the Addition of a center turn lane	SD79 from W Chicago to Meade County Line	0.44
3990	PH6991(1)	Addition of Left Turn Lane	New York & 5th in Rapid City	10.34
4352	P-PHOENH(32)	Addition of Pedestrian Walkway	Jct. SD73 E. to Sunrise Housing Area	0
4449	P-PH0115(33)82	Cold Plastic Pavement Marking	SD115 from 18th St. to 33rd St.	25.23
4537, 4539	PH8006(26)	Signal Upgrade and Pavement Marking	Orchard Dr. & 22nd Ave 8th & Medary Main E. to 2nd Ave. S	5.7
4538 (1)	PH0281(58)196	Roadway Lighting	US281 - from 4th St. N NW to Fair Grounds Road	4.75
4538 (2)	PH0281(58)196	Addition of Left Turn Lane	US281 - from 4th St. N NW to Fair Grounds Road	2.38

PCEM	Project	Improvement Type	Location Description	Benefit/cost by location
4540	P-PH0018(125)339	Addition of Pedestrian Walkway	US18 from 3rd Ave in Lake Andes East	0
4541	PH0115(28)89	Reconst. - Continuous Center Turn Lane	SD 115 from North of I-90 North thru Residential Area in Sioux Falls	0.55
4545	PH8059(1)	Signing	County rds at various locations in Stanley Co.	0.98
4547, 412R	PH0238(03)43	Signal Upgrade	St Patrick & St Joseph, St Patrick & Creek Dr	1.49
4548	PH8052(38)	Cold Plastic Pavement Marking	St Patrick from Elm to St Joseph in Rapid City	15.96
4549	PH8052(39)	Addition of Left Turn Lane	Canyon Lake Dr. & Dakota Dr. in Rapid City	0.33
4551 (Dark)	PH0018(124)44	Roadway Lighting	SD79 & US18 East of Hot Springs	18.93
4551 (Norm)	PH0018(124)44	Roadway Lighting	SD79 & US18 East of Hot Springs	0
4554, 4555	PH0230(2)47 PH6269(4)	Cold Plastic Pavement Marking	Duster Corner to Main Gate Rd in Box Elder	2.36
4579, 4546	P000S(135) PH8061(4)	Signing	County Roads in Todd County	6.54
4785	P-PH0115(32)88	Reconst. - Increase Turning Radii	Cliff Ave. & 54th St. in Sioux Falls	1.50
4878	PH1332(06)	Signal Upgrade and Pavement Upgrade	14th & Main in Sioux Falls	11.42
4879	PH-P2050(05)409	Signal Upgrade	SD50 Loop Cherry St from Cottage St East to Plum St in Vermillion	2.35
4880	PH8052(38)	Cold Plastic Pavement Marking	5th St. from Columbus South to Fairmont Blvd.	26.53
5182	PH0115(31)89	Cold Plastic Pavement Marking	Cliff Ave from I-90 S to Benson Road in Sioux Falls	4.80
5183, 4799	PH1543(1) & SA 0643	Signal Upgrade and Pavement Marking	St Patrick & St Joseph in Rapid City	0.35
5184, 5437	PH2090(20)298 PH3710(01)	Pavement Marking - Continuous Center Turn Lane	Havens St from Ohlman to Burr in Mitchell	0.55
5185	PH 1282(4)	Addition of Right Turn Lane	Russel & Kiwanis in Sioux Falls	5.33
5186	PH-P0042(31)365	Signal Upgrade and Pavement Marking	12th & Grange in Sioux Falls	0.32
5189, 5355	PH-IM1575(14) IM90-2(13)57	Signal Upgrade	Disk Dr. & Lacrosse in Rapid City	-0.49
5440	PH0050(70)416	Resurface - Addition of Center Turn Lane	SD 50 WBL from Vermillion East to I29	1.97
5442	PH-P0050(63)385	Resurface - Addition of Center Turn Lane	SD50 from Ferdig Ave in Yankton E to Divided Highway	0.87
5591, 5356	IM90-2(101)59 NH-PH2016(08)71	Lengthened Left Turn Lane	E. North St. & Campbell (US16B) in Rapid City	2.08
5672	PH1774(2)	Addition of Right Turn Lane	Watertown & Lacrosse in Rapid City	9.73
5683	PH0042(8)373	Addition of Acceleration Lane	Jct. SD42 & SD11 South of Brandon	2.41
606R, 604R	PH0115(19)87 0291-271/272	Cold Plastic Pavement Marking	SD 115 from N of Robur Dr S to Benson road in Sioux Falls	13.67
660H, 661H	P-PH0015(13)155 P-PH0020(76)439	Slope flattening of approaches	SD 15/20 from US 212 N. to 1.3 Mi S. of Milbank	2.98
A697	P-PH1555(1)	Reconst. - General	Twilight Dr. from SD44 to Moon St.	0.08

Table VI

Accident Reduction Factors Comparisons

Improvement Type	Average ARF's (%) for South Dakota	University of Kentucky Average ARF's (%)	CTRE - ISU Average ARF's(%)	Oregon Dept. of Trans. ARF's(%)	North Carolina DOT ARF's (%)
Addition of Acceleration Lane	80.00%	20.00%	N/A	N/A	N/A
Addition of Left Turn Lane	28.00%	25.00%	10.00%	30.00%	50.00%
Addition of Pedestrian Walkway	N/A	65.00%	N/A	N/A	85.00%
Addition of Right Turn Lane	52.00%	25.00%	10.00%	N/A	50.00%
Close Intersection	N/A	N/A	N/A	N/A	N/A
Cold Plastic Pavement Marking	33.00%	15.00%	N/A	N/A	21.00%
Install signal with Pavement Marking	29.00%	25.00%	29.00%	N/A	20.00%
Install signal with turn radii	54.00%	N/A	N/A	N/A	N/A
Lengthened Left Turn Lane	22.00%	N/A	N/A	N/A	15.00%
Pavement Marking-Continuous Center Turn Lane	10.00%	N/A	N/A	N/A	30.00%
Pavement Marking-Left Turn Lane	35.00%	35.00%	N/A	N/A	N/A
Realignment-Horizontal	79.00%	40.00%	N/A	N/A	43.00%
Realignment-Horizontal and Vertical	-12.00%	50.00%	N/A	N/A	N/A
Reconst.-Continuous Center Turn Lane	12.00%	30.00%	N/A	N/A	N/A
Reconst.-General	8.00%	N/A	N/A	N/A	N/A
Reconst.-Increase Turning Radii	34.00%	15.00%	N/A	N/A	N/A
Reconst.-Left Turn Lane	31.00%	25.00%	N/A	N/A	N/A
Reconst.-Left Turn Lane with signal phase	-2.00%	N/A	35.00%	N/A	N/A
Reconst.-Realign Intersection	19.00%	40.00%	N/A	N/A	N/A
Remove Fixed Object	100.00%	30.00%	N/A	N/A	N/A
Resurface-Addition of Center Turn Lane	37.00%	N/A	N/A	N/A	N/A
Roadway Lighting	21.00%	25.00%	N/A	N/A	N/A
Shoulder Widening	20.00%	20.00%	N/A	43.00%	22.00%*
Signal Upgrade	32.00%	20.00%	N/A	N/A	N/A
Signal Upgrade and Pavement Marking	21.00%	N/A	N/A	N/A	N/A
Signing	4.00%	35.00%	N/A	N/A	37.5%*
Slope flattening of approaches	8.00%	N/A	N/A	N/A	N/A
Widen for the addition of a center turn lane	20.00%	N/A	N/A	N/A	10.00%