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ADOT State-Specific Crash Prediction Models: An Arizona Needs Study

Arizona Department of Transportation Research Center

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December 2016

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16. Abstract

The predictive method in the Highway Safety Manual (HSM) includes a safety performance function (SPF), crash modification factors (CMFs), and a local calibration factor (C), if available. Two alternatives exist for applying the HSM prediction methodology to local conditions. They are either calibration of the SPFs found in the HSM or the development of jurisdiction-specific SPFs

The objective of this study was to develop a process to evaluate the SPFs contained in the HSM for road segments and intersections on the Arizona State Highway System and to determine if those SPFs should be calibrated or if Arizona-specific SPFs should be developed.

The recommendations are that ADOT move forward with SPF calibration for all HSM safety performance functions as for project-level safety analysis in Arizona. A specific calibration function has been calculated for two-lane rural undivided highways. Safety analysis is progressing at a promising rate and can be used to attain significant reductions in fatal crashes and crash severity. To achieve this, ADOT will need to make a significant commitment to developing and maintaining a comprehensive database of roadway characteristics combined with crash data and average annual daily traffic volume data that are all linked through a common linear referencing system.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS AND ACRONYMS

AADT	average annual daily traffic
ADOT	Arizona Department of Transportation
C	local calibration factor
CARE	Critical Analysis Reporting Environment
CMF	crash modification factor
CURE	Cumulative Residual
DOT	department of transportation
EB	Empirical Bayes
GAM	generalized additive models
GIS	Geographic Information Systems
GOF	goodness of fit
FHWA	Federal Highway Administration
ft	feet
HSIS	Highway Safety Information System
HSM	Highway Safety Manual
MAD	mean-absolute-deviation
MIRE	model inventory of roadway elements
MMUCC	model minimum uniform crash criteria
MPB	mean-predication-bias
MPD	Multimodal Planning Division
MPSE	mean-squared-prediction error
NB	negative binomial
NCHRP	National Cooperative Highway Research Program
NOVA	Northern Virginia
P	Poisson
PDO	property damage only
PMT	project management team
RHS	right-hand side
RISE	roadway safety improvement safety evaluation
RMSE	root-mean-square error
SAS GENMOD	Statistical Analysis System
SPF	safety performance function
TAC	technical advisory committee
TWLTL	two-way left turn lane
VDOT	Virginia Department of Transportation

EXECUTIVE SUMMARY

Predictive methods are used to estimate crash frequency and severity as a function of traffic volume and geometric conditions on roadways and at intersections. The predictive method in the Highway Safety Manual (HSM) published by the American Association of State Highway and Transportation Officials (AASHTO)n 2010 (AASHTO 2010) includes a safety performance function (SPF), crash modification factors (CMFs), and a local calibration factor (C), if available. The HSM SPFs were developed using crash data from several locations throughout the United States. Two alternatives exist for applying the HSM prediction methodology to local conditions:

- Calibration is a simpler method that uses a sample data set of local conditions to adjust the SPFs found in the HSM to be more representative of local conditions. A calibration factor uses a simple ratio of observed crashes over predicted crashes for the sample set to adjust the SPF.
- Development of jurisdiction-specific SPFs is a more detailed method that requires the complete data set for the particular facility type represented with the SPF. In addition to requiring a larger data set, statistical expertise is needed to accurately determine an appropriate SPF for the data set.

The purpose of this study was two-fold:

- Develop a process for the Arizona Department of Transportation (ADOT) to evaluate the SPFs in the HSM and from other agencies for use on Arizona road segments and intersections.
- Determine if ADOT should calibrate the SPFs in the HSM or develop Arizona-specific SPFs.

There are different SPFs developed for use in network screening versus project-level safety analysis. The focus of this study is on project-level SPFs. The process of calibrating SPFs for two-lane rural undivided highways in Arizona provided in the HSM was selected to exemplify the calibration process using Arizona-specific conditions. The process also followed the guidance provided by the “User’s Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors” (*Calibration User’s Guide*, Bahar 2014).

The in-depth investigation into the possibility of estimating calibration factors for two-lane rural undivided highways used data for five years (2008 – 2012) from 196 two-lane rural road sites in Arizona. The 2008 – 2012 timeframe was the most current full-year data available at the time of the crash analysis. The investigation assessed the impact of different attributes such as geographic region, highway function, average annual daily traffic (AADT) values, alignment (curve versus tangent), curve radius, and year (temporal variation). It was found that mountainous region versus the flat and rolling region performed very similarly and do not justify separate calibration factors. Calibration factors for curves and tangents were found to be quite different depending on AADTs, as well as the magnitude of the curve radii.

The research of best practices around the country, the existing condition of relevant data in Arizona, and the team’s experience with calibration for this study led to the following recommendations for SPF calibrations versus development and for data collection and processing.

This study recommends the following for project-level safety analysis:

- Move forward with SPF calibration for all HSM SPFs for project-level safety analysis in Arizona. A specific calibration function has been calculated for two-lane rural undivided highways. Safety analysis is progressing at a promising rate and can be used to attain significant reductions in fatal crashes and crash severity. To achieve this, ADOT will need to make a significant commitment to developing and maintaining a comprehensive database of roadway characteristics combined with crash data and average annual daily traffic volume data that are all linked through a common linear referencing system.
- Prioritize SPFs based on criteria including the fatality types that will be addressed by a significant number of upcoming projects and have sufficient relevant data.
- Calibrate and assess the fit of each SPF using a separate calibration factor for subsections of the data for based on the AADT or by region. If there is not an acceptable goodness of fit for any of these calibration factors, proceed with simplified calibration functions.
- Make a significant commitment to developing and maintaining a comprehensive database of roadway characteristics combined with crash data and AADT volume data linked through a common linear referencing system. ADOT should review guidance provided in the Federal Highway Administration (FHWA)'s *Implementation of GIS-Based Highway Safety Analysis: Bridging the Gap* report (Smith 2001) and review best practices from other departments of transportation (DOTs) on developing a comprehensive safety analysis database.

It may be appropriate to move forward with independent SPFs when the relevant data is readily available in the future.

CHAPTER 1. INTRODUCTION

The American Association of State Highway and Transportation Officials (AASHTO) published the Highway Safety Manual (HSM) in 2010 based on over 10 years of effort and thousands of volunteer hours to provide fact-based analytical tools and techniques to quantify the potential safety impacts of planning, design, operations, and maintenance decisions (AASHTO 2010). Part C of the HSM contains the predictive methods for two-lane rural highways, multi-lane rural highways, and urban and suburban arterials.

Predictive methods are used to estimate crash frequency and severity as a function of traffic volume and geometric conditions on roadways and at intersections. The predictive method in the HSM includes a safety performance function (SPF), crash modification factors (CMFs), and a local calibration factor (C), if available. SPFs are equations used to calculate the predicted average crash frequency for a given set of site conditions, referred to as base conditions. Adjusting the HSM SPF base conditions to project site-specific conditions are made by multiplying the SPF by appropriate CMFs. The HSM SPFs were developed using crash data from several locations throughout the United States. Calibration is important because "the general level of crash frequencies may vary substantially from one jurisdiction to another for a variety of reasons, including crash reporting thresholds and crash reporting system procedures" (AASHTO 2010, C-18). Two alternatives exist to apply the HSM prediction methodology to local conditions:

- Calibration is a simpler method that uses a sample data set of local conditions to adjust the SPFs found in the HSM to be more representative of local conditions. A calibration factor uses a simple ratio of observed crashes over predicted crashes for the sample set to adjust the SPF.
- Development of jurisdiction-specific SPFs is a more detailed method that requires the complete data set for the particular facility type that is being represented with the SPF. In addition to requiring a larger data set, statistical expertise is needed to accurately determine an appropriate SPF for the data set.

STUDY OBJECTIVES

The study objectives were to develop a process for the Arizona Department of Transportation (ADOT) to evaluate the SPFs in the HSM and from other agencies for use on Arizona road segments and intersections and also to determine if ADOT should calibrate the SPFs or develop Arizona-specific SPFs.

PROJECT APPROACH

This process began with a national literature review and telephone interviews of key HSM implementers working for other state departments of transportation (DOT). The literature review and telephone interviews identified three key guidance documents:

- Safety Performance Function Decision Guide: SPF Calibration Versus SPF Development
- Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs
- User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors

The data collection and preparation process followed the guidance set in the *User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors*. Data were assembled from the Arizona Department of Transportation (ADOT) Multimodal Planning Division (MPD) in individual Geographic Information Systems (GIS) data sets (i.e. shoulder width, Average Annual Daily Traffic (AADT), lane width). Where GIS data were not available, the study team collected roadway characteristics by field review, aerial imagery, or other means. Most of the data elements deemed required (as opposed to desirable) for SPF calibration were gathered with some exceptions such as the number of driveways by land-use type for urban and suburban arterials, the presence of left-turn phasing, type of left-turn phasing, use of right-turn-on-red signal operation, and the use of red-light cameras for signalized intersections along urban and suburban arterials.

The process for calibration of the HSM SFPs for the two-lane rural undivided highways in Arizona was selected to exemplify the calibration process using Arizona specific conditions. The process also followed the guidance of *User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors*. The calibration process is outlined by six steps, as follows:

- Step 1: Identify facility types for which the applicable Part C predictive model is to be calibrated
- Step 2: Select sites for calibration of the predictive model for each facility
- Step 3: Obtain data for each facility type applicable to a specific calibration period
- Step 4: Apply the applicable Part C predictive model to predict total crash frequency for each site during the calibration period
- Step 5: Compute calibration factors for use in Part C prediction model
- Step 6: Compute calibration functions

An in-depth investigation into the possibility of estimating calibration factors for two-lane rural undivided highways used data for five years (2008 - 2012) from 196 two-lane rural road sites in Arizona. The 2008 – 2012 timeframe was the most current full year data available at the time of the crash analysis. The total length of these segments is 187.5 miles. The investigation assessed the impact of different attributes such as geographic region, highway function, AADT values, alignment (curve versus tangent), curve radius, and year (temporal variation).

As mentioned in the *Calibration User's Guide*, one way to assess the quality of the calibration model is to use goodness of fit tests such as Cumulative Residual (CURE) plots. CURE plots can be used to assess the overall fit of the model and to assess the appropriateness of the functional form of specific independent variables. The overall calibration factor, as well as the calibrated factors by AADT range and segment length, were evaluated for goodness of fit. The assessment of the calibration factors confirmed the need to proceed with the development of calibration functions as recommended in the *Calibration User's Guide*. Six distinct calibration function types were estimated and evaluated.

CHAPTER 2. LITERATURE REVIEW

OVERVIEW

A total of nine documents were reviewed, consisting of the documents listed in the ADOT Task Assignment supplemented by research and applied research documents on SPF development and calibration. This chapter contains capsule summaries for each document reviewed. Additional details on each document are provided in Appendix A.

LIST OF REVIEWED DOCUMENTS

Table 1 provides a list of documents that were reviewed.

Table 1. Literature Review Documents

Document ID	Title/Location	Authors	Date
1	*Calibration of Predictive Models for Estimating the Safety of Ramp Design Configurations*/Texas	Lord, Bonneson	March 2005
2	*Development of a Safety Evaluation Procedure for Identifying High-Risk Signalized Intersections in the Virginia Department of Transportation's Northern Virginia District*/Virginia	Kweon	September 2007
3	*Development and Application of Safety Performance Functions for Illinois*/Illinois	Tegge, Jo, Ouyang	March 2010
4	*Development of Safety Performance Functions for Two-Lane Roads Maintained by the Virginia Department of Transportation*/Virginia	Garber, Hass, Gosse	June 2010
5	*Development of Safety Performance Functions for North Carolina/North Carolina*	Srinivasan, Carter	December 2011
6	*Calibrating the Future Highway Safety Manual Predictive Methods for Oregon State Highways*/Oregon	Dixon, Monsere, Xie, Gladhill	February 2012
7	*Safety Performance Function Decision Guide: SPF Calibration versus SPF Development*	Srinivasan, Carter, Bauer	September 2013
8	*Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs*	Srinivasan, Bauer	September 2013
9	*User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors*	Bahar	January 2014

SUMMARY OF REVIEWED DOCUMENTS

1. Calibration of Predictive Models for Estimating the Safety of Ramp Design Configurations

Authors. Dominique Lord, Texas Transportation Institute and Texas A&M University System. James A. Bonneson, P.E., Texas Transportation Institute, Texas A&M University System.

Date. March 2005

Summary. This study documents the procedure used to calibrate crash prediction models for ramp configurations including diamond ramps, non-free-flow loop ramps, free-flow loop ramps, and outer-connection ramps. Calibration was considered necessary because of the low-frequency of ramp-related crashes and the need to estimate the safety performance of these ramp designs.

Data collected for the calibration was dictated by the variables included in the original predictive model (i.e., crash data, ramp geometry, environmental features, and traffic characteristics). Data were collected from 44 ramps at 10 interchanges in Travis County near Austin, Texas.

Separate calibration factors were developed for all combinations of area types, ramp types, and ramp configurations, instead of one calibration factor for all attribute types. This analysis allowed for better fit to the data. A separate analysis was also performed for “total crashes” and “fatal and injury crashes.” Based on this analysis, it was determined that separate calibration factors for urban and rural ramps would improve safety prediction models.

Overall, this report showed that more crashes occur on exit ramps than entrance ramps by a ratio of approximately 60/40, and non-free flow ramps experience twice as many crashes than other types of ramps. The calibration process indicated that ramp-related crashes in Texas occur less often than in the state of Washington; however, Texas experiences more fatal and injury crashes. This may be because crash reporting standards are different across states. Urban ramp SPFs were inflated by a factor of 1.6 to account for under-reporting of urban ramp crashes. The study recommends recalibrating predictive models every three years to ensure they continue to reflect recent crash frequency and severity, current driver behaviors, and design practices.

Key Findings and Best Practices. This study highlights the following key findings and best practices:

- Given the cost of data collection, the calibration of available crash prediction models to local conditions is often the only method available to transportation agencies to estimate the safety of transportation facilities.
- It is imperative that the calibration process uses high-quality data with sufficient sample sizes for crashes and sites. A data management process to link crashes, roadway characteristics, and traffic volumes is desirable.
- Crash counts are integer and nonnegative; thus, conventional regression-based models using normal error distribution cannot be used.

- The calibration process should be validated using a combination of different statistical techniques including the Cumulative Residual (CURE) method, dispersion parameter-based R, t-test, and the root-mean-square error (RMSE).
- A dual approach involving internal and external validation should be considered. The tools used for external validation include the Pearson product moment of correlation, mean-prediction-bias (MPB), mean-absolute-deviation (MAD), and the mean-squared prediction error (MPSE). Internal validation consists of assessing potential biases introduced in the original predictive models used in the calibration process. The goal is to assess the quality of the data utilized in the development of the original models, potentially omitted variables, and the regression-to-the-mean bias.
- The calibration process should develop separate calibration factors for each combination of area type, ramp type, ramp configuration, and crash type by crash frequency and severity. This disaggregated approach allows for a better fit to the data if the effect of an attribute differs. Separate analyses were conducted for the “all crash” and the “fatal and injury crash” models.

2. Development of a Safety Evaluation Procedure for Identifying High Risk Signalized Intersections in the Virginia Department of Transportation’s Northern Virginia District

Authors. Young-Jun Kweon, Ph.D., Virginia Department of Transportation (VDOT)

Date. September 2007

Summary. This document describes an evaluation procedure used to identify high-risk, four-legged signalized intersections in the VDOT Northern Virginia (NOVA) District. The procedure consisted of three stages:

- Data collection and preliminary data analysis
- Traffic crash prediction model development using mean and variance models
- Expected crash performance rate development using the empirical Bayes (EB) method

The data collection stage defined traffic crash patterns. A total of 49 signalized intersections in the NOVA District were selected for data collection based on the availability of traffic volume data. Hourly traffic volume data by turning movement and left-turn signal phase data were extracted from Synchro files. Traffic crashes were analyzed separately for different crash patterns. Time-of-day was observed to be a factor in crash occurrence.

After the dataset was prepared for each site, mean and variance models were developed. For the mean model, a relationship between crash frequency and traffic volumes was observed. A Poisson assuming equidispersion or negative binomial assuming overdispersion count response model was then selected based on tests for overdispersion. After a final mean model was estimated, a final variance model was developed.

Using the crash prediction models, the expected crash frequencies were determined using the EB method for the 49 signalized intersections selected in the NOVA District.

Key Findings and Best Practices. The key findings and best practices are as follows:

- This report demonstrated that EB procedures can be effectively used by traffic engineers to evaluate the safety of four-legged signalized intersections.
- The EB procedure was considered cost-effective and readily applicable since limited additional data are needed to apply the EB procedure. All the data required for applying the EB procedure were obtained from a crash database and Synchro.
- Additional efficiencies would result by developing an integrated database for calibrating the EB procedures.

2. *Development and Application of Safety Performance Functions for Illinois*

Authors. Robert A. Tegge, University of Illinois at Urbana-Champaign; Jang-Hyeon Jo, University of Illinois at Urbana-Champaign; Yanfeng Ouyang, University of Illinois at Urbana-Champaign

Date. March 2010

Summary. This report addresses a variety of objectives, including the development of Illinois-specific SPFs for network screening, incorporation of the developed SPFs into an Illinois Center for Transportation project which uses Safety Analyst, and development of computer software to facilitate SPF development and calibration.

Data collection focused on crashes and roadway characteristics. The datasets consisted of roadway, crash, intersection, and translation data. Data organization included developing methods for merging data, organizing data into intersection- or segment-related crashes, and disaggregating the dataset into different base condition groups. The study defined 17 groups of road segments and 10 groups of intersections.

The Illinois-specific SPFs were developed using a negative binomial regression using a statistical analysis system (SAS GENMOD). The SPFs were developed for a five-year period, and the results of the regression produced the expected number of crashes per five years. Five years was used due to roadway data limitations. SPFs were developed for fatal crashes, Type-A injury crashes, Type-B injury crashes, and fatal plus injury crashes.

Utilizing the EB procedure, segments on the Illinois roadway network were screened to determine sites with the potential for safety improvements. The report used two different screening techniques. The first technique separated segments from intersections and the second technique was the sliding window analysis for segments, which continuously moves the window over the length of the roadway.

To determine the factors predominantly contributing to roadway crashes, a multivariate analysis technique was used. This analysis included variables such as access control, shoulder type, lane width, and median type. This analysis utilized a negative binomial regression using the SAS GENMOD software. This analysis showed how different variables contribute to crashes.

Key Findings and Best Practices. The key findings and best practices are as follows:

- The development of SPFs is critical for network-wide screening procedures. The system allows for an unbiased analysis of the roadway network because personal perceptions, public scrutiny, and user experiences did not influence the analysis.
- The rankings provide extreme flexibility in the identification of locations with safety concerns and the development of future safety projects to mitigate concerns at severe locations.
- A multivariate analysis is necessary to show how certain variables may contribute to crashes to determine why crashes occur and provide a more proactive model.
- Datasets development and maintenance methods can result in errors that limit model accuracy.
- Developing an automated system for easy analysis of the roadway network, providing a crash correction methodology to compensate for errors in the datasets, and implementing the SPFs in both the state's safety programs and Safety Analyst was recommended to significantly increase the efficiencies of the analyses.

4. Development of Safety Performance Functions for Two Lane Roads Maintained by the VDOT

Authors. Nicholas J. Garber, Ph.D., P.E., Virginia Transportation Research Council; Phillip R. Hass, Virginia Transportation Research Council; Conrad Gosse, Virginia Transportation Research Council

Date. June 2010

Summary. The purpose of this research was to develop a set of SPFs that could be used to prioritize safety improvement projects along two-lane highway segments in Virginia. The State of Virginia developed Virginia-specific SPFs for two-lane highways to better identify sites with a high potential for safety improvements. SPFs were developed using annual average daily traffic values from 139,635 sites separated into urban and rural segments. The SPFs were developed to estimate total crashes and fatal plus injury crashes.

The report first looked into the transferability of SPFs created for other states to Virginia's two-lane roads. These were compared using a geographical and coefficient-of-determination comparisons. This analysis showed that the non-Virginia-specific SPFs would not be optimal.

To provide more optimal SPFs that could be applied to Virginia, new models were developed using Virginia data. This was done using a negative binomial distribution linear model for crashes. The study developed 36 SPF models cases for total crashes and 36 for fatal plus injury crashes. It was observed that the Virginia-specific SPFs resulted in a better fit with the Virginia data.

Further efforts were made to improve the estimating capabilities of the models through the stratification of site characteristics including primary and secondary road classifications; regions; and physical road, topographic, driver, and operational characteristics.

Overall, the report demonstrated the need to develop SPFs specifically for Virginia because the existing models in Safety Analyst™ did not accurately describe Virginia's characteristics. The site disaggregation into geographical regions and the classification of the two-lane roads into rural-primary, rural-secondary, urban-primary, and urban-secondary demonstrated the potential to improve the predictive capability of the SPFs.

Key Findings and Best Practices. Graphical methods and statistical tests (R-square and the Freeman-Tukey coefficient) were used to test the transferability of SPFs developed for other states (using Safety Analyst™) to Virginia. It was observed that the transferability of existing SPFs were not optimal.

Techniques found in the HSM (AASHTO 2010) were used to calibrate the existing SPFs using Virginia data. It was observed that calibration improved the model fit; however, the improvement was limited because the SPF model coefficients were not modified by the calibration process.

The development of SPFs specifically for Virginia was necessary because the existing models provided by Safety Analyst™ did not adequately describe Virginia's characteristics. Virginia's unique topography, combination of heavily rural and urban regions, and vast network of state-maintained secondary roads all contribute to the need for Virginia-specific SPFs.

Site disaggregation into geographical regions and the road classifications has the potential to improve the fit of the SPFs. Site disaggregation enhances homogeneity with respect to roadway characteristics and driver expectations.

The use of the EB method with the appropriate SPFs identifies sites with a high potential for safety improvements. This is in contrast to the use of crash rates which assume a linear relationship between crashes and traffic volumes. The results of the site prioritization analysis demonstrate the efficacy of using the EB method and the appropriate SPFs for identifying sites for safety improvement.

Further research is needed to investigate the inclusion of additional independent variables during the development of SPFs for network screening, as more variables may improve the predictive capabilities of these models. Factors such as shoulder and lane widths and the number of driveways may all have important impacts on the number of crashes; however, they are explicitly unaccounted for in the current SPFs in Safety Analyst™.

5. Development of Safety Performance Functions for North Carolina

Authors. Raghavan Srinivasan, University of North Carolina Highway Safety Research Center; Daniel Carter, University of North Carolina Highway Safety Research Center

Date. December 2011

Summary. This report calibrates the crash prediction models found in the HSM using North Carolina data in order to conduct network screenings and project-level analyses and to evaluate the effects of engineering treatments. These SPFs, referred to as Type 1, use traffic volume data as the only independent variable. Calibration factors were developed for six types of roadway segments and eight types of intersections listed in the HSM. The report used the data from the Highway Safety Information System (HSIS), such as number of lanes, type of median division, population density, and town limits, to classify each segment into one of the HSM facility types. There was also a classification based on geographic location.

SPFs were developed for Type 1 SPFs using volume data for nine crash types along 16 roadway types. SPFs were also developed for rural, two-lane roadways for project-level analyses using volume data and other site characteristics including shoulder width, shoulder type, and terrain. These SPFs were estimated using negative binomial regression. While the ultimate goal is to develop SPFs for all North Carolina facility types, this may not be feasible because data may not be available for a sufficient number of sample sites..

This report demonstrates how SPFs can be used for network screenings, project-level analyses, and before and after evaluations that apply the EB method. The report provides guidance on how the North Carolina DOT can update SPFs using development or calibration techniques.

Key Findings and Best Practices. In time, the SPFs and calibration factors developed during this effort will become less accurate at predicting expected crash frequencies. It will be beneficial to use the most recent years of data to re-develop or re-calibrate the SPFs. If sufficient expertise and resources are available, the SPFs may be re-developed. If not, the SPFs should be updated for future years by calculating a calibration factor for each future year, similar to the way in which calibration factors were calculated for the HSM SPFs.

6. Calibrating the Future HSM Predictive Methods for Oregon State Highways

Authors. Karen Dixon, Oregon State University; Chris Monsere, Portland State University; Fei Xie, Oregon State University; Kristie Gladhill, Portland State University

Date. February 2012

Summary. This report describes a process for calibrating SPFs contained in the HSM (AASHTO 2010) using historic crash data in Oregon. SPFs are calibrated for rural two-lane, two-way roads; rural multilane roads; urban arterials; and suburban arterials. The report describes methods for site selection, the collection of crash and site-specific data, and analysis methods for calibration. Calibration was justified because of differences between crash reporting procedures, driver population, animal populations, and weather conditions.

Methods contained in the HSM were altered for site selection in Oregon due to the number and variability of sites. HSM guidance for random site selection was considered critical; however, HSM sample size and minimum crash thresholds were considered somewhat arbitrary. For example, the number of segment crashes for rural two-lane roads were easily attainable using the 100 crashes per year criteria. This was not the case for multilane, signalized intersections where the recommended 50-site criteria would need to produce an average of 100 crashes per year or two crashes per site per year. The majority of the data required for calibration was available from existing databases; however, some required extensive data collection and analysis. Examples of data that were unavailable included pedestrian volumes at urban intersections, minor-road signal phasing and timing, and minor-road traffic volumes at rural intersections. Unavailable data were estimated using a variety of analytical techniques.

The report investigated methods for identifying homogeneous segments, assigning crash data to segments, estimating minor-road volumes, calculating calibration factors, and identifying other issues that can be associated with using locally-derived parameters such as crash-type percentages in the calibration process.

There is a significantly different proportion of severe crashes in Oregon versus the proportion shown in the HSM demonstrated the need to develop Oregon-specific calibration factors for fatal and injury level as well as total crashes. The authors recommend that, in the future, the calibration factors for total crashes can be done without the local proportions of crashes, if data are not available. However, there is a critical need to use locally-derived proportions to determine specific distributions of crash types, such as single-vehicle crashes by severity level, and to develop calibration factors for fatal and injury crashes–even for two-lane rural roads when the HSM only refers to total crashes for this road facility type.

The authors recommend developing calibration factors for each severity level (i.e., not only for total crashes as recommended in the HSM). If the HSM procedure is followed (i.e., developing and applying the total calibration factor for all severity models) fatal and injury crashes will be underestimated in Oregon.

Key Findings and Best Practices. This study includes the following key findings and best practices:

- Calibration dataset development can be time-consuming. Acquisition of the data needed for calibration allows HSM (AASHTO 2010) predictive procedures to be applied on a network level.
- The HSM-recommended minimum sample size of 100 crashes per year may not apply to all facilities. It is reasonable to adjust sample size expectations for under-represented facility types by basing an assumption on average crash history for similar facilities.
- Oregon crash reporting procedures and thresholds introduce a significant difference in observed and predicted total crash frequency. As a result, the use of severity-based calibration factors or Oregon-specific fatal plus injury SPFs seems more appropriate for cost-benefit decisions.
- Calibration factors developed with small sample sizes and where there are design differences between HSM and local road datasets should be used with care.
- Road characteristic data developed for the purposes of calibration should be preserved, and calibration factors can be updated with future observed crashes and updated traffic volumes) with minimal additional effort in future years.
- To enhance the precision of crash predictions, it is recommended that jurisdiction-specific collision type and crash severity distribution tables and factors found in the HSM be replaced with local data.
- This research effort identified several recommendations that should be considered for future editions of the HSM:
    - The one-size-fits-all sample size does not appear to be appropriate for all facility types and should be enhanced.

- The calibration of severity-level models requires additional consideration. The HSM severity-model rebalancing procedure should be incorporated into the calibration process and sample size techniques appropriate for the severity-level models are needed.
- While the calibration factors developed for this effort are suitable for evaluations within a jurisdiction, overall HSM calibration techniques should address the severity-level and sample size considerations before comparing predicted, calibrated crash frequencies between different jurisdictions with varying reporting thresholds or procedures.

7. Safety Performance Function Design Guide: SPF Calibration versus SPF Development

Authors. Raghavan Srinivasan, University of North Carolina Highway Safety Research Center; Daniel Carter, University of North Carolina Highway Safety Research Center; Karen Bauer, MRI Global

Date. September 2013

Summary. This document is one of a series of documents currently being developed by FHWA and the National Cooperative Highway Research Program (NCHRP) to facilitate the implementation of the HSM (AASHTO 2010) by states. The titles of the other reports are a *User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors*, *Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs*, and *SPF Needs Assessment.*

This study summarizes what SPFs are and how they are used. There are three different applications for the SPFs:

- Determine safety impacts of design changes at the project level
- Identify sections that may have the potential for crash reductions (network screening)
- Conduct before and after studies to evaluate the safety effectiveness of crash countermeasures

For project-level decisions, SPFs are used to estimate the average expected crash frequency for existing conditions, evaluate alternative countermeasures, or develop design features for new roadways. For network screening, SPFs are used to identify locations that may benefit the most from application of countermeasures. SPFs from the HSM, Part C can be used for project-level decision making and SPFs from the Safety Analyst™ can be used for network screening.

The report points out that there are two choices for developing SPFs: calibrating existing SPFs or developing jurisdictional-specific SPFs. Calibration was recommended when "the general level of crash frequencies may vary substantially from one jurisdiction to another for a variety of reasons including crash reporting thresholds and crash reporting system procedures" (AASHTO 2010, C-18). This report gives an overview of procedures for calibrating SPFs for both project-level analysis and network screening. A project-level analysis predicts the crash frequency for a base set of conditions and uses crash modification factors to adjust the prediction to the actual conditions of the site under analysis. Network screening does not evaluate a base condition, and these SPFs are used to predict the number of crashes for a particular traffic volume and facility type.

To improve the accuracy of crash predictions, the development of jurisdiction-specific SPFs that "are likely to enhance the reliability of Part C predictive methods" is recommended. These allow agencies to produce SPFs in functional forms different than the ones available in the HSM or Safety Analyst™. The importance of statistical expertise is stressed for estimating negative binomial regression models using generalized linear modeling techniques. Datasets with the same base conditions as the HSM can be used, or datasets can be developed for specific facility types.

This report recommends steps for calibrating existing SPFs or developing jurisdiction-specific SPFs. This process starts with calibration, then moves to developing SPFs if the calibration model is considered unacceptable for the intended safety analysis. It is noted that calibrating SPFs requires less resources, time, statistical expertise, and data. Developing SPFs requires an extensive dataset for a large sample of sites. The process of obtaining SPFs differs by state depending on data availability.

Key Findings and Best Practices. This study includes the following key findings and best practices:

- The intended use of the SPF and road facility type of interest are keys to deciding whether to calibrate or develop a jurisdiction-specific SPF. If an existing SPF from the HSM (AASHTO 2010) or Safety Analyst™ is not available for a given facility type, developing a jurisdiction-specific SPF may be the only option.
- Sample size requirements and the cost of collecting and organizing datasets are keys to deciding whether to calibrate or develop a jurisdiction-specific SPF. If representative sites, crash counts, or both are insufficient for the intended use of the SPF, calibration may be the only option.
- Calibration can be done by staff with limited or no statistical experience and can be implemented using spreadsheet software and established procedures, such as those described in the *User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors*.
- The quality of the calibration factor should be assessed. A calibration factor that is very different from 1.0 (i.e., much less or much greater) indicates that the agency's crash experience is much different from that determined during SPF development and the agency should consider developing jurisdiction-specific SPF.
- For project-level SPFs, a good-quality calibration factor can be used along with the HSM predictive methodology to conduct project-level analysis. For network screening SPFs, a good-quality calibration factor can be used. If the calibration factor is not of good quality, the agency should develop SPFs using the procedure discussed in the *How to Guidebook for States Developing Jurisdiction-Specific SPFs*.
- Many agencies want to have an idea of the cost of the effort to calibrate and/or develop jurisdiction-specific SPFs. Table 2 provides the estimated ranges of staff time required for each endeavor. The staff time required to collect and prepare the data can range greatly depending on the following factors:
    - Number of SPFs to be addressed. If many SPFs are being calibrated or developed in the same project, data collection is more efficient per SPF because the data collector can obtain data on many types of sites during the same effort. For instance, a data collector

who is collecting field data on rural, two-lane road segments can also gather field data on rural, two-lane road intersections with minimal additional effort.

- Availability of roadway inventory data. Most state jurisdictions have available data in their roadway inventory. If most of the required data elements are contained in the agency's existing inventory, data collection time will be minimal. However, greater time is needed to assemble the required data if fewer data elements are available in the inventory. Methods for collecting the data may involve aerial photos, online imagery, construction plans, and/or field visits.

Table 2. Level of Effort Estimates for Calibration and Development

Intended Use	Process	Minimum Sample Size Needed (based on HSM Part C)	Staff Hours Needed: Data Collection and Preparation (per SPF)	Staff Hours Needed: Statistical Analyst (per SPF)
Project Level	Calibrate SPF	30 - 50 sites. At least 100 crashes per year for the total group. At least three years of data are recommended.	150 to 350	N/A
	Develop SPF	100 - 200 intersections or 100 - 200 miles. At least 300 crashes per year for total group. At least three years of data are recommended.	450 to 1,050	16 to 40
Network Screening	Calibrate SPF	Must use entire network to be screened. No minimum sample size specified. At least three years of data are recommended.	24 to 40	N/A
	Develop SPF	Must use entire network to be screened. Minimum sample would be 100 - 200 intersections or 100 -200 miles; at least 300 crashes per year for total group. At least three years of data are recommended.	24 to 40	8 to 24

8. Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs

Authors. Raghavan Srinivasan, University of North Carolina Highway Safety Research Center; Karen Bauer, MRI Global

Date. September 2013

Summary. The *SPF Development Guide* is one of a series of documents currently being developed by the FHWA and the NCHRP to facilitate the implementation of the HSM (AASHTO 2010) by states. The titles of the other reports are *Safety Performance Function Decision Guide: SPF Calibration Versus SPF*

Development, *User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors*, and *SPF Needs Assessment.*

The report summarized several statistical issues associated with the development of jurisdiction-specific SPFs including over-dispersion, selection of explanatory variables, functional form of the model and the explanatory variables, over-fitting of SPFs, correlation among explanatory variables, homogenous segments and aggregation, presence of outliers, endogenous explanatory variables, estimation of SPFs for different crash types and severities, and goodness-of-fit.

The report also presents steps for identifying the specific situations for which SPFs are desired. After the data requirements for the development of SPFs are documented, including facility type, database preparation, and statistical modeling, the steps are as follows:

- Step 1. Determine how the SPF will be used (i.e., network screening, project-level analysis, derive crash reduction factors [CMFs] directly from the SPF, or before-after evaluation)
- Step 2. Identify the facility type (e.g., rural, two-lane highway; urban, two-way highway).
- Step 3. Compile the necessary data (e.g., lane width, shoulder width).
- Step 4. Prepare and cleanse the database (evaluation of basic descriptive statistics, checking for outliers and data entry errors).
- Step 5. Develop the SPF
- Step 6. Develop the SPF for the base condition
- Step 7. Develop CMFs for specific treatments
- Step 8. Document the SPFs

Key Findings and Best Practices. Temporal correlation can lead to incorrect estimates of the standard errors of the coefficients and may arise when multiple observations are used for the same roadway unit. A common approach to dealing with temporal correlation is to aggregate the data so that each roadway unit has one observation. For example, if three years of data are available for SPF estimation and crash counts and site characteristics are available for each of these three years, the total crash counts over the three years is computed and used as the dependent variable along with the average value of the site characteristics over the three-year period as the explanatory variables for each roadway unit.

Some recent studies have used model forms other than the negative binomial form. These include zero-inflated models, Poisson-lognormal models, and Conway-Maxwell-Poisson models.

Generalized additive models (GAM) introduce smoothing functions for each explanatory variable in the model and hence provide a more flexible functional form. GAMs can include both parametric and non-parametric forms. However, GAMs do not have coefficients associated with the smoothing functions and hence are much more difficult to use and interpret as an SPF.

While random-parameter models allow the estimated parameters (coefficients) to vary across the individual observations, they are usually based on a pre-specified distribution. The goal of these models is to account for the unobserved heterogeneity from one observation to another.

9. User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors (Calibration User's Guide)

Author. Geni B. Bahar, P.E., NAVIGATS Inc.

Date. January 2014

Summary. This guide was developed to assist in the calibration of safety performance functions from the HSM focused particularly on the predictive method found in Part C of the HSM (AASHTO 2010). This guide complements two other guides including this literature review: the *Safety Performance Function Decision Guide: SPF Calibration versus SPF Development* and *Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs* (items 7 and 8). The guide aimed to support the development of calibration factors and the adaptation of crash distribution tables and adjustment factors to local and current conditions. The goal of this guide is to expand Appendix A of HSM Part C into a comprehensive and clear resource by providing guidance on four key aspects:

- Why calibration is needed
- How to implement the calibration process
- How to assess the results of calibration
- How to prepare for future calibration updates

Within the guide, there are three main parts. Section 4, intended for managers and decision makers, discusses the use of HSM predictive models and why calibration of the models are needed. More specifically, the section emphasizes the need to find a way to combine short-term historical crash data and traffic volumes along any selected corridor while still maintaining the ability to estimate the long-term average crash frequency and severity for a given corridor. This section provides a concise description of the purpose of calibration factors in the context of using the HSM Part C for planning, operational, and design safety considerations, as well as the data required to undertake the calibration effort, including developing jurisdiction-specific crash severity and collision type distributions.

Because the HSM SPFs were developed using data associated with a limited number of highway networks around the country and acquired several years ago, the use of the predictive models in any jurisdiction necessitates the calibration of the SPFs in the HSM Part C and the replacement of "default" crash distribution tables and adjustment factors to local conditions. If applied to another state or county network or corridor or to time period, the predictions are likely to be biased. The purpose of calibration is to ensure that the bias is tolerably small to provide better estimates for jurisdiction-specific conditions. The calibrated models are used to estimate the existing and future safety of project corridors or sites while considering potential engineering improvements.

The second main part, Section 5, is intended for agency's data personnel as well as the safety professionals leading the calibration efforts. This section provides an overview of the data needs for the development of the SPF calibration factors, as well as recommendations on good practices for long-term data storage, collection, and management for future cyclical re-calibration or jurisdiction-specific SPF. This section advances the understanding of the general data requirements using jurisdiction-specific data sources and describes various data collection methods such as office tools (e.g., GoogleMap

Streetview, video-tapes) and field tools (e.g., site visits, traffic counts). This guide describes a detailed data assembly process for basic data elements, required and desirable data elements for the development of SPF calibration factors, supplemental data collection methods, and data preservation and expansion requirements.

The third main part, Section 6, is intended for statistical analysts as well as all others involved in the data preparation and prediction analysis. This section covers all stages of the development of calibration factors for each facility type, including the development of jurisdiction-specific crash severity and collision type distributions and adjustment factors. Furthermore, recommendations for further consideration of calibration factors that will account for differences in regional subsets of an agency's highway network and account for different segment lengths, AADT volumes, and other issues are also included in this section. The guide follows Appendix A of HSM Part C's calibration procedure consisting of five steps:

- Step 1: Identify facility types for which the applicable Part C predictive model is to be calibrated
- Step 2: Select sites for calibration of the predictive model for each facility
- Step 3: Obtain data for each facility type applicable to a specific calibration period
- Step 4: Apply the applicable Part C predictive model to predict total crash frequency for each site during the calibration period
- Step 5: Compute calibration factors for use in Part C prediction model

Finally, the guide provides case studies and lessons learned by past calibration efforts and presents frequently asked questions to provide a quick source of information for those considering developing calibration factors.

Key Findings and Best Practices. The key findings and best practices are as follows:

- The guide recommends replacing many of crash distribution tables and adjustment factors found in the HSM using jurisdiction-specific data for the same years as the jurisdiction-specific SPF calibration factors. Differences in climate, driver populations, animal populations, crash reporting thresholds, crash reporting system procedures, and time periods (i.e., different years) are some of the reasons why such calibration and adjustments are necessary.
- An important task in this process is defining a site-specific location identifier (i.e., milepost or geo-coordinates). All data elements (i.e., crash, traffic volumes, geometric elements, and traffic control devices) should be brought into one table (e.g., Excel spreadsheet) or database platform using this unique identifier. The unique location or site identifier will also play an ongoing key function as data elements are collated and entered into the databases for re-calibration of the SPFs during subsequent years.
- Jurisdiction-specific data are needed for each of the required elements. For data elements identified as desirable in the HSM, the HSM provides guidance and some assumptions for data default values when jurisdiction-specific data are not available. It is, however, recommended that actual data be used for all elements whenever possible.
- Typically, a time period of one to three years may be necessary to reach a sufficient sample size of crash frequencies that were observed or recorded at sites that are similar to those used for

the development of each HSM SPF. If more years of data are available, they may be helpful to determine whether there is a time trend of annual estimates of calibration factors.

- It is important to plan for long-term data storage in a format allowing annual traffic and safety data entries (e.g., annual traffic volumes, observed annual crash frequencies, severity levels) and updates about geometric and traffic control elements based on implemented modifications (e.g., stop-control intersection modified to signalized, addition of a left-turn lane at an intersection, shoulder is paved) or the completion of new roads.
- It is recommended that agencies continue to advance their data capability maturity levels in the following focus areas considered essential to create robust, data-driven safety programs and decision-making:
    - Roadway inventory data collection and technical standards
    - Data analysis tools and uses
    - Data management
    - Data interoperability and expandability

- It is recommended that agencies have a comprehensive annual traffic count and safety data collection programs that include Model Inventory of Roadway Elements (MIRE) and Model Minimum Uniform Crash Criteria (MMUCC) data elements for all public roads. This is fundamental to achieve a sound safety management program. The FHWA has developed two supporting models for data required for data-driven safety analysis:
    - MIRE: Provides a structure for roadway inventory data (available at www.mireinfo.org)
    - MMUCC: Provides a set of uniform crash data elements, definitions, and attributes

  Highway agencies are encouraged to adopt MIRE and MMUCC for consistent definitions and attributes as their data capability is enhanced (available at www.mmucc.us)
- It is recommended that agencies follow the prioritization process outlined in the guide.
- The aspect of selecting sites randomly is important because it is anticipated that calibration factors will differ for various subsets of the facility type such as for regional subsets and low and high AADT ranges, among other factors (Dixon et al 2012, Persaud et al 2002, Srinivasan 2011). The guide recommends using a computer-generated random number system to select sites.
- When choosing a sample size, it is recommended to calculate the estimate of the calibration factor to a sufficient accuracy. The guide suggests using the work developed by Dr. Ezra that uses variance and standard deviation to determine sufficient accuracy. It is suggested that the standard deviation of the estimate of the calibration factor C be of +/- 0.1 C.
- During the process of dividing segments into homogeneous sub-segments, it is recommended that a homogenous site be 0.1 miles or longer. If these sub-segments are shorter than 0.1 mile, it is recommended to regroup them to a minimum length of 0.1 mile and calculate a combined average crash reduction factor (CMF) value for estimation of the Nu, the unadjusted $N_{predicted}$.

AGENCY INTERVIEWS

Phone interviews were completed with representatives from other states that have been active with SPF calibration and development for many years. The purpose of the phone interviews was to gather lessons learned and best practices from their experience. Table 3 summarizes the interviews.

Table 3. Best Practices Interview Contacts

ID	State	Contact
1	Alabama	Tim Barnett, Alabama DOT Safety Engineer Steven Jones, University of Alabama
2	Colorado	David Swenka, Colorado DOT Safety and Traffic Engineer
3	Kansas	Howard Lubliner, Kansas DOT District Engineer Cheryl Bornheimer, Kansas DOT Safety Engineer
4	Florida	Joseph Santos, Florida DOT Safety Engineer Frank Sullivan, Florida DOT Roadway Engineer
5	Virginia	Stephen Read, Virginia DOT HSIP Program Manager

A summary of each individual call is included in the Appendix A. Table 4 summarizes each state's relevant experience with SPF calibration and development for network screening, project level analyses, or both.

Table 4. Best Practices Interview Summary

		Network Screening				Project Level			
		Segment		Intersection		Segment		Intersection	
ID	State	Calibrate	Develop	Calibrate	Develop	Calibrate	Develop	Calibrate	Develop
1	Alabama	-	-	-	-	Yes	Yes	Ongoing	Ongoing
2	Colorado	-	Yes	-	Yes	-	Yes	-	Yes
3	Kansas	Yes	-	Ongoing	-	Yes	Validation	Yes	-
4	Florida	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Virginia		Yes		Yes		Yes		Yes

The following is a summary of the key elements of the five states' interviews:

- Kansas has chosen to focus on calibration only.
- Colorado and Virginia are focusing on developing jurisdiction-specific SPFs and are using different functional forms than those found in the HSM or SafetyAnalyst™.
- Alabama and Florida are calibrating and then developing jurisdiction-specific SPFs as needed.
- Alabama is only calibrating and developing jurisdiction-specific SPFs for project level.
- Four states have some jurisdiction-specific SPFs.
- Colorado is developing separate SPFs for injury crashes.
- Colorado and Alabama are using independent programs for safety analysis along with their jurisdiction-specific SPFs.
- Colorado is using the same jurisdiction-specific SPFs for both network- and project-level analyses.
- Virginia is the only state that developed regional SPFs.

- Alabama found SPF calibration just as accurate as jurisdiction-specific SPFs. Florida concluded that SPF development led to much more accurate outcomes.
- For all states, SPFs for segments were completed first, followed by intersections. There are significant data challenges related to gathering and preparing data for intersections.
- Data were the biggest challenge; all concluded that the most important focus should be on improving data collection and cleaning.
- Multiple years (three to nine) have been spent on these efforts and will continue on as an ongoing effort.

The following is a summary of the lessons learned and best practices from the five state interviews:

- SPF calibration and development are critical for application of the HSM, but take a significant commitment to attaining and maintaining the data. It is critical to assign personal resources to gathering and preparing data on an ongoing basis.
- Getting good data is very difficult. The second significant challenge is cleaning and storing the data, which requires knowledge of database, as Microsoft Excel will not work with most of these huge data sets.
- The horizontal curve data are very important. The SPFs are different for the tangent and curved roadway segments.
- There will initially be gaps in data and assumptions need to be made. It is critical to make sure assumptions are valid.
- Site sample selection is typically done using stratified sampling to make sure all the roads are well represented in the sample. Use a random generator to select random sites.
- Most states started with SPF calibration and then determined if the calibration was accurate enough for their conditions.
- Segment data are typically most straight forward with the exception of horizontal curve data. Intersection data are most challenging to attain with all the necessary elements and to attain large enough sample sizes for calibration.
- The segmentation process is important. Roadway segments can be as short as 0.1 mile, but it is understood that crash data are not accurate enough for this level. Thus, grouping non-homogeneous segments can replace longer segments. The differences accounted for by the CMF values. Potentially, segment lengths of at least 0.1 mile are envisioned, with possible lengths of a quarter-mile for urban and one mile for rural, if feasible.
- Another benefit of creating jurisdiction-specific SPFs is that the state can handle facility types that are not included in the current HSM.
- Definitions of urban versus rural is a gray area for roads in and around small communities. There is a need for better definitions and consistent application of suburban.

SUMMARY AND BEST PRACTICES

The literature and best practices review, as related to the ADOT State-Specific Crash Prediction Models: An Arizona Needs Study is summarized below.

SPF Calibration Versus SPF Development

The *Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs* and the *User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors* (i.e., *Calibration User's Guide,* [Bahar 2014]) are the most relevant documents for this project. Each document provides a wealth of information related to the specific topic.

Data Collection

Best practices regarding data collection are summarized as follows:

- It is important to have a thorough plan for long-term data storage in a format allowing annual traffic and safety data entries (e.g., annual traffic volumes, observed annual crash frequencies, and severity levels) and updates about geometric and traffic control elements based on implemented modifications (e.g., stop-control intersection modified to signalized, addition of a left-turn lane at an intersection, shoulder is paved) or the completion of new roads. This effort needs dedicated staff.
- An important task in this process is defining a site-unique location identifier (i.e., milepost or geo-coordinates). All data elements (i.e., crash, traffic volumes, geometric elements, and traffic control devices) should be brought together onto one table (e.g., Excel spreadsheet) or database platform using this unique identifier. The unique location or site identifier will also play an ongoing key function as data elements are collated and entered into the databases for re-calibration of the SPFs during subsequent years.
- It is recommended that agencies have a comprehensive annual traffic counting program that includes all public roads. This is fundamental to achieving a sound safety management program. The FHWA has developed two supporting models for data required for data-driven safety analysis:
    - MIRE: Provides a structure for roadway inventory data (available at
    - MMUCC: Provides a set of uniform crash data elements, definitions, and attributes (available at www.mmucc.us/)
    - Highway agencies are encouraged to adopt MIRE and MMUCC for common consistent definitions and attributes as their data capability is enhanced.
- During the process of dividing segments into homogeneous sub-segments, it is recommended that a homogenous site be 0.1 miles or longer. If these sub-segments are shorter than 0.1 mile, it is recommended to regroup them to a length of 0.1 mile as a minimum and calculate a combined average CMF value for estimation of the N_u, the unadjusted $N_{predicted}$.

SPF Calibrations versus Jurisdiction-Specific SPF Development

Best practices regarding SPF calibrations versus jurisdiction-specific SPF developments are summarized as follows:

- Decision-making calibrating existing SPFs or developing jurisdiction-specific SPFs is a common issue for state DOTs that desire to use SPFs in safety analyses on state highway systems.

- Calibration can be done by staff with limited statistical experience and can be implemented using spreadsheets and procedures such as those included in the *SPF Calibration* Guide (Srinivasan et al. 2013). SPF development needs to be performed by someone with expertise in statistical analysis.
- Given the costs of data collection, calibration of available crash prediction models to local conditions is often the only method available to transportation agencies to estimate the safety of transportation facilities. Creating a procedure for data management to continue to add annual data to the originally collected data sets will lead to a cost-effective way to update the calibration factors (annually or as needed) and develop jurisdiction-specific SPFs in future.
- The quality of the calibration factor should be assessed. A calibration factor significantly different than 1.0 (i.e., much less or greater) indicates that the agency's crash experience is much different than the SFP development. The agency should consider developing jurisdiction-specific SPFs.
- For project-level SPFs, a good-quality calibration factor can be used along with the HSM (AASHTO 2010) predictive methodology to conduct project-level analysis. For network screening SPFs, a good-quality calibration factor can be used. If the calibration factor is not of good quality, the agency should develop SPFs using the procedure discussed in the *How to Guidebook for States Developing Jurisdiction-Specific SPFs*.
- The Virginia DOT concluded that the development of SPFs specifically for network screening for Virginia was necessary because the existing SPFs in Safety Analyst™ did not adequately describe Virginia's characteristics. Virginia's unique topography, combination of heavily rural and heavily urban regions, and vast network of state-maintained secondary roads all contributed to the distinctive set of attributes that underlined the need for Virginia-specific SPFs.
- Site disaggregation into geographical regions and road classifications has the potential to improve the fit of the SPFs. Site disaggregation enhances homogeneity with respect to roadway characteristics.
- Over time, SPFs and the calibration factors which developed them will become less accurate at predicting expected crash frequencies. It will be beneficial to use the most recent years of data to re-develop or re-calibrate the SPFs. If sufficient expertise and resources are available, SPFs may be re-developed. If not, the SPFs should be updated for future years by calculating a calibration factor for each future year–similar to the way in which calibration factors were calculated for the HSM SPFs.
- Many agencies want an idea of the cost of the effort required to calibrate and/or develop SPFs. Table 5 provides the estimated ranges of staff time required for each endeavor (assumes the HSM Part C minimum sample size recommendations). The staff time required to collect and prepare the data can range greatly depending on the following factors:
    - *Number of SPFs being addressed.* If many SPFs are being calibrated or developed in the same project, data collection per SPF will become more efficient because the data collector can obtain data on many types of sites during the same effort. For instance, a data collector collecting data on rural, two-lane road segments can also gather information on rural, two-lane road intersections with minimal additional effort.

- *Available data in existing roadway inventory.* If most of the required data elements are contained in the agency's existing inventory, data collection time will be minimal. However, the fewer the data elements available in the inventory, the time needed to assemble the required data will be greater. Methods for collecting the data may involving aerial photos, online imagery, construction plans, and/or field visits.

Table 5. Level of Effort Estimates for Calibration and Development

Intended Use	Process	Minimum Sample Size needed (based on HSM Part C)	Staff hours needed – data collection and preparation (per SPF)	Staff hours needed – statistical analyst (per SPF)
Project Level	Calibrate SPF	30 - 50 sites; at least 100 crashes per year for the total group. At least three years of data are recommended.	150 to 350	N/A
	Develop SPF	100 - 200 intersections or 100 - 200 miles; at least 300 crashes per year for total group. At least three years of data are recommended.	450 to 1,050	16 to 40
Network Screening	Calibrate SPF	Must use entire network to be screened. No minimum sample size specified. At least three years of data are recommended.	24 to 40	n/a
	Develop SPF	Must use entire network to be screened. Minimum sample would be 100 - 200 intersections or 100 - 200 miles; at least 300 crashes per year for total group. At least three years of data are recommended.	24 to 40	8 to 24

Calibration

Best practices for calibration include:

- The HSM (AASHTO 2010) states that a sample size of 100 crashes per year is too generic, and it is not recommended. A procedure to estimate sample sizes for each calibration effort is provided in the *Calibration User's Guide* (Bahar 2014). It is imperative that the calibration process use high-quality data with sufficient sample sizes for crashes and sites.
- Calibration factors developed with small sample sizes and where there are design differences between HSM and local road datasets (not accounted by the CMFs for base conditions) should not be used.
- Road characteristic data developed for the purposes of calibration should be preserved, and calibration factors can be updated with future observed crashes and updated traffic volumes with minimal additional effort in future years. The same data will be useful for future jurisdiction-specific SPF development.
- The one-size-fits-all sample size is not appropriate for all facility types and should be enhanced. In addition, the calibration of severity-level models requires additional consideration. The HSM severity-model rebalancing procedure should be incorporated into the calibration process and sample size techniques appropriate for the severity-level models are needed. The calibration factors developed for this effort are suitable for evaluations within a jurisdiction; however, overall HSM calibration techniques should address severity-level and sample size considerations before comparing predicted, calibrated crash frequencies between different jurisdictions with varying reporting thresholds or procedures.
- A data management process to link crashes, roadway characteristics, and traffic volumes is desirable.
- Crash counts are integer and nonnegative; thus, conventional regression-based models using normal error distribution cannot be used.
- The calibration process should be validated using a combination of different statistical techniques including the CURE method, dispersion parameter-based R, t-test, and RMSE.
- The calibration process should develop separate calibration factors for the different area types: ramp type, ramp configuration, and each crash type (i.e., frequency and severity). This disaggregate approach allows for a better fit with the data if the effect of an attribute differs. Some states have done separate analyses for the "all crash" and the "fatal and injury crash" models.
- It is recommended to replace the crash distribution tables and adjustment factors found in the HSM jurisdiction-specific data for the same years as the jurisdiction-specific SPF calibration factors. Differences in climate, driver and animal populations, crash reporting thresholds, crash reporting system procedures, and time periods (i.e., different years) are some of the reasons why such calibration and adjustments are necessary.

Jurisdiction-Specific SPF Development

Best practices for jurisdiction-specific SPF development include:

- Temporal correlation can lead to incorrect estimates of the standard errors of the coefficients. Temporal correlation may arise when multiple observations are used for the same roadway unit. A common approach to dealing with temporal correlation is to aggregate the data so that each roadway unit has one observation. For example, if three years of data are available for SPF estimation and crash counts and site characteristics are available for each of these three years, then for each roadway unit, the total crash counts over the three years is computed and used as the dependent variable along with the average value of the site characteristics over the three-year period as the explanatory variables.
- Some recent studies have used model forms other than the negative binomial form. These include zero-inflated models, Poisson-lognormal models, and Conway-Maxwell-Poisson models.
- GAMs introduce smoothing functions for each explanatory variable in the model and hence provide a more flexible functional form. GAMs can include both parametric and non-parametric forms. However, GAMs do not have coefficients associated with the smoothing functions and hence are much more difficult to use and interpret as an SPF.
- Random-parameters models allow the estimated parameters (coefficients) to vary across the individual observations, but usually based on a pre-specified distribution. The goal of these models is to account for the unobserved heterogeneity from one observation to another.
- Graphical methods and statistical tests (i.e., R-square and the Freeman-Tukey coefficient) were used to test the transferability of SPFs developed for other states (using Safety Analyst™) to Virginia. It was observed that the transferability of existing SPFs were not optimal.
- To determine the reason crashes occur and provide a more proactive model, a multivariate analysis is necessary to show how certain variables contribute to crashes.
- Datasets development and maintenance methods produced a source of error that limited the accuracy of the models.

CHAPTER 3. DATA COLLECTION

OVERVIEW

HSM (AASHTO 2010) SPFs and potential calibration factors are shown in Table 6. The HSM 2014 Supplement was not available at the time of the data collection in the first half of 2014, so freeway and ramp data were not collected.

Table 6. Possible Calibration Factors For SPFs in the HSM—Rural Undivided Roadways (AASHTO 2010)

Facility Type and HSM Prediction Models	HSM SPFs	Calibration Factors
Rural undivided two-lane, two-way roadway segments (Equation 10-2)	**For 2U**: Equation 10-6 for total (KABCO) crash frequency	$C_{\text{2U total}}$
Rural undivided two-lane, two-way roadway intersections (Equation 10-3)	**For 3ST**: Equation 10-8 for total (KABCO) crash frequency	$C_{\text{2U 3ST total}}$
	For 4ST: Equation 10-9 for total (KABCO) crash frequency	$C_{\text{2U 4ST total}}$
	For 4SG: Equation 10-10 for total (KABCO) crash frequency	$C_{\text{2U 4SG total}}$

Table 7. Possible Calibration Factors For SPFs in the HSM—Rural Multilane Roadways (AASHTO 2010)

Rural multilane roadway segments (Equation 11-2 and Equation 11-3)	For 4U: **Equation 11-7 and Table 11-3 for total (KABCO), fatal and injury (KABC), or fatal and injury (KAB) crash frequency**	**$C_{\text{4U total}}$**
		$C_{\text{4U KABC}}$
		C_{4UKAB}
	For 4D: Equation 11-9 and Table 11-5 for total (KABCO), fatal and injury (KABC), or fatal and injury (KAB) crash frequency	$C_{\text{4D total}}$
		$C_{\text{4D KABC}}$
		C_{4DKAB}
Rural multilane roadway intersections (Equation 11-4)	**For 3ST**: Equation 11.11 and Table 11-7 for total (KABCO), fatal and injury (KABC), or fatal and injury (KAB) crash frequency	$C_{\text{4R 3STtotal}}$ $C_{\text{4RU 3STtotal}}$ $C_{\text{4RD 3STtotal}}$
		$C_{\text{4R 3ST KABC}}$ $C_{\text{4RU 3ST KABC}}$ $C_{\text{4RD 3ST KABC}}$
		$C_{\text{4R 3ST KAB}}$ $C_{\text{4RU 3ST KAB}}$ $C_{\text{4RD 3ST KAB}}$
	For 4ST: Equation 11.11 and Table 11-7 for total (KABCO), fatal and injury (KABC), or fatal and injury (KAB) crash frequency	$C_{\text{4R 4STtotal}}$ $C_{\text{4RU 4STtotal}}$ $C_{\text{4RD 4STtotal}}$
		$C_{\text{4R 4ST KABC}}$ $C_{\text{4RU 4ST KABC}}$ $C_{\text{4RD 4ST KABC}}$
		$C_{\text{4R 4ST KAB}}$ $C_{\text{4RU 4ST KAB}}$ $C_{\text{4RD 4ST KAB}}$
	For 4SG: Equation 11-11 (or 11-12) and Table 11-8 for total (KABCO), fatal and injury (KABC), or fatal and injury (KAB) crash frequency	$C_{\text{4R 4SG total}}$ $C_{\text{4RU 4SG total}}$ $C_{\text{4RD 4SG total}}$
		$C_{\text{4R 4SG KABC}}$ $C_{\text{4RU 4SG KABC}}$ $C_{\text{4RD 4SG KABC}}$
		$C_{\text{4R 4SG KAB}}$ $C_{\text{4RU 4SG KAB}}$ $C_{\text{4RD 4SG KAB}}$

Table 8. Possible Calibration Factors For SPFs in the HSM—Urban and Suburban Arterial Segments (AASHTO 2010)

Urban and suburban arterial roadway segments (Equation 12-2, Equation 12-3, and Equation 12-4)	*Multiple-vehicle non-driveway collisions*: **Equation 12-10 and Table 12-3 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency**	$\mathbf{C_{BRMV\ 2U\ total}}$
		$C_{BRMV\ 2U\ KABC}$
		$C_{BRMV\ 2U\ O}$
	Single-vehicle crashes: Equation 12-13 and Table 12-5 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRSV\ 2U\ total}$
		$C_{BRSV\ 2U\ KABC}$
		$C_{BRSV\ 2U\ O}$
	Multiple-vehicle driveway-related collisions: Equation 12-16 and Table 12-7 for total (KABCO)	$C_{BRDRY\ 2U\ total}$
	Multiple-vehicle non-driveway collisions: Equation 12-10 and Table 12-3 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRMV\ 3T\ total}$
		$C_{BRMV\ 3T\ KABC}$
		$C_{BRMV\ 3T\ O}$
	Single-vehicle crashes: Equation 12-13 and Table 12-5 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRSV\ 3T\ total}$
		$C_{BRSV\ 3T\ KABC}$
		$C_{BRSV\ 3T\ O}$
	Multiple-vehicle driveway-related collisions: Equation 12-16 and Table 12-7 for total (KABCO)	$C_{BRDRY\ 3T\ total}$
	Multiple-vehicle non-driveway collisions: Equation 12-10 and Table 12-3 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRMV\ 4U\ total}$
		$C_{BRMV\ 4U\ KABC}$
		$C_{BRMV\ 4U\ O}$
	Single-vehicle crashes: Equation 12-13 and Table 12-5 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRSV\ 4U\ total}$
		$C_{BRSV\ 4U\ KABC}$
		$C_{BRSV\ 4U\ O}$
	Multiple-vehicle driveway-related collisions: Equation 12-16 and Table 12-7 for total (KABCO)	$C_{BRDRY\ 4U\ total}$
	Multiple-vehicle non-driveway collisions: Equation 12-10 and Table 12-3 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRMV\ 5T\ total}$
		$C_{BRMV\ 5T\ KABC}$
		$C_{BRMV\ 5T\ O}$
	Single-vehicle crashes: Equation 12-13 and Table 12-5 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{BRSV\ 5T\ total}$
		$C_{BRSV\ 5T\ KABC}$
		$C_{BRSV\ 5T\ O}$
	Multiple-vehicle driveway-related collisions: Equation 12-16 and Table 12-7 for total (KABCO)	$C_{BRDRY\ 5T\ total}$

Table 9. Possible Calibration Factors For SPFs in the HSM—Urban and Suburban Arterial Intersections (AASHTO 2010)

Urban and suburban arterial Intersections (Equation 12-5, Equation 12-6, and Equation 12-7)	*Multiple-vehicle collisions*: **Equation 12-21 and Table 12-10 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency**	**$C_{\text{BIMV 3ST total}}$**
		$C_{\text{BIMV 3ST KABC}}$
		$C_{\text{BIMV 3ST O}}$
	Single-vehicle crashes: Equation 12-24 and Table 12-12 for total (KABCO) crash frequency, or property-damage-only (O) crash frequency	$C_{\text{BISV 3ST total}}$
		$C_{\text{BISV 3ST O}}$
	Multiple-vehicle collisions: Equation 12-21 and Table 12-10 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{\text{BIMV 4ST total}}$
		$C_{\text{BIMV 4ST KABC}}$
		$C_{\text{BIMV 4ST O}}$
	Single-vehicle crashes: Equation 12-24 and Table 12-12 for total (KABCO) crash frequency, or property-damage-only (O) crash frequency	$C_{\text{BISV 4ST total}}$
		$C_{\text{BISV 4ST O}}$
	Multiple-vehicle collisions: Equation 12-21 and Table 12-10 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{\text{BIMV 3SG total}}$
		$C_{\text{BIMV 3SG KABC}}$
		$C_{\text{BIMV 3SG O}}$
	Single-vehicle crashes: Equation 12-24 and Table 12-12 for total (KABCO) crash frequency, fatal and injury (KABC) crash frequency, or property-damage-only (O) crash frequency	$C_{\text{BISV 3SG total}}$
		$C_{\text{BISV 3SG KABC}}$
		$C_{\text{BISV 3SG O}}$
	Vehicle-pedestrian collisions: Equation 12-29 and Table 12-14 for fatal and injury (KABC) collision frequency	$C_{\text{ped 3SG KABC}}$
	Multiple-vehicle collisions: Equation 12-21 and Table 12-10 for total (KABCO), fatal and injury (KABC), or property-damage-only (O) crash frequency	$C_{\text{BIMV 4SG total}}$
		$C_{\text{BIMV 4SG KABC}}$
		$C_{\text{BIMV 4SG O}}$
	Single-vehicle crashes: Equation 12-24 and Table 12-12 for total (KABCO) crash frequency, fatal and injury (KABC)crash frequency, or property-damage-only (O) crash frequency	$C_{\text{BISV 4SG total}}$
		$C_{\text{BISV 4SG KABC}}$
		$C_{\text{BISV 4SG O}}$
	Vehicle-pedestrian collisions: Equation 12-29 and Table 12-14 for fatal and injury (KABC) collision frequency	$C_{\text{ped 4SG KABC}}$

DATA REQUIREMENTS

Calibration of Part C predictive models requires data pertaining to site characteristics for each facility type. Data needs are described in HSM Table A-2, Data Needs for Calibration of Part C Predictive Models by Facility Type (AASHTO 2010). For each site in the calibration data set, the data set should include:

- Total observed crash frequency for a period of one or more years in duration
- All site characteristic data needed to apply the applicable Part C predictive model

HSM Table A-2 specifies “required” data and “desired” data. "Desired" data are considered to be less sensitive to crash propensity.

A key element of data requirements is determining the appropriate sample size for the SPF calibration. For each roadway type, the HSM recommends a sample size of 30 to 50 sites selected at random that experience at least 100 crashes per year. Data for each of the “required” elements for each site are needed for calibration. If data for some required elements are not readily available, it may be possible to select sites for which data are available. For example, if data regarding horizontal curves are not available, it may be possible to limit the calibration data set to tangent sections, or to sites for which the data are available. However, since the HSM publication in 2010, several research studies and practical calibrations assignments have concluded that the HSM recommendations do not lead to an accurate way of computing calibration because this process excludes important information from the state-wide data set. It was determined that the *Calibration User’s Guide* (Bahar 2014) would be used for determining the appropriate sample size in this study. More information on the sample size for calibration is included in Section 5.

For data identified as “desirable,” actual data should be used if available. Where “desirable” data are not available, HSM Table A-2 provides assumption suggestions. The *Calibration User’s Guide* provides a complete list of required and desirable data elements (i.e., Table 5.1A, Table 5.1B, and Table 5.1C)

During the data collection and processing stages of the calibration process, data were assembled from the ADOT MPD in individual GIS data sets (i.e., shoulder width, AADT, and lane width). Where GIS data were not available, the study team collected roadway characteristics by field review, aerial imagery, or other means.

Tables 7 through 14 summarize calibration data needs as described in the HSM for each facility type. The study team recommends that “desirable” data that are available in GIS data sets be collected and analyzed. “Desirable” data that are not readily available in GIS data sets or other database will not be collected and analyzed. HSM recommended assumptions will be utilized.

Tables 7 through 14 also summarize the status of the data for utilization by the project team. Data status is denoted as “obtained”, “field review required,” or “recommended to not collect”. “Required” data that are not available in GIS or other database format is in bold/grey.

Table 10. Rural Two-Lane, Two-Way Roads

Rural Two-Lane, Two-Way Roads		Data Item No. (Refer to Table 13)		
Data Element	**Data Need**		**Data Status**	**Comments**
Segment length	Required	2	Obtained	GIS data set
Average Annual Daily Traffic (AADT)	Required	3	Obtained	GIS data set
Length of horizontal curves and tangents	Required	4	Obtained	GIS data set, Requires additional estimation with GIS
Radii of horizontal curves	Required	5	Obtained	GIS data set and field review GIS data set, Requires additional estimation with CAD
Presence of spiral transition for horizontal curves	Desirable	6	Recommended to not collect	Not maintained by MPD GIS
Superelevation variance for horizontal curves	Desirable	7	Recommended to not collect	Not maintained by MPD GIS
Percent grade	Desirable	8	Obtained	GIS data set and field review
Lane width	Required	9	Obtained	GIS data set
Shoulder type	Required	10	Obtained	GIS data set
Shoulder width right	Required	11	Obtained	GIS data set
Shoulder width left	Required	12	Obtained	GIS data set
Presence of lighting	Desirable	13	Recommended to not collect	Not maintained by MPD GIS
Driveway density	Desirable	14	Recommended to not collect	Not maintained by MPD GIS
Presence of passing lane	Desirable	15	Obtained	GIS data set
Presence of short four-lane section	Desirable	16	Obtained	GIS data set
Presence of center two-lane left turn lane (**TWLTL**)	Required	17	Obtained	GIS data set
Presence of centerline rumble strip	Desirable	18	Recommended to not collect	Not maintained by MPD GIS
Roadside hazard rating	Desirable	19	Recommended to not collect	Not maintained by MPD GIS
Use of automated speed enforcement	Desirable	20	Recommended to not collect	Not maintained by MPD GIS

Table 11. Rural Multi-Lane Highways

Rural Multi-Lane Highways		Data Item No. (Refer to Table 13)	Data Status	Comments
Data Element	**Data Need**			
FOR ALL RURAL MULTI-LANE HIGHWAYS				
Segment length	Required	2	Obtained	GIS data set
AADT	Required	3	Obtained	GIS data set
Lane width	Required	9	Obtained	GIS data set
Shoulder width right	Required	11	Obtained	GIS data set
Shoulder width left	Required	12	Obtained	GIS data set
Presence of lighting	Required	13	Obtained	Excel spreadsheet
Use of automated speed enforcement	Desirable	20	Recommended to not collect	Not maintained by MPD GIS
FOR UNDIVIDED HIGHWAYS ONLY				
Sideslope	Required	21	Obtained	ADOT design standards and construction drawings
FOR DIVIDED HIGHWAYS ONLY				
Median width	Required	23	Obtained	GIS data set

Table 12. Urban and Suburban Arterials

Urban and Suburban Arterials		Data Item No. (Refer to Table 13)	Data Status	Comments
Data Element	Data Need			
Segment length	Required	2	Obtained	GIS data set
AADT	Required	3	Obtained	GIS data set
Presence of lighting	Desirable	13	Recommended to not collect	Not maintained by MPD GIS
Presence of center TWLTL	Required	17	Obtained	GIS data set
Presence of automated speed enforcement	Desirable	20	Recommended to not collect	Not maintained by MPD GIS
Number of driveways by land-use type	Required	22	Field/aerial review required	Not maintained by MPD GIS
Presence of median	Required	24	Obtained	GIS data set
Number of through traffic lanes	Required	25	Obtained	GIS data set
Low-speed versus intermediate or high speed	Required	26	Obtained	GIS data set
Presence of on street parking	Required	27	Obtained	GIS data set
Roadside fixed object density	Desirable	28	Recommended to not collect	Not maintained by MPD GIS

Table 13. Intersection: Two-Lane, Two-Way Roads

Intersection: Two-Lane, Two-Way Roads		Data Item No. (Refer to Table 14)	Data Status	Comments
Data Element	Data Need			
Number of intersection legs	Required	1	Obtained	GIS data set
Type of traffic control	Required	2	Obtained	GIS data set
AADT major	Required	3	Obtained	GIS data set
AADT minor	Required	4	Obtained	GIS data set
Intersection skew angle	Desirable	5	Recommended to not collect	Not maintained by MPD GIS
Number of approaches with left-turn lanes	Required	6	Obtained	GIS data set
Number of approaches with right-turn lanes	Required	7	Obtained	GIS data set
Presence of lighting	Required	13	Obtained	Excel spreadsheet

Table 14. Intersection: Rural Multi-Lane Highways

Intersection: Rural multilane highways		**Data Item No. (Refer to Table 14)**	**Data Status**	**Comments**
Data Element	**Data Need**			
Number of intersection legs	Required	1	Obtained	GIS data set
Type of traffic control	Required	2	Obtained	GIS data set
AADT major	Required	3	Obtained	GIS data set
AADT minor	Required	4	Obtained	GIS data set
Intersection skew angle	Desirable	5	Recommended to not collect	Not maintained by MPD GIS
Number of approaches with left-turn lanes	Required	6	Obtained	GIS data set
Number of approaches with right-turn lanes	Required	7	Obtained	GIS data set
Presence of lighting	Required	13	Obtained	Excel spreadsheet

Table 15. Intersection: Urban and Suburban Arterials

Intersection: Urban and Suburban Arterials Data Element	Data Need	Data Item No. (Refer to Table 14)	Data Status	Comments
FOR ALL INTERSECTIONS ON ARTERIALS				
Number of intersection legs	Required	1	Obtained	GIS data set
Type of traffic control	Required	2	Obtained	GIS data set
AADT major	Required	3	Obtained	GIS data set
AADT minor	Required	4	Obtained	GIS data set
Number of approaches with left-turn lanes	Required	6	Obtained	GIS data set
Number of approaches with right-turn lanes	Required	7	Obtained	GIS data set
Presence of lighting	Required	13	Obtained	Excel spreadsheet
FOR SIGNALIZED INTERSECTIONS ONLY				
Presence of left-turn phasing	Required	9	Field review required	Not maintained by MPD GIS
Type of left-turn phasing	Required	10	Field review required	Not maintained by MPD GIS
Use of right-turn-on-red signal operation	Required	11	Field review required	Not maintained by MPD GIS
Use of red-light cameras	Required	12	Field review required	Not maintained by MPD GIS
Pedestrian volume	Desirable	13	Recommended to not collect	Not maintained by MPD GIS
Maximum number of lanes crossed by pedestrians on any approach	Desirable	14	Obtained	GIS data set
Presence of bus stops within 1,000 feet (ft)	Desirable	15	Recommended to not collect	Not maintained by MPD GIS
Presence of schools within 1,000 ft	Desirable	16	Recommended to not collect	Not maintained by MPD GIS
Presence of alcohol sales establishments within 1,000 ft	Desirable	17	Recommended to not collect	Not maintained by MPD GIS

DATA SOURCE AND DESCRIPTION

The data described in Table 13 (Segments) and Table 14 (Intersections) were obtained from ADOT. Appendix B includes an additional, in-depth description of each data element.

Table 16. Segment Data Source and Availability

No.	Data Item	HSM Default Assumptions	Data Source	Data Format	Field Name	Description
1	Crash data	Need actual data	ADOT	Excel spreadsheet	Multiple	Five-year state wide crash history (2008-2012). Includes incident, person, and unit data. Refer to Appendix B-1
2	Segment length	Need actual data	ADOT	GIS Shape File (FuncClass)	FuncCode, Miles, ThruLanes	Functional classification, urban or rural and number of through lanes. Refer to Appendix B-2
3	AADT	Need actual data	ADOT	GIS Shape File (AADT_2012)	VALUE_NUME	Provides 2012 AADT values for specific roadway segments
4	Length of horizontal curves and tangents	Need actual data	Aerial review	N/A	N/A	Estimation using GIS. Refer to Appendix B-3
5	Radii of horizontal curves	Need actual data	Aerial review	N/A	N/A	Estimation using CAD. Refer to Appendix B-3
6	Presence of spiral transition for horizontal curves	Base default on agency design policy	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS

Table 16. Segment Data Source and Availability

No.	Data Item	HSM Default Assumptions	Data Source	Data Format	Field Name	Description
7	Superelevation variance for horizontal curves	No superelevation variance	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS
8	Percent grade	Base default on terrain	ADOT	GIS shape file (Grades 2012)	DATA_ITEM and VALUE_NUME	Provides grades Refer to Appendix B-4
9	Lane width	Need actual data	ADOT	GIS shape file (Lanes)	AVGLNWIDTH	Number of lanes and average lane width. Refer to Appendix B-5
10	Shoulder type	Need actual data	ADOT	GIS shape file (ShoulderSurfaceType_2012)	SHTY	2012 shoulder surface type. Refer to Appendix B-6
11	Shoulder width right	Need actual data	ADOT	GIS shape file (ShoulderWidthRight_2012)	RSW	2012 right shoulder width. Refer to Appendix B-7
12	Shoulder width left	Need actual data	ADOT	GIS shape file (ShoulderWidthLeft_2012)	LSW	2012 left shoulder width. Refer to Appendix B-8
13	Presence of lighting	Assume no lighting	ADOT	N/A	N/A	Excel spreadsheet of roadway lighting by mile post
14	Driveway density	Assume five driveways per mile	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS

Table 16. Segment Data Source and Availability						
No.	**Data Item**	**HSM Default Assumptions**	**Data Source**	**Data Format**	**Field Name**	**Description**
15	Presence of passing lane	Assume not present	ADOT	GIS shape file (Auxiliary Lanes)	SYMSUB	Auxiliary lanes (e.g., turn lanes, medians, acceleration lanes). Refer to Appendix B-9
16	Presence of short four-lane section	Assume not present	ADOT	GIS shape file (Lanes)	LANES	Number of lanes and average lane width Refer to Appendix B-5
17	Presence of center TWLTL	Need actual data	ADOT	GIS shape file (Auxiliary Lanes)	SYMSUB	Auxiliary lanes (e.g., turn lanes, medians, acceleration lanes). Refer to Appendix B-9
18	Presence of centerline rumble strip	Base default on agency design policy	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS
19	Roadside hazard rating	Assume roadside hazard rating of 3	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS
20	Use of automated speed enforcement	Base default on current practice	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS
21	Sideslope	Need actual data	ADOT	N/A	N/A	ADOT design standards and construction drawings
22	Number of driveways by land-use type	Need actual data	Field Review	values	N/A	Not maintained by MPD GIS

Table 16. Segment Data Source and Availability

No.	Data Item	HSM Default Assumptions	Data Source	Data Format	Field Name	Description
23	Median width	Need actual data	ADOT	GIS shape file (Auxiliary Lanes)	SYMSUB and AVGLNWIDTH	Auxiliary lanes such (e.g., turn lanes, medians, acceleration lanes). Refer to Appendix B-9
24	Presence of median	Need actual data	ADOT	GIS shape file (Auxiliary Lanes)	SYMSUB	Auxiliary lanes such (e.g., turn lanes, medians, acceleration lanes). Refer to Appendix B-9
25	Number of through traffic lanes	Need actual data	ADOT	GIS shape file (Lanes)	LANES	Number of lanes and average lane width. Refer to Appendix B-5
26	Low-speed versus intermediate or high speed	Need actual data	ADOT	GIS shape file (Speed Limit)	SpeedLimit	Posted speed limit on Arizona roadways. Refer to Appendix B-10
27	Presence of on street parking	Need actual data	ADOT	GIS shape file (ParkingInThePeakPeriod)	PeakPark	Provides information regarding on street parking. Refer to Appendix B-11
28	Roadside fixed object density	Database values	Field review	Values	N/A	Not maintained by MPD GIS

Table 17. Intersection Data Source and Availability

No.	Data	Default Assumptions	Source	Data Form	Location/Column Name	Description
1	Number of intersection legs	Need actual data	ADOT and Field Review	GIS shape file (Junctions)	Possible derivation from junctions, possible field review confirmation	Locations of at-grade intersections with information about type of traffic control junction type. Refer to Appendix B-12
2	Type of traffic control	Need actual data	ADOT	GIS shape file (Junctions)	TrafficControl, Detection and Signalization	Locations of at-grade intersections with information about type of traffic control junction type. Refer to Appendix B-12
3	AADT major	Need actual data	ADOT	GIS shape file (AADT_2012)	VALUE_NUME	2012 state AADT values
4	AADT minor	Need actual data	ADOT	GIS shape file (AADT_2012)	VALUE_NUME	2012 state AADT values
5	Intersection skew angle	Assume no skew	N/A	N/A	N/A	Will not collect. Not maintained by MPD GIS
6	Number of approaches with left-turn lanes	Need actual data	ADOT	GIS Shape file (Junctions)	TURN_CODE	Locations of at-grade intersections with information about type of traffic control junction type Refer to Appendix B-12
7	Number of approaches with right-turn lanes	Need actual data	ADOT	GIS Shape file (Junctions)	TURN_CODE	Locations of at-grade intersections with information about type of traffic control junction type Refer to Appendix B-12
8	Presence of lighting	Need actual data	Field review	Values	N/A	Excel spreadsheet of roadway lighting by mile post
9	Presence of left-turn phasing	Need actual data	Field review	Values	N/A	Not maintained by MPD GIS
10	Type of left-turn phasing	Prefer actual data, but agency practice may be used as a default	Field review	Values	NA	Not maintained by MPD GIS

No.	Data	Default Assumptions	Source	Data Form	Location/Column Name	Description
11	Use of right-turn-on-red signal operation	Need actual data	Field review	Values	N/A	Not maintained by MPD GIS
12	Use of red-light cameras	Need actual data	Field review	Values	N/A	Not maintained by MPD GIS
13	Pedestrian volume	Estimate with Table 12-21	N/A	N/A	N/A	Will not collect, not maintained by MPD GIS
14	Maximum number of lanes crossed by pedestrians on any approach	Estimate with number of lanes and presence of median on major road	ADOT	GIS shape file (Lanes and Auxiliary Lanes)	LANES	Number of lanes and average lane width. Refer to Appendix B-5
15	Presence of bus stops within 1,000 ft	Assume Not Present	NA	NA	NA	Will not collect, Not maintained by MPD GIS
16	Presence of schools within 1,000 ft	Assume Not Present	NA	NA	NA	Will not collect, Not maintained by MPD GIS
17	Presence of alcohol sales establishments within 1,000 ft	Assume not Present	NA	NA	NA	Will not collect, Not maintained by MPD GIS

SUMMARY

Section 4 summarizes the data collected. These fall under data "required" or "desirable" for SPF calibration and jurisdiction-specific SPF development.

“Required” data have been provided in the form of GIS data sets or other databases. A number of “required” elements will require field review or review by means of aerial imagery or other means. The "required" data that need to be collected through field review or other means are shown in Table 15.

Table 18. Data Gap Summary

Facility: Segments
URBAN AND SUBURBAN ARTERIALS
• Number of driveways by land-use type
Facility: Intersections
URBAN AND SUBURBAN ARTERIALS
• Presence of left-turn phasing • Type of left-turn phasing • Use of right-turn-on-red signal operation • Use of red-light cameras

CHAPTER 4. CALIBRATION PROCESS

OVERVIEW

The process for calibration of the HSM Part C's (AASHTO 2010) SPFs followed "Section 6: SPF Calibration Considerations" found in the *Calibration User's Guide* (Bahar 2014). This guide outlines five steps for the calibration process as follows:

- Step 1: Identify facility types for which the applicable Part C predictive model is to be calibrated.
- Step 2: Select sites for calibration of the predictive model for each facility.
- Step 3: Obtain data for each facility type applicable to a specific calibration period.
- Step 4: Apply the applicable Part C predictive model to predict total crash frequency for each site during the calibration period.
- Step 5: Compute calibration factors for use in Part C prediction model.

The *Calibration User's Guide* also discusses the potential for a calibration function and this project included this as a sixth step. The following sections describe the process followed for the SPR-704 project.

Step 1: Identify Facility Types

The first step in the calibration process for the SPR-704 project was to identify which facility types would be calibrated—two-lane rural highways, multi-lane highways, urban and suburban arterials, or freeways. For the SPR 704 project, two-lane rural undivided highways were calibrated. This roadway type was the most abundant in Arizona and had the most available roadway characteristic data. The experience used for calibration versus independent development for two-lane rural highways will be used to make recommendations for all facility types for Arizona.

Step 2: Data Processing and Site Selection

Data used in the data collection and processing stages of the calibration process came from ADOT in individual GIS data sets (i.e., shoulder-width, shoulder-type, lane-width, and AADT). ArcGIS was used to combine the data sets, where possible, to make the assigning data selected sites possible. This process was time-consuming, requiring trial and error. In some cases, an error was not realized until it presented itself later in the process. Each data set was constructed independently from other data sets. Despite having similar coordinate systems, each dataset was slightly different in dividing the segments into unique lengths, which made combining the data sets challenging.

The first attempt was to combine all the data into one data set where segments could be filtered and data easily assigned to segments. It started with the functional class layer and running the 'Identity' tool in ArcGIS. The 'Identity' tool can be used to create a database of homogeneous segments that breaks segments at the intersection of the input features. The 'Identity' tool was used to intersect the following layers: lanes, carriage ways, AADT, auxiliary lanes, LT shoulder, RT shoulder, shoulder-type, speed, and urban boundaries. This caused the functional class layer to split at the endpoints of the overlapping layers as well every time there was a change in attributes. This first attempt resulted in 86,065 "homogeneous" segments with 12% of the segments shorter than 1/10th mile. It was determined that site selection at this stage would exclude 12% of the segments and it was deemed unacceptable.

Learning from the first attempt, the team's second attempt took a different approach. It started with the function class layer and running the 'Identity' tool in ArcGIS intersecting the 'carriage way' and 'lanes' layers. The team maintained only the data fields needed to select the two-lane rural, undivided highways. Next the team ran the 'Dissolve' tool in ArcGIS on the output of step one. The 'Dissolve' tool can be used to aggregate segments based on common attributes. The 'Dissolve' tool was used to select route, functional class, divided highways and lanes as the fields to dissolve the file; this step combined the adjoining segments sharing common attributes and reducing the number of segments. The 'Split Line at Point' tool can be used to break segments into multiple segments at a particular point. We ran the 'Split Line at Point' tool in ArcGIS using the ADOT milepost layer and the output of step two to segment into one-mile segments. This resulted in 3,941 segments with 1% of the segments shorter than 1/10th mile, thus more acceptable than the first attempt (i.e., resulting in 12% of the segments excluded). It was determined that this sample of two-lane rural, undivided highways was sufficient to begin the site selection process. Figure 1 is a map showing two-lane rural undivided highways for the State of Arizona.

After the combined data set was finished for two-lane rural undivided highways, the next step was to select the sample of sites that will be used for the calibration. For each roadway type, the HSM recommends a sample size of 30 to 50 sites selected at random that experience at least 100 crashes per year (AASHTO 2010). The *Calibration User's Guide* provides more in-depth guidance to select a sufficient sample size to provide sufficient accuracy for the calibration factor (Bahar 2014). The report suggests sites be no less than 1/10th mile selected randomly from a large set of candidate sites using an Excel RND function. Sites need to be long enough to adequately represent physical and safety conditions for the facility. Variance and standard deviation are used to determine sample size. The *Calibration User's Guide* recommends that it is reasonable to attain a standard deviation of the estimate of the calibration factor C of about +/- 0.1.

When selecting sites for SPF calibration for each facility type, consider preparing sub-sets of data for the selection of a random sample of sites:

- Regional networks or separate terrain types or climate regions
- AADT ranges (e.g., may prioritize the calibration effort for high volume sites if upcoming projects are situated on such traffic volume ranges)

When deciding on sample size to estimate a calibration factor to a desired accuracy, consider separating observed crash frequency by crash injury severity level for separate calibration factors for available HSM SPFs consisting of:

- Total (i.e., all crashes)
- Fatal and injury (i.e., KABC crashes of the KABCO scale)
- Property damage only (PDO) (i.e., O crashes of the KABCO scale)

The sample size can be determined based on the jurisdiction-specific data and an analyst-selected desired variance or standard deviation for the estimate of calibration factor C, as described in the *Calibration User's Guide*. The *Calibration User's Guide* presents five alternative ways to calculate the variance or standard deviation for the estimate of calibration factor, depending on the data available. The alternative ways are based on:

- A lower limit, assuming no overdispersion. This alternative does not require AADT, segment length, or observed crash data but provides merely an initial estimate of the absolute minimum number of observed crashes for a desired standard deviation and an approximation of the calibration factor C.
- Segment length, AADT, observed crashes for segments (or AADT max, AADT min, and observed crashes for intersections), and the calculation of unadjusted N predicted for each site. This alternative is recommended when segment length, AADT, and observed crash data are available.
- Observed crash frequencies for segments (or intersections) and an approximation of the calibration factor C. This alternative is valuable when AADT data are missing or incomplete.
- Segment length and AADT for segments (or AADT max, AADT min, for intersections), the calculation of unadjusted N predicted for each site, and an approximation of the calibration factor C. This alternative leads to a smoother estimate of variance of the estimate of C. This alternative is also valuable when observed crash data are missing.
- Average length and average AADT for segments (or AADT maximum, AADT minimum, for intersections), an approximation of the calibration factor C, and a desired standard deviation of the estimate of C. This alternative is an approximation option when observed crash data are missing, and only the average segment length and the average AADT values are available.

By following this procedure as provided in the *Calibration User’s Guide* (Bahar 2014), data from 196 sites resulted in a 0.1167 standard deviation of the calibration factor, which is only slightly higher than 0.1 C (the recommended standard deviation in the *Calibration User’s Guide*). Despite not reaching the recommended level of accuracy, it was determined with consultation with NAVIGATS, that 196 sites with approximately 130 crashes for 2012 was deemed acceptable. The calibration accuracy spreadsheet can be seen in Appendix C.

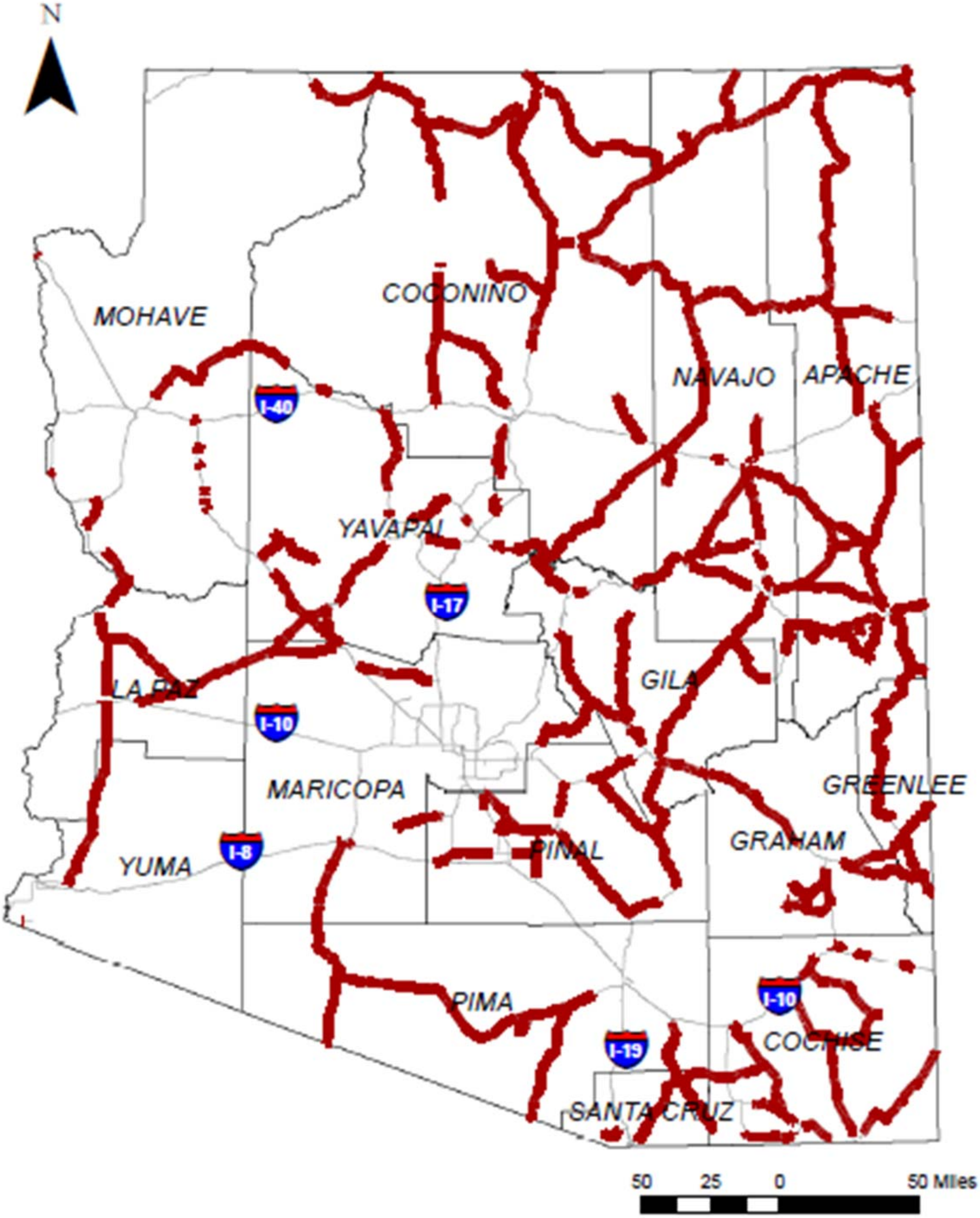

Figure 1. Two-Lane Rural Undivided Highways in Arizona

Step 3: Obtain and Assign Data for Selected Sites

As stated in Section 4: Data Collection, calibration of Part C predictive models requires specific data for each site. Data needs are described in HSM Table A-2, Data Need for Calibration of Part C Predictive Models by Facility Type (AASHTO 2010). Data for each of the "required" elements for each site needed for calibration were collected. For data identified as "desirable," actual data were used if available. Where "desirable" data were not available, HSM Table A-2 provides assumption suggestions. The study team collected and analyzed "desirable" data that are available in GIS. "Desirable" data that were not readily available in GIS data sets or other database were not collected. HSM-recommended assumptions were adopted and used in the estimations.

Assigning data to each segment was done by visual inspection of the GIS data layers in ArcGIS. Once the segment was located with the "site ID" in ArcGIS, the site was split into homogenous segments. This occurs where given data elements, as noted in the HSM, change, such as shoulder width or horizontal vs. tangent section or AADT (Refer to the *Calibration User's Guide* [Bahar 2014] pages 74-76 for a complete list of traffic and road elements that define a homogeneous segment). Once homogeneous segmentation was complete, the data sheet, Table 6.4A (in Appendix D), was completed with information such as segment number, AADT, and length, etc. The data were pulled from the different GIS data sets that were located in the map. The map was exported using the 'Export Map' tool with 'Write World File' selected. This map was imported into AutoCAD with the 'Import Map' command, and the radius of the curve was estimated using the 'Arc' tool. Sample data sheet is shown in Appendix D.

Step 4: Apply the Applicable Part C Predictive Model

The applicable Part C predictive model was used after all data were compiled into one excel spreadsheet, as shown in Appendix E. All the available data for each year were compiled.

Step 5: Compute Calibration factors

The results of the investigation into the possibility of estimating calibration factors for two-lane rural undivided highways are presented in the next paragraphs. Data for five years (2008 - 2012) from 196 two-lane rural road sites in Arizona were used in this effort. These 196 sites constitute a total of 509 homogenous segments. The total length of these segments is 187.5 miles. Over the five-year period, these segments experienced a total of 753 crashes.

Tables 16 through 22 show the calibration factors based on individual site characteristics (since AADT is expected to be a significant factor that is related to the calibration factor, the average AADT[1] is also shown in the tables). The tables show the total observed crashes (for five years), the total predicted crashes (for five years based on the prediction method from the HSM [AASHTO 2010]), the calibration factor, and the average AADT. Tables based on region, functional code, AADT, alignment, curve radius, and year, are shown below.

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[1] The average AADT was calculated by applying weights proportional to the length of a segment. For example, if segment A is 0.5 miles long with an AADT of 1,000 veh/day and segment B is 1 mile long with an AADT of 2,000 veh/day, the average AADT for segments A and B combined will be: (0.5*1,000 + 1*2,000)/1.5 = 1,667 veh/day.

Table 19. Calibration Factors by Region

Region	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor	Average AADT
Flat and Rolling	396	359.0	1.103	2,759.6
Mountainous	357	338.7	1.054	2,194.6
All	753	697.7	1.079	2,463.8

Table 20. Calibration Factors by Highway Functional Code

Highway Functional code	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor	Average AADT
2-Rural Principal Arterial	226	214.3	1.054	4,751.0
6-Rural Minor Arterial	224	231.1	0.969	2,624.2
7-Rural Minor Collector	286	242.6	1.179	1,722.5
8-Rural Major Collector	17	9.7	1.753	529.8
All	753	697.7	1.079	2,463.8

Table 21. Calibration Factors by AADT Category

AADT range (veh/day)	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor
0-2,500	292	226.1	1.292
2,501-5,000	262	258.4	1.014
>5,000	199	213.2	0.933
All	753	697.7	1.079

Table 22. Calibration Factors by Segment Length

Segment Length range (mile)	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor
0-0.4	337	239.4	1.408
0.4-0.8	149	150.5	0.990
0.8 -1.2	267	307.9	0.867
All	753	697.7	1.079

Table 23. Calibration Factors by Alignment

Alignment	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor	Average AADT
Curve	215	179.6	1.197	2,166.1
Tangent	538	518.1	1.038	2,571.7
All	753	697.7	1.079	2,463.8

Table 24. Calibration Factors by Curve Radius

Curve radius (feet)	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor	Average AADT
<=500	15	9.4	1.593	525.4
501-1000	29	22.7	1.279	1.194.4
1001-2000	58	39.4	1.473	1,953.7
2001-3000	29	26.0	1.114	2,431.2
>3000	84	82.1	1.023	3,124.7
All curves	215	179.6	1.197	2,166.1

Table 25. Calibration Factors by Year

Year	Observed Crashes	Predicted Crashes (HSM)	Calibration Factor
2008	174	139.7	1.246
2009	146	141.4	1.032
2010	165	137.9	1.196
2011	138	139.9	0.987
2012	130	138.8	0.937
All	753	697.7	1.079

Here is a brief summary of the findings from Tables 16 through 22:

- Calibration factors decreases with increasing AADT.
- The calibration factors for the flat and rolling region versus mountainous region are very close to each other.
- The calibration factors for the highway functional codes 7 and 8 are much higher, and their respective average AADT are also lower in comparison with highway functional codes 2 and 6. It is noted that the sample size for functional code 8 is small and the results need to be considered with caution.

- Curves with lower average AADTs are associated with a higher calibration factor in comparison with all tangents. Calibration factors for curves with higher average AADTs, which are similar in magnitude to AADTs along all tangents, are quite similar to the tangent calibration factor (reference Table 20 - $C_{tangent} = 1.038$ and Table 21 - C= 1.023 for curves with radii greater than 3,000 feet)
- Flatter curves are associated with higher AADTs compared to sharper curves. For curves with radii above 2,000 feet, calibration factors are lower.
- The calibration factors for 2008 and 2010 are higher than the calibration factors for 2009, 2011, and 2012. There seems to be a downward trend from 2008 to 2012.

ASSESSMENT OF THE CALIBRATED MODEL

As mentioned in the *Calibration User's Guide* (Bahar 2014), one way to assess the quality of the calibration model is to use goodness-of-fit tests such as CURE plots. CURE plots can be used to assess the overall fit of the model and to assess the appropriateness of the functional form of specific independent variables. The procedure for developing CURE plots is discussed in Hauer and Bamfo (1997) and Hauer (2015). A brief discussion of the steps that were followed in creating the CURE plots along with the results is presented in the next paragraphs.

Since the overall calibration factor is 1.079, the prediction model for rural two-lane roads can be represented as follows in Eq. 1:

$$N_p = 1.079 \times (HSM\ Pred) \qquad \text{(Eq. 1)}$$

Where N_p = the predicted number of crashes in a segment after calibration
HSM Pred = the total number of predicted crashes based on the HSM (AASHTO 2010) procedure before calibration

The total predicted crashes for the five-year period was estimated by adding the predictions for each year which made use of the AADT for that particular year—the other site characteristics were assumed to be unchanged during the five-year period). The right-hand side (RHS) of the equation is also called the ‘fitted value.’

The first step entails preparing data that include information about each road segment (e.g., AADT, fitted value, residual[2], segment length, etc.). If the intent of this effort is to assess the overall fit of the model, then this file is sorted in the increasing order of the fitted value and the cumulative residuals are computed for each observation. The plot of the cumulative residuals with the fitted value is called the CURE plot. The data in the CURE plot are expected to oscillate around the value 0. If the cumulative residuals are consistently drifting upward within a particular range of fitted values, then it would imply that there were more observed than predicted crashes. On the other hand, if the cumulative residuals are consistently drifting downward within a particular range of fitted values, then it would imply that there were fewer observed than predicted crashes. Vertical lines in the CURE plot usually imply the

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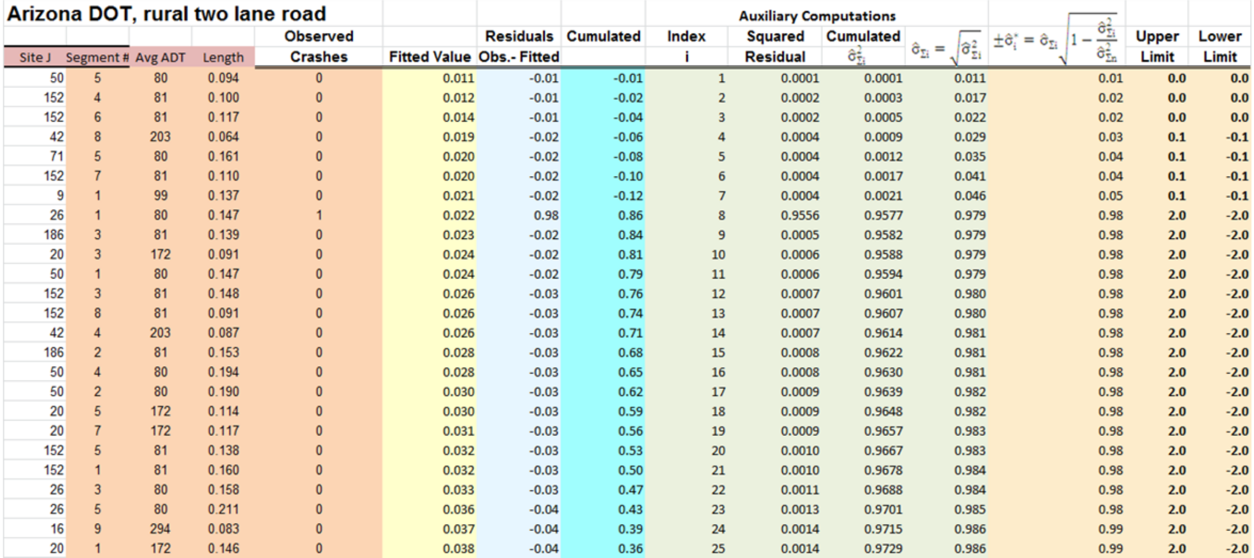
[2] The residual for each segment is the number of observed crashes minus the fitted value.

presence of outliers. There are also confidence limits for the plot ($\pm\sigma$) beyond which the plot should go only rarely (Hauer and Bamfo 1997).

Table 23 shows s a screen shot from the excel file that shows the variables that were used in creating the CURE plot for fitted values for this study.

Table 26. **Screen Shot of an Excel File used to create the CURE Plot**



Arizona DOT, rural two lane road								Auxiliary Computations						
				Observed		Residuals	Cumulated	Index	Squared	Cumulated	$\hat{\sigma}_{\Sigma i} = \sqrt{\hat{\sigma}^2_{\Sigma i}}$	$\pm\hat{\sigma}'_i = \hat{\sigma}_{\Sigma i}\sqrt{1-\frac{\hat{\sigma}^2_{\Sigma i}}{\hat{\sigma}^2_{\Sigma n}}}$	Upper	Lower
Site J	Segment #	Avg ADT	Length	Crashes	Fitted Value	Obs.- Fitted		i	Residual	$\hat{\sigma}^2_{\Sigma i}$			Limit	Limit
50	5	80	0.094	0	0.011	-0.01	-0.01	1	0.0001	0.0001	0.011	0.01	0.0	0.0
152	4	81	0.100	0	0.012	-0.01	-0.02	2	0.0002	0.0003	0.017	0.02	0.0	0.0
152	6	81	0.117	0	0.014	-0.01	-0.04	3	0.0002	0.0005	0.022	0.02	0.0	0.0
42	8	203	0.064	0	0.019	-0.02	-0.06	4	0.0004	0.0009	0.029	0.03	0.1	-0.1
71	5	80	0.161	0	0.020	-0.02	-0.08	5	0.0004	0.0012	0.035	0.04	0.1	-0.1
152	7	81	0.110	0	0.020	-0.02	-0.10	6	0.0004	0.0017	0.041	0.04	0.1	-0.1
9	1	99	0.137	0	0.021	-0.02	-0.12	7	0.0004	0.0021	0.046	0.05	0.1	-0.1
26	1	80	0.147	1	0.022	0.98	0.86	8	0.9556	0.9577	0.979	0.98	2.0	-2.0
186	3	81	0.139	0	0.023	-0.02	0.84	9	0.0005	0.9582	0.979	0.98	2.0	-2.0
20	3	172	0.091	0	0.024	-0.02	0.81	10	0.0006	0.9588	0.979	0.98	2.0	-2.0
50	1	80	0.147	0	0.024	-0.02	0.79	11	0.0006	0.9594	0.979	0.98	2.0	-2.0
152	3	81	0.148	0	0.026	-0.03	0.76	12	0.0007	0.9601	0.980	0.98	2.0	-2.0
152	8	81	0.091	0	0.026	-0.03	0.74	13	0.0007	0.9607	0.980	0.98	2.0	-2.0
42	4	203	0.087	0	0.026	-0.03	0.71	14	0.0007	0.9614	0.981	0.98	2.0	-2.0
186	2	81	0.153	0	0.028	-0.03	0.68	15	0.0008	0.9622	0.981	0.98	2.0	-2.0
50	4	80	0.194	0	0.028	-0.03	0.65	16	0.0008	0.9630	0.981	0.98	2.0	-2.0
50	2	80	0.190	0	0.030	-0.03	0.62	17	0.0009	0.9639	0.982	0.98	2.0	-2.0
20	5	172	0.114	0	0.030	-0.03	0.59	18	0.0009	0.9648	0.982	0.98	2.0	-2.0
20	7	172	0.117	0	0.031	-0.03	0.56	19	0.0009	0.9657	0.983	0.98	2.0	-2.0
152	5	81	0.138	0	0.032	-0.03	0.53	20	0.0010	0.9667	0.983	0.98	2.0	-2.0
152	1	81	0.160	0	0.032	-0.03	0.50	21	0.0010	0.9678	0.984	0.98	2.0	-2.0
26	3	80	0.158	0	0.033	-0.03	0.47	22	0.0011	0.9688	0.984	0.98	2.0	-2.0
26	5	80	0.211	0	0.036	-0.04	0.43	23	0.0013	0.9701	0.985	0.98	2.0	-2.0
16	9	294	0.083	0	0.037	-0.04	0.39	24	0.0014	0.9715	0.986	0.99	2.0	-2.0
20	1	172	0.146	0	0.038	-0.04	0.36	25	0.0014	0.9729	0.986	0.99	2.0	-2.0

Figure 2 depicts the CURE plot for fitted values for the calibrated model.

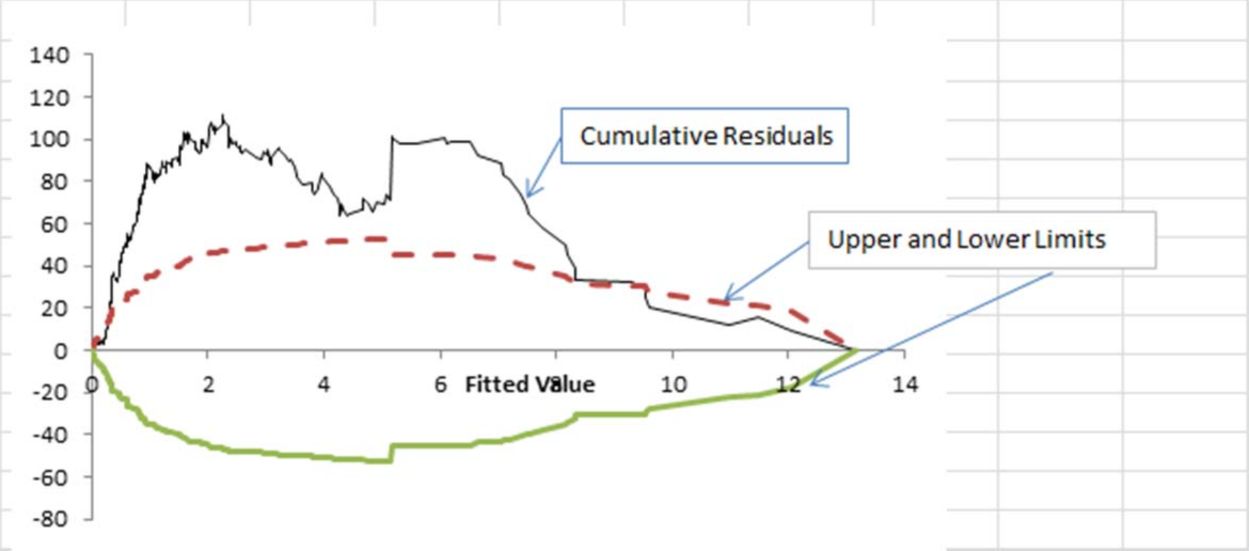


Figure 2. CURE Plot for Fitted Values for Calibration Factor.

It is clear that a significant portion of the CURE plot is outside the confidence limits indicating that the calibrated model does not fit the data very well.

A CURE plot against AADT shows the reasonableness of the functional form for the AADT variable. So, if the CURE plot is within the limits, then it means that the functional form for AADT is reasonable. A CURE plot against fitted values provides insight into the overall fit of the model.

Figure 3 depicts the CURE plot for AADT for the calibrated model. To create this CURE plot, the data are sorted in the increasing order of AADT, instead of the fitted values.

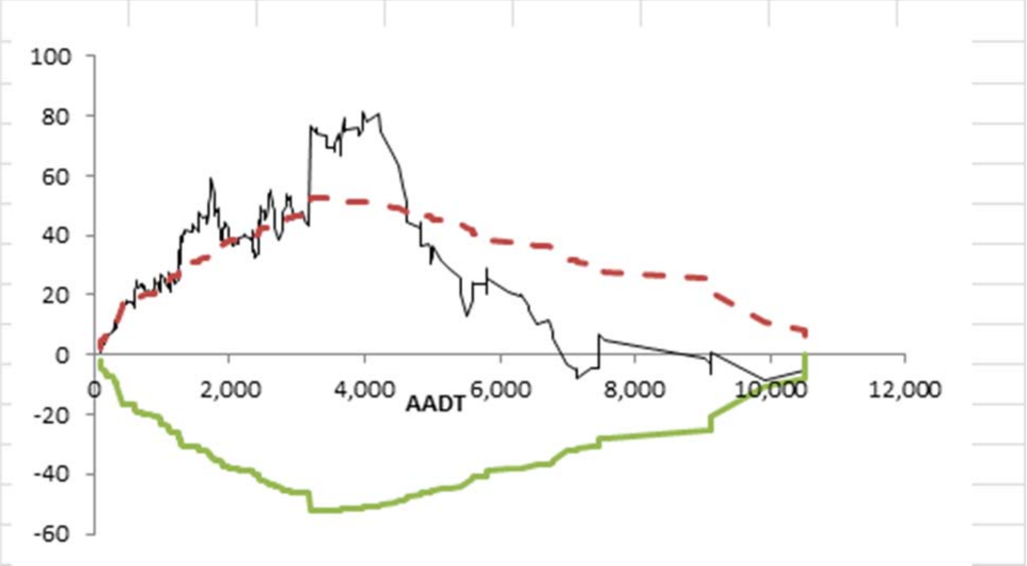


Figure 3. CURE Plot for AADT for Calibration Factor.

It is clear, once again, that a significant portion of the CURE plot is outside the confidence limits, indicating that the functional form for AADT in the HSM (AASHTO 2010) SPFs is not appropriate for the Arizona data. The two CURE plots in Figures 2 and 3 indicate that a single calibration factor is not appropriate.

An option is to apply a separate calibration factor for particular AADT ranges. Figure 4 depicts the CURE plot for fitted values for the calibrated model using the following calibration factors:

- AADT 0 – 2,500: 1.292
- AADT 2,501 – 5,000: 1.014
- AADT >5,000: 0.933

In Figure 5, the CURE plot was developed for AADT for the model calibrated by AADT range. To create this CURE plot, the data are sorted in the increasing order of AADT instead of the fitted values.

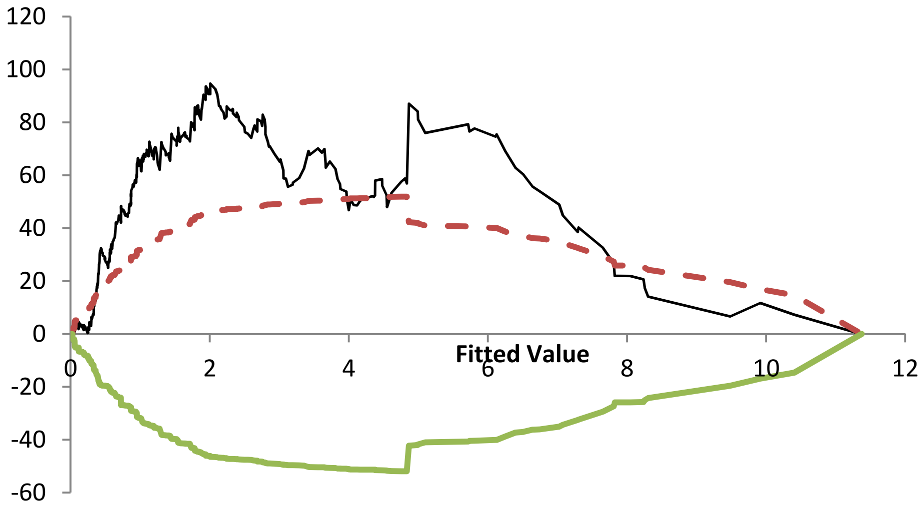


Figure 4. CURE Plot for Fitted Values for AADT Range Calibration Factors.

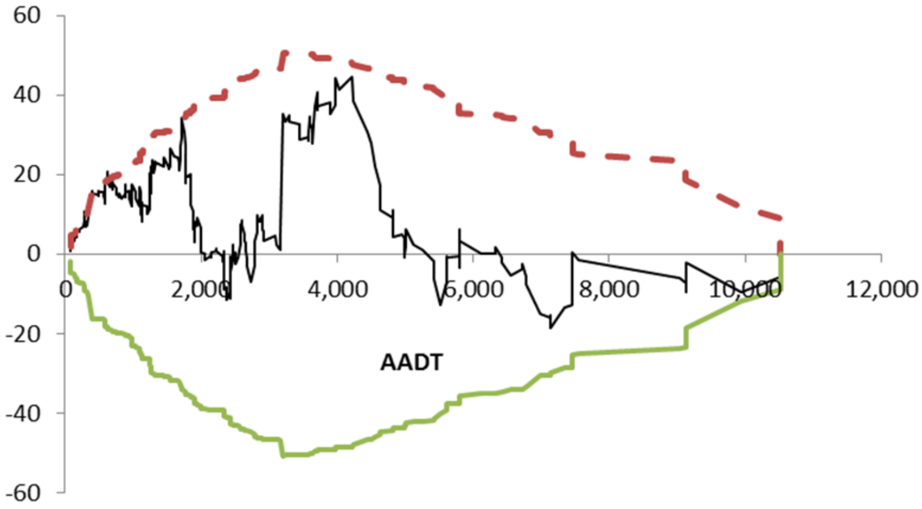


Figure 5. CURE Plot for AADT for AADT Range Calibration Factors.

Again, it is clear that a significant portion of the CURE plot shown in Figure 4 is outside the confidence limits, while the CURE plot shown in Figure 5 is completely contained within the boundaries of the confidence limits.

Finally, another alternative in this exploratory investigation is to apply a separate calibration factor for particular segment length. Figure 6 depicts is the CURE plot for fitted values for the calibrated model using the following calibration factors:

- Segment Length <0.4 miles: 1.408
- Segment Length between 0.4 and 0.8 miles: 0.99
- Segment Length > 0.8 miles: 0.867

In Figure 7, the CURE plot was developed for segment length for the model calibrated by segment length. To create this CURE plot, the data are sorted in the increasing order of segment length, instead of the fitted values.

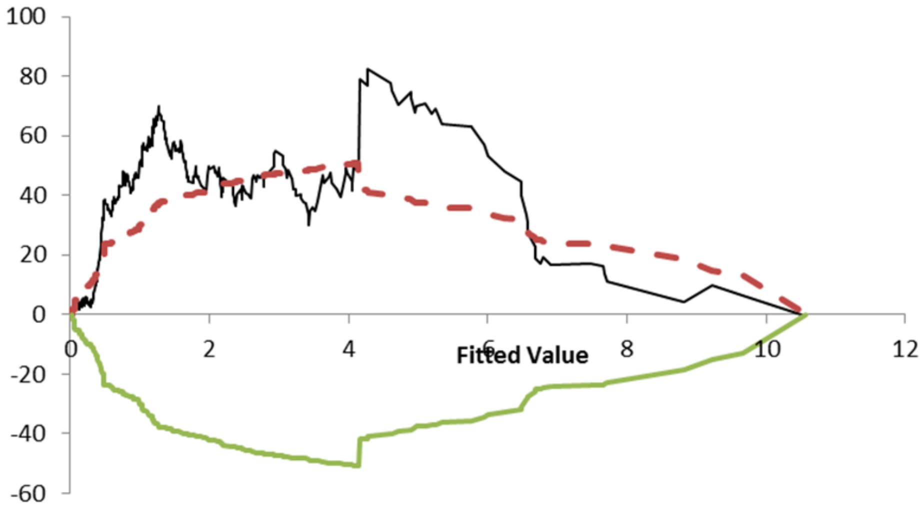


Figure 6. CURE Plot for Fitted Values for Segment Length Range Calibration Factors.

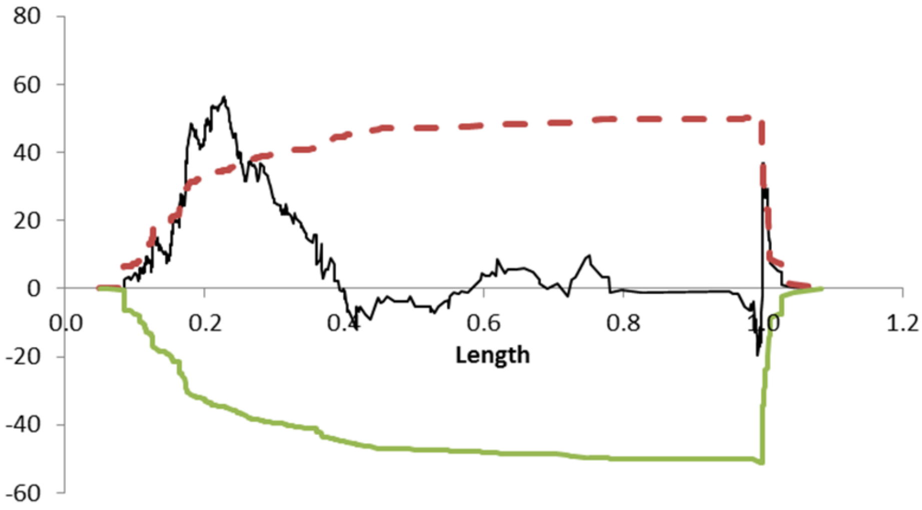


Figure 7. CURE Plot for Segment Lengths for Segment Length Range Calibration Factors.

Similarly to the outcome shown for AADT values (Figures 4 and 5), a significant portion of the CURE plot shown in Figure 6 is outside the confidence limits, while the CURE plot shown in Figure 7 is mostly contained within the boundaries of the confidence limits.

Reviewing all three of the CURE plots against fitted values shown previously, it is clear that a significant portion of the CURE plot is outside the confidence limits indicating that the calibrated model does not fit the data very well, and that the estimation of a calibration function would be worthwhile.

Step 6: Estimation of Calibration Function

Further into the calibration factors effort described in Section 5.6, the team proceeded to develop calibration functions as recommended in the *Calibration User's Guide* (Bahar 2014). Calibration functions can be estimated in different ways. As calibration functions becomes more complex by including many variables, they become synonymous with estimating jurisdiction-specific safety performance functions. Hence, only simpler calibration functions were estimated in this effort.

Type 1 Calibration Function. As a first step, the following relationship between observed crashes and predicted crashes was investigated, as show in Eq. 2:

$$N_p = a \times (HSM\ Pred)^b \qquad \text{(Eq. 2)}$$

Variables a and b are factors to be defined by the statistical analysis. If b = 1, ‘a’ becomes the calibration factor (i.e., 1.079). The model in equation 1 above was estimated using ordinary least squares, Poisson (P) regression, and negative binomial (NB) regression. All the models were estimated under the constraint that the total observed crashes is equal to the total fitted crashes. The models were estimated using Microsoft Excel and verified using SAS. Table 24 shows the results of the estimation. The procedure used for estimating the models using Microsoft Excel is provided in Appendix F.

Table 27. Type 1 Calibration Function Estimation Results

Parameter	Ordinary Least Squares	Poisson Regression	Negative Binomial Regression
a	1.417	1.385	1.380
b	0.650	0.689	0.694
ϕ[3]	Not applicable	Not applicable	3.869
LL (abb)[4]	Not applicable	-186.4	-108.8

Figures 8 and 9 depict CURE plots for fitted values and AADT based on the NB model for Type 1 calibration function, respectively.

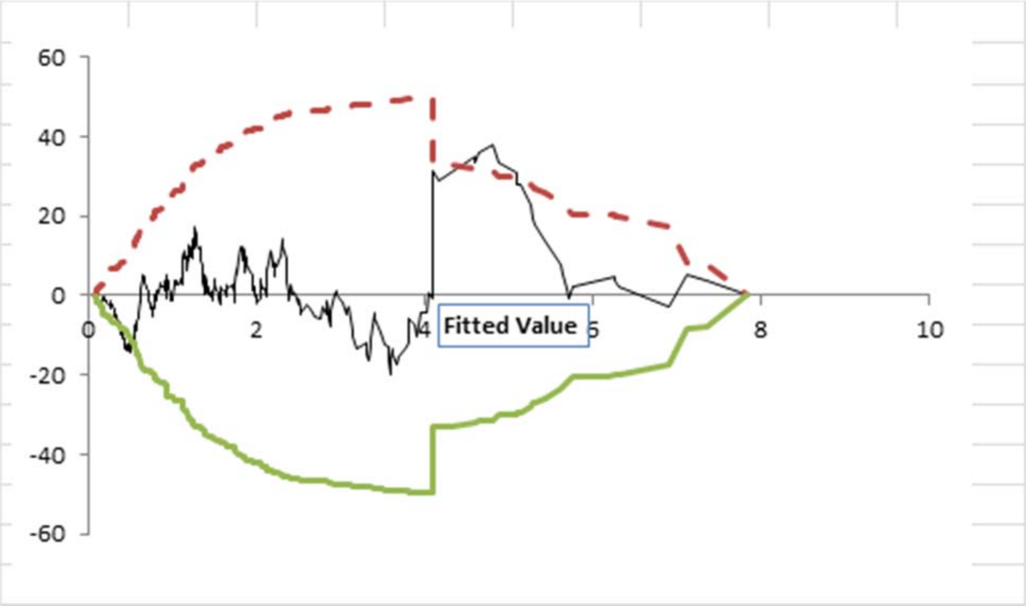


Figure 8. CURE Plot for Fitted Values for Type 1 Calibration Function.

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[3] Inverse overdispersion parameter. ϕ was estimated on a per-mile basis, i.e., the relationship between the variance (V) and the mean (E) of the NB model is as follows: $V = E + \frac{E^2}{\phi L}$, and the overdispersion parameter $k = 1/\phi$

[4] This is the abbreviated log-likelihood, which does not include the term $\sum \ln(X_i!)$, where X_i is the number of crashes in segment *i*, and *ln* represents the natural logarithm. Since this term is not a function of the parameters, it is often excluded when the log-likelihood is maximized.

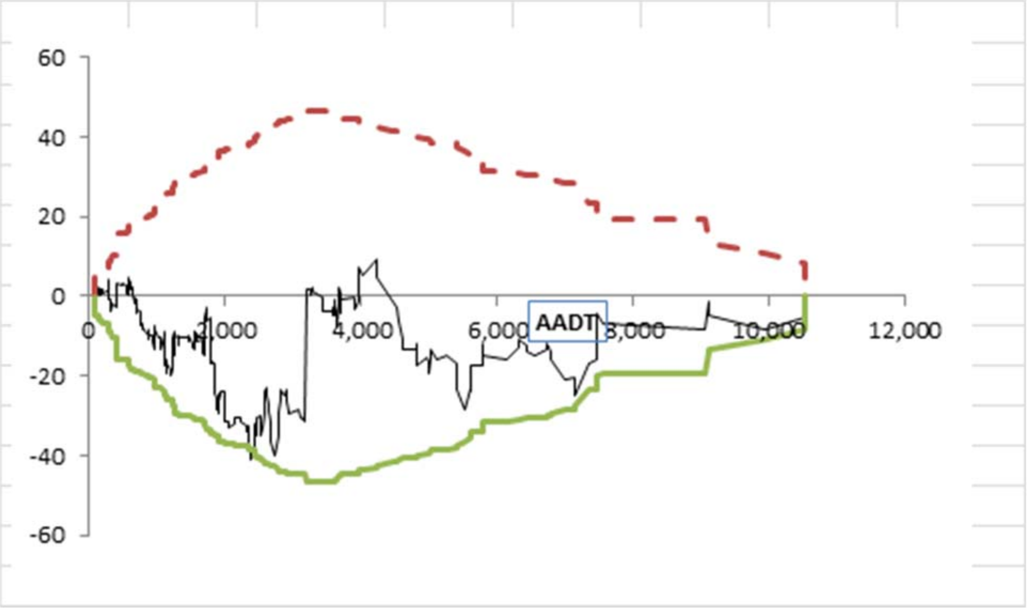

Figure 9. CURE Plot for AADT for Type 1 Calibration Function.

Unlike the CURE plots based on a single calibration factor, a significant portion of the CURE plots show in Figures 8 and 9 are within the confidence limits indicating a much better fit.

In Table 24, all the three models indicate that b is quite different from 1.0. Again, this indicates that a single calibration factor is not appropriate. Since there is over-dispersion in crash data, the results from NB regression are preferred. However, the results from P regression are very close to the results from NB regression, and P regression is easier to estimate for a practitioner using a commonly available tool such as Microsoft Excel. Thus, this is a possible choice in future similar efforts.

If the NB model is chosen, the calibration function is the following:

$$N_p = 1.380 \times (HSM\ Pred)^{0.694} \quad \text{(Eq. 3)}$$

Additional Calibration Functions. Additional functions were estimated to further examine the calibration functions. For rural two-lane roads, the predicted number of crashes based on the HSM (AASHTO 2010) procedure is the following shown in Eq. 4:

$$= Constant \times L \times AADT \times \prod_{i=1}^{12} CMF_i \quad \text{(Eq. 4)}$$

Where L = segment length

AADT = average annual daily traffic

$\prod_{i=1}^{12} CMF_i$ = the product of 12 CMFs (i.e., $CMF_1 \times CMF_2 \times CMF_3 \times CMF_4 \times CMF_5 \times CMF_6 \times CMF_7 \times CMF_8 \times CMF_9 \times CMF_{10} \times CMF_{11} \times CMF_{12}$), and Constant = $365 \times 10^{-6} \times e^{-0.312}$

Among these CMFs:

Where CMF_2 = the CMF for shoulder width and type
CMF_3 = the CMF for horizontal alignment

Apart from these two CMFs, most of the other CMFs in this data set include default values based on the guidance provided in the HSM.

With the Type 1 calibration function estimated above, all the terms (including AADT, segment length, and the CMFs) are assumed to have the same power b. In other words, the Type 1 calibration function can be written as follows in Eq. 5:

$$N_p = 1.380 \times (Constant)^{0.694} L^{0.694} AADT^{0.694} \left(\prod_{i=1}^{12} CMF_i\right)^{0.694} \qquad \text{(Eq. 5)}$$

With the six additional calibration functions estimated and shown in Table 25, this assumption is relaxed. It is noted that the average AADT over the five-year period was used in the functions in Table 24.

Table 28. Additional Calibration Functions

Calibration Function Type	Calibration Function	Parameter Estimates and Goodness of Fit (GOF) Statistics					
		a	b	c	d	ϕ	LL (abb)
2	$a \times L \times \left(\frac{AADT}{1000}\right)^{b} \times \prod_{i=1}^{12} CMF_i$	2.010	0.693			3.394	-117.6
3	$a \times L^{c} \times \left(\frac{AADT}{1000}\right)^{b} \times \prod_{i=1}^{12} CMF_i$	1.633	0.728	0.763		3.674	-112.7
4	$a \times L^{c} \times \left(\frac{AADT}{1000}\right)^{b} \times e^{d \times (\frac{AADT}{1000})} \times \prod_{i=1}^{12} CMF_i$	1.598	0.688	0.769	0.018	3.674	-112.7
5	$a \times L^{c} \times \left(\frac{AADT}{1000}\right)^{b} \times \left(\prod_{i=1}^{12} CMF_i\right)^{d}$	1.920	0.654	0.634	-0.229	4.132	-103.2
6	$a \times L^{c} \times \left(\frac{AADT}{1000}\right)^{b}$	1.871	0.667	0.657		4.117	-103.5

In general, higher values of the GOF statistics (LL(abb) and ɸ) indicate better models. Among the calibration functions shown in Table 25, functions 5 and 6 fit the data better. In function 2, length and the CMFs are included as multipliers, but AADT is included as a power function. In function 3, length and AADT are included as power functions, and that improved the GOF. Function 4 introduced an additional term for AADT, but that did not really improve the GOF. Function 5 introduced the CMFs as a power function, and function 6 excluded the CMFs. Comparing the GOF statistics for functions 5 and 6, it is clear that including the CMFs did not really improve the function. This may be because a majority of the CMFs used for this calibration effort are default values provided in the HSM (AASHTO 2010). It is noted, that since CMF_2 and CMF_3 are based on observed values rather than defaults, these two CMFs were included in function 6 without including the other CMFs; however, that did not really improve function 6 any further. Additional calibration functions were estimated by including functional code and region (not shown here), but they did not improve the existing functions show in Table 25.

Figures 10 through 19 depict CURE plots for fitted values for Type 2 through Type 6 calibration functions (Table 25).

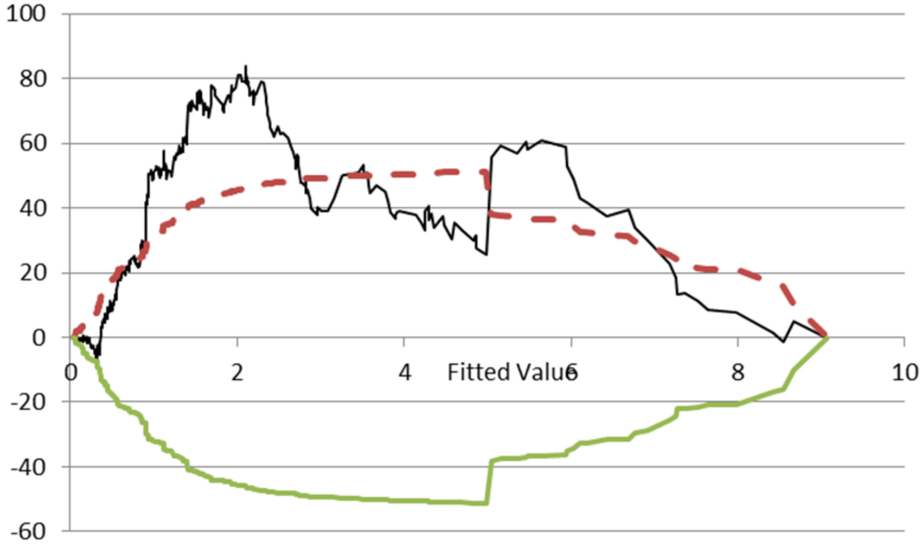

Figure 10. CURE Plot for Fitted Values for Type 2 Calibration Function.

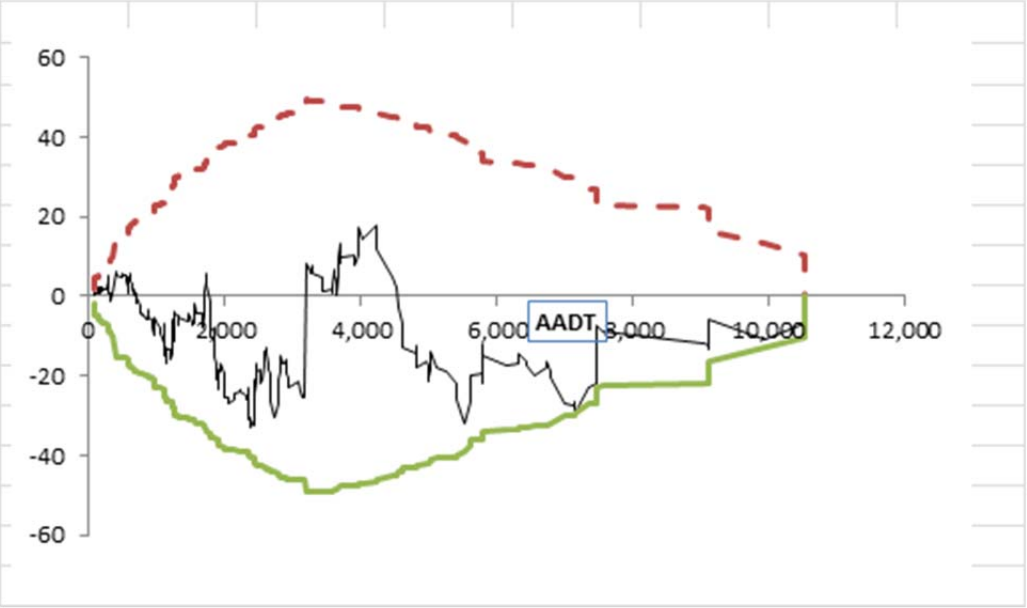

Figure 11. CURE Plot for AADT for Type 2 Calibration Function.

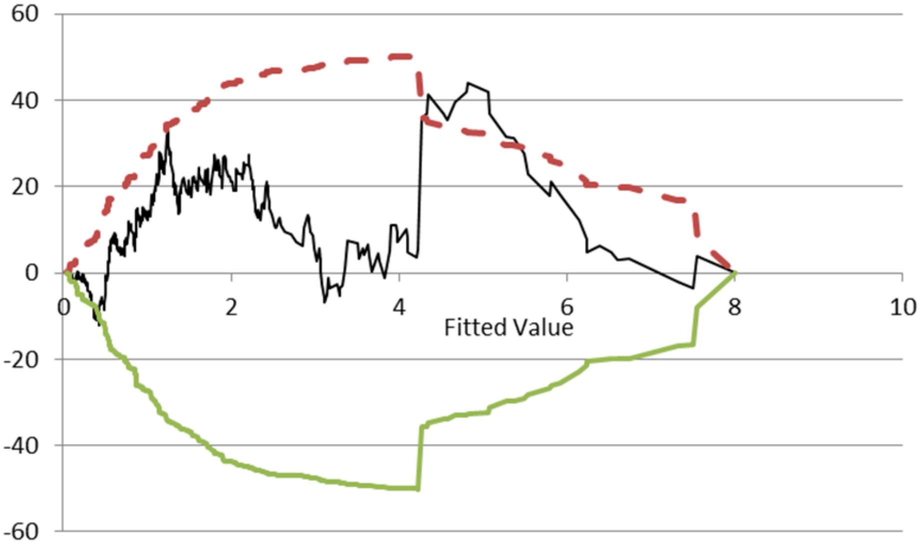

Figure 12. CURE Plot for Fitted Values for Type 3 Calibration Function.

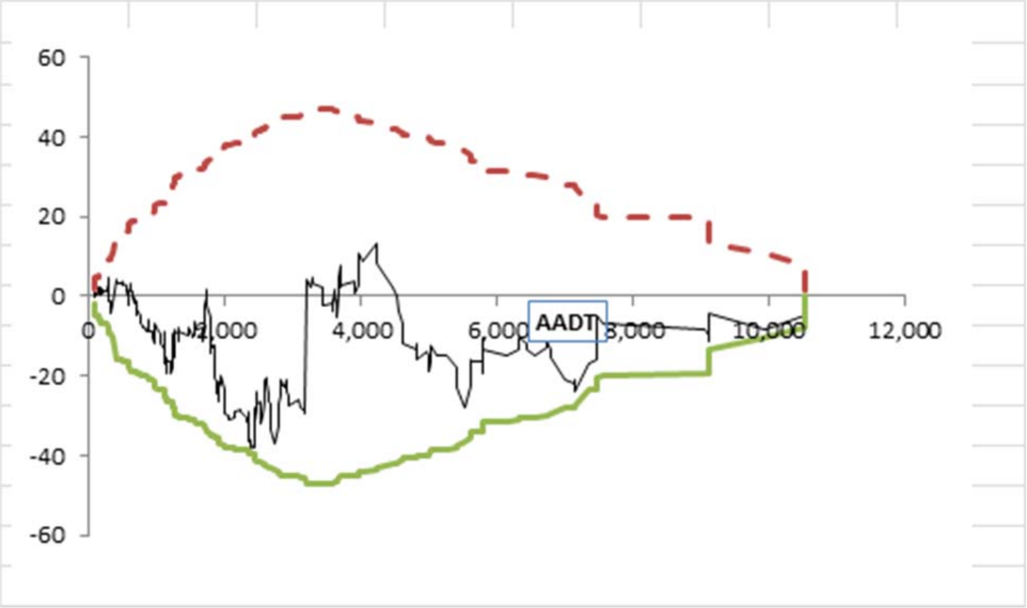

Figure 13. CURE Plot for AADT for Type 3 Calibration Function.

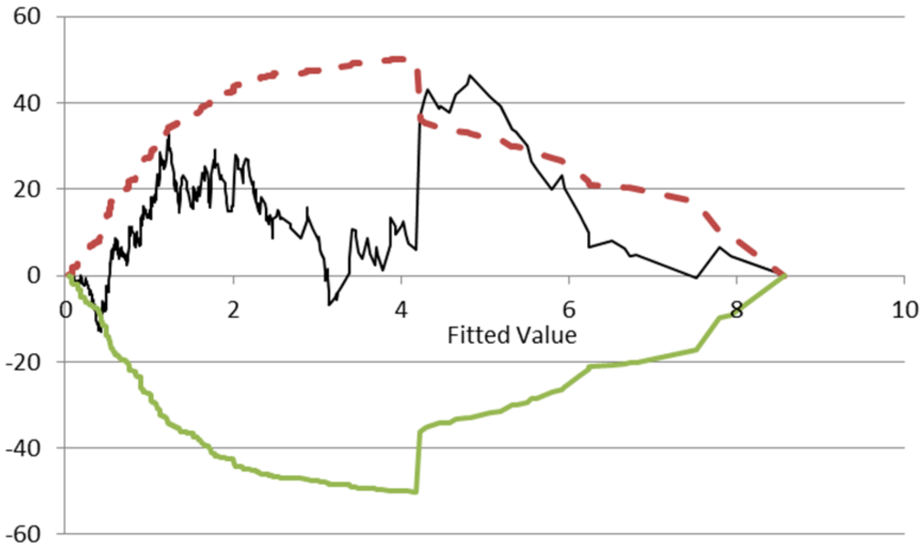

Figure 14. CURE Plot for Fitted Values for Type 4 Calibration Function.

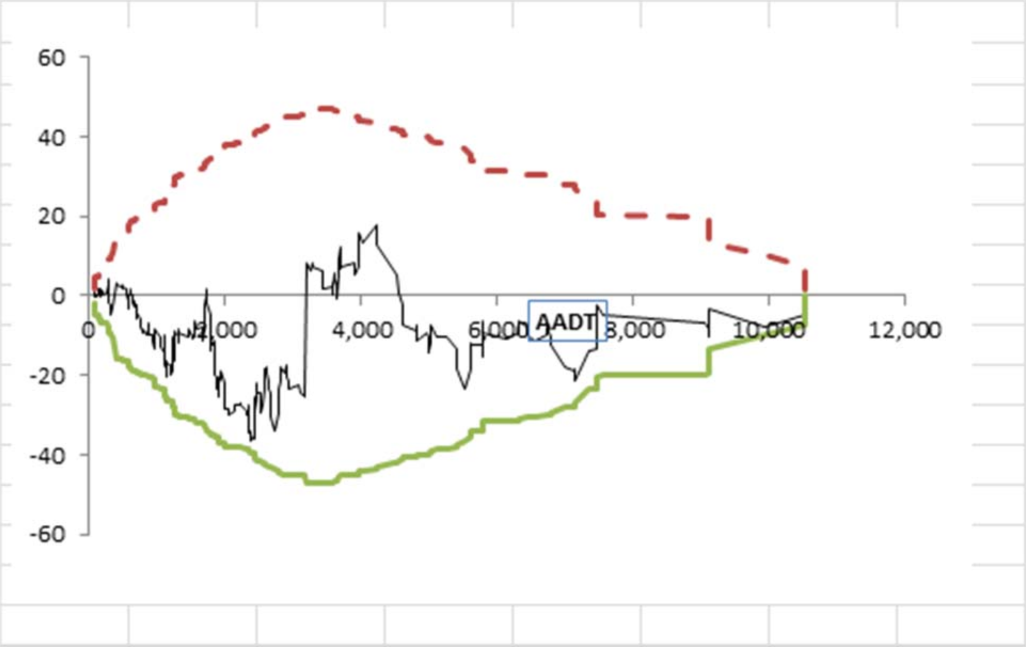

Figure 15. CURE Plot for AADT for Type 4 Calibration Function.

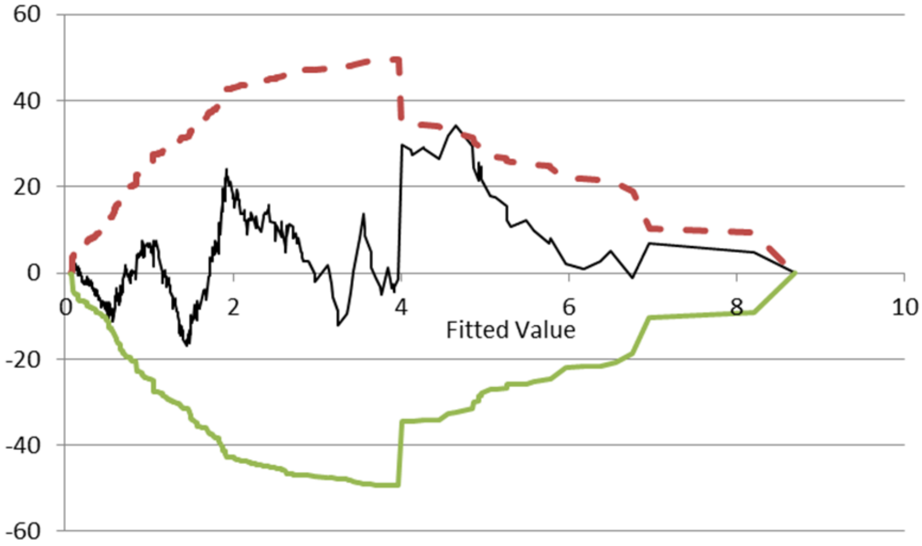

Figure 16. CURE Plot for Fitted Values for Type 5 Calibration Function.

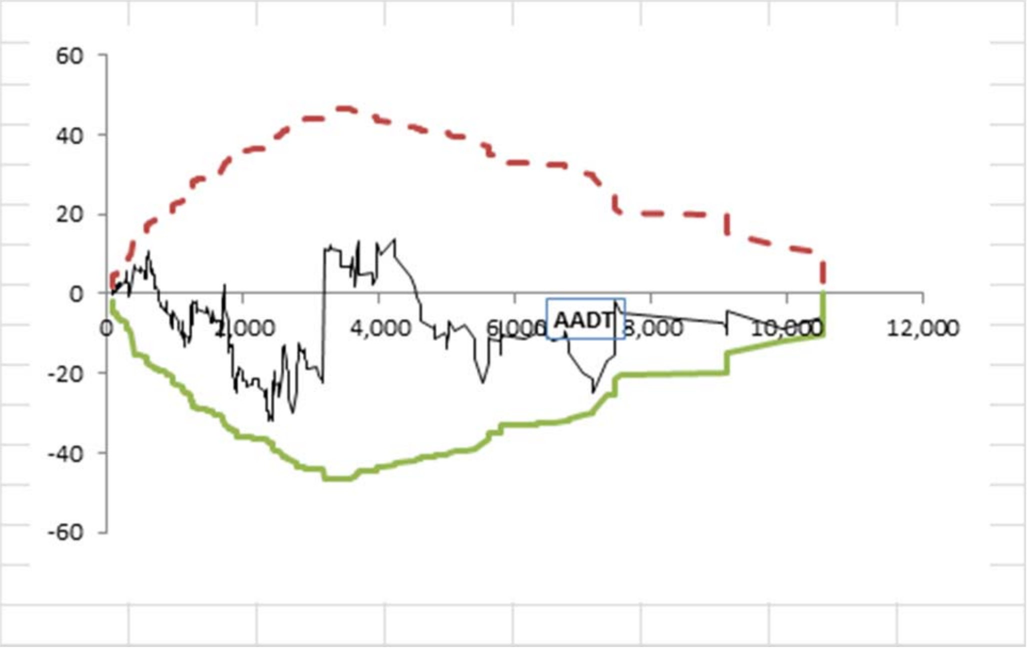

Figure 17. CURE Plot for AADT for Type 5 Calibration Function.

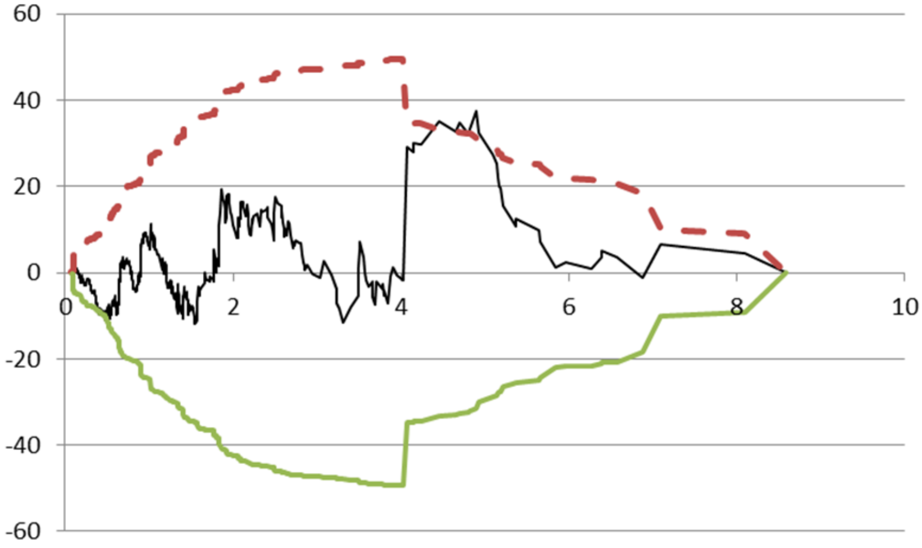

Figure 18. CURE Plot for Fitted Values for Type 6 Calibration Function.

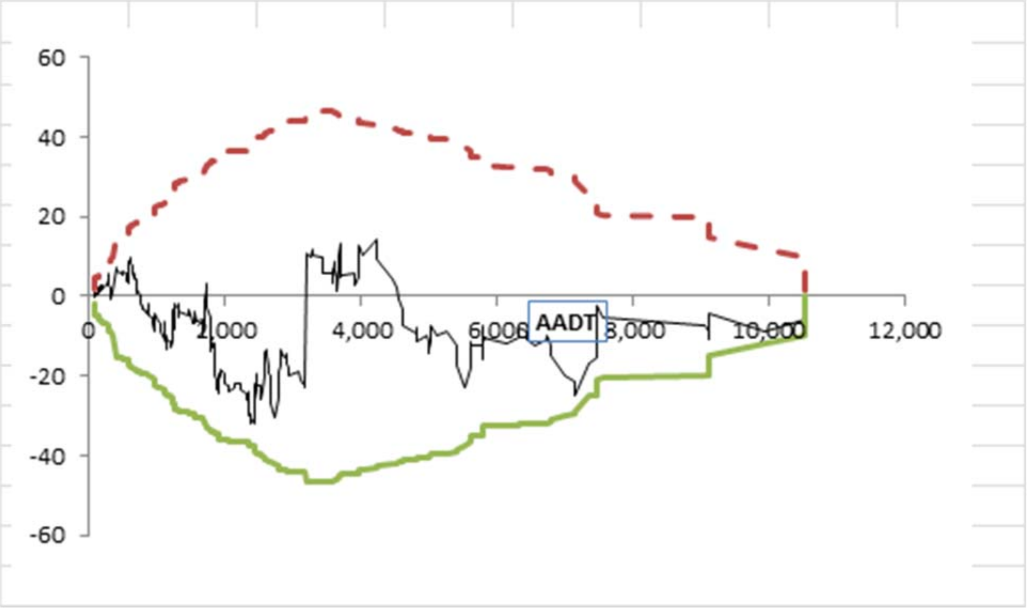

Figure 19. CURE Plot for AADT for Type 6 Calibration Function.

SUMMARY OF FINDINGS

As noted earlier, calibration functions were estimated in order to account for the fact that the calibration factor may be a function of site characteristics including AADT. Among the six calibration functions that were estimated, two functional types were selected as best options for Arizona—Function Types 1 and 6. Which functional type will be implemented in future will depend on the potential advancement in data collection of geometric and traffic elements that form part of CMFs noted in the predictive models of the HSM (AASHTO 2010). If using default HSM CMF values, the simpler Type 1 calibration function may be quite adequate. Function Type 6 does not include CMFs and could be criticized for that reason. There may be many reasons why the CMFs do not seem to add much value for this data set: (1) many of the CMFs are default values; (2) curvature is correlated with AADT (curves have lower AADT) and AADT is already included in the functions; and, (3) the CMFs are not independent and multiplying them may not be appropriate. If CMFs are to be included, the simpler Function Type 1 may be appropriate. If Arizona or another state decides to estimate calibration functions on their own, then the simpler Poisson regression model should be considered.

It is also noted that there are other issues that need to be resolved, and further research is recommended. If any of the NB functions discussed here are used in an empirical Bayes procedure, then the analyst can either use the over-dispersion parameter provided in this report, or the over-dispersion parameter provided in the HSM for the rural two-lane prediction models. The argument in favor of using the over-dispersion parameter from this report is that it was estimated based on data from Arizona, but with a relatively small sample. On the other hand, the over-dispersion parameter in the HSM is based on a much larger data set, but they were estimated using older data from 1990s from another state.

Two-Lane Rural Undivided Highways SPF Calibration Summary

A brief summary of the results of the SPF calibration of two-lane rural undivided highways is presented below:

- The model calibrated with the base calibration factor of 1.079 had a significant portion of the CURE plot outside the confidence limits indicating that the calibrated model does not fit the data very well.
- The calibration factor for the Flat and Rolling Region (1.10) does not show a significant difference from the Mountainous Region (1.05).
- The models calibrated based on AADT and segment length ranges had significant portions of the CURE plot outside of the confidence limits indicating that the calibrated models did not fit the data very well.
- The models calibrated with a calibration function typically improved the fit of the data and had a significant portion of the CURE plot inside the confidence limits.
- Among the six calibration functions that were estimated, function types 1 and 6 are good candidates for Arizona. The Type 1 calibration function is recommended due to its simplified form compared to the others with similar results.

Eq. 6 is the Type 1 calibration function:

$$N_p = 1.380 \times (HSM\ Pred)^{0.694} \qquad \text{(Eq. 6)}$$

Time and Resource Estimation

The staff hours needed to calibrate or develop jurisdiction-specific SPFs vary depending on the facility type and available data. The bulk of the time will be spent on data collection and preparation. The time to perform the calibration calculations and exploration is significantly less than the data effort. Time estimates were shown in the *Safety Performance Function Decision Guide: SPF Calibration Versus SPF Development* (Srinivasan et al. 2013) and shown in Table 26 The estimates for calibrating SPFs included 30 to 50 sites, 100 crashes per year and three years of data (as per HSM [AASHTO 2010] recommendations).

The overall time to calibrate two-lane undivided rural roadway segments for SPR-704 was 180 hours. This included 196 sites, an average of 151 crashes per year and five years of data. It took roughly 100 hours to collect and prepare the data into a usable form (i.e., combine GIS data sets in ArcGIS) and 80 hours for site selection and compiling data for each of the 196 sites. However, it is understood that the time taken including the trial and error effort to compile the data into a usable form for this facility type will be somewhat shortened for future similar efforts, based on the lessons learned. For other facility types, it is estimated that it will take 40 fewer hours to collect and prepare the data due to the familiarity with the data sets. For each subset of facility types, i.e. where it changes from undivided segments to divided segments for rural multilane highways, it is estimated that is will take 30 fewer hours for this process due to the familiarity with the data and facility type. In conclusion, it is estimated that the total effort for calibrating all *roadway segment* HSM facility types is 1,000 hours. According to the *SPF Development Guide*'s (Srinivasan et al. 2013) estimates, the staff hours needed to develop jurisdiction-specific SPFs is roughly three times more than the effort to calibrate SPFs. Using this relationship, it is estimated that is would take between 330 and 540 hours to develop an SPF for a specific facility type. *It is important to note that that these staff hours were associated with the higher quality approach recommended by the Calibration User's Guide (Bahar 2014) where the accuracy (standard deviation) of the calibration factor/s is selected by the analyst; it is not based on the "rule of thumb" and simplistic guidance found in the HSM.* Table 27 shows a breakdown of the roadway segments effort estimates based on the approach used in this report.

The effort estimates for calibrating *intersection SPFs* is similar to the estimates for roadway segments. The calibration for an intersection SPF was not performed in the SPR-704 project. The data requirements for calibrating intersection SPF is roughly a third less than that of roadway segments. Therefore, it is estimated that the estimated effort for calibrating intersection SPFs be a third less. The estimated total effort for calibrating all intersection HSM facility types is 860 hours. Table 28 shows a breakdown of the intersection effort estimates.

Table 29. Level of Effort Estimates for Calibration and Development

Intended Use	**Process**	**Minimum Sample Size needed (based on HSM Part C)**	**Staff hours needed – data collection and Preparation (per SPF)**	**Staff hours needed– statistical analyst (per SPF)**
Project Level	Calibrate SPF	30-50 sites; at least 100 crashes per year for total group. At least three years of data are recommended.	150 to 350	n/a
	Develop SPF	100 - 200 intersections or 100 - 200 miles; at least 300 crashes per year for total group. At least three years of data are recommended.	450 to 1,050	16 to 40

Table 30. SPR-704 Roadway Segment Level of Effort Estimates for Calibration and Development

Facility	**Staff hours needed: Calibration**	**Staff hours needed: Development**	
	Data Collection and Preparation	Data Collection and Preparation	Statistical Analyst
RURAL TWO-LANE, TWO-WAY ROADS			
Two-Lane undivided segments	Completed (180 Hours)	540	16-40
RURAL MULTILANE HIGHWAYS			
Undivided Segments	140 Hours	405	16-40
Divided Roadway Segments	110 Hours	330	16-40
URBAN AND SUBURBAN ARTERIALS			
Two-Lane Undivided Segments	135 Hours	405	16-40
Three-Lane Segments with TWLTL	110 Hours	330	16-40
Four-Lane Undivided Segments	110 Hours	330	16-40
Four-Lane Divided Segments	110 Hours	330	16-40
Five-Lane Segments with TWLTL	100 Hours	330	16-40
Total	**1000 Hours**	**3000 Hours**	**128-320 Hours**

Table 31. SPR-704 Intersection Level of Effort Estimates for Calibration and Development

	Staff hours needed: Calibration	Staff hours needed: Development	
Facility	**Data Collection and Preparation**	**Data Collection and Preparation**	**Statistical Analyst**
RURAL TWO-LANE, TWO-WAY ROADS			
Three-Leg Intersections with Minor-Road Stop Control	100 Hours	300	16-40
Four-Leg Intersections with Minor-Road Stop Control	80 Hours	240	16-40
Four-Leg Signalized intersections	80 Hours	240	16-40
RURAL MULTILANE HIGHWAYS			
Three-Leg Intersections with Minor-Road Stop Control	100 Hours	300	16-40
Four-Leg Intersections with Minor-Road Stop Control	80 Hours	240	16-40
Four-Leg Signalized intersections	80 Hours	240	16-40
URBAN AND SUBURBAN ARTERIALS			
Three-Leg Intersections with Minor-Road Stop Control	100 Hours	300	16-40
Three-Leg Signalized Intersections	80 Hours	240	16-40
Four-Leg Intersections with Minor-Road Stop Control	80 Hours	240	16-40
Four-Leg Signalized intersections	80 Hours	240	16-40
Total	**860 Hours**	**2580 Hours**	**160-400 Hours**

CHAPTER 5. RECOMMENDED SPF CALIBRATION AND DEVELOPMENT PROCESS

The research of best practices around the country, the existing condition of relevant data in Arizona, and the team's experience with calibration for this study lead to the following recommendations for SPF calibrations versus development and data collection and processing.

SPF CALIBRATION VERSUS DEVELOPMENT RECOMMENDATIONS

It is recommended that ADOT move forward with SPF calibration for all HSM (AASHTO 2010) safety performance functions for project-level safety analysis in Arizona. Safety analysis is progressing at a very promising rate and can be used to attain significant reductions in fatal crashes and crash severity.

There are different SPFs developed for use in network screening versus project-level safety analysis. The focus of this study is on project-level SPFs. The recommended SPF calibration process for project-level safety analysis is summarized below:

Step 1 – Prioritize SPFs

Determine which SPFs have the highest priority in Arizona based on the criteria specified in the *Calibration User's Guide* (Bahar 2014):

- Criterion 1 (C1): Which facility types correspond to safety-motivated, planning, and design projects in the upcoming years? (Rank from current or near future [1] to longer term [4])
- Criterion 2 (C2): Which facility types have one to three years of traffic volume data coinciding with same period of crash data? (√ = yes; blank = no)
- Criterion 3 (C3): Which facility types have a corresponding inventory of geometric elements that can be integrated into a dataset with crash and traffic volume respective data? (√ = yes for most; ~ = yes for required and limited to none for desirable elements; blank = none or very few elements)

Step 2 – Calibrate SPFs

If the highest priority SPF has not been calibrated, proceed with data collection and calibration. Then evaluate the calibrated SPF using CURE plots. If the calibrated SPF does not have a good fit, evaluate using a separate calibration factor for subsections of the data for AADT or by region. If there is not an acceptable goodness of fit for any of these calibration factors, proceed with simplified calibration functions.

SPFs used in network screening are typically calibrated within the software analysis program used for network screening. ADOT was evaluating Safety Analyst for network screening as part of its Safety Management Process under the ADOT SPR-693 project at the time of this report. If ADOT continues with Safety Analyst, the SPF calibration will be addressed within that program. If ADOT does not go forward with Safety Analyst, a separate but similar process will need to be completed for network screening SPFs. Network screening SPFs use a small subset of the data needed for project-level SPFs and, as such, would not require any additional data gathering.

Jurisdiction-specific SPFs can also be used within before- and after-studies for a specific countermeasure. For such before- and after-studies, that particular project scope should include SPF calibration or development.

In the future when the relevant data is readily available, it may be appropriate to move forward with independent SPFs.

DATA COLLECTION AND PROCESSING RECOMMENDATIONS

To effectively calibrate and apply SPFs on a broad scale, it would be necessary to commit to developing and maintaining a comprehensive database of roadway characteristics combined with crash data and AADT volume data that are all linked through a common linear referencing system.

During this study, the major effort in the process to calibrate SPFs from Part C of the HSM (AASHTO 2010) for Arizona was collecting and preparing the data from the various data sources. To be more efficient, it is recommended that ADOT maintain a consolidated GIS database of roadway geometry and crash data. This consolidated database could then be filtered to select the relevant data for the specific category of safety performance function, such as two-lane undivided highways, rural multilane undivided highways, and others. The consolidated database would contain specific highway data such as AADT, lane width, horizontal curvature, and shoulder width/type for each segment. Data consolidated in such a manner would significantly reduce the amount of time needed for the calibration as a whole. Refer to the *Calibration User's Guide* (Bahar 2014) for a comprehensive description of what to collect, how to collect it, and how to consolidate data elements.

Specific data elements could be collected more effectively to provide better data for calibration. Below are specific recommendations for particular data elements:

- Horizontal curve data: The horizontal curve data set should include the length and radius of all horizontal curves on a specific basis. Currently the data set contains general horizontal curve information based on six classes of curvature. For a given length of roadway, it groups like curves and gives the total length of each classification of curve. It would also be helpful for the curve data to be provided in radii (feet). To follow the data needs from the HSM completely, superelevation and the presence of spiral transition should also be documented.
- Grade data: The grade data set should include percent grade data for all roadway segments. Like the horizontal curve data set, the grade data set currently contains general grade information based on six classes of grades. For a given length of roadway, it groups like grades and gives the total length of each classification of grade.
- Shoulder type: The shoulder surface type dataset should include information on what the shoulder consists of. The data set currently has this information within the data set but in limited form. It was noticed during the calibration process for two-lane rural undivided highways that all shoulder surface type was paved according to the data set. Upon observation, some shoulders consisted of other materials.

- Presence of lighting: It is recommended that lighting information be collected and maintained into a GIS data set. There is currently no GIS data set of this information. It does exist in Excel format.
- Driveway density: It is recommended that driveway density information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Presence of centerline rumble strip: It is recommended that centerline rumble strip information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Roadside hazard rating: It is recommended that roadside hazard rating information be collected and maintained into a GIS data set. This should be based on the roadside hazard ratings from the HSM (AASHTO 2010). There is currently no GIS data set of this information.
- Automated speed enforcement: It is recommended that automated speed enforcement information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Sideslope: It is recommended that sideslope information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Roadside fixed object density: It is recommended that roadside fixed object density information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Intersection skew angle: It is recommended that intersection skew angle information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Signal information: It is recommended that signal information be collected and maintained into a GIS data set. This includes presence of left-turn phasing, type of left-turn phasing, use of right-turn-on-red signal operations, and use of red light cameras. There is currently no GIS data set of this information.
- Pedestrian volumes: It is recommended that pedestrian volumes information be collected and maintained into a GIS data set. There is currently no GIS data set of this information.
- Establishment proximity: It is recommended that establishment-proximity information be collected and maintained into a GIS data set. This includes the presence of bus stops, schools, and alcohol establishments within 1,000 feet of intersections. There is currently no GIS data set of this information.

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APPENDIX A: STATE INTERVIEW SUMMARIES

STATE OF ALABAMA

Interviewees:	Tim Barnett, Alabama DOT Safety Steven Jones, University of Alabama
Date:	Monday January 27, 2014
Interviewed by:	Mike Colety

Table A-1. State of Alabama Interviews

A. SPF Calibration Factors for HSM Part C (AASHTO 2010)	Yes
B. SPF Calibration Factors for Safety Analyst use	No
C. SPF Calibration Factors for SPFs other than HSM's (project level SPFs)	No
D. Agency-specific SPF development for Network screening purposes	No
E. Agency-specific SPF development for project-level purposes	Yes

Note: Sections in gray are expanded upon below

SPF Calibration Factors for HSM Part C

HSM Part C is about a predictive method for estimating expected average crash frequency at an individual site. The predictive method relies on safety performance functions (SPF). Three chapters of Rural Two-Lane and Two-Way Roads, Rural Multilane Highways, and Urban and Suburban Arterials are included in the manual.

1. *Has your state developed SPF calibration factors to use the HSM Part C SPFs? (If yes, continue, if not go to next set of questions)*

Yes. University will calibrate Freeway once chapters are published. Termini and ramps may be different. Maybe own SPFs for ramp and termini. Similar to intersections, can't fit intersections to models.

Had some success developing own models for segments, moving away from standard negative binomial. Now working at specific problems of bridge rails and highway grade crossing and some other models. Plan to modify spreadsheets with new

Have Critical Analysis Reporting Environment (CARE) software for data analysis. Working on Roadway Safety Improvement Safety Evaluation (RISE) program. Integral with CARE program. If they ever get decent roadway inventory, will likely use Safety Analyst. Roadway inventory data getting there, crash data there, Plan to LIDAR all of system and high definition video for non-system for MIRE points. Three years out. Trying to get interest in IHSDM, and believes it can be modified. Thinks it can accept any SPF form.

Research – Gaurav Mehta

2. *What were the reasons for developing SPF calibration factors?*

The default SPFs and CMFs in HSM are developed based on data from selected states and may not apply universally. It is important and recommended by HSM to adjust HSM models through calibration factors or develop new SPFs specific to local jurisdictions before actual implementation.

3. *Did your state prioritize the facility types for SPF calibration factors? If yes, what were the criteria used?*

No

4. *Did your state calibrate many of the HSM Part C's SPFs? If yes, which ones have been calibrated to date?*

- Rural two-lane, two-way roads: done-roadway segments
- Rural multilane highways: done-four-lane divided highways
- Urban and suburban arterials: Two lane undivided highways

5. *What data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

There is no good information in our database regarding horizontal curves and grades. Hence these two variables, which are found to be important predictors by several studies, were eliminated from the analysis. Crash modification factors (CMFs) are not used in the analysis for calibration, since our data was aggregated. For example the shoulder width was in range of 1-4ft, 4-8ft and so on, while the available CMFs are in increment of 1 feet of shoulder width.

6. *Did you put in place enhanced data collection programs for future calibrations or SPF development?*

No

7. *Did your calibration factors development cover specific state regions? If yes, how did you decide on groupings of regional data?*

Nothing sub-state

8. *Did you develop calibration factors for different HSM SPF by crash severity?*

- In the current bridge and rail crossing projects, we are developing SPFs by crash severity.
- AADT, bridge length, transition (conforming or not), percent trucks.

9. *Did you consider calibration factors for different AADT ranges or other elements (e.g., segment length)?*

- No, for the rural two-lane, two-way road model and four-lane divided highway model, AADT and other road characteristics were used to create homogeneous sites in the data preparation so as to capture the impacts of those factors.
- Variable of AADT in models. Data in one tenth mile for entire system. They used homogenous sites.

10. *Did you use the IHSDM? If yes, did you use the calibration factors developed as described before, or use the Calibration Utility of IHSDM? What were the lessons learned?*

No

11. *Did the calibration factors developed by state personnel or a contractor?*

University of Alabama

12. *What were your lessons learned during the calibration process (areas of interest include calibration process that you followed, site selection, sample size, crash data issues, roadway data issues, SPF application issues, etc.)?What is your plan going forward for SPF calibration factors development?*

- Getting good data is very difficult. The second big problem is cleaning the data, which requires knowledge of database, since Microsoft Excel won’t work with most of these huge data sets.
- The horizontal curve information is very important. The SPFs are different for the tangent and curved roadway segment. Curved segments can be analyzed separately or needs a crash modification factor.
- Site selection was done using stratified sampling to make sure all the roads were well represented in the sample.
- Used random generator to select random sites. Some roads were very small and not represented in site selection. After random selection, and then saw what roads that were not selected and randomly selected a few sites so there were a few sites.

Agency-specific SPF development for project-level purposes

13. *Has your state developed agency-specific SPFs for project level purposes? (If yes continue, if not any other comments?)*

Yes

14. *What were the reasons for developing SPFs?*

The default SPFs and CMFs in HSM are developed based on data from selected states and may not apply universally. It is important and recommended by HSM to adjust HSM models through calibration factors or develop new SPFs specific to local jurisdictions before actual implementation.

15. *Did your state prioritize the facility types for SPF development? If yes, what were the criteria used?*

Started with the best available data from the HSM and Tim provided direction

16. *Did your state develop SPFs for many of the HSM Part C's facility types? If yes, which ones have been developed to date?*

17. *What data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

18. *Did you put in place enhanced data collection programs for future SPF developments?*

19. *Did your SPF development cover specific state regions? If yes, how did you decide on groupings of regional data?*

20. *Did you develop different SPFs by crash severity?*

21. *Did you consider SPFs for different AADT ranges or other elements (e.g., segment length)?*

22. *Did you compare the estimates of the calibrated HSM SPFs with your own SPFs'? describe*

23. *Were the SPFs developed by state personnel or a contractor?*

24. *What were your lessons learned during the calibration process (areas of interest include calibration process that you followed, site selection, sample size, crash data issues, roadway data issues, SPF application issues, etc.)?*

University of South Alabama will be doing a separate project for AADT under 1500 or 1200. Jurisdiction-specific SPF development. Weak spot of HSM that for low volume routes the equations don't quite work very well.

25. *What is your plan going forward for SPF development and cyclical updates?*

- After developing and calibrating, found SPF developed, to be much more accurate.
- After getting data, got training dataset and developed state, then validation dataset and used HSM for predicted crashes and then expected, got calibration factor of 1.5. Now used agency specific dataset and compared agency specific. Ideally there would not be overlap between datasets and that is how they did it.
- Going forward, ideally do calibration first and then do SPF development.
- Alabama DOT is using it in Safety first, wanted calibration/SPF development accurate first, then push out to other divisions.
- Freeways, similar issue of getting enough data.
- Unsignalized intersections should be there after next set of data.
- There will be some that come up with roundabout SPFs, expect to rely on national data since not many roundabouts in Alabama.
- Network screening being done separately by hand without HSM calibration or independent development. Issue without intersection data.
- Data management became an issue. They have over 1.45 million rows of data and outgrew Microsoft Excel. Use MS Access now for database.

- 600,000 data points for just two lane rural. Used Macros in Excel for homogeneous sites, but it was overloading program capabilities.

COLORADO DEPARTMENT OF TRANSPORTATION SAFETY

Interviewees:	Swenka, David, Colorado DOT Safety
Date:	Friday January 24, 2014
Interviewed by:	Mike Colety

Table A-2. State of Colorado Interview

A. SPF Calibration Factors for HSM Part C (AASHTO 2010)	No
B. SPF Calibration Factors for Safety Analyst use	No
C. SPF Calibration Factors for SPFs other than HSM's (project level SPFs)	No
D. Agency-specific SPF development for Network screening purposes	Yes
E. Agency-specific SPF development for project-level purposes	Yes

Note: Sections in gray are expanded upon below

Agency-specific SPF development for project-level and network screening purposes

1. *Has your state developed agency-specific SPFs for project level purposes? (If yes continue, if not any other comments?)*

Yes, Colorado DOT developed jurisdiction-specific SPF approximately 10 years ago and uses them for both network screening and project level analyses.

2. *What were the reasons for developing SPFs?*

Improved safety analysis.

3. *Did your state prioritize the facility types for SPF development? If yes, what were the criteria used?*

All at once. Segments first, then intersections.

4. *Did your state developed SPFs for many of the HSM Part C's facility types? If yes, which ones have been developed to date?*

For project level, apply CMF from part D, part C and CMF Clearinghouse.
The following SPFs were developed for network screening:

- Segments

  - Rural Flat and Rolling 2-Lane Undivided Highways
  - Rural Mountainous 2-Lane Undivided Highways
  - Rural Flat and Rolling 4-Lane Divided Highways
  - Rural Mountainous 4-Lane Divided Highways
  - Rural Flat and Rolling 4-Lane Divided Freeways
  - Rural Mountainous 4-Lane Divided Freeways
  - Urban 4-Lane Divided Freeways
  - Urban 6-Lane Divided Freeways
  - Urban 8-Lane Divided Freeways
  - Intersections:
  - Urban 2-Lane Divided Unsignalized 3-Leg Intersections
  - Urban 2-Lane Undivided Unsignalized 3-Leg Intersections
  - Urban 2-Lane Undivided Unsignalized 4-Leg Intersections
  - Urban 4-Lane Divided Signalized 3-Leg Intersections
  - Urban 4-Lane Divided Signalized 4-Leg Intersections
  - Urban 4-Lane Divided Unsignalized 3-Leg Intersections
  - Urban 4-Lane Divided Unsignalized 4-Leg Intersections
  - Urban 4-Lane Undivided Unsignalized 3-Leg Intersections
  - Urban 4-Lane Undivided Unsignalized 4-Leg Intersections
  - Urban 6-Lane Divided Signalized 4-Leg Intersections
  - Use larger number of approach lanes if streets differ

- Ramp Intersections
  - Signalized 6-Lane Ramp Intersections
  - Unsignalized 2-Lane Ramp Intersections
  - Unsignalized 4-Lane Ramp Intersections
  - Signalized 2-Lane Ramp Intersections
  - Signalized 4-Lane Ramp Intersections
  - They cover most of the roadways in Colorado.

5. *What data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

- The jurisdiction-specific SPFs only used data that was currently available.
- The SPFs incorporate functional class (type, how many lanes, divided, undivided), severity and ADT).

6. *Did you put in place enhanced data collection programs for future SPF developments?*

- Continuing down path of SPFs with basic conditions then CMFs to others.
- Database is pretty complete for data they are using
- All SPFs based on state highway system, no approach for expanding in the future. Still feel this is estimating reasonable.

- Challenge using non state highways

7. *Did your SPF development cover specific state regions? If yes, how did you decide on groupings of regional data?*

No

8. *Did you develop different SPFs by crash severity?*

They do all crashes and then the do KABC.

9. *Did you consider SPFs for different AADT ranges or other elements (e.g., segment length)?*

Since they weren't restricted by the functional form in the HSM, they found a function that applied to all AADT ranges.

10. *Did you compare the estimates of the calibrated HSM SPFs with your own SPFs'? Describe*

No. However, they have just recently been using empirical Bayes and feel that has been beneficial.

11. *Were the SPFs developed by state personnel or a contractor?*

In-house and consultant

12. *What were your lessons learned during the calibration process (areas of interest include calibration process that you followed, site selection, sample size, crash data issues, roadway data issues, SPF application issues, etc.)?*

Feel jurisdiction-specific SPF development is worth the time and effort.

13. *What is your plan going forward for SPF development and cyclical updates?*

Continuing same approach, it is working. Update on a more frequent basis.

FLORIDA DEPARTMENT OF TRANSPORTATION

Interviewees: Frank Sullivan, Florida DOT Roadway Engineer

Date: Friday January 24, 2014

Interviewed by: Mike Colety

Table A-3. State of Florida Interview

A. SPF Calibration Factors for HSM Part C (AASHTO 2010)	Yes
B. SPF Calibration Factors for Safety Analyst use	Yes
C. SPF Calibration Factors for SPFs other than HSM's (project level SPFs)	No
D. Agency-specific SPF development for Network screening purposes	Yes
E. Agency-specific SPF development for project-level purposes	Yes

Notes: Sections in gray are expanded upon below. Also doing CMF development.

SPF Calibration Factors for HSM Part C

1. *Has your state developed SPF calibration factors to use the HSM Part C SPFs? (If yes, continue, if not go to next set of questions)*

    - Yes, research effort back in 2011 with University of Florida, Research report number, BDK7797706. Development and calibration of HSM equations for Florida Conditions. Completed in 2011.Frank Sullivan in FDOT Roadway Design managed this project. Through that effort assessed the availability of data, focused on Part B, and calibrated SPFs for Florida for segment and intersection.
    - Developed software for updating calibration factors. Will help when updating them in the future. Realized that the software tool didn't quite meet the needs completely. Making some changes to the software tool.

2. *What were the reasons for developing SPF calibration factors?*

Wanted to improve the accuracy of the prediction models

3. *Did your state prioritize the facility types for SPF calibration factors? If yes, what were the criteria used?*

All segments at once

4. *Did your state calibrate many of the HSM Part C's SPFs? If yes, which ones have been calibrated to date?*

All segment types in Part B

5. *What data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

   - Issue on segments was that, did not have complete curve data, assumptions made, challenges with accommodating curve data.
   - Tool data from RCI database (maintenance inventory); created and maintained for maintenance purposes.
   - Gaps in data. Missing data. Had to make some assumptions. Research team, when calibrating data, eliminated sections with curves, did sensitivity analysis on assumptions, came out with some calibration factors that had a good level of confidence, other not.
   - Crash data only from long forms, so no PDOs unless criminal offense. They calibrated for KABC because of this. Need to be real careful in how it is applied. Joe has teamed up with local law enforcement and they are collecting a lot of crash data on local roads.
   - Really don't know how good calibration factors are. University of Florida did a script that would extract data from RCI roadway database and prepare it so all the segments are created.
   - Next time, he wants to rerun the script on the database and then go out and randomly go around the state and select 40 to 50 sites of full data. Next time include curves.
   - Still looking at how it is done in the future. Might do on the fly calibration. Four to six year window approach.
   - Would be good to go out and select enough sites and monitor
   - Random selection process, what Frank did with the intersections, is he dumped all the sites into a spreadsheet and then he randomized them, start from top and go down, determine if valid site, if no = discard, if yes = use. Do not discard just because it had no crashes.
   - Roadway segments, went down to .1 mile, but don't feel crash data is accurate enough for that. Thinking at least a quarter mile for urban and one mile for rural. Need to adjust for base conditions. MRI provided guidance on how they can account for changing base conditions within the 1 mile rural segment.
   - Want to answer a few questions, before going on to SPF development
   - Looking at SAS – statistical application package. Used in pavement management.
   - Still a lot of work to do, but committed.
   - Feel good about process that they did of focusing on calibration first, improving data, (Frank wanted to do it in-house; Jim Mills wanted research project), Problem with research is too technical, make it too much of a science; If they do research now and look at sample sites, next time, they can just use same sites to re-calibrate as long as base conditions don't change, if 10 have conditions change and get thrown out, then can just use remaining 90. Worthwhile going forward. Could also do real time calibration. Hard to say if it would be worth it.
   - Benefit of creating your own SPFs is so you can handle facility types that are outside of HSM.
   - Mentioned they think having bike lanes has a crash reduction impact that is not mentioned and they will be looking into it.

- Challenge at FDOT with improper use of HSM. Needs to be only used when direct application of appropriate conditions.

6. *Did you put in place enhanced data collection programs for future calibrations or SPF development?*

- Since 2011, been focusing on data collection for intersection calibration. Consultant on site capturing count data, inventory data. Manually reviewing video cameras and they are filling out spreadsheet. Labor intensive to find good intersections.
- Lessons learned on intersections, finding the right intersections that meet the intent of the intersections, rural intersections, challenge with getting rural signalized intersections, Some in Florida in communities that have a small population, 1 signal community, has some curb and gutter and maybe some sidewalk, haven't felt comfortable as a rural intersection. What is suburban limit? Feel rural intersections are gray area.

7. *Did your calibration factors development cover specific state regions? If yes, how did you decide on groupings of regional data?*

Looked at regions, but didn't see much difference and kept it statewide. Intersections the same.

8. *Did you develop calibration factors for different HSM SPF by crash severity?*

No, except they did KABC because they don't have PDO crashes. Additional severity analysis might come next.

9. *Did you consider calibration factors for different AADT ranges or other elements (e.g., segment length)?*

- Don't feel this was an issue, look into report.
- Using AADT ranges for intersections for calibration.

10. *Did you use the IHSDM? If yes, did you use the calibration factors developed as described before, or use the Calibration Utility of IHSDM? What were the lessons learned?*

Not actively using the IHSDM. May use in future.

11. *Did the calibration factors developed by state personnel or a contractor?*

- Researcher, University of Florida
- In house in the future. Part C calibration would likely be with roadway design staff. In part B, either safety or systems planning. Haven't finalized future approach yet.

12. *What were your lessons learned during the calibration process (areas of interest include calibration process that you followed, site selection, sample size, crash data issues, roadway data issues, SPF application issues, etc.)?What is your plan going forward for SPF calibration factors development?*

- Getting adequate data and sample sizes for intersections is a challenge.
- Many assumptions built into calibration and need to make sure they are appropriate.

SPF Calibration Factors for Safety Analyst Use

13. *Has your state develop SPF calibration factors to use the Safety Analyst? (If yes, continue, if not go to next set of questions)*

Yes

14. *What were the reasons for developing SPF calibration factors for Safety Analyst SPFs?*

Felt be more accurate. Not as labor intensive as for Part C.

15. *Did your state prioritize the facility types for SPF calibration factors? If yes, what were the criteria used?*

- Focused on all segment types first, then intersections.
- Intersection calibration had some issues with sample sizes

16. *What AADT ranges or facility type data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

Data was available

17. *Did you put in place enhanced data collection programs for future re-calibrations or SPF development?*

Working on this now

18. *Were the calibration factors developed by state personnel or a contractor?*

University of Florida

19. *What were your lessons learned during the calibration process?*

Northing significant

20. *What is your plan going forward for SPF calibration factors development and use of Safety Analyst?*

- Focusing on Safety Analyst implementation this year. Did successfully do network screening at state level, next step is to work with district staff. Have planning staff use the output.
- District safety engineer in each district in traffic operations center. Plan is to have Safety Analyst maintained through planning division but that hasn't been coordinated yet.

Agency-Specific SPF Development for Network Screening Purposes

- Florida International, Dr. Albert Gan
- Original research back in 2009. BDK84977701 – Development of Interface with crash database and Safety Analyst. University of South Florida
- 2012 work back in 2012, BDK8977707 Preparing Florida for deploying Safety Analyst for all roads. Now working on what they can do to improve the process for implementing.

Agency-Specific SPF Development for Project-Level Purposes

- Ongoing research, not quite done yet. Evaluating CMFs and how much different and potential for developing state specific CMFs.
- This research is with University of Central Florida, researcher is Dr. Mohammad Abdul Aty.

Overall Lessons Learned

- Need to know right questions to ask.
- More practitioners will need to be trained on process

What is your plan going forward?

- Update calibration factors every 2 to 3 years.
- Anticipate developing our own SPFs with different base conditions, the base conditions that they have good data for and are relevant to crashes in Florida, which will be more base conditions than currently in the HSM.
- Rumble strips throughout Interstate, so bring that into base conditions.
- Potentially friction course, open grade versus dense course.

KANSAS DEPARTMENT OF TRANSPORTATION

Interviewees: Howard Lubliner, Kansas DOT Acting Metro Engineer
Cheryl Bornheimer, Kansas DOT Road Safety

Date: Monday January 27, 2014

Interviewed by: Mike Colety

Table A-4. Kansas Department of Transportation

A. SPF Calibration Factors for HSM Part C (AASHTO 2010)	Yes
B. SPF Calibration Factors for Safety Analyst use	Yes
C. SPF Calibration Factors for SPFs other than HSM's (project level SPFs)	No
D. Agency-specific SPF development for Network screening purposes	No
E. Agency-specific SPF development for project-level purposes	No

Note: Sections in gray are expanded upon below.

SPF Calibration Factors for HSM Part C

1. *Has your state developed SPF calibration factors to use the HSM Part C SPFs? (If yes, continue, if not go to next set of questions)*

Yes

2. *What were the reasons for developing SPF calibration factors?*

   - Did development and calibration and found that calibration was just as accurate.
   - With SPF development, often they aren't able to include all the factors and thus not effective.
   - Kansas is fairly homogenous, flat roadways, not very sharp.

3. *Did your state prioritize the facility types for SPF calibration factors? If yes, what were the criteria used?*

   - Rural two lane because it accounts for the majority of their system and crashes.
   - Working on rural multi-lane, just started a couple months ago. Kansas State University.

4. *Did your state calibrate many of the HSM Part C's SPFs? If yes, which ones have been calibrated to date?*

   - Only calibrated rural two lane, segments and intersections. Combined three legs and four legs, so few crashes. Seem to performing similarly.
   - Working on rural multi-lane, just started a couple months ago. Kansas State University.

5. *What data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

   - Did a robust effort to complete the data. Reviewed plans, reviewed google. Collected roadside hazard.
   - Estimated side street AADT, consistent with how estimated in design process.

6. *Did you put in place enhanced data collection programs for future calibrations or SPF development?*

Discussed additional roadway feature data that would be helpful in the future but not sure.

7. *Did your calibration factors development cover specific state regions? If yes, how did you decide on groupings of regional data?*

Looked at regional areas (see report) and then did either statewide calibration, variable calibration function based on deer crashes.

8. *Did you develop calibration factors for different HSM SPF by crash severity?*

No

9. *Did you consider calibration factors for different AADT ranges or other elements (e.g., segment length)?*

No

10. *Did you use the IHSDM? If yes, did you use the calibration factors developed as described before, or use the Calibration Utility of IHSDM? What were the lessons learned?*

IHSDM was used for re-calibration (not available first time). Worked well. One issue was with the combined calibration for intersections, Nice to have it all in one spot.

11. *Did the calibration factors developed by state personnel or a contractor?*

Universities

12. *What were your lessons learned during the calibration process (areas of interest include calibration process that you followed, site selection, sample size, crash data issues, roadway data issues, SPF application issues, etc.)?What is your plan going forward for SPF calibration factors development?*

- Good luck with the sample sizes recommended in HSM. Doubled sample size for segments recently and not much changed, but difficult to get enough data for intersections.
- For data collection, did it in 20 and 10 mile segments. Much simpler than taking 1000 homogeneous segments. Than IHSDM broke the site into segments. Feel it reduced the error for crash reporting accuracy than if you were doing all independent segments due to where the crash is assigned.
- Working on multilane, than freeway.
- Don’t think they will do urban/suburban because state system has very low urban/rural mileage. KDOT focusing on KDOT roadways and not local roadways.
- Since re-calibrated two lane rural, keep increasing the sample pool.
- Empirical Bayes helps without calibration for accuracy.
- Most valuable exercise was running segments through the predictive model, then see how model predicted in different areas.

SPF Calibration Factors for Safety Analyst Use

13. *Has your state develop SPF calibration factors to use the Safety Analyst? (If yes, continue, if not go to next set of questions)*

All segment data, been using it. No 5% reports. Used it to identify critical highway segments.

14. *What were the reasons for developing SPF calibration factors for Safety Analyst SPFs?*

All segments, no ramps and intersections.

15. *Did your state prioritize the facility types for SPF calibration factors? If yes, what were the criteria used?*

Focused on where the crashes are

16. *What AADT ranges or facility type data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

No

17. *Did you put in place enhanced data collection programs for future re-calibrations or SPF development?*

- Merged the features and crashes database into one for segments. There were some issues with minimum segment length. Had to hand address some segments. Stuck with Safety Analyst minimum.
- We're lacking intersections features database. Recently began intersection data collection.

18. Were the calibration factors developed by state personnel or a contractor?

Internal. Took about 3 years.

19. What were your lessons learned during the calibration process?

One problem was the champion for use of Safety Analyst left KDOT and others don't have experience using it because it is a unique software.

20. What is your plan going forward for SPF calibration factors development and use of Safety Analyst?

Looking into goodness of fit for SPFs

21. What will you do going forward?

- More of the same = calibration
- No jurisdiction-specific SPFs planned for project level.
- Safety Analyst possible for SPF development but no plans at this point.

VIRGINIA DEPARTMENT OF TRANSPORTATION SAFETY

Interviewees:	Stephen Read, Virginia DOT Safety Cheryl Bornheimer, Kansas DOT Road Safety
Date:	Monday January 24, 2014
Interviewed by:	Mike Colety

Table A-5. Virginia Department of Transportation

A. SPF Calibration Factors for HSM Part C (AASHTO 2010)	No
B. SPF Calibration Factors for Safety Analyst use	No
C. SPF Calibration Factors for SPFs other than HSM's (project level SPFs)	No
D. Agency-specific SPF development for Network screening purposes	Yes
E. Agency-specific SPF development for project-level purposes	Yes

Note: Sections in gray are expanded upon below.

Agency-specific SPF development for Network Screening Purposes and Project Level Analysis

1. *Has your state developed agency-specific SPFs for network screening purposes? (If yes, continue, if not go to next set of questions)*

Yes. Different SPFs developed for network screening and project level but following responses applicable to both.

2. *Did your state prioritize the facility types for SPF calibration factors? If yes, what were the criteria used?*

   - Started with the easiest, rural 2 lane, worked from there and developed over time with research. In the end it ended up with a database guy getting everything compiled and then researches just did statistical analysis.
   - Biggest thing was getting dataset prepared. First graduate student took forever and still needed significant cleaning. Spent day a week of internal staff for data after that. Big part is getting someone dedicated to data.

3. *What AADT ranges or facility type data elements were not available and adopted default values or assumed values? How did it affect the accuracy of your estimates?*

   - Looked at models by AADT range, but did not get better fit.
   - Maintain entire network, 56,000 miles of county roads with data. Plus state system. 2200 directional miles, 12,000 direction miles of primary.

4. *Did you put in place enhanced data collection programs for future re-calibrations or SPF development?*

Yes

5. *Did the SPFs follow similar functional form to Safety Analyst?*

Yes. Thought they could get it into Safety Analyst but actually it has been too difficult. Still only using Oracle.

6. *Did you compare the estimates using SPF calibration factors or agency-specific SFP? Describe the differences, if available.*

No calibration factors

7. *Were the SPFs developed by state personnel or a contractor?*

University

8. *What were your lessons learned during the SPF development process?*

   - Make sure someone is dedicated to gathering data. Statistical analysis is straight forward.
   - Regional models are very different
   - Coastal, east of I-95

- Rolling hills
- Mountains
- Urban crescent (coastal and more urbanized) but still rural)
- Crash severity, crash type, time of day proportion tables are very different from Virginia and different by district/region
- There urban versus rural is defined by MPO
- HSM definitions of urban versus rural is vague, need more clarification.

9. *What is your plan going forward for SPF development?*

- Develop a roadway departure specific SPF. Virginia is a focus state. Potentially develop a model for roadway departure crashes.
- Looking to collect enough data to do intersections for Part C and rest of segments
- Struggled with lack of model for larger multilane. Decided to do RSA and CMFs, but limited countermeasures to those with CMFs.
- Jurisdiction-specific SPFs, started back in 2005. Different graduate students.
- Felt state chosen for state highways were not like Minnesota's so went straight to independent development. Only felt comfortable using North Carolina, but that wasn't picked.
- Statewide, then regional with similar conditions
- Developed models based on five years of crash data.
- Calibration will be there for each district
- When model is run against newer data, calibrate for each district, in addition to independent regional SPFs.
- Not enough data for rural T-intersections on two lane roads signalized, so statewide model.
- Did rural multilane models for Safety Analyst, but then had all data for part C, so they developed part C model also. Know how much it takes. Looked at percentage tables and looked at how much work that will be, determined that segments for rural multilane they had enough data, but not the rest. Only thing needed was lanes and shoulder width.
- Been a struggle to use IHSDM for project level because a struggle to do anything that takes more time in the design process. Already behind
- Suggest talking to Louisiana about this.

APPENDIX B: DATA COLLECTION

Appendix B include additional detail on each data element used in the analysis.

B-1
Crash Data
2008 – 2012

Crashes statewide on ADOT-maintained roadways (excludes local roads)

Table B-1. Crashes per Year

Years	Number of Crashes
2008	39165
2009	33548
2010	35196
2011	35412
2012	35456
TOTAL	178777

Table B-2. Five-Year Crash Severity

Crash Severity	Number of Crashes
Fatal	1630
Incapacitating Injury	5606
Non Incapacitating Injury	21897
Possible Injury	26692
No Injury	122952
TOTAL	178777

Table B-3. Injury Severity by Year

Year	Fatal	Incapacitating	Non Incapacitating	Possible Injury	No Injury
2008	376	1204	4600	5733	27152
2009	326	1123	3997	4836	23266
2010	295	1056	4249	5268	24328
2011	325	1066	4558	5280	24183
2012	308	1057	4493	5575	24023
2008	376	1204	4600	5733	27152

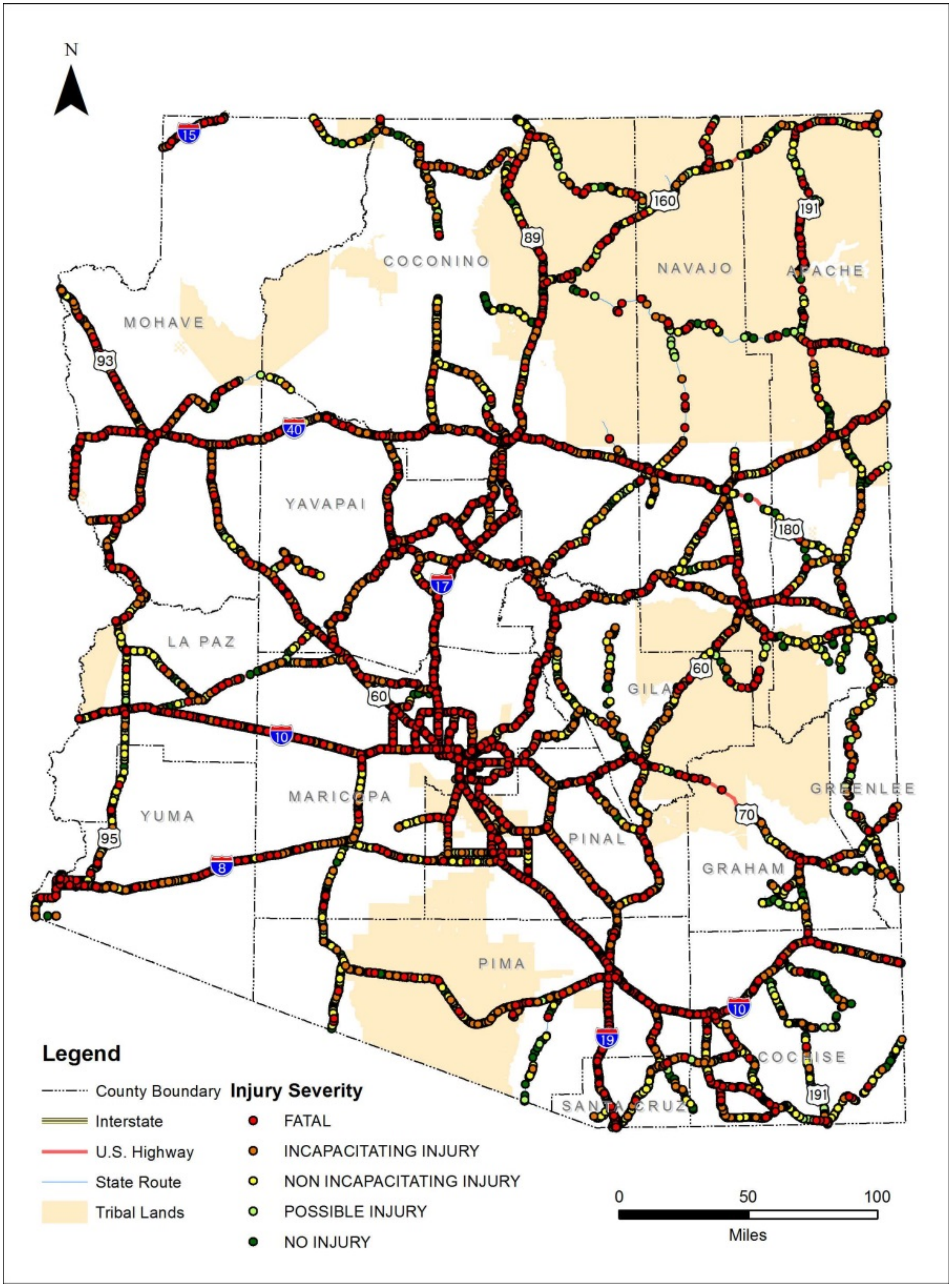


Figure B-1. Crash Data Map (2008 – 2012).

B-2

The following summarizes the Roadway Characteristics Inventory (RCI) data structure that was used for this analysis. The roadway database was migrated to a new linear referencing system platform in August 2014, which changes the attribute type description.

Feature Name:	ADOT.DBO.FuncClass_Master
Feature Type:	Polyline
Feature Description:	Arizona Functional Classification for Highways and Major Arterials.
Feature Projection:	NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
Feature Extent:	Statewide
Methodology:	Developed by from the HPMS dataset.
Credit:	ADOT
Location:	ADOT SDE – ADOT_DBO_FuncClass
Last Updated:	August 2012
Data Contact:	Multimodal Planning Division-GIS
Phone Number:	(602)712-7333
Office:	Multimodal Planning Division

Table B-4. Roadway Characteristics Inventory Data

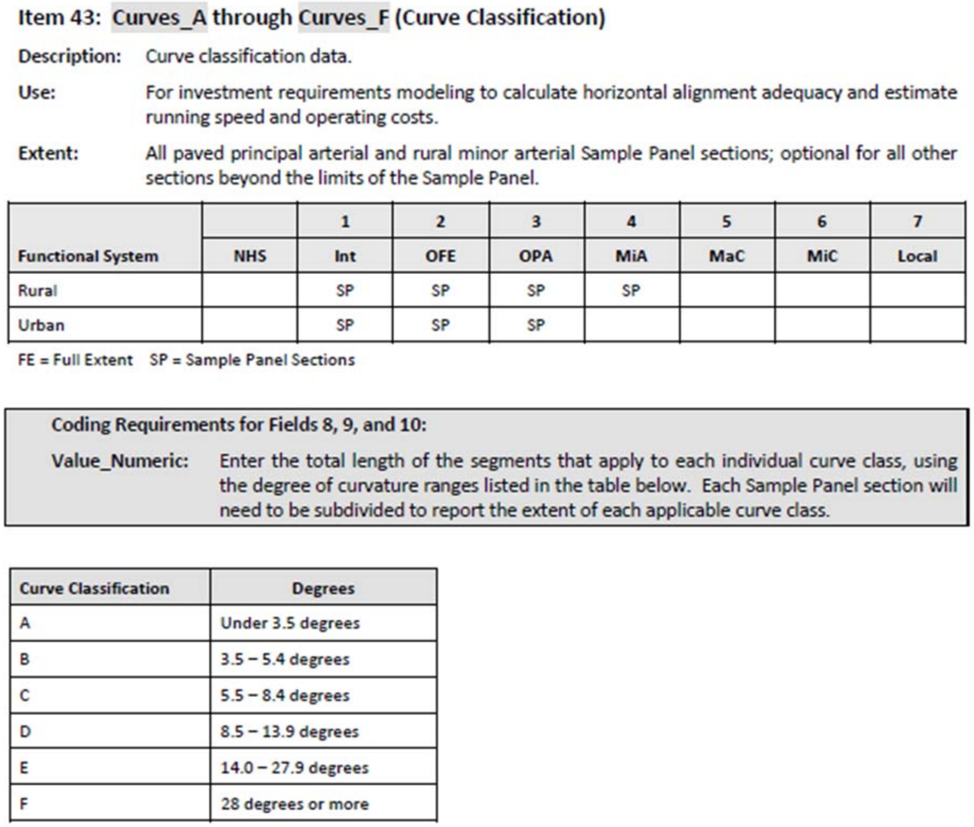
Column Name	Column Type/Length	Column Description
ONROAD	Text (32)	ATIS nomenclature represents name of road
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
FUNCCODE	Short (5)	Functional Classification number
RURALURBAN	Short (5)	Rural or Urban number
URBCODE	Text (4)	Rural or Urban code
URBCHANGE	Double (38, 8)	Change from urban and rural
NC	Text (4)	Non-cardinal
COUNTY_FIP	Text (3)	County ID
COG	Text (6)	Roads within a COG/MPO boundary
NHS	Short (5)	National Highway System

Column Name	Column Type/Length	Column Description
MILES	Double (38, 8)	Length of segment in miles
SHORT_NAME	Text (32)	Short name of road
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad
LASTGEOCODE	Date	Field automatically updates with last edit made
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
len	Double (38, 8)	Length
LengthMiles	Double (38, 8)	Length of segment in miles
FUNCCODE2010	Short (5)	2010 Functional Classification number
NeedsXferToHpms	Short (5)	Changes to HPMS

B-3

Length and radius of horizontal curves

The GIS data sets provided for length and radius of horizontal curves do not supply specific information for curves, rather they show a general idea of curves along a particular roadway segment. The GIS data set is described below. To estimate the length of curve, ArcGIS was used to split the line features into horizontal and tangent sections. The segments could then be measured. This aerial was then exported and imported into AutoCAD where the Arc tool was used to trace the horizontal curve. An estimation of the radius of curve could then be calculated.



Item 43: Curves_A through Curves_F (Curve Classification)

Description: Curve classification data.

Use: For investment requirements modeling to calculate horizontal alignment adequacy and estimate running speed and operating costs.

Extent: All paved principal arterial and rural minor arterial Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel.

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural		SP	SP	SP	SP			
Urban		SP	SP	SP				

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the total length of the segments that apply to each individual curve class, using the degree of curvature ranges listed in the table below. Each Sample Panel section will need to be subdivided to report the extent of each applicable curve class.

Curve Classification	Degrees
A	Under 3.5 degrees
B	3.5 – 5.4 degrees
C	5.5 – 8.4 degrees
D	8.5 – 13.9 degrees
E	14.0 – 27.9 degrees
F	28 degrees or more

Figure B-2. Curves A through Curves F Curve Classification.

Value_Text:	No entry required. Available for State Use.
Value_Date:	No entry required. Available for State Use.

Guidance: This information may be available from construction plans, GIS databases, and contracts for other data collection activities such as International Roughness Index (IRI) or pavement data, and video log.

The primary goal is to populate curve data for each paved sample on the applicable functional system. There are 6 classes of curvature (i.e., Curve Class A through Curve Class F). The beginning and ending points will remain constant for each of the data items; however the values for these data items will reflect the length of that particular curve class. Furthermore, the sum of the values for each of the 6 curve class Data Items must be equal to the total length of the entire sample.

Each curve and tangent segment is coded as a separate curve; segments are summed by curve class to obtain the total length in each class. Report the sum of the class lengths for each of the six curve classes (in units of miles); the sum of all curve lengths must equal the Sample Panel section length.

Example:

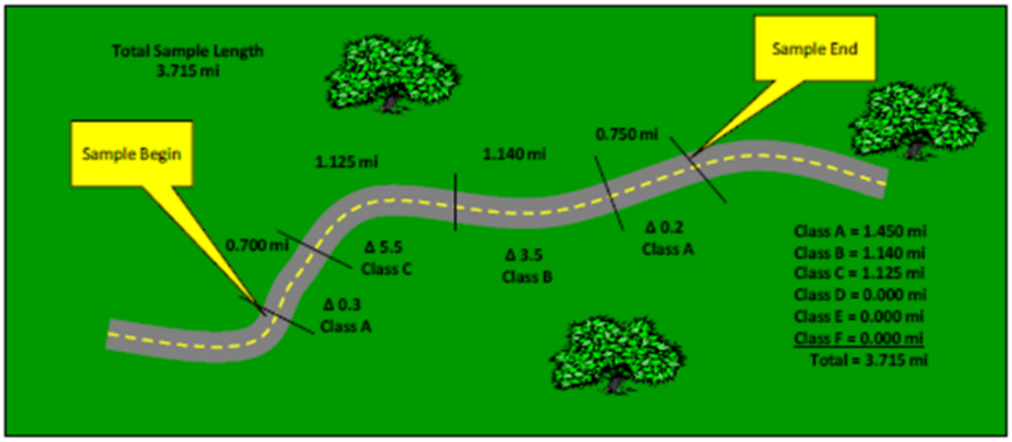
Milepoint	0.00	1.75	3.00	3.75	4.57	5.69
	A	B	C	E	C	
Curve Length		1.75	1.25	0.75	0.82	1.12

This example depicts a Sample Panel section for which the HPMS software would expect 4 records reported in the Sections dataset as depicted below:

```
2009|45|SCXXX|0|5.69|CURVES_A|5.69|1.75|||
2009|45|SCXXX|0|5.69|CURVES_B|5.69|1.25|||
2009|45|SCXXX|0| 5.69|CURVES_C|5.69|1.87|||
2009|45|SCXXX|0| 5.69|CURVES_E|5.69|0.82|||
```

Since no data exists for curve classes D and F in this example, there would not be a record reported for either class. Moreover, the value for Curve Class C is calculated by adding the values for both Curve Class C parts together. The beginning and ending points are consistent throughout all records within the sample. The sum of all of the Curve Class lengths must equal the total length of the Sample Panel section.

Figure B-3. Curve Classification Example.



Source: TxDOT, Transportation Planning and Programming Division

Figure B-4. Curve Classification Example Schematic.

B-4

Item 45: Grades_A through Grades_F (Grade Classification)

Description: Grade classification data.

Use: For investment requirements modeling to calculate vertical alignment adequacy and estimate running speed and operating costs and in the truck size and weight analysis process.

Extent: All paved interstate, other freeway and expressway, other principal arterial, and rural minor arterial Sample Panel sections; optional for all other sections beyond the limits of the Sample Panel.

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural		SP	SP	SP	SP			
Urban		SP	SP	SP				

FE = Full Extent SP = Sample Panel Sections

Figure B-5. Curves A through Curves F Grade Classification.

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the total length of the segments that apply to each individual grade class, using the percent grade ranges listed in the table below. Each sample will need to be subdivided to report the extent of each applicable grade class.

Grade Classification	Percent Grade
A	0.0 – 0.4
B	0.5 – 2.4
C	2.5 – 4.4
D	4.5 – 6.4
E	6.5 – 8.4
F	8.5 or greater

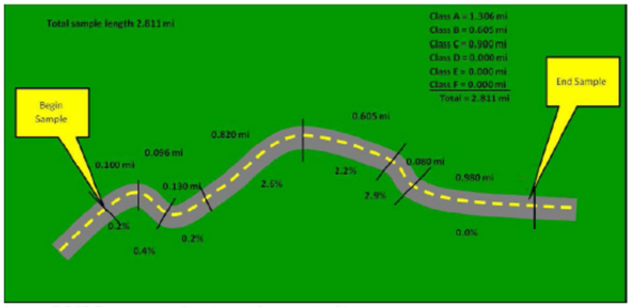
Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: This information may be available from construction plans, GIS databases, and contracts for other data collection activities.

Each grade and flat segment is to be coded as a separate segment; segments are typically measured between vertical points of intersection (VPI) and summed by grade class to obtain the total length in each class. The sum of all of the Grade Class lengths must equal the total length of the Sample Panel section.

Figure 4.71 Grade Classification Example



Source: TxDOT, Transportation Planning and Programming Division.

Figure B-6. Curve Grade Classification Example.

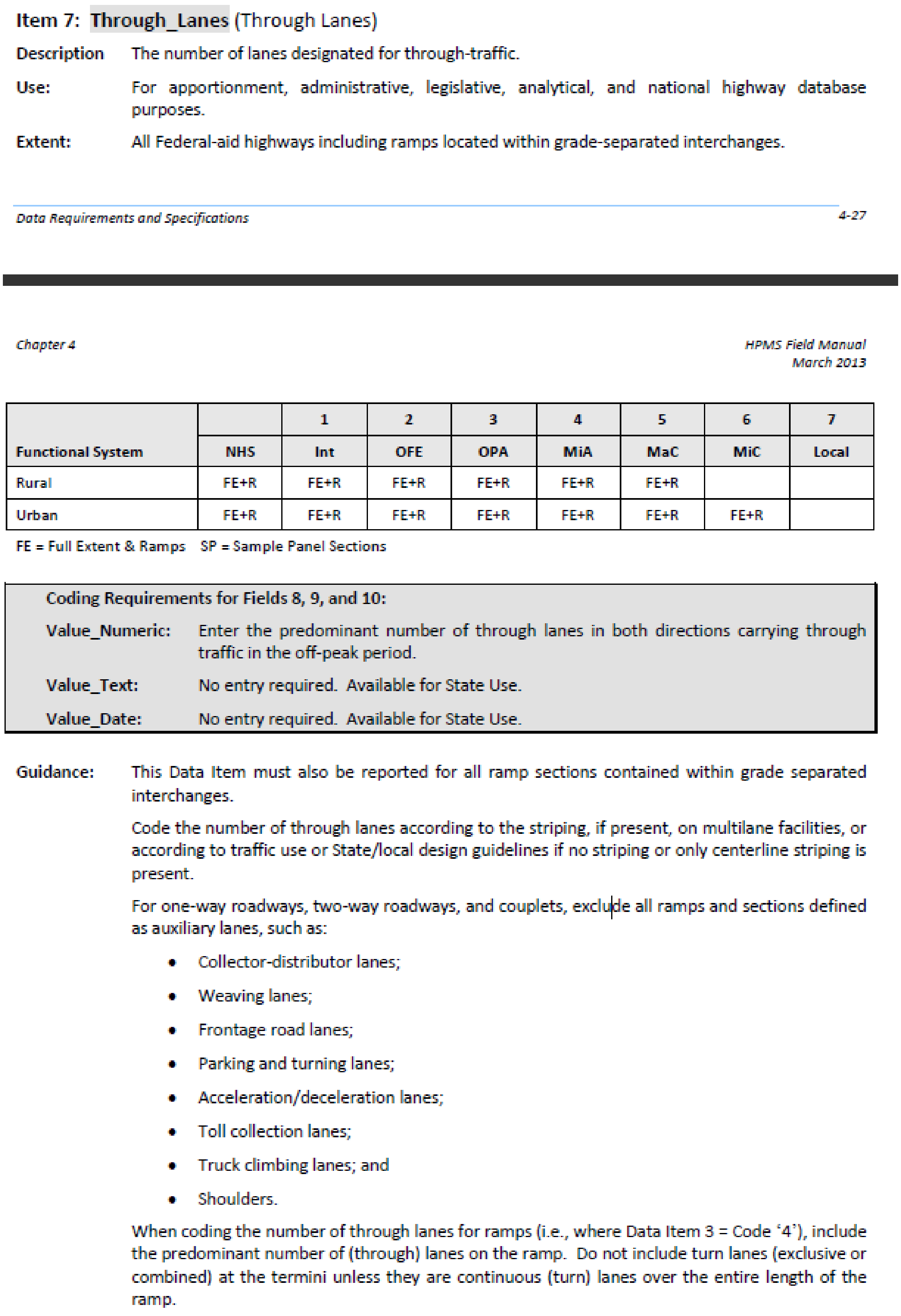
B-5

- Feature Name: ADOT.DBO.Lanes
- Feature Type: Polyline
- Feature Description: This is a simple polyline feature class representing the number of though travel lanes along a road section. On divided highways, there are separate records for each travel direction. Key attribute fields include number of lanes (LANES), and average lane width (AVGLNWIDTH).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by extracting lane data from the HPMS dataset.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-5. Lane Width Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
LANES	Double (38, 8)	Number of Lanes
SW	Double (38, 8)	Blank field
COMMENT	Text (100)	Details on the curb and gutter location review and source
ONROAD	Text (32)	ATIS nomenclature represents name of road
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)

Column Name	Column Type/Length	Column Description
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
LOWESTMARKER	Text (12)	Milepost for the lowest marker
KEEPLM	Short (5)	Code to keep LM
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LASTGEOCODE	Date	Field automatically updates with last edit made
LEDITDATE	Date	Quality control metric
MILES	Double (38, 8)	Length in miles
PARTS	Short (5)	Blank field
NONCARDCPM	Short (5)	Non-cardinal CPM
RARF	Short (5)	Regional Area Road Fund
AVGLNWIDTH	Double (38, 8)	Average Lane Width
VirtualDeletion	Short (5)	Track virtual deletions
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
NeD	Text (3)	Direction from the northeast reference that the northeast offset will apply



Item 7: Through_Lanes (Through Lanes)

Description The number of lanes designated for through-traffic.

Use: For apportionment, administrative, legislative, analytical, and national highway database purposes.

Extent: All Federal-aid highways including ramps located within grade-separated interchanges.

Data Requirements and Specifications *4-27*

Chapter 4

HPMS Field Manual
March 2013

		1	**2**	**3**	**4**	**5**	**6**	**7**
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R		
Urban	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	FE+R	

FE = Full Extent & Ramps SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the predominant number of through lanes in both directions carrying through traffic in the off-peak period.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: This Data Item must also be reported for all ramp sections contained within grade separated interchanges.

Code the number of through lanes according to the striping, if present, on multilane facilities, or according to traffic use or State/local design guidelines if no striping or only centerline striping is present.

For one-way roadways, two-way roadways, and couplets, exclude all ramps and sections defined as auxiliary lanes, such as:

- Collector-distributor lanes;
- Weaving lanes;
- Frontage road lanes;
- Parking and turning lanes;
- Acceleration/deceleration lanes;
- Toll collection lanes;
- Truck climbing lanes; and
- Shoulders.

When coding the number of through lanes for ramps (i.e., where Data Item 3 = Code '4'), include the predominant number of (through) lanes on the ramp. Do not include turn lanes (exclusive or combined) at the termini unless they are continuous (turn) lanes over the entire length of the ramp.

Figure B-7. Through Lane Coding.

B-6

- Feature Name: ADOT.DBO.ShoulderSurfaceType
- Feature Type: Polyline
- Feature Description: This is a simple polyline feature class representing the locations of shoulders along highways. Key attribute fields include type of shoulder surface (SHTY).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by extracting data from HPMS.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-6. Shoulder Surface Type Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
SHTY	Short (5)	Surface Type
COMMENT	Text (100)	Details on the curb and gutter location review and source
ONROAD	Text (32)	ATIS nomenclature represents name of road
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad

Column Name	Column Type/Length	Column Description
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
LOWESTMARKER	Text (12)	Milepost for the lowest marker
KEEPLM	Short (5)	Code to keep LM
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LASTGEOCODE	Date	Field automatically updates with last edit made
LEDITDATE	Date	Quality control metric
MILES	Double (38, 8)	Length in miles
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
VirtualDeletion	Short (5)	Track virtual deletions

The following are the shoulder surface types:

- Asphaltic concrete (AC): AC may be rubberized, but that is not signified in the annual ADOT State Highway System Log
- AC/portland concrete cement (PCC): Thin layer of AC over PCC subpavement. AC may be rubberized but that is not signified in the Highway Log.
- AC/stress absorbing membrane interlayer (SAMI): AC over asphalt-rubber stress-absorbing membrane. AC may be rubberized but that is not signified in the Highway Log
- Asphalt-rubber stress-absorbing membrane (ARSAM)
- Bituminous surface treated (BST)
- Combination concrete and mixed bituminous (CCMB)
- Mixed Bituminous, High Type (MBH, high relates primarily to the overall thickness)
- Mixed Bituminous, Low Type (MBL, low relates primarily to the overall thickness)
- Portland cement concrete (PCC)
- Ultra-thin whitetopping (UTW): concrete mixture similar to PCC with steel shard additives to reduce cracking.
- Gravel: Non-paved
- Continuously reinforced concrete pavement (CRCP)
- AC/CRCP: AC over CRCP
- Asphalt bituminous (AB)

B-7

- Feature Name: ADOT.DBO.ShoulderWidthRight
- Feature Type: Polyline
- Feature Description: This is a simple polyline feature class representing the locations of right shoulders along roads and highways in the direction of travel. Key attribute fields include shoulder width (RSW, RSW_END).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by extracting data from HPMS.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-7. Right Shoulder Width Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
RSW	Double (38, 8)	Right Shoulder Width
LSW_END	Double (38, 8)	Right Shoulder Width End
COMMENT	Text (100)	Details on the curb and gutter location review and source
ONROAD	Text (32)	ATIS nomenclature represents name of road
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad

Column Name	Column Type/Length	Column Description
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
LOWESTMARKER	Text (12)	Milepost for the lowest marker
KEEPLM	Short (5)	Code to keep LM
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LASTGEOCODE	Date	Field automatically updates with last edit made
LEDITDATE	Date	Quality control metric
MILES	Double (38, 8)	Length in miles
YR	Text (8)	Year
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
NeD	Text (3)	Direction from the northeast referent that the northeast offset will apply
VirtualDeletion	Short (5)	Track virtual deletions

B-8

- Feature Name: ADOT.DBO.ShoulderWidthLeft
- Feature Type: Polyline
- Feature Description: This is a simple polyline feature class representing the locations of left shoulders along roads and highways in the direction of travel. Key attribute fields include shoulder width (LSW, LSW_END).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by extracting data from HPMS.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-8. Left Shoulder Width Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
LSW	Double (38, 8)	Left Shoulder Width
LSW_END	Double (38, 8)	Left Shoulder Width End
COMMENT	Text (100)	Details on the curb and gutter location review and source
ONROAD	Text (32)	ATIS nomenclature represents name of road
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
LOWESTMARKER	Text (12)	Milepost for the lowest marker
KEEPLM	Short (5)	Code to keep LM
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LASTGEOCODE	Date	Field automatically updates with last edit made
LEDITDATE	Date	Quality control metric
MILES	Double (38, 8)	Length in miles
YR	Text (8)	Year
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
NeD	Text (3)	Direction from the northeast referent that the northeast offset will apply
VirtualDeletion	Short (5)	Track virtual deletions

B-9

- Feature Name: ADOT.DBO.AuxiliaryLanes
- Feature Type: Polyline
- Feature Description: This is a measured polyline feature class representing the locations of various auxiliary lanes (e.g., turn lanes, medians, acceleration lanes). Key attribute fields include lane description (SYM, SymSub, Data), number of lanes (LANES), and average lane width (AVGLNWIDTH).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by from the HPMS dataset. Auxiliary lanes are digitized via aerial imagery or plan sheets. It requires ATIS centerline support.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-9. Auxiliary Lanes Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
SYM	Text (2)	Turn Lane
LANES	Double (38, 8)	Number of Lanes
TSW	Double (38, 8)	TSW Code
YR	Text (8)	Year
COMMENT	Text (100)	Comment on edits
ONROAD	Text (32)	ATIS nomenclature represents name of road
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS

Column Name	Column Type/Length	Column Description
		intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
LOWESTMARKER	Text (12)	Milepost for the lowest marker
KEEPLM	Short (5)	Code to keep LM
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LASTGEOCODE	Date	Field automatically updates with last edit made
LEDITDATE	Date	Quality control metric
MILES	Double (38, 8)	Length of segment in miles
RARF	Short (5)	Ramps
AVGLNWIDTH	Double (38, 8)	Average width of lanes
Paint	Text (1)	Rendering of the side of the road and the offset from the centerline
SymSub	Short (5)	Turn Lane
Data	Text (70)	Supplies a descriptive term for the added lane
NodePolygonID	Long (10)	Assigned integer value which groups features into the same node.
MaxMdWidth	Short (5)	Maximum width of lanes
MinMdWidth	Short (5)	Minimum width of lanes
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
NeD	Text (3)	Direction from the northeast referent that the northwest offset will apply
MLINENAME	Text (32)	Line name
MLINEMEAS	Double (38, 8)	Line measure
FR_X	Long (10)	Blank
FR_Y	Long (10)	Blank
VirtualDeletion	Short (5)	Track virtual deletions

Auxiliary Lanes Codes (SymSub)

- Left-turn lane
- Right-turn lane
- Bicycle lane
- Auxiliary lane
- Passing lane
- Soil median
- Curbed soil median
- 0-12-foot Painted Median
- Guardrail-protected median
- Concrete barrier median
- Cable carrier Soil median
- Curbed concrete median
- Concrete carrier Soil median
- Soil with elevation difference positive barrier
- Available
- TWLTL
- Painted channelization
- Non-painted channelization

B-10

- Feature Name: ADOT.DBO.SpeedLimit
- Feature Type: Polyline
- Feature Description: This is a measured polyline feature class representing the posted speed limits along segments of a route. Key attribute fields include speed limit (SpeedLimit), direction of travel where the speed limit applies (Direction), and the dates the speed limit were adopted and posted (DateAdopted, DateInstalledConfirmed).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by extracting data from HPMS.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-10. Speed Limit Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
EndMP	Double (38, 8)	Ending Marker Point
Direction	Text (255)	Direction of speed limit
SpeedLimit	Double (38, 8)	Speed Limit
Flag	Text (4)	Flag Code
DenotesChange	Text (255)	Change made
DateAdopted	Date	Date when change was adopted
Notes	Text (255)	Notes on speed limit
District	Text (255)	Speed Limit per Transportation Board District
SR_No	Text (255)	Highway Name
DateInstalledConfirmed	Text (255)	Date when installation occurred
Source	Text (50)	Page document source
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
ONROAD	Text (32)	ATIS nomenclature represents name of road
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
NETERM	Text (32)	ATIS nomenclature represents name of N or E cross-reference in ATIS intersection table
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where

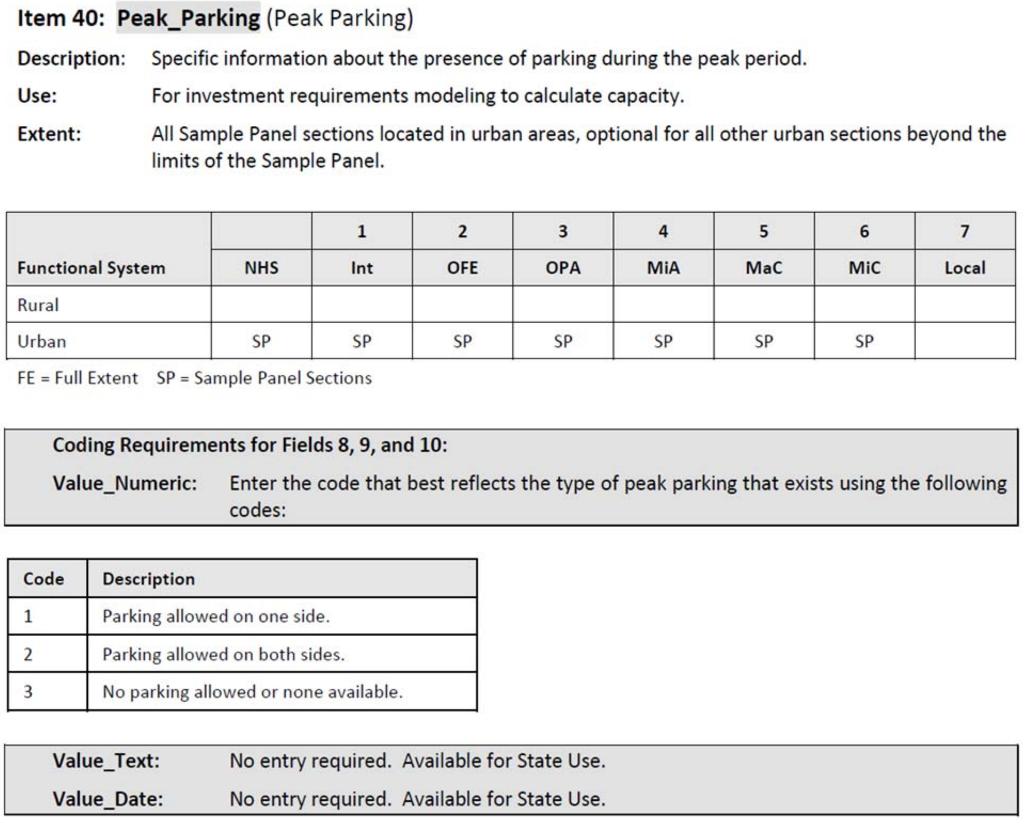
Column Name	Column Type/Length	Column Description
		NeTerm crosses OnRoad
LASTGEOCODE	Date	Field automatically updates with last edit made
LEDITDATE	Date	Quality control metric
LOWESTMARKER	Text (12)	Milepost for the lowest marker
HIGHMARKER	Text (12)	Milepost for the highest marker
COMMENT	Text (100)	Details on the curb and gutter location review and source
Road	Text (30)	Road name
From_	Text (32)	From
To_	Text (32)	To
VirtualDeletion	Short (5)	Track virtual deletions

B-11

- Feature Name: ADOT.DBO.ParkingInThePeakPeriod
- Feature Type: Polyline
- Feature Description: This is a simple polyline feature class representing whether parking is allowed along the road segment in the peak period. The key attribute field is a coded value attribute field describing whether parking is allowed, as defined by HPMS (PEAKPARK).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by acquiring data from COGs/MPOs such as pavement and associating it with the LRS layer. This file will be submitted to FHWA on an annual basis.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HPMS
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-11. Peak Period Parking Data Description

Column Name	Column Type/Length	Column Description
ALPHA	Text (3)	Unique code this is used in data processing
PeakPark	Short (5)	Peak parking area
ONROAD	Text (32)	ATIS nomenclature represents name of road
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
EKMP	Double (38, 8)	Measure along OnRoad where NeTerm adjusted by NeO is located
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad
SwTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
NeD	Text (3)	Direction from the northeast referent that the northeast offset will apply
NEO	Double (38, 8)	Numeric offset from NeTerm in miles (+ is positive direction of measure)
NET_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where NeTerm crosses OnRoad
NET_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where NeTerm crosses OnRoad
NeTERM	Text (32)	ATIS nomenclature represents name ofN or E cross-reference in ATIS intersection table
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LEDITDATE	Date	Quality control metric
LASTGEOCODE	Date	Field automatically updates with last edit made
VirtualDeletion	Short (5)	Track virtual deletions



Item 40: Peak_Parking (Peak Parking)

Description: Specific information about the presence of parking during the peak period.

Use: For investment requirements modeling to calculate capacity.

Extent: All Sample Panel sections located in urban areas, optional for all other urban sections beyond the limits of the Sample Panel.

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural								
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the code that best reflects the type of peak parking that exists using the following codes:

Code	Description
1	Parking allowed on one side.
2	Parking allowed on both sides.
3	No parking allowed or none available.

Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Figure B-8. Peak Parking Coding.

B-12

- Feature Name: ADOT.DBO.Junctions
- Feature Type: Point
- Feature Description: This is a point feature class representing the locations of at-grade intersections, restricted crossovers on divided highways, and termini points for specific routes. Key attribute fields include type of junction (INT_TYPE), agency responsible for maintenance (Maint_By), Traffic Control (TrafficControl), and a text description of the specific instance of the feature (Data).
- Feature Projection: NAD_1983_StatePlane_Arizona_Central_FIPS_0202_Feet_Intl
- Feature Extent: Statewide
- Methodology: Developed by overlaying the ATIS dataset and using the connecting nodes of roadways to describe the junction.
- Credit: ADOT
- Location: ADOT SDE – ADOT_DBO_HighwayLog
- Last Updated: January 2014
- Data Contact: Multimodal Planning Division-GIS
- Phone Number: (602) 712-7333
- Office: Multimodal Planning Division

Table B-12. Junction Data Description

Column Name	Column Type/Length	Column Description
ROUTE	Text (20)	Route Number and Name using ATIS nomenclature
CARDTYPE	Text (1)	Cardinal or Non-cardinal direction
BKMP	Double (38, 8)	Measure along OnRoad where SwTerm adjusted by SwO is located
SYM	Text (2)	Code 'J' on the entry for at-grade junctions
DATA	Text (65)	Details on the curb and gutter location
TURN_CODE	Text (10)	Turn code
YR	Text (8)	Year
COMMENT	Text (100)	Details on the curb and gutter location review and source
ONROAD	Text (32)	ATIS nomenclature represents name of road
SWTERM	Text (32)	ATIS nomenclature represents name of S or W cross-reference in ATIS intersection table
SWO	Double (38, 8)	Numeric offset from SwTerm in miles (+ is positive direction of measure)
SWT_X	Long (10)	State plane Central (NAD83) X-coordinate value of point where SwTerm crosses OnRoad
SWT_Y	Long (10)	State plane Central (NAD83) Y-coordinate value of point where SwTerm crosses OnRoad

Column Name	Column Type/Length	Column Description
LOWESTMARKER	Text (12)	Milepost for the lowest marker
KEEPLM	Short (5)	Code to keep LM
O	Short (5)	Offset on geocode
F	Short (5)	Confidence level on geocode
T	Short (5)	Confidence level on geocode
LASTGEOCODE	Date	Field automatically updates with last edit made
ORG	Text (5)	Maintenance Org code
LEDITDATE	Date	Quality control metric
County	Text (10)	County Name
Alpha	Text (3)	Unique code that is used in data processing
NodePolygonID	Long (10)	ID for polygon nodes
SwD	Text (3)	Direction from the southwest referent that the southwest offset will apply
Maint_By	Text (20)	Junction maintenance agency
INT_TYPE	Text (255)	Interchange Type
Transfer	Text (1)	Ramp transfer
ID_in_SOURCE	Long (10)	Source ID
TrafficControl	Short (5)	Traffic Control Type
MLINENAME	Text (32)	Road name
MLINEMEAS	Double (38, 8)	Measure
VirtualDeletion	Short (5)	Track virtual deletions

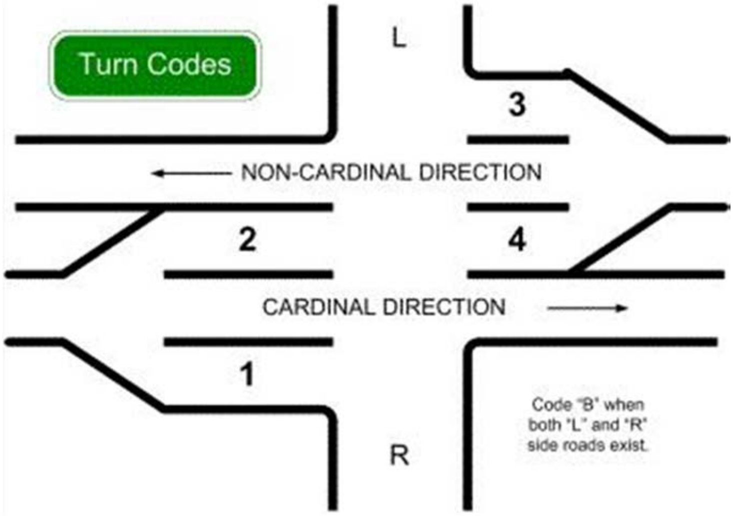
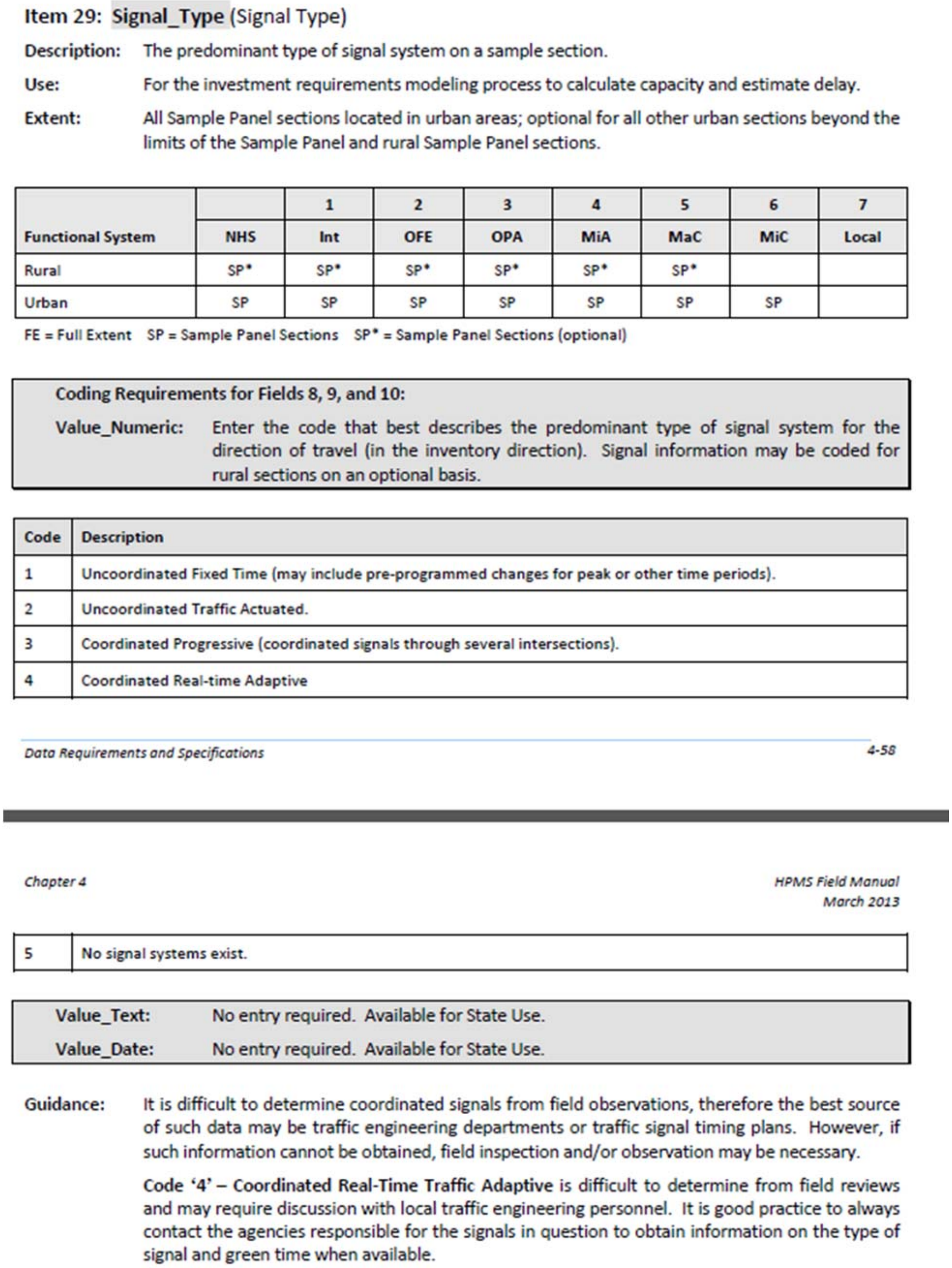


Figure B-9. Junction Turn Codes.



Item 29: Signal_Type (Signal Type)

Description: The predominant type of signal system on a sample section.

Use: For the investment requirements modeling process to calculate capacity and estimate delay.

Extent: All Sample Panel sections located in urban areas; optional for all other urban sections beyond the limits of the Sample Panel and rural Sample Panel sections.

		1	2	3	4	5	6	7
Functional System	**NHS**	**Int**	**OFE**	**OPA**	**MiA**	**MaC**	**MiC**	**Local**
Rural	SP*	SP*	SP*	SP*	SP*	SP*		
Urban	SP	SP	SP	SP	SP	SP	SP	

FE = Full Extent SP = Sample Panel Sections SP* = Sample Panel Sections (optional)

Coding Requirements for Fields 8, 9, and 10:

Value_Numeric: Enter the code that best describes the predominant type of signal system for the direction of travel (in the inventory direction). Signal information may be coded for rural sections on an optional basis.

Code	Description
1	Uncoordinated Fixed Time (may include pre-programmed changes for peak or other time periods).
2	Uncoordinated Traffic Actuated.
3	Coordinated Progressive (coordinated signals through several intersections).
4	Coordinated Real-time Adaptive
5	No signal systems exist.

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Value_Text: No entry required. Available for State Use.

Value_Date: No entry required. Available for State Use.

Guidance: It is difficult to determine coordinated signals from field observations, therefore the best source of such data may be traffic engineering departments or traffic signal timing plans. However, if such information cannot be obtained, field inspection and/or observation may be necessary.

Code '4' – Coordinated Real-Time Traffic Adaptive is difficult to determine from field reviews and may require discussion with local traffic engineering personnel. It is good practice to always contact the agencies responsible for the signals in question to obtain information on the type of signal and green time when available.

Figure B-10. Signal Types Coding.

APPENDIX C: CALIBRATION ACCURACY SPREADSHEET

The review of calibration accuracy follows Section 6.2 “Step 2 – Select Sites for Calibration of the Predictive Model for Each Facility Type” of the *Calibration User's Guide* (Bahar 2014). The HSM (2010) Equation A-1 (Equation 6.1 of the *Calibration User's Guide*) was used to estimate the calibration factor, as shown below:

$$C = \frac{\sum_{\text{all j}} \text{observed crashes at site j}}{\sum_{\text{all j}} N_u \text{at site j}}$$

This analysis follows the working paper developed by Dr. Ezra Hauer referenced the in *Calibration User's Guide* (Bahr 2014). This paper concludes that the sample size can be determined based on the jurisdiction-specific data and an analyst-selected desired variance or standard deviation to estimate the calibration factor C.

Appendix C comprises the site identification, length, AADT year 1, and observed crash frequency for each site in year one. As discussed in the HSM (2010), the calibration sites need to be representative of jurisdiction-specific conditions for the facility type selected. To accomplish this, an Excel RND function is used to generate the random number (column “Random”), and sites are sorted in the decreasing order of this random number.

Appendix C shows the calculations used to determine the variance and standard deviation for the estimated calibration factor. The calculation of the unadjusted $N_{\text{predicted}}$ for each site is done on the basis of the relevant HSM SPF only by assuming base conditions for all sites (i.e., CMF = 1 for all conditions).

After this process is complete, the desired standard deviation of the estimate of C is selected by the relevant number of sites required to meet this accuracy. As stated in the *Calibration User's Guide*, the effort necessary to undertake this calibration process primarily depends on the analyst's choice of the desired standard deviation of C. Based on the considerations described in Appendix B, it is suggested that the standard deviation of the estimate of the calibration factor C be of ±0.1 C. Thus, for a C = 1.3, a sample size of sites that results in a standard deviation of ±0.13 is deemed reasonable. A sample size that results in a standard deviation ±0.08 is deemed reasonable for a C = 0.8.

As stated in Chapter 4 of this report, data from 196 sites resulted in a 0.1167 standard deviation of the calibration factor, which is only slightly higher than 0.1 C (i.e., the recommended standard deviation in the *Calibration User’s Guide*). Despite not reaching the recommended level of accuracy, it was determined (is consultation with NAVIGATS), that 196 sites with approximately 130 crashes for 2012 was deemed acceptable.

Calculations from Tables C-1 thru Table C-8

Where: N_u = Miles * AADT * EXP(-0.312)/1000000
Comul $N_{u =}$ N_U + Comul N_u
K_J = 0.236/Miles
Crashes + K_j * Crashes^2 = Crashes + K_j * Crashes^2
CUM K_j * Crashses^2 = (Crashes + K_j * Crashes^2) + (CUM K_j * Crashses^2)
Variance = ((CUM K_j * Crashses^2)/ (Comul N_u)^2)
Standard Deviation = SQRT(((CUM K_j * Crashses^2)/ (Comul N_u)^2))

Table C-1. Selection of Site Sample Size (Input, Sites 1-44)

Site J	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES	AADT	CRASHES
1	0.999201656	7	S 098	UH	2	2584	0.99300	2321	1
2	0.998960824	2	U 095	UH	2	584	1.00174	1634	1
3	0.998426615	6	S 264	UH	2	1292	0.99182	709	0
4	0.998322993	7	S 260	UH	2	2799	1.01532	1545	1
5	0.997965412	7	S 097	UH	2	2525	0.91191	699	0
6	0.997679665	6	S 080	UH	2	933	1.00076	1906	0
7	0.996866228	2	U 160	UH	2	716	0.16571	3200	0
8	0.99626781	8	S 266	UH	2	3774	0.17820	301	0
9	0.99594373	7	S 083	UH	2	2182	0.98892	99	0
10	0.995662843	7	S 377	UH	2	2941	1.00351	1936	1
11	0.99504842	6	S 264	UH	2	1300	1.00092	1559	0
12	0.994931616	7	S 238	UH	2	2751	0.99989	1491	0
13	0.994922781	7	S 096	UH	2	2497	0.99871	600	0
14	0.994463392	7	S 067	UH	2	1907	0.95899	1150	1
15	0.994169136	8	S 288	UH	2	3857	0.96962	721	0
16	0.993656132	8	S 473	UH	2	3884	1.03459	292	0
17	0.993362953	6	U 180	UH	2	1702	0.99947	1892	1
18	0.99331832	6	S 086	UH	2	1096	0.99894	2842	1
19	0.993278238	6	S 086	UH	2	1135	0.99810	1149	0
20	0.992880129	7	S 366	UH	2	2906	0.95622	181	0
21	0.992862749	2	U 160	UH	2	674	0.95667	5210	0
22	0.992852045	7	S 377	UH	2	2957	0.85173	1936	1
23	0.992764123	6	S 587	UH	2	1425	0.98211	7195	2
24	0.992674076	7	S 066	UH	2	1825	1.00028	4216	1
25	0.992434303	6	S 169	UH	2	1258	0.99782	4997	2
26	0.992110783	7	U 191	UH	2	3356	0.95654	80	0
27	0.991266521	7	S 260	UH	2	2770	0.99403	1284	1
28	0.990716841	6	U 180	UH	2	1670	1.03594	1444	2
29	0.989727471	7	S 188	UH	2	2683	0.20859	2866	1
30	0.989620679	6	S 264	UH	2	1321	0.99967	709	0
31	0.989380505	7	S 080	UH	2	2096	0.99814	480	1
32	0.989230801	6	S 086	UH	2	1156	1.00230	7842	1
33	0.989121113	2	S 095	UH	2	214	0.31583	12177	1
34	0.988984215	7	S 260	UH	2	2807	1.02088	1545	0
35	0.988910818	7	S 067	UH	2	1883	0.69868	1150	0
36	0.988852729	7	S 188	UH	2	2707	1.00218	786	1
37	0.98865875	8	S 078	UH	2	3698	0.98471	322	0
38	0.988446483	7	U 060	UH	2	3068	0.99797	322	0
39	0.98758028	6	S 079	UH	2	895	0.99772	2756	1
40	0.98748052	7	UX191	UH	2	3659	1.00610	315	0
41	0.987353175	7	S 286	UH	2	2857	1.00923	230	0
42	0.987243564	7	S 386	UH	2	2968	0.93462	200	1
43	0.986920067	7	S 074	UH	2	2005	0.99265	8741	1
44	0.986715271	7	S 088	UH	2	2421	1.02067	146	0

Table C-2. Selection of Site Sample Size (Output, Sites 1-44)

		Cumul NU		Crashes+	CUM K_i*Crash			
Site J	**N_u**	**0**	**K_j**	**K_j*Crash**	**0.00**	**Variance**	**Standard Deviation**	**Estimated C**
1	0.62	0.62	0.24	1.24	1.24	3.2641	1.8067	1.6240
2	0.44	1.05	0.24	1.24	2.47	2.2302	1.4934	1.8992
3	0.19	1.24	0.24	0.00	2.47	1.6060	1.2673	1.6116
4	0.42	1.66	0.23	1.23	3.71	1.3447	1.1596	1.8072
5	0.17	1.83	0.26	0.00	3.71	1.1061	1.0517	1.6390
6	0.51	2.34	0.24	0.00	3.71	0.6768	0.8227	1.2821
7	0.14	2.48	1.42	0.00	3.71	0.6017	0.7757	1.2089
8	0.01	2.50	1.32	0.00	3.71	0.5948	0.7712	1.2019
9	0.03	2.52	0.24	0.00	3.71	0.5825	0.7632	1.1895
10	0.52	3.04	0.24	1.24	4.94	0.5342	0.7309	1.3153
11	0.42	3.46	0.24	0.00	4.94	0.4132	0.6428	1.1567
12	0.40	3.86	0.24	0.00	4.94	0.3322	0.5764	1.0372
13	0.16	4.02	0.24	0.00	4.94	0.3063	0.5534	0.9959
14	0.29	4.31	0.25	1.25	6.19	0.3329	0.5770	1.1598
15	0.19	4.50	0.24	0.00	6.19	0.3058	0.5530	1.1116
16	0.08	4.58	0.23	0.00	6.19	0.2951	0.5432	1.0920
17	0.51	5.08	0.24	1.24	7.42	0.2872	0.5359	1.1802
18	0.76	5.84	0.24	1.24	8.66	0.2537	0.5037	1.1981
19	0.31	6.15	0.24	0.00	8.66	0.2290	0.4786	1.1384
20	0.05	6.20	0.25	0.00	8.66	0.2256	0.4750	1.1299
21	1.33	7.53	0.25	0.00	8.66	0.1529	0.3910	0.9300
22	0.44	7.97	0.28	1.28	9.94	0.1565	0.3956	1.0041
23	1.89	9.86	0.24	2.96	12.90	0.1328	0.3644	1.0147
24	1.13	10.98	0.24	1.24	14.13	0.1172	0.3423	1.0016
25	1.33	12.31	0.24	2.95	17.08	0.1126	0.3356	1.0557
26	0.02	12.33	0.25	0.00	17.08	0.1123	0.3351	1.0540
27	0.34	12.68	0.24	1.24	18.32	0.1140	0.3376	1.1045
28	0.40	13.08	0.23	2.91	21.23	0.1242	0.3524	1.2237
29	0.16	13.23	1.13	2.13	23.36	0.1334	0.3652	1.2845
30	0.19	13.42	0.24	0.00	23.36	0.1296	0.3600	1.2664
31	0.13	13.55	0.24	1.24	24.60	0.1339	0.3660	1.3282
32	2.10	15.65	0.24	1.24	25.83	0.1054	0.3247	1.2139
33	1.03	16.68	0.75	1.75	27.58	0.0991	0.3148	1.1991
34	0.42	17.10	0.23	0.00	27.58	0.0943	0.3071	1.1695
35	0.21	17.32	0.34	0.00	27.58	0.0920	0.3033	1.1550
36	0.21	17.53	0.24	1.24	28.81	0.0938	0.3063	1.1982
37	0.08	17.61	0.24	0.00	28.81	0.0929	0.3048	1.1924
38	0.09	17.70	0.24	0.00	28.81	0.0920	0.3033	1.1867
39	0.73	18.43	0.24	1.24	30.05	0.0885	0.2974	1.1936
40	0.08	18.52	0.23	0.00	30.05	0.0877	0.2961	1.1882
41	0.06	18.58	0.23	0.00	30.05	0.0871	0.2951	1.1842
42	0.05	18.63	0.25	1.25	31.30	0.0902	0.3003	1.2347
43	2.32	20.95	0.24	1.24	32.54	0.0742	0.2723	1.1458
44	0.04	20.99	0.23	0.00	32.54	0.0739	0.2718	1.1436

Table C-3. Selection of Site Sample Size (Input, Sites 45-88)

Site J	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES	AADT	CRASHES
45	0.986219803	6	S 077	UH	2	863	0.98583	1520	0
46	0.986111971	6	S	UH	2	986	0.96430	1288	1
47	0.986077173	7	U 163	UH	2	3145	0.99391	2051	1
48	0.985923007	6	S 264	UH	2	1284	1.00225	5001	1
49	0.985827175	6	S 089	UH	2	1220	1.00587	3174	0
50	0.985762015	7	U 191	UH	2	3365	1.00189	80	0
51	0.985484433	6	U 070	UH	2	1577	0.97394	1243	0
52	0.985006039	2	U 089	UH	2	452	0.98243	2681	1
53	0.984815602	6	U 060	UH	2	1530	0.59618	2351	0
54	0.984532304	2	S 095	UH	2	136	1.00872	2593	1
55	0.984392096	2	U 093	UH	2	489	0.99823	6161	0
56	0.984049912	7	U 163	UH	2	3142	1.00134	2051	0
57	0.984033457	7	S 097	UH	2	2519	0.85958	699	0
58	0.983679367	2	U 160	UH	2	689	0.98872	2730	0
59	0.983553665	7	S 188	UH	2	2684	0.99670	2866	1
60	0.982890006	2	S 260	UH	2	251	1.00474	3672	3
61	0.982780995	7	S 177	UH	2	2598	0.99038	2341	2
62	0.982676835	7	S 080	UH	2	2074	0.98533	480	0
63	0.982528674	7	S 092	UH	2	2491	0.17546	3613	1
64	0.982386097	6	S 079	UH	2	876	1.00313	2634	0
65	0.982331234	7	S 082	UH	2	2119	0.99951	1882	1
66	0.982313789	7	S 066	UH	2	1827	1.00971	1988	1
67	0.98191196	2	S 089	UH	2	122	0.99754	7879	2
68	0.981806682	2	S 260	UH	2	258	0.99923	3672	1
69	0.981706775	2	U 160	UH	2	659	1.00952	4162	0
70	0.981573366	6	S 086	UH	2	1150	1.00127	2842	1
71	0.981522322	7	U 191	UH	2	3346	0.98051	80	0
72	0.981238449	6	S 264	UH	2	1361	0.97025	1731	0
73	0.980502955	7	U 191	UH	2	3453	0.98868	947	0
74	0.98043472	7	S 260	UH	2	2774	0.73032	1284	0
75	0.980356895	8	S 288	UH	2	3866	0.97530	721	1
76	0.980335044	7	S 073	UH	2	1995	0.98720	547	1
77	0.980176404	7	S 089	UH	2	2449	0.94841	2140	0
78	0.979980828	7	U 191	UH	2	3213	0.95373	2925	2
79	0.979956059	7	S 366	UH	2	2912	0.99205	181	0
80	0.979954642	7	S 177	UH	2	2599	1.00659	2062	0
81	0.979331598	7	S 277	UH	2	2826	1.00168	2361	1
82	0.979305925	6	S 264	UH	2	1314	1.02017	2169	0
83	0.979270256	7	S 075	UH	2	2045	0.98398	1977	0
84	0.979183267	7	U 191	UH	2	3403	0.98576	564	0
85	0.978991702	7	S 366	UH	2	2913	0.82620	181	0
86	0.978974649	6	U 070	UH	2	1610	0.97863	4070	0
87	0.978806432	7	S 092	UH	2	2489	1.00071	3514	2
88	0.978777999	6	U 180	UH	2	1710	0.65837	993	1

Table C-4. Selection of Site Sample Size (Output, Sites 45-88)

Site J	N_u	Cumul NU	K_j	Crashes+	CUM K_i*Crash	Variance	Standard Deviation	Estimated C
		0		K_j*Crash	0.00			
45	0.40	21.39	0.24	0.00	32.54	0.0711	0.2667	1.1222
46	0.33	21.72	0.24	1.24	33.79	0.0716	0.2676	1.1511
47	0.54	22.26	0.24	1.24	35.02	0.0707	0.2658	1.1679
48	1.34	23.60	0.24	1.24	36.26	0.0651	0.2551	1.1440
49	0.85	24.46	0.23	0.00	36.26	0.0606	0.2462	1.1041
50	0.02	24.48	0.24	0.00	36.26	0.0605	0.2460	1.1031
51	0.32	24.80	0.24	0.00	36.26	0.0590	0.2428	1.0887
52	0.70	25.50	0.24	1.24	37.50	0.0577	0.2401	1.0979
53	0.37	25.88	0.40	0.00	37.50	0.0560	0.2366	1.0820
54	0.70	26.58	0.23	1.23	38.73	0.0548	0.2342	1.0912
55	1.64	28.22	0.24	0.00	38.73	0.0486	0.2205	1.0276
56	0.55	28.77	0.24	0.00	38.73	0.0468	0.2163	1.0080
57	0.16	28.93	0.27	0.00	38.73	0.0463	0.2151	1.0024
58	0.72	29.65	0.24	0.00	38.73	0.0441	0.2099	0.9781
59	0.76	30.41	0.24	1.24	39.97	0.0432	0.2079	0.9864
60	0.99	31.40	0.23	5.11	45.08	0.0457	0.2138	1.0510
61	0.62	32.02	0.24	2.95	48.04	0.0469	0.2165	1.0931
62	0.13	32.15	0.24	0.00	48.04	0.0465	0.2156	1.0888
63	0.17	32.31	1.35	2.35	50.38	0.0482	0.2197	1.1140
64	0.71	33.02	0.24	0.00	50.38	0.0462	0.2150	1.0902
65	0.50	33.52	0.24	1.24	51.62	0.0459	0.2143	1.1037
66	0.54	34.06	0.23	1.23	52.85	0.0456	0.2134	1.1157
67	2.10	36.16	0.24	2.95	55.80	0.0427	0.2066	1.1062
68	0.98	37.14	0.24	1.24	57.03	0.0413	0.2033	1.1039
69	1.12	38.26	0.23	0.00	57.03	0.0390	0.1974	1.0716
70	0.76	39.02	0.24	1.24	58.27	0.0383	0.1956	1.0763
71	0.02	39.04	0.24	0.00	58.27	0.0382	0.1955	1.0757
72	0.45	39.49	0.24	0.00	58.27	0.0374	0.1933	1.0635
73	0.25	39.74	0.24	0.00	58.27	0.0369	0.1921	1.0568
74	0.25	39.99	0.32	0.00	58.27	0.0364	0.1909	1.0502
75	0.19	40.18	0.24	1.24	59.51	0.0369	0.1920	1.0702
76	0.14	40.32	0.24	1.24	60.75	0.0374	0.1933	1.0911
77	0.54	40.87	0.25	0.00	60.75	0.0364	0.1907	1.0767
78	0.75	41.61	0.25	2.99	63.74	0.0368	0.1919	1.1054
79	0.05	41.66	0.24	0.00	63.74	0.0367	0.1916	1.1042
80	0.55	42.21	0.23	0.00	63.74	0.0358	0.1891	1.0897
81	0.63	42.85	0.24	1.24	64.98	0.0354	0.1881	1.0969
82	0.59	43.44	0.23	0.00	64.98	0.0344	0.1856	1.0820
83	0.52	43.96	0.24	0.00	64.98	0.0336	0.1834	1.0692
84	0.15	44.11	0.24	0.00	64.98	0.0334	0.1828	1.0656
85	0.04	44.15	0.29	0.00	64.98	0.0333	0.1826	1.0646
86	1.06	45.21	0.24	0.00	64.98	0.0318	0.1783	1.0396
87	0.94	46.15	0.24	2.94	67.92	0.0319	0.1786	1.0618
88	0.17	46.32	0.36	1.36	69.28	0.0323	0.1797	1.0793

Table C-5. Selection of Site Sample Size (Input, Sites 89-132)

Site J	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES	AADT	CRASHES
89	0.97842535	7	S 075	UH	2	2032	1.00680	1532	1
90	0.978411909	6	U 180	UH	2	1677	0.99606	1193	1
91	0.978296043	7	S 066	UH	2	1854	1.01263	1163	2
92	0.97824525	2	U 160	UH	2	630	1.02074	4066	0
93	0.978058136	6	S 086	UH	2	1115	1.00060	1149	1
94	0.977973028	2	U 095	UH	2	534	1.00887	7488	3
95	0.97771581	6	U 180	UH	2	1651	1.00371	597	1
96	0.977341909	6	U 060	UH	2	1482	1.00123	2365	0
97	0.976962561	2	S 095	UH	2	192	1.00081	6590	1
98	0.976944446	2	S 080	UH	2	98	1.01291	5420	1
99	0.976425589	6	S 077	UH	2	849	1.03203	1520	3
100	0.976263507	6	U 070	UH	2	1615	1.00887	6732	0
101	0.976121921	6	U 070	UH	2	1612	1.00748	2899	0
102	0.975960585	6	S 287	UH	2	1420	0.98787	10642	0
103	0.975464567	2	U 095	UH	2	593	1.00137	1634	0
104	0.97535129	6	U 070	UH	2	1637	0.99899	2576	0
105	0.974808541	7	S 071	UH	2	1927	1.04468	664	0
106	0.974644678	7	U 191	UH	2	3488	1.00692	4730	0
107	0.97448558	7	S 087	UH	2	2348	1.05854	1624	0
108	0.974329552	2	U 089	UH	2	383	1.00422	7019	1
109	0.974110238	2	U 093	UH	2	490	0.24111	7322	0
110	0.974035233	6	S 264	UH	2	1342	1.02628	1731	0
111	0.974017541	2	S 095	UH	2	187	1.03263	5224	2
112	0.973943675	2	U 160	UH	2	680	0.99624	5210	0
113	0.973891619	8	S 266	UH	2	3789	0.99468	301	0
114	0.973413042	2	U 160	UH	2	711	0.98712	2730	0
115	0.973356078	7	S 366	UH	2	2916	0.99690	181	0
116	0.973160199	7	U 060	UH	2	3082	0.99824	2503	0
117	0.973115389	7	S 073	UH	2	1978	0.99057	774	0
118	0.973042543	8	S 288	UH	2	3868	0.98290	721	1
119	0.972801578	6	S	UH	2	1011	1.01064	1850	1
120	0.972466685	7	U 191	UH	2	3509	0.99099	4659	1
121	0.972379847	2	U 089	UH	2	376	1.03350	6264	3
122	0.972332786	6	S 084	UH	2	967	1.00312	976	0
123	0.971587234	6	S 089	UH	2	1229	1.00099	2734	2
124	0.971517642	2	U 093	UH	2	492	0.99637	6161	0
125	0.97149522	7	S 366	UH	2	2923	0.99275	181	0
126	0.971182586	7	S 188	UH	2	2720	0.99893	2008	0
127	0.970789529	7	S 181	UH	2	2639	0.98521	104	0
128	0.970712117	6	S 086	UH	2	1082	0.99470	2815	0
129	0.970413971	7	U 191	UH	2	3517	1.00323	4659	0
130	0.970349774	2	U 093	UH	2	491	1.00272	7322	1
131	0.970343697	8	S 099	UH	2	3720	0.99003	332	0
132	0.970192579	7	S 061	UH	2	1806	0.98920	1679	1

Table C-6. Selection of Site Sample Size (Output, Sites 89-132)

		Cumul NU		Crashes+	CUM K_i*Crash			
Site J	**N_u**	**0**	**K_j**	**K_j*Crash**	**0.00**	**Variance**	**Standard Deviation**	**Estimated C**
89	0.41	46.74	0.23	1.23	70.51	0.0323	0.1797	1.0912
90	0.32	47.05	0.24	1.24	71.75	0.0324	0.1800	1.1051
91	0.31	47.37	0.23	2.93	74.68	0.0333	0.1824	1.1400
92	1.11	48.48	0.23	0.00	74.68	0.0318	0.1783	1.1139
93	0.31	48.78	0.24	1.24	75.92	0.0319	0.1786	1.1274
94	2.02	50.80	0.23	5.11	81.02	0.0314	0.1772	1.1417
95	0.16	50.96	0.24	1.24	82.26	0.0317	0.1780	1.1577
96	0.63	51.60	0.24	0.00	82.26	0.0309	0.1758	1.1435
97	1.76	53.36	0.24	1.24	83.49	0.0293	0.1712	1.1245
98	1.47	54.82	0.23	1.23	84.73	0.0282	0.1679	1.1126
99	0.42	55.24	0.23	5.06	89.78	0.0294	0.1715	1.1585
100	1.81	57.06	0.23	0.00	89.78	0.0276	0.1661	1.1217
101	0.78	57.84	0.23	0.00	89.78	0.0268	0.1638	1.1065
102	2.81	60.65	0.24	0.00	89.78	0.0244	0.1562	1.0553
103	0.44	61.08	0.24	0.00	89.78	0.0241	0.1551	1.0477
104	0.69	61.77	0.24	0.00	89.78	0.0235	0.1534	1.0361
105	0.19	61.96	0.23	0.00	89.78	0.0234	0.1529	1.0330
106	1.27	63.23	0.23	0.00	89.78	0.0225	0.1499	1.0122
107	0.46	63.69	0.22	0.00	89.78	0.0221	0.1488	1.0049
108	1.88	65.57	0.24	1.24	91.02	0.0212	0.1455	0.9913
109	0.47	66.04	0.98	0.00	91.02	0.0209	0.1445	0.9842
110	0.47	66.52	0.23	0.00	91.02	0.0206	0.1434	0.9772
111	1.44	67.96	0.23	2.91	93.93	0.0203	0.1426	0.9859
112	1.39	69.35	0.24	0.00	93.93	0.0195	0.1398	0.9662
113	0.08	69.43	0.24	0.00	93.93	0.0195	0.1396	0.9650
114	0.72	70.15	0.24	0.00	93.93	0.0191	0.1382	0.9551
115	0.05	70.20	0.24	0.00	93.93	0.0191	0.1381	0.9545
116	0.67	70.86	0.24	0.00	93.93	0.0187	0.1368	0.9455
117	0.20	71.07	0.24	0.00	93.93	0.0186	0.1364	0.9428
118	0.19	71.26	0.24	1.24	95.17	0.0187	0.1369	0.9543
119	0.50	71.76	0.23	1.23	96.41	0.0187	0.1368	0.9616
120	1.23	72.99	0.24	1.24	97.65	0.0183	0.1354	0.9590
121	1.73	74.72	0.23	5.06	102.70	0.0184	0.1356	0.9770
122	0.26	74.98	0.24	0.00	102.70	0.0183	0.1352	0.9736
123	0.73	75.71	0.24	2.94	105.64	0.0184	0.1358	0.9906
124	1.64	77.35	0.24	0.00	105.64	0.0177	0.1329	0.9696
125	0.05	77.40	0.24	0.00	105.64	0.0176	0.1328	0.9690
126	0.54	77.94	0.24	0.00	105.64	0.0174	0.1319	0.9623
127	0.03	77.96	0.24	0.00	105.64	0.0174	0.1318	0.9620
128	0.75	78.71	0.24	0.00	105.64	0.0171	0.1306	0.9528
129	1.25	79.96	0.24	0.00	105.64	0.0165	0.1285	0.9380
130	1.96	81.92	0.24	1.24	106.88	0.0159	0.1262	0.9277
131	0.41	46.74	0.23	1.23	70.51	0.0323	0.1797	1.0912
132	0.32	47.05	0.24	1.24	71.75	0.0324	0.1800	1.1051

Table C-7. Selection of Site Sample Size (Input, Sites 133-176)

Site J	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES	AADT	CRASHES
133	0.969995968	7	S 074	UH	2	2027	0.98205	5384	1
134	0.968895436	2	U 060	UH	2	297	1.05564	6439	7
135	0.968288709	7	U 060	UH	2	3109	0.19531	2531	1
136	0.968006777	7	U 191	UH	2	3271	1.00506	3073	0
137	0.967707895	6	S 080	UH	2	931	1.03801	1906	0
138	0.967479689	6	S 264	UH	2	1364	1.04456	1731	0
139	0.967468676	6	S 264	UH	2	1365	0.96964	1731	0
140	0.966868959	6	S 086	UH	2	1106	1.00410	1149	2
141	0.96626233	7	U 191	UH	2	3435	0.99897	947	0
142	0.966180129	7	S 088	UH	2	2404	0.95386	4122	5
143	0.966001947	7	S 366	UH	2	2902	0.90484	181	0
144	0.965730011	7	S 072	UH	2	1962	1.00195	2899	0
145	0.965472441	6	U 070	UH	2	1641	1.00236	3058	0
146	0.96540796	7	U 060	UH	2	3118	0.99936	1934	1
147	0.965101328	6	U 060	UH	2	1480	1.02223	2365	5
148	0.964891644	7	S 087	UH	2	2283	1.00033	605	0
149	0.96446741	7	U 180	UH	2	3197	0.77178	1307	1
150	0.964397403	7	S 072	UH	2	1947	0.99618	1757	0
151	0.964266565	8	S 078	UH	2	3694	1.00116	322	0
152	0.963864479	7	U 191	UH	2	3301	0.99947	81	0
153	0.96370953	6	U 180	UH	2	1729	1.00090	292	1
154	0.963706507	2	S 260	UH	2	247	0.93086	5793	4
155	0.963532954	2	S 090	UH	2	126	0.98942	4066	2
156	0.962974537	6	S 087	UH	2	1184	1.08426	5216	3
157	0.96271756	7	U 060	UH	2	3108	1.00047	2335	0
158	0.96269908	7	U 191	UH	2	3508	1.01083	6459	0
159	0.962684189	6	U 060	UH	2	1516	1.01799	2365	0
160	0.962415313	6	S 064	UH	2	773	0.99758	2481	2
161	0.961950063	2	U 089	UH	2	430	0.94489	3272	1
162	0.961825118	7	S 277	UH	2	2832	0.99136	940	2
163	0.96168251	7	SB040(8)	UH	2	3051	0.22798	5294	0
164	0.961226242	7	S 097	UH	2	2515	0.49482	699	1
165	0.961068495	6	S 079	UH	2	913	0.99992	5260	0
166	0.960966119	6	S 086	UH	2	1070	0.99593	2815	2
167	0.960340225	6	S 085(1)	UH	2	1001	1.04259	1288	0
168	0.959608625	6	U 070	UH	2	1594	0.98779	2576	0
169	0.959534144	7	UA089	UH	2	3582	1.00980	1200	0
170	0.958139631	6	S 264	UH	2	1332	1.00100	1780	0
171	0.958122339	7	S 260	UH	2	2783	0.39873	1160	0
172	0.957975398	7	U 163	UH	2	3152	0.98086	2051	1
173	0.957902692	6	S 080	UH	2	959	1.00526	3455	2
174	0.95768866	7	S 098	UH	2	2590	1.02632	7423	0
175	0.957064644	7	U 191	UH	2	3534	0.99964	981	0
176	0.956779105	7	SB010(4)	UH	2	3043	0.66270	946	0

Table C-8. Selection of Site Sample Size (Output, Sites 133-176)

		Cumul NU		Crashes+	CUM K_i*Crash			
Site J	**N_u**	**0**	**K_j**	**K_j*Crash**	**0.00**	**Variance**	**Standard Deviation**	**Estimated C**
133	1.41	83.87	0.24	1.24	109.36	0.0155	0.1247	0.9301
134	1.82	85.68	0.22	17.95	127.31	0.0173	0.1317	0.9920
135	0.13	85.81	1.21	2.21	129.52	0.0176	0.1326	1.0022
136	0.83	86.64	0.23	0.00	129.52	0.0173	0.1314	0.9926
137	0.53	87.17	0.23	0.00	129.52	0.0170	0.1306	0.9866
138	0.48	87.65	0.23	0.00	129.52	0.0169	0.1298	0.9812
139	0.45	88.10	0.24	0.00	129.52	0.0167	0.1292	0.9762
140	0.31	88.41	0.24	2.94	132.46	0.0169	0.1302	0.9954
141	0.25	88.66	0.24	0.00	132.46	0.0169	0.1298	0.9925
142	1.05	89.71	0.25	11.19	143.65	0.0178	0.1336	1.0367
143	0.04	89.75	0.26	0.00	143.65	0.0178	0.1335	1.0362
144	0.78	90.53	0.24	0.00	143.65	0.0175	0.1324	1.0273
145	0.82	91.35	0.24	0.00	143.65	0.0172	0.1312	1.0181
146	0.52	91.87	0.24	1.24	144.88	0.0172	0.1310	1.0232
147	0.65	92.51	0.23	10.77	155.65	0.0182	0.1349	1.0701
148	0.16	92.67	0.24	0.00	155.65	0.0181	0.1346	1.0683
149	0.27	92.94	0.31	1.31	156.96	0.0182	0.1348	1.0759
150	0.47	93.41	0.24	0.00	156.96	0.0180	0.1341	1.0705
151	0.09	93.50	0.24	0.00	156.96	0.0180	0.1340	1.0696
152	0.02	93.52	0.24	0.00	156.96	0.0179	0.1340	1.0693
153	0.08	93.60	0.24	1.24	158.20	0.0181	0.1344	1.0791
154	1.44	95.04	0.25	8.06	166.25	0.0184	0.1357	1.1048
155	1.07	96.11	0.24	2.95	169.21	0.0183	0.1353	1.1133
156	1.51	97.62	0.22	4.96	174.17	0.0183	0.1352	1.1268
157	0.62	98.25	0.24	0.00	174.17	0.0180	0.1343	1.1196
158	1.74	99.99	0.23	0.00	174.17	0.0174	0.1320	1.1001
159	0.64	100.64	0.23	0.00	174.17	0.0172	0.1311	1.0931
160	0.66	101.30	0.24	2.95	177.11	0.0173	0.1314	1.1057
161	0.83	102.12	0.25	1.25	178.36	0.0171	0.1308	1.1065
162	0.25	102.37	0.24	2.95	181.31	0.0173	0.1315	1.1234
163	0.32	102.69	1.04	0.00	181.31	0.0172	0.1311	1.1198
164	0.09	102.79	0.48	1.48	182.79	0.0173	0.1315	1.1286
165	1.41	104.19	0.24	0.00	182.79	0.0168	0.1298	1.1133
166	0.75	104.94	0.24	2.95	185.74	0.0169	0.1299	1.1244
167	0.36	105.30	0.23	0.00	185.74	0.0168	0.1294	1.1206
168	0.68	105.98	0.24	0.00	185.74	0.0165	0.1286	1.1134
169	0.32	106.30	0.23	0.00	185.74	0.0164	0.1282	1.1100
170	0.48	106.78	0.24	0.00	185.74	0.0163	0.1276	1.1051
171	0.12	106.90	0.59	0.00	185.74	0.0163	0.1275	1.1038
172	0.54	107.44	0.24	1.24	186.98	0.0162	0.1273	1.1076
173	0.93	108.37	0.23	2.94	189.92	0.0162	0.1272	1.1166
174	2.04	110.40	0.23	0.00	189.92	0.0156	0.1248	1.0960
175	0.26	110.67	0.24	0.00	189.92	0.0155	0.1245	1.0934
176	0.17	110.83	0.36	0.00	189.92	0.0155	0.1243	1.0917

Table C-9. Selection of Site Sample Size (Input, Sites 177-196)

Site J	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES	AADT	CRASHES
177	0.956664699	6	S 077	UH	2	838	0.98585	7019	1
178	0.956465743	2	S 080	UH	2	102	1.00044	4187	1
179	0.955925051	6	S 086	UH	2	1134	0.98720	1149	0
180	0.955381695	2	U 060	UH	2	304	0.95221	665	0
181	0.954596021	2	S 095	UH	2	183	1.00213	5224	1
182	0.954506519	6	S 080	UH	2	929	1.00849	1906	0
183	0.954320297	6	S 264	UH	2	1326	1.00550	1780	0
184	0.953565821	7	S 188	UH	2	2688	0.99825	1059	0
185	0.953340784	2	U 160	UH	2	623	0.99666	2137	0
186	0.953051248	7	U 191	UH	2	3330	0.98456	81	0
187	0.952963129	7	U 191	UH	2	3393	0.98965	564	0
188	0.952738865	7	S 087	UH	2	2274	1.00006	1396	3
189	0.95273458	2	U 089	UH	2	429	0.99351	3272	0
190	0.952494678	7	U 180	UH	2	3201	1.01623	1307	2
191	0.951914625	7	S 083	UH	2	2208	1.02367	1239	0
192	0.951771276	7	S 074	UH	2	2017	1.00951	4398	0
193	0.951647944	7	S 377	UH	2	2940	1.00059	1937	0
194	0.951340019	7	S 071	UH	2	1916	1.29741	664	0
195	0.950779106	6	U 070	UH	2	1569	0.96806	1243	1
196	0.950616625	7	S 071	UH	2	1930	0.99984	894	0

Table C-10. Selection of Site Sample Size (Output, Sites 177-196)

		Cumul NU		Crashes+	CUM K_i*Crash			
Site J	N_u	0	K_j	K_j*Crash	0.00	Variance	Standard Deviation	Estimated C
177	1.85	112.68	0.24	1.24	191.16	0.0151	0.1227	1.0827
178	1.12	113.80	0.24	1.24	192.39	0.0149	0.1219	1.0808
179	0.30	114.10	0.24	0.00	192.39	0.0148	0.1216	1.0780
180	0.17	114.27	0.25	0.00	192.39	0.0147	0.1214	1.0764
181	1.40	115.67	0.24	1.24	193.63	0.0145	0.1203	1.0720
182	0.51	116.19	0.23	0.00	193.63	0.0143	0.1198	1.0673
183	0.48	116.66	0.23	0.00	193.63	0.0142	0.1193	1.0629
184	0.28	116.95	0.24	0.00	193.63	0.0142	0.1190	1.0603
185	0.57	117.51	0.24	0.00	193.63	0.0140	0.1184	1.0552
186	0.02	117.54	0.24	0.00	193.63	0.0140	0.1184	1.0550
187	0.15	117.69	0.24	0.00	193.63	0.0140	0.1182	1.0537
188	0.37	118.06	0.24	5.12	198.75	0.0143	0.1194	1.0757
189	0.87	118.93	0.24	0.00	198.75	0.0141	0.1185	1.0679
190	0.35	119.28	0.23	2.93	201.68	0.0142	0.1191	1.0815
191	0.34	119.62	0.23	0.00	201.68	0.0141	0.1187	1.0784
192	1.19	120.81	0.23	0.00	201.68	0.0138	0.1176	1.0678
193	0.52	121.32	0.24	0.00	201.68	0.0137	0.1171	1.0633
194	0.23	121.55	0.18	0.00	201.68	0.0136	0.1168	1.0613
195	0.32	121.88	0.24	1.24	202.93	0.0137	0.1169	1.0667
196	0.24	122.12	0.24	0.00	202.93	0.0136	0.1167	1.0646

APPENDIX D: SEGMENT DATA ASSIGNMENT

Appendix D includes sample data sheets for the data assigned to individual segments.

Table D-1. Sample Segment Data

Site ID	2584	2584	2584
Site #	1	1	1
Segment #	1	2	3
HWY #	S 098	S 098	S 098
Beg MP or Coordinate(Mid point x coord)	893597.7878	893597.7878	893597.7878
End MP or Coordinate(Mid point y coord)	2065791.215	2065791.215	2065791.215
AADT (year i)	2321	2321	2321
Tangent (T) or Curve (H or V)	H	T	H
Overall Length	0.993		
Length (mi)	0.260	0.218	0.515
Lane Width (ft)	12	12	12
Shoulder Width (ft)	5	5	5
Shoulder Type (p,g,c or t)	Paved	Paved	Paved
Curve Spiral Transition 1 or 1/2 (If on approach only) or 0 (none)a	0	0	0
Horizontal Curve Radius (ft)	1876.9426	0.00	1876.9426
Curve Superelevation (ft/ft)[b]	0	0	0
Vertical Grade (%)[c]	0	0	0
# of Driveways	0	0	0
Driveway Density (Both sides) Per Mile[e,g]	0	0	0
Centerline Rumble Strips (y or no)[a]	N	N	N
Passing Lane or Short 4-Lane (PL, SH or n)	N	N	N
TWLTL (y or n)	N	N	N
Roadside design (1-7)[f]	3	3	3
Lighting (y or n)[f]	N	N	N
Automated Speed Enforcement (y or n)[a]	N	N	N

Table D-2. Statewide Two-Way Rural Crashes

	O	KABC	KABCO
Single-Vehicle Crashes			
Collisions with animals	20.79%	2.82%	14.26%
Collisions with Bicycle	0.00%	0.40%	0.15%
Collision with Pedestrian	0.00%	0.70%	0.26%
Overturned	4.88%	19.62%	10.24%
Ran Off Road	48.14%	34.42%	43.16%
Other Single-Vehicle Crash	2.00%	2.00%	2.00%
Total Single-Vehicle Crash	75.82%	59.96%	70.05%
Multi-Vehicle Crashes			
Angle collision	2.93%	10.76%	5.78%
Head-on collision	0.29%	4.83%	1.94%
Rear-end collision	7.52%	9.96%	8.41%
Sideswipe collision	7.29%	6.54%	7.02%
Other multi-vehicle collision	6.15%	7.95%	6.80%
Total multi-vehicle collision	24.18%	40.04%	29.95%
Total Crashes	100.00%	100.00%	100.00%

Table D-3. Sample Segment CMFs

Features	CMF	2584-1-1	2584-1-2	2584-1-3
Lane Width	CMF_{1r}=(CMF_{ra} - 1.0) x P_{ra} + 1.0	1.00	1.00	1.00
	CMF_{ra}	1.00	1.00	1.00
	P_{ra}	52.11%	52.11%	52.11%
Shoulder Width and Type	CMF_{2r}=(CMF_{wra} x CMF_{tra} - 1.0) x P_{ra} + 1.0	1.08	1.08	1.08
	CMF_{wra}	1.15	1.15	1.15
	CMF_{tra}	1.00	1.00	1.00
	P_{ra}	52.11%	52.11%	52.11%
Horizontal Curves		1.11	1.00	1.05
	CMF_{3r}=((1.55 x L_C) + (80.2/R) - (0.012 x S)) / (1.55 x L_C)	1.11	#DIV/0!	1.05
	Y/N	H	T	H
	$L_{C\ (miles)}$	0.26	0.22	0.51
	R (feet)	1876.94	0.00	1876.94
	S	0	0	0
Superelevation	CMF_{4r}	1.00	1.00	1.00
Grades	CMF_{5r}=**Table 10-11**	1.00	1.00	1.00
Driveway Density		1.00	1.00	1.00
	CMF_{6r}=(0.322 + DD x [0.05-0.005 x Ln(AADT)]) / (0.322 + 5 x [0.05-0.005 x Ln(AADT)])	0.53	0.53	0.53
	Less tham 5 CMF is 1 DD	0.00	0.00	0.00
Rumble Strip	CMF_{7r}	1.00	1.00	1.00
	Y/N	N	N	N
Passing Lane	CMF_{8r}	1.00	1.00	1.00
	Y/N	N	N	N
TWLTL	CMF_{9r}=1.0 - (0.7 x P_{dwy} x $P_{LT/D}$)	1.00	1.00	1.00
	Pdwy=((0.0047 x DD) + (0.0024 x DD^(2))) / (1.199 + (0.0047 x DD) + (0.0024 x DD^(2)))	0	0	0
	DD	0.00	0.00	0.00
	$P_{LT/D}$	0	1	2
Roadside Design	CMF_{10r}=e^(-0.6869 + 0.0668 x RHR) / e^(-0.4865)	1.00	1.00	1.00
	RHR	3.00	3.00	3.00
Lighting	$CMF_{11r=}$	1.00	1.00	1.00
	Y/N	N	N	N
	If Yes =1-[(1-.72 x P_{inr} - .83 x P_{pnr}) x P_{nr}	0.83	0.83	0.83
ASE	CMF_{12r}	1.00	1.00	1.00
	Y/N	N	N	N

Table D-3. Sample Segment CMFs

Features	CMF	2584-1-1	2584-1-2	2584-1-3
Predicted	$N_{predicted}=N_{spfx}$ x (CMF_{1x} x CMF_{2x} x…x CMF_{yx}) x C_x			
	(CMF1x x CMF2x x…x CMFyx)	1.193	1.078	1.136
Base Condition	$N_{spf\ rs}$=AADT x L x 365 x 10^(-6) x e^(-0.312)	0.161	0.135	0.319
	Predicted Number of Crashes	0.192	0.146	0.363
	Sum Crashes	0.701		
	C	5.204	0.000	0.000

Table D-4. CMF_{ra} (Lane Width)

Feature	AADT	AADT	AADT
Lane Width	<400	400-2000	>2000
9' or less	1.05	1.589801	1.5
10'	1.02	1.356175	1.3
11'	1.01	1.058025	1.05
12' or more	1	1	1

Table D-5. CMF_{wra} (Shoulder Width)

Feature	AADT	AADT	AADT
Shoulder Width	<400	400-2000	>2000
0'	1.1	1.58025	1.5
2'	1.07	1.344703	1.3
4'	1.02	1.17608125	1.15
6'	1	1	1

Table D-6. CMF_{tra} (Shoulder Type)

	Shoulder Width (feet)						
Shoulder Type	0	1	2	3	4	6	8
Paved	1	1	1	1	1	1	1
Gravel	1	1	1.01	1.01	1.01	1.02	1.02
Composite	1	1.01	1.02	1.02	1.03	1.04	1.06
Turf	1	1.01	1.03	1.04	1.05	1.08	1.11
Shoulder Type	0	1	2	3	4	6	8

Table D-7. CMF_{5r} (Approximate Grade)

Level Grade	Moderate Terrain	Steep Terrain
(<= 3%)	(3% -<=6%)	(>6%)
1	1.1	1.16

Table D-8. CMF_{12r} (Proportion of Nightime Crashes)

Roadway Type	KABC P_{inr}	0 P_{pnr}	KABCO P_{nr}
2U	0.23	0.37	0.32

Table D-9. Sample Site Crash Data

CMF	2584-1-1	2584-1-2	2584-1-3
Observed total (KABCO) crash frequency for year i	1	0	0
Observed total (KABC) crash frequency for year i	0	0	0
Observed PDO (O) crash frequency for year i	1	0	0
Observed driveway-related crash frequency	0	0	0
Observed total (KABCO) nightime crash frequency at unlit segment	0	0	0
Observed Fatal and Injury (KABC) nightime crash frequency at unlit segments	0	0	0
Observed PDO (O) nightime crash frequency at unlit segments	0	0	0

APPENDIX E: SITE DATA

Table E-1 on the following page presents the data used for the predictive analysis of individual segments.

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
1	1	0.9992017	7	S 098	UH	2	2584	0.993
1	2	0.9992017	7	S 098	UH	2	2584	
1	3	0.9992017	7	S 098	UH	2	2584	
2	1	0.9989608	2	U 095	UH	2	584	1.00174
3	1	0.9984266	6	S 264	UH	2	1292	0.99182
4	1	0.998323	7	S 260	UH	2	2799	1.01532
4	2	0.998323	7	S 260	UH	2	2799	
4	3	0.998323	7	S 260	UH	2	2799	
5	1	0.9979654	7	S 097	UH	2	2525	0.91191
5	2	0.9979654	7	S 097	UH	2	2525	
5	3	0.9979654	7	S 097	UH	2	2525	
5	4	0.9979654	7	S 097	UH	2	2525	
5	5	0.9979654	7	S 097	UH	2	2525	
6	1	0.9976797	6	S 080	UH	2	933	1.00076
6	2	0.9976797	6	S 080	UH	2	933	
6	3	0.9976797	6	S 080	UH	2	933	
6	4	0.9976797	6	S 080	UH	2	933	
6	5	0.9976797	6	S 080	UH	2	933	
6	6	0.9976797	6	S 080	UH	2	933	
6	7	0.9976797	6	S 080	UH	2	933	
7	1	0.9968662	2	U 160	UH	2	716	0.16571
8	1	0.9962678	8	S 266	UH	2	3774	0.1782
9	1	0.9959437	7	S 083	UH	2	2182	0.98892
9	2	0.9959437	7	S 083	UH	2	2182	
9	3	0.9959437	7	S 083	UH	2	2182	
10	1	0.9956628	7	S 377	UH	2	2941	1.00351
11	1	0.9950484	6	S 264	UH	2	1300	1.00092
11	2	0.9950484	6	S 264	UH	2	1300	
11	3	0.9950484	6	S 264	UH	2	1300	
11	4	0.9950484	6	S 264	UH	2	1300	
12	1	0.9949316	7	S 238	UH	2	2751	0.99989
12	2	0.9949316	7	S 238	UH	2	2751	
13	1	0.9949228	7	S 096	UH	2	2497	0.99871
13	2	0.9949228	7	S 096	UH	2	2497	
13	3	0.9949228	7	S 096	UH	2	2497	
13	4	0.9949228	7	S 096	UH	2	2497	
13	5	0.9949228	7	S 096	UH	2	2497	
13	6	0.9949228	7	S 096	UH	2	2497	
14	1	0.9944634	7	S 067	UH	2	1907	0.95899
14	2	0.9944634	7	S 067	UH	2	1907	
14	3	0.9944634	7	S 067	UH	2	1907	
15	1	0.9941691	8	S 288	UH	2	3857	0.96962

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
15	2	0.9941691	8	S 288	UH	2	3857	
15	3	0.9941691	8	S 288	UH	2	3857	
15	4	0.9941691	8	S 288	UH	2	3857	
16	1	0.9936561	8	S 473	UH	2	3884	1.03459
16	2	0.9936561	8	S 473	UH	2	3884	
16	3	0.9936561	8	S 473	UH	2	3884	
16	4	0.9936561	8	S 473	UH	2	3884	
16	5	0.9936561	8	S 473	UH	2	3884	
16	6	0.9936561	8	S 473	UH	2	3884	
16	7	0.9936561	8	S 473	UH	2	3884	
16	8	0.9936561	8	S 473	UH	2	3884	
16	9	0.9936561	8	S 473	UH	2	3884	
16	10	0.9936561	8	S 473	UH	2	3884	
16	11	0.9936561	8	S 473	UH	2	3884	
17	1	0.993363	6	U 180	UH	2	1702	0.99947
17	2	0.993363		U 180	UH	2	1702	
18	1	0.9933183	6	S 086	UH	2	1096	0.99894
19	1	0.9932782	6	S 086	UH	2	1135	0.9981
20	1	0.9928801	7	S 366	UH	2	2906	0.95622
20	2	0.9928801	7	S 366	UH	2	2906	
20	3	0.9928801	7	S 366	UH	2	2906	
20	4	0.9928801	7	S 366	UH	2	2906	
20	5	0.9928801	7	S 366	UH	2	2906	
20	6	0.9928801	7	S 366	UH	2	2906	
20	7	0.9928801	7	S 366	UH	2	2906	
20	8	0.9928801	7	S 366	UH	2	2906	
21	1	0.9928627	2	U 160	UH	2	674	0.95667
22	1	0.992852	7	S 377	UH	2	2957	0.85173
22	2	0.992852	7	S 377	UH	2	2957	
23	1	0.9927641	6	S 587	UH	2	1425	0.98211
23	2	0.9927641	6	S 587	UH	2	1425	
23	3	0.9927641	6	S 587	UH	2	1425	
24	1	0.9926741	7	S 066	UH	2	1825	1.00028
25	1	0.9924343	6	S 169	UH	2	1258	0.99782
25	2	0.9924343	6	S 169	UH	2	1258	
25	3	0.9924343	6	S 169	UH	2	1258	
26	1	0.9921108	7	U 191	UH	2	3356	0.95654
26	2	0.9921108	7	U 191	UH	2	3356	
26	3	0.9921108	7	U 191	UH	2	3356	
26	4	0.9921108	7	U 191	UH	2	3356	
26	5	0.9921108	7	U 191	UH	2	3356	
27	1	0.9912665	7	S 260	UH	2	2770	0.99403
28	1	0.9907168	6	U 180	UH	2	1670	1.03594
28	2	0.9907168	6	U 180	UH	2	1670	
28	3	0.9907168	6	U 180	UH	2	1670	
29	1	0.9897275	7	S 188	UH	2	2683	0.20859
30	1	0.9896207	6	S 264	UH	2	1321	0.99967
30	2	0.9896207	6	S 264	UH	2	1321	
30	3	0.9896207	6	S 264	UH	2	1321	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
30	4	0.9896207	6	S 264	UH	2	1321	
31	1	0.9893805	7	S 080	UH	2	2096	0.99814
32	1	0.9892308	6	S 086	UH	2	1156	1.0023
33	1	0.9891211	2	S 095	UH	2	214	0.31583
33	2	0.9891211	2	S 095	UH	2	214	
33	3	0.9891211	2	S 095	UH	2	214	
34	1	0.9889842	7	S 260	UH	2	2807	1.02088
34	2	0.9889842	7	S 260	UH	2	2807	
34	3	0.9889842	7	S 260	UH	2	2807	
34	4	0.9889842	7	S 260	UH	2	2807	
34	5	0.9889842	7	S 260	UH	2	2807	
34	6	0.9889842	7	S 260	UH	2	2807	
35	1	0.9889108	7	S 067	UH	2	1883	0.69868
35	2	0.9889108	7	S 067	UH	2	1883	
35	3	0.9889108	7	S 067	UH	2	1883	
36	1	0.9888527	7	S 188	UH	2	2707	1.00218
36	2	0.9888527	7	S 188	UH	2	2707	
36	3	0.9888527	7	S 188	UH	2	2707	
36	4	0.9888527	7	S 188	UH	2	2707	
36	5	0.9888527	7	S 188	UH	2	2707	
37	1	0.9886588	8	S 078	UH	2	3698	0.98471
37	2	0.9886588	8	S 078	UH	2	3698	
37	3	0.9886588	8	S 078	UH	2	3698	
37	4	0.9886588	8	S 078	UH	2	3698	
37	5	0.9886588	8	S 078	UH	2	3698	
37	6	0.9886588	8	S 078	UH	2	3698	
38	1	0.9884465	7	U 060	UH	2	3068	0.99797
38	2	0.9884465	7	U 060	UH	2	3068	
39	1	0.9875803	6	S 079	UH	2	895	0.99772
40	1	0.9874805	7	UX191	UH	2	3659	1.0061
40	2	0.9874805	7	UX191	UH	2	3659	
40	3	0.9874805	7	UX191	UH	2	3659	
40	4	0.9874805	7	UX191	UH	2	3659	
41	1	0.9873532	7	S 286	UH	2	2857	1.00923
42	1	0.9872436	7	S 386	UH	2	2968	0.93462
42	2	0.9872436	7	S 386	UH	2	2968	
42	3	0.9872436	7	S 386	UH	2	2968	
42	4	0.9872436	7	S 386	UH	2	2968	
42	5	0.9872436	7	S 386	UH	2	2968	
42	6	0.9872436	7	S 386	UH	2	2968	
42	7	0.9872436	7	S 386	UH	2	2968	
42	8	0.9872436	7	S 386	UH	2	2968	
42	9	0.9872436	7	S 386	UH	2	2968	
43	1	0.9869201	7	S 074	UH	2	2005	0.99265
44	1	0.9867153	7	S 088	UH	2	2421	1.02067
44	2	0.9867153	7	S 088	UH	2	2421	
44	3	0.9867153	7	S 088	UH	2	2421	
44	4	0.9867153	7	S 088	UH	2	2421	
44	5	0.9867153	7	S 088	UH	2	2421	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
45	1	0.9862198	6	S 077	UH	2	863	0.98583
45	2	0.9862198	6	S 077	UH	2	863	
46	1	0.986112	6	S 085(1)	UH	2	986	0.9643
47	1	0.9860772	7	U 163	UH	2	3145	0.99391
47	2	0.9860772	7	U 163	UH	2	3145	
47	3	0.9860772	7	U 163	UH	2	3145	
47	4	0.9860772	7	U 163	UH	2	3145	
48	1	0.985923	6	S 264	UH	2	1284	1.00225
49	1	0.9858272	6	S 089	UH	2	1220	1.00587
50	1	0.985762	7	U 191	UH	2	3365	1.00189
50	2	0.985762	7	U 191	UH	2	3365	
50	3	0.985762	7	U 191	UH	2	3365	
50	4	0.985762	7	U 191	UH	2	3365	
50	5	0.985762	7	U 191	UH	2	3365	
51	1	0.9854844	6	U 070	UH	2	1577	0.97394
52	1	0.985006	2	U 089	UH	2	452	0.98243
53	1	0.9848156	6	U 060	UH	2	1530	0.59618
54	1	0.9845323	2	S 095	UH	2	136	1.00872
54	2	0.9845323	2	S 095	UH	2	136	
54	3	0.9845323	2	S 095	UH	2	136	
55	1	0.9843921	2	U 093	UH	2	489	0.99823
56	1	0.9840499	7	U 163	UH	2	3142	1.00134
57	1	0.9840335	7	S 097	UH	2	2519	0.85958
57	2	0.9840335	7	S 097	UH	2	2519	
57	3	0.9840335	7	S 097	UH	2	2519	
57	4	0.9840335	7	S 097	UH	2	2519	
57	5	0.9840335	7	S 097	UH	2	2519	
57	6	0.9840335	7	S 097	UH	2	2519	
57	7	0.9840335	7	S 097	UH	2	2519	
58	1	0.9836794	2	U 160	UH	2	689	0.98872
59	1	0.9835537	7	S 188	UH	2	2684	0.9967
59	2	0.9835537	7	S 188	UH	2	2684	
59	3	0.9835537	7	S 188	UH	2	2684	
60	1	0.98289	2	S 260	UH	2	251	1.00474
60	2	0.98289	2	S 260	UH	2	251	
61	1	0.982781	7	S 177	UH	2	2598	0.99038
61	2	0.982781	7	S 177	UH	2	2598	
61	3	0.982781	7	S 177	UH	2	2598	
61	4	0.982781	7	S 177	UH	2	2598	
61	5	0.982781	7	S 177	UH	2	2598	
62	1	0.9826768	7	S 080	UH	2	2074	0.98533
63	1	0.9825287	7	S 092	UH	2	2491	0.17546
64	1	0.9823861	6	S 079	UH	2	876	1.00313
64	2	0.9823861	6	S 079	UH	2	876	
64	3	0.9823861	6	S 079	UH	2	876	
65	1	0.9823312	7	S 082	UH	2	2119	0.99951
65	2	0.9823312	7	S 082	UH	2	2119	
66	1	0.9823138	7	S 066	UH	2	1827	1.00971
66	2	0.9823138	7	S 066	UH	2	1827	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
67	1	0.981912	2	S 089	UH	2	122	0.99754
67	2	0.981912	2	S 089	UH	2	122	
67	3	0.981912	2	S 089	UH	2	122	
67	4	0.981912	2	S 089	UH	2	122	
68	1	0.9818067	2	S 260	UH	2	258	0.99923
69	1	0.9817068	2	U 160	UH	2	659	1.00952
70	1	0.9815734	6	S 086	UH	2	1150	1.00127
70	2	0.9815734	6	S 086	UH	2	1150	
71	1	0.9815223	7	U 191	UH	2	3346	0.98051
71	2	0.9815223	7	U 191	UH	2	3346	
71	3	0.9815223	7	U 191	UH	2	3346	
71	4	0.9815223	7	U 191	UH	2	3346	
71	5	0.9815223	7	U 191	UH	2	3346	
71	6	0.9815223	7	U 191	UH	2	3346	
72	1	0.9812384	6	S 264	UH	2	1361	0.97025
73	1	0.980503	7	U 191	UH	2	3453	0.98868
74	1	0.9804347	7	S 260	UH	2	2774	0.73032
75	1	0.9803569	8	S 288	UH	2	3866	0.9753
75	2	0.9803569	8	S 288	UH	2	3866	
75	3	0.9803569	8	S 288	UH	2	3866	
75	4	0.9803569	8	S 288	UH	2	3866	
76	1	0.980335	7	S 073	UH	2	1995	0.9872
77	1	0.9801764	7	S 089	UH	2	2449	0.94841
77	2	0.9801764	7	S 089	UH	2	2449	
77	3	0.9801764	7	S 089	UH	2	2449	
78	1	0.9799808	7	U 191	UH	2	3213	0.95373
78	2	0.9799808	7	U 191	UH	2	3213	
78	3	0.9799808	7	U 191	UH	2	3213	
79	1	0.9799561	7	S 366	UH	2	2912	0.99205
79	2	0.9799561	7	S 366	UH	2	2912	
79	3	0.9799561	7	S 366	UH	2	2912	
79	4	0.9799561	7	S 366	UH	2	2912	
79	5	0.9799561	7	S 366	UH	2	2912	
79	6	0.9799561	7	S 366	UH	2	2912	
80	1	0.9799546	7	S 177	UH	2	2599	1.00659
80	2	0.9799546	7	S 177	UH	2	2599	
81	1	0.9793316	7	S 277	UH	2	2826	1.00168
82	1	0.9793059	6	S 264	UH	2	1314	1.02017
82	2	0.9793059	6	S 264	UH	2	1314	
82	3	0.9793059	6	S 264	UH	2	1314	
82	4	0.9793059	6	S 264	UH	2	1314	
82	5	0.9793059	6	S 264	UH	2	1314	
82	6	0.9793059	6	S 264	UH	2	1314	
83	1	0.9792703	7	S 075	UH	2	2045	0.98398
83	2	0.9792703	7	S 075	UH	2	2045	
83	3	0.9792703	7	S 075	UH	2	2045	
83	4	0.9792703	7	S 075	UH	2	2045	
84	1	0.9791833	7	U 191	UH	2	3403	0.98576
85	1	0.9789917	7	S 366	UH	2	2913	0.8262

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
86	1	0.9789746	6	U 070	UH	2	1610	0.97863
86	2	0.9789746	6	U 070	UH	2	1610	
87	1	0.9788064	7	S 092	UH	2	2489	1.00071
88	1	0.978778	6	U 180	UH	2	1710	0.65837
89	1	0.9784253	7	S 075	UH	2	2032	1.0068
90	1	0.9784119	6	U 180	UH	2	1677	0.99606
90	2	0.9784119	6	U 180	UH	2	1677	
91	1	0.978296	7	S 066	UH	2	1854	1.01263
91	2	0.978296	7	S 066	UH	2	1854	
91	3	0.978296	7	S 066	UH	2	1854	
91	4	0.978296	7	S 066	UH	2	1854	
91	5	0.978296	7	S 066	UH	2	1854	
92	1	0.9782452	2	U 160	UH	2	630	1.02074
93	1	0.9780581	6	S 086	UH	2	1115	1.0006
94	1	0.977973	2	U 095	UH	2	534	1.00887
94	2	0.977973	2	U 095	UH	2	534	
95	1	0.9777158	6	U 180	UH	2	1651	1.00371
95	2	0.9777158	6	U 180	UH	2	1651	
95	3	0.9777158	6	U 180	UH	2	1651	
95	4	0.9777158	6	U 180	UH	2	1651	
96	1	0.9773419	6	U 060	UH	2	1482	1.00123
96	2	0.9773419	6	U 060	UH	2	1482	
96	3	0.9773419	6	U 060	UH	2	1482	
97	1	0.9769626	2	S 095	UH	2	192	1.00081
98	1	0.9769444	2	S 080	UH	2	98	1.01291
98	2	0.9769444	2	S 080	UH	2	98	
99	1	0.9764256	6	S 077	UH	2	849	1.03203
99	2	0.9764256	6	S 077	UH	2	849	
99	3	0.9764256	6	S 077	UH	2	849	
99	4	0.9764256	6	S 077	UH	2	849	
99	5	0.9764256	6	S 077	UH	2	849	
99	6	0.9764256	6	S 077	UH	2	849	
100	1	0.9762635	6	U 070	UH	2	1615	1.00887
101	1	0.9761219	6	U 070	UH	2	1612	1.00748
102	1	0.9759606	6	S 287	UH	2	1420	0.98787
103	1	0.9754646	2	U 095	UH	2	593	1.00137
104	1	0.9753513	6	U 070	UH	2	1637	0.99899
105	1	0.9748085	7	S 071	UH	2	1927	1.04468
106	1	0.9746447	7	U 191	UH	2	3488	1.00692
107	1	0.9744856	7	S 087	UH	2	2348	1.05854
107	2	0.9744856	7	S 087	UH	2	2348	
107	3	0.9744856	7	S 087	UH	2	2348	
108	1	0.9743296	2	U 089	UH	2	383	1.00422
108	2	0.9743296	2	U 089	UH	2	383	
109	1	0.9741102	2	U 093	UH	2	490	0.24111
110	1	0.9740352	6	S 264	UH	2	1342	1.02628
111	1	0.9740175	2	S 095	UH	2	187	1.03263
111	2	0.9740175	2	S 095	UH	2	187	
111	3	0.9740175	2	S 095	UH	2	187	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
111	4	0.9740175	2	S 095	UH	2	187	
112	1	0.9739437	2	U 160	UH	2	680	0.99624
113	1	0.9738916	8	S 266	UH	2	3789	0.99468
113	2	0.9738916	8	S 266	UH	2	3789	
113	3	0.9738916	8	S 266	UH	2	3789	
114	1	0.973413	2	U 160	UH	2	711	0.98712
114	2	0.973413	2	U 160	UH	2	711	
114	3	0.973413	2	U 160	UH	2	711	
115	1	0.9733561	7	S 366	UH	2	2916	0.9969
115	2	0.9733561	7	S 366	UH	2	2916	
115	3	0.9733561	7	S 366	UH	2	2916	
115	4	0.9733561	7	S 366	UH	2	2916	
115	5	0.9733561	7	S 366	UH	2	2916	
115	6	0.9733561	7	S 366	UH	2	2916	
115	7	0.9733561	7	S 366	UH	2	2916	
115	8	0.9733561	7	S 366	UH	2	2916	
116	1	0.9731602	7	U 060	UH	2	3082	0.99824
116	2	0.9731602	7	U 060	UH	2	3082	
117	1	0.9731154	7	S 073	UH	2	1978	0.99057
118	1	0.9730425	8	S 288	UH	2	3868	0.9829
118	2	0.9730425	8	S 288	UH	2	3868	
118	3	0.9730425	8	S 288	UH	2	3868	
118	4	0.9730425	8	S 288	UH	2	3868	
118	5	0.9730425	8	S 288	UH	2	3868	
119	1	0.9728016	6	S 085(1)	UH	2	1011	1.01064
119	2	0.9728016	6	S 085(1)	UH	2	1011	
120	1	0.9724667	7	U 191	UH	2	3509	0.99099
121	1	0.9723798	2	U 089	UH	2	376	1.0335
121	2	0.9723798	2	U 089	UH	2	376	
122	1	0.9723328	6	S 084	UH	2	967	1.00312
123	1	0.9715872	6	S 089	UH	2	1229	1.00099
124	1	0.9715176	2	U 093	UH	2	492	0.99637
125	1	0.9714952	7	S 366	UH	2	2923	0.99275
126	1	0.9711826	7	S 188	UH	2	2720	0.99893
126	2	0.9711826	7	S 188	UH	2	2720	
126	3	0.9711826	7	S 188	UH	2	2720	
127	1	0.9707895	7	S 181	UH	2	2639	0.98521
128	1	0.9707121	6	S 086	UH	2	1082	0.9947
129	1	0.970414	7	U 191	UH	2	3517	1.00323
130	1	0.9703498	2	U 093	UH	2	491	1.00272
131	1	0.9703437	8	S 099	UH	2	3720	0.99003
131	2	0.9703437	8	S 099	UH	2	3720	
131	3	0.9703437	8	S 099	UH	2	3720	
132	1	0.9701926	7	S 061	UH	2	1806	0.9892
133	1	0.969996	7	S 074	UH	2	2027	0.98205
134	1	0.9688954	2	U 060	UH	2	297	1.05564
134	2	0.9688954	2	U 060	UH	2	297	
134	3	0.9688954	2	U 060	UH	2	297	
134	4	0.9688954	2	U 060	UH	2	297	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
134	5	0.9688954	2	U 060	UH	2	297	
134	6	0.9688954	2	U 060	UH	2	297	
135	1	0.9682887	7	U 060	UH	2	3109	0.19531
136	1	0.9680068	7	U 191	UH	2	3271	1.00506
137	1	0.9677079	6	S 080	UH	2	931	1.03801
137	2	0.9677079	6	S 080	UH	2	931	
137	3	0.9677079	6	S 080	UH	2	931	
138	1	0.9674797	6	S 264	UH	2	1364	1.04456
138	2	0.9674797	6	S 264	UH	2	1364	
138	3	0.9674797	6	S 264	UH	2	1364	
139	1	0.9674687	6	S 264	UH	2	1365	0.96964
139	2	0.9674687	6	S 264	UH	2	1365	
139	3	0.9674687	6	S 264	UH	2	1365	
139	4	0.9674687	6	S 264	UH	2	1365	
140	1	0.966869	6	S 086	UH	2	1106	1.0041
140	2	0.966869	6	S 086	UH	2	1106	
140	3	0.966869	6	S 086	UH	2	1106	
140	4	0.966869	6	S 086	UH	2	1106	
140	5	0.966869	6	S 086	UH	2	1106	
141	1	0.9662623	7	U 191	UH	2	3435	0.99897
142	1	0.9661801	7	S 088	UH	2	2404	0.95386
143	1	0.9660019	7	S 366	UH	2	2902	0.90484
144	1	0.96573	7	S 072	UH	2	1962	1.00195
144	2	0.96573	7	S 072	UH	2	1962	
145	1	0.9654724	6	U 070	UH	2	1641	1.00236
145	2	0.9654724	6	U 070	UH	2	1641	
145	3	0.9654724	6	U 070	UH	2	1641	
146	1	0.965408	7	U 060	UH	2	3118	0.99936
147	1	0.9651013	6	U 060	UH	2	1480	1.02223
147	2	0.9651013	6	U 060	UH	2	1480	
147	3	0.9651013	6	U 060	UH	2	1480	
147	4	0.9651013	6	U 060	UH	2	1480	
147	5	0.9651013	6	U 060	UH	2	1480	
148	1	0.9648916	7	S 087	UH	2	2283	1.00033
148	2	0.9648916	7	S 087	UH	2	2283	
148	3	0.9648916	7	S 087	UH	2	2283	
148	4	0.9648916	7	S 087	UH	2	2283	
148	5	0.9648916	7	S 087	UH	2	2283	
149	1	0.9644674	7	U 180	UH	2	3197	0.77178
149	2	0.9644674	7	U 180	UH	2	3197	
150	1	0.9643974	7	S 072	UH	2	1947	0.99618
151	1	0.9642666	8	S 078	UH	2	3694	1.00116
151	2	0.9642666	8	S 078	UH	2	3694	
151	3	0.9642666	8	S 078	UH	2	3694	
151	4	0.9642666	8	S 078	UH	2	3694	
151	5	0.9642666	8	S 078	UH	2	3694	
152	1	0.9638645	7	U 191	UH	2	3301	0.99947
152	2	0.9638645	7	U 191	UH	2	3301	
152	3	0.9638645	7	U 191	UH	2	3301	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
152	4	0.9638645	7	U 191	UH	2	3301	
152	5	0.9638645	7	U 191	UH	2	3301	
152	6	0.9638645	7	U 191	UH	2	3301	
152	7	0.9638645	7	U 191	UH	2	3301	
152	8	0.9638645	7	U 191	UH	2	3301	
153	1	0.9637095	6	U 180	UH	2	1729	1.0009
154	1	0.9637065	2	S 260	UH	2	247	0.93086
154	2	0.9637065	2	S 260	UH	2	247	
154	3	0.9637065	2	S 260	UH	2	247	
155	1	0.963533	2	S 090	UH	2	126	0.98942
155	2	0.963533	2	S 090	UH	2	126	
155	3	0.963533	2	S 090	UH	2	126	
156	1	0.9629745	6	S 087	UH	2	1184	1.08426
157	1	0.9627176	7	U 060	UH	2	3108	1.00047
158	1	0.9626991	7	U 191	UH	2	3508	1.01083
158	2	0.9626991	7	U 191	UH	2	3508	
159	1	0.9626842	6	U 060	UH	2	1516	1.01799
159	2	0.9626842	6	U 060	UH	2	1516	
159	3	0.9626842	6	U 060	UH	2	1516	
160	1	0.9624153	6	S 064	UH	2	773	0.99758
160	2	0.9624153	6	S 064	UH	2	773	
160	3	0.9624153	6	S 064	UH	2	773	
160	4	0.9624153	6	S 064	UH	2	773	
160	5	0.9624153	6	S 064	UH	2	773	
161	1	0.9619501	2	U 089	UH	2	430	0.94489
161	2	0.9619501	2	U 089	UH	2	430	
161	3	0.9619501	2	U 089	UH	2	430	
162	1	0.9618251	7	S 277	UH	2	2832	0.99136
162	2	0.9618251	7	S 277	UH	2	2832	
162	3	0.9618251	7	S 277	UH	2	2832	
163	1	0.9616825	7	SB040(8)	UH	2	3051	0.22798
163	2	0.9616825	7	SB040(8)	UH	2	3051	
164	1	0.9612262	7	S 097	UH	2	2515	0.49482
165	1	0.9610685	6	S 079	UH	2	913	0.99992
166	1	0.9609661	6	S 086	UH	2	1070	0.99593
167	1	0.9603402	6	S 085(1)	UH	2	1001	1.04259
168	1	0.9596086	6	U 070	UH	2	1594	0.98779
168	2	0.9596086	6	U 070	UH	2	1594	
169	1	0.9595341	7	UA089	UH	2	3582	1.0098
169	2	0.9595341	7	UA089	UH	2	3582	
169	3	0.9595341	7	UA089	UH	2	3582	
169	4	0.9595341	7	UA089	UH	2	3582	
169	5	0.9595341	7	UA089	UH	2	3582	
169	6	0.9595341	7	UA089	UH	2	3582	
169	7	0.9595341	7	UA089	UH	2	3582	
170	1	0.9581396	6	S 264	UH	2	1332	1.001
170	2	0.9581396	6	S 264	UH	2	1332	
170	3	0.9581396	6	S 264	UH	2	1332	
170	4	0.9581396	6	S 264	UH	2	1332	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
171	1	0.9581223	7	S 260	UH	2	2783	0.39873
172	1	0.9579754	7	U 163	UH	2	3152	0.98086
173	1	0.9579027	6	S 080	UH	2	959	1.00526
173	2	0.9579027	6	S 080	UH	2	959	
173	3	0.9579027	6	S 080	UH	2	959	
174	1	0.9576887	7	S 098	UH	2	2590	1.02632
175	1	0.9570646	7	U 191	UH	2	3534	0.99964
176	1	0.9567791	7	SB010(4)	UH	2	3043	0.6627
176	2	0.9567791	7	SB010(4)	UH	2	3043	
176	3	0.9567791	7	SB010(4)	UH	2	3043	
176	4	0.9567791	7	SB010(4)	UH	2	3043	
177	1	0.9566647	6	S 077	UH	2	838	0.98585
177	2	0.9566647	6	S 077	UH	2	838	
177	3	0.9566647	6	S 077	UH	2	838	
177	4	0.9566647	6	S 077	UH	2	838	
177	5	0.9566647	6	S 077	UH	2	838	
177	6	0.9566647	6	S 077	UH	2	838	
178	1	0.9564657	2	S 080	UH	2	102	1.00044
179	1	0.9559251	6	S 086	UH	2	1134	0.9872
179	2	0.9559251	6	S 086	UH	2	1134	
179	3	0.9559251	6	S 086	UH	2	1134	
179	4	0.9559251	6	S 086	UH	2	1134	
179	5	0.9559251	6	S 086	UH	2	1134	
179	6	0.9559251	6	S 086	UH	2	1134	
180	1	0.9553817	2	U 060	UH	2	304	0.95221
181	1	0.954596	2	S 095	UH	2	183	1.00213
181	2	0.954596	2	S 095	UH	2	183	
181	3	0.954596	2	S 095	UH	2	183	
182	1	0.9545065	6	S 080	UH	2	929	1.00849
182	2	0.9545065	6	S 080	UH	2	929	
182	3	0.9545065	6	S 080	UH	2	929	
182	4	0.9545065	6	S 080	UH	2	929	
183	1	0.9543203	6	S 264	UH	2	1326	1.0055
183	2	0.9543203	6	S 264	UH	2	1326	
183	3	0.9543203	6	S 264	UH	2	1326	
183	4	0.9543203	6	S 264	UH	2	1326	
184	1	0.9535658	7	S 188	UH	2	2688	0.99825
184	2	0.9535658	7	S 188	UH	2	2688	
184	3	0.9535658	7	S 188	UH	2	2688	
184	4	0.9535658	7	S 188	UH	2	2688	
185	1	0.9533408	2	U 160	UH	2	623	0.99666
185	2	0.9533408	2	U 160	UH	2	623	
186	1	0.9530512	7	U 191	UH	2	3330	0.98456
186	2	0.9530512	7	U 191	UH	2	3330	
186	3	0.9530512	7	U 191	UH	2	3330	
186	4	0.9530512	7	U 191	UH	2	3330	
187	1	0.9529631	7	U 191	UH	2	3393	0.98965
188	1	0.9527389	7	S 087	UH	2	2274	1.00006
188	2	0.9527389	7	S 087	UH	2	2274	

Table E -1. Predictive Analysis Data

Site	Segment	Random	FuncCode	Route	Sym	LANES	Site_ID	MILES
188	3	0.9527389	7	S 087	UH	2	2274	
188	4	0.9527389	7	S 087	UH	2	2274	
189	1	0.9527346	2	U 089	UH	2	429	0.99351
189	2	0.9527346	2	U 089	UH	2	429	
189	3	0.9527346	2	U 089	UH	2	429	
189	4	0.9527346	2	U 089	UH	2	429	
189	5	0.9527346	2	U 089	UH	2	429	
190	1	0.9524947	7	U 180	UH	2	3201	1.01623
190	2	0.9524947	7	U 180	UH	2	3201	
190	3	0.9524947	7	U 180	UH	2	3201	
190	4	0.9524947	7	U 180	UH	2	3201	
191	1	0.9519146	7	S 083	UH	2	2208	1.02367
191	2	0.9519146	7	S 083	UH	2	2208	
191	3	0.9519146	7	S 083	UH	2	2208	
191	4	0.9519146	7	S 083	UH	2	2208	
191	5	0.9519146	7	S 083	UH	2	2208	
192	1	0.9517713	7	S 074	UH	2	2017	1.00951
193	1	0.9516479	7	S 377	UH	2	2940	1.00059
193	2	0.9516479	7	S 377	UH	2	2940	
193	3	0.9516479	7	S 377	UH	2	2940	
194	1	0.95134	7	S 071	UH	2	1916	1.29741
194	2	0.95134	7	S 071	UH	2	1916	
195	1	0.9507791	6	U 070	UH	2	1569	0.96806
195	2	0.9507791	6	U 070	UH	2	1569	
195	3	0.9507791	6	U 070	UH	2	1569	
196	1	0.9506166	7	S 071	UH	2	1930	0.99984

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
1	2321	2283	2229	2369	2344	2309
1	2321	2283	2229	2369	2344	2309
1	2321	2283	2229	2369	2344	2309
2	1634	1633	2569	1405	2147	1878
3	709	709	803	804	758	757
4	1545	1584	1585	1583	1455	1550
4	1545	1584	1585	1583	1455	1550
4	1545	1584	1585	1583	1455	1550
5	699	701	638	542	950	706
5	699	701	638	542	950	706
5	699	701	638	542	950	706
5	699	701	638	542	950	706
5	699	701	638	542	950	706
6	1906	1645	1684	1671	1679	1717
6	1906	1645	1684	1671	1679	1717
6	1906	1645	1684	1671	1679	1717
6	1906	1645	1684	1671	1679	1717
6	1906	1645	1684	1671	1679	1717
6	1906	1645	1684	1671	1679	1717
6	1906	1645	1684	1671	1679	1717
7	3200	3066	3104	3332	2741	3089
8	301	301	301	301	236	288
9	99	96	99	99	102	99
9	99	96	99	99	102	99
9	99	96	99	99	102	99
10	1936	1917	1966	1972	1724	1903
11	1559	709	803	804	1673	1110
11	1559	709	803	804	1673	1110
11	1559	709	803	804	1673	1110
11	1559	709	803	804	1673	1110
12	1491	1280	1686	1593	1941	1598
12	1491	1280	1686	1593	1941	1598
13	600	600	485	474	675	567
13	600	600	485	474	675	567
13	600	600	485	474	675	567
13	600	600	485	474	675	567
13	600	600	485	474	675	567
13	600	600	485	474	675	567
14	1150	1168	1154	1142	1055	1134
14	1150	1168	1154	1142	1055	1134
14	1150	1168	1154	1142	1055	1134
15	721	721	721	721	89	595
15	721	721	721	721	89	595
15	721	721	721	721	89	595
15	721	721	721	721	89	595
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294
16	292	292	292	292	304	294
17	1892	1851	1889	2334	2317	2057
17	1892	1851	1889	2334	2317	2057
18	2842	2815	2789	2752	2746	2789
19	1149	977	768	729	827	890
20	181	181	181	181	137	172
20	181	181	181	181	137	172
20	181	181	181	181	137	172
20	181	181	181	181	137	172
20	181	181	181	181	137	172
20	181	181	181	181	137	172
20	181	181	181	181	137	172
20	181	181	181	181	137	172
21	5210	4759	4800	4867	4464	4820
22	1936	1917	1966	1972	1724	1903
22	1936	1917	1966	1972	1724	1903
23	7195	7313	7249	7143	6774	7135
23	7195	7313	7249	7143	6774	7135
23	7195	7313	7249	7143	6774	7135
24	4216	3149	2814	2801	2756	3147
25	4997	4980	5000	4545	4560	4816
25	4997	4980	5000	4545	4560	4816
25	4997	4980	5000	4545	4560	4816
26	80	78	83	81	79	80
26	80	78	83	81	79	80
26	80	78	83	81	79	80
26	80	78	83	81	79	80
26	80	78	83	81	79	80
27	1284	1256	1301	1328	1423	1318
28	1444	1444	1452	1547	1419	1461
28	1444	1444	1452	1547	1419	1461
28	1444	1444	1452	1547	1419	1461
29	2866	2895	3000	4245	4209	3443
30	709	709	803	804	758	757
30	709	709	803	804	758	757
30	709	709	803	804	758	757
30	709	709	803	804	758	757
31	480	475	351	347	373	405
32	7842	7170	7602	6951	7187	7350
33	12177	10593	9097	9113	11603	10517
33	12177	10593	9097	9113	11603	10517
33	12177	10593	9097	9113	11603	10517
34	1545	1584	1585	1583	1455	1550

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	2012	2011	2010	2009	2008	Avg
34	1545	1584	1585	1583	1455	1550
34	1545	1584	1585	1583	1455	1550
34	1545	1584	1585	1583	1455	1550
34	1545	1584	1585	1583	1455	1550
34	1545	1584	1585	1583	1455	1550
35	1150	1168	1154	1142	1055	1134
35	1150	1168	1154	1142	1055	1134
35	1150	1168	1154	1142	1055	1134
36	786	786	795	808	817	798
36	786	786	795	808	817	798
36	786	786	795	808	817	798
36	786	786	795	808	817	798
36	786	786	795	808	817	798
37	322	322	322	322	312	320
37	322	322	322	322	312	320
37	322	322	322	322	312	320
37	322	322	322	322	312	320
37	322	322	322	322	312	320
37	322	322	322	322	312	320
38	322	2609	1550	1687	1489	1531
38	322	2609	1550	1687	1489	1531
39	2756	2807	2846	3104	2973	2897
40	315	297	320	311	295	308
40	315	297	320	311	295	308
40	315	297	320	311	295	308
40	315	297	320	311	295	308
41	230	223	230	230	444	271
42	200	141	200	200	272	203
42	200	141	200	200	272	203
42	200	141	200	200	272	203
42	200	141	200	200	272	203
42	200	141	200	200	272	203
42	200	141	200	200	272	203
42	200	141	200	200	272	203
42	200	141	200	200	272	203
43	8741	8872	9182	9317	9106	9044
44	146	146	146	1288	722	490
44	146	146	146	1288	722	490
44	146	146	146	1288	722	490
44	146	146	146	1288	722	490
44	146	146	146	1288	722	490
45	1520	2669	2722	2682	2766	2472
45	1520	2669	2722	2682	2766	2472
46	1288	1306	1385	1315	1247	1308
47	2051	1971	2570	2573	2546	2342
47	2051	1971	2570	2573	2546	2342
47	2051	1971	2570	2573	2546	2342
47	2051	1971	2570	2573	2546	2342

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	2012	2011	2010	2009	2008	Avg
48	5001	5040	4102	4403	4284	4566
49	3174	3175	3389	3407	3292	3287
50	80	78	83	81	79	80
50	80	78	83	81	79	80
50	80	78	83	81	79	80
50	80	78	83	81	79	80
50	80	78	83	81	79	80
51	1243	1240	1002	1003	1013	1100
52	2681	2786	3132	3571	3416	3117
53	2351	2469	2690	2637	2726	2575
54	2593	2693	2727	2531	2488	2606
54	2593	2693	2727	2531	2488	2606
54	2593	2693	2727	2531	2488	2606
55	6161	6302	6183	6248	6722	6323
56	2051	1971	2570	2573	2546	2342
57	699	701	638	542	950	706
57	699	701	638	542	950	706
57	699	701	638	542	950	706
57	699	701	638	542	950	706
57	699	701	638	542	950	706
57	699	701	638	542	950	706
57	699	701	638	542	950	706
58	2730	2821	2700	2783	2378	2682
59	2866	2895	3000	4245	4209	3443
59	2866	2895	3000	4245	4209	3443
59	2866	2895	3000	4245	4209	3443
60	3672	3612	4220	4298	4066	3974
60	3672	3612	4220	4298	4066	3974
61	2341	3346	3375	3340	3460	3172
61	2341	3346	3375	3340	3460	3172
61	2341	3346	3375	3340	3460	3172
61	2341	3346	3375	3340	3460	3172
61	2341	3346	3375	3340	3460	3172
62	480	475	351	347	373	405
63	3613	3382	3788	3740	3825	3670
64	2634	2755	2868	3128	2973	2872
64	2634	2755	2868	3128	2973	2872
64	2634	2755	2868	3128	2973	2872
65	1882	1845	1860	1917	2171	1935
65	1882	1845	1860	1917	2171	1935
66	1988	1407	2299	2288	2756	2148
66	1988	1407	2299	2288	2756	2148
67	7879	7862	9572	10157	10153	9125
67	7879	7862	9572	10157	10153	9125
67	7879	7862	9572	10157	10153	9125
67	7879	7862	9572	10157	10153	9125
68	3672	3612	4220	4298	4066	3974
69	4162	4274	4327	4332	4057	4230
70	2842	2815	2789	2752	2746	2789

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
70	2842	2815	2789	2752	2746	2789
71	80	78	83	81	79	80
71	80	78	83	81	79	80
71	80	78	83	81	79	80
71	80	78	83	81	79	80
71	80	78	83	81	79	80
71	80	78	83	81	79	80
72	1731	1737	1770	1900	1753	1778
73	947	983	1026	964	954	975
74	1284	1256	1301	1328	1423	1318
75	721	721	721	721	89	595
75	721	721	721	721	89	595
75	721	721	721	721	89	595
75	721	721	721	721	89	595
76	547	547	609	804	618	625
77	2140	2156	1747	1743	1725	1902
77	2140	2156	1747	1743	1725	1902
77	2140	2156	1747	1743	1725	1902
78	2925	2908	3015	3028	2285	2832
78	2925	2908	3015	3028	2285	2832
78	2925	2908	3015	3028	2285	2832
79	181	2361	181	2361	137	1044
79	181	2361	181	2361	137	1044
79	181	2361	181	2361	137	1044
79	181	2361	181	2361	137	1044
79	181	2361	181	2361	137	1044
79	181	2361	181	2361	137	1044
80	2062	3052	3143	3125	3237	2924
80	2062	3052	3143	3125	3237	2924
81	2361	2495	2620	2628	2596	2540
82	2169	2170	2794	2797	2638	2514
82	2169	2170	2794	2797	2638	2514
82	2169	2170	2794	2797	2638	2514
82	2169	2170	2794	2797	2638	2514
82	2169	2170	2794	2797	2638	2514
82	2169	2170	2794	2797	2638	2514
83	1977	1970	2038	1970	1991	1989
83	1977	1970	2038	1970	1991	1989
83	1977	1970	2038	1970	1991	1989
83	1977	1970	2038	1970	1991	1989
84	564	588	592	691	670	621
85	181	3514	181	181	137	839
86	4070	2871	2816	2795	3681	3247
86	4070	2871	2816	2795	3681	3247
87	3514	3371	3818	3769	3825	3659
88	993	969	1027	863	861	943
89	1532	1474	1522	1471	1486	1497
90	1193	1165	1240	1428	1311	1267
90	1193	1165	1240	1428	1311	1267
91	1163	1169	1630	1623	1060	1329
91	1163	1169	1630	1623	1060	1329
91	1163	1169	1630	1623	1060	1329
91	1163	1169	1630	1623	1060	1329
91	1163	1169	1630	1623	1060	1329
92	4066	4062	4076	4081	3849	4027
93	1149	977	768	729	827	890
94	7488	7838	5995	5756	5038	6423
94	7488	7838	5995	5756	5038	6423
95	597	585	600	831	763	675
95	597	585	600	831	763	675
95	597	585	600	831	763	675
95	597	585	600	831	763	675
96	2365	2458	2522	2380	2462	2437
96	2365	2458	2522	2380	2462	2437
96	2365	2458	2522	2380	2462	2437
97	6590	6094	6129	5983	5844	6128
98	5420	5273	5101	4634	4657	5017
98	5420	5273	5101	4634	4657	5017
99	1520	2669	2722	2682	2766	2472
99	1520	2669	2722	2682	2766	2472
99	1520	2669	2722	2682	2766	2472
99	1520	2669	2722	2682	2766	2472
99	1520	2669	2722	2682	2766	2472
99	1520	2669	2722	2682	2766	2472
100	6732	6755	7118	7047	7270	6984
101	2899	2871	2816	2795	2857	2848
102	10642	11104	10871	7934	9115	9933
103	1634	1633	2569	1405	2147	1878
104	2576	2395	2640	3003	3069	2737
105	664	584	625	618	611	620
106	4730	4812	4268	4234	4225	4454
107	1624	1622	1690	1743	1705	1677
107	1624	1622	1690	1743	1705	1677
107	1624	1622	1690	1743	1705	1677
108	7019	6557	6739	7030	6564	6782
108	7019	6557	6739	7030	6564	6782
109	7322	7576	9846	6248	6722	7543
110	1731	1737	1770	1900	1753	1778
111	5224	5642	5488	6708	5919	5796
111	5224	5642	5488	6708	5919	5796
111	5224	5642	5488	6708	5919	5796
111	5224	5642	5488	6708	5919	5796
112	5210	4759	4800	4867	4464	4820
113	301	301	301	301	236	288
113	301	301	301	301	236	288
113	301	301	301	301	236	288
114	2730	2821	2700	2783	2378	2682
114	2730	2821	2700	2783	2378	2682

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
114	2730	2821	2700	2783	2378	2682
115	181	774	181	181	137	291
115	181	774	181	181	137	291
115	181	774	181	181	137	291
115	181	774	181	181	137	291
115	181	774	181	181	137	291
115	181	774	181	181	137	291
115	181	774	181	181	137	291
115	181	774	181	181	137	291
116	2503	2516	2115	2228	2491	2371
116	2503	2516	2115	2228	2491	2371
117	774	775	1000	1262	928	948
118	721	721	721	721	89	595
118	721	721	721	721	89	595
118	721	721	721	721	89	595
118	721	721	721	721	89	595
118	721	721	721	721	89	595
119	1850	1800	1940	1912	1531	1807
119	1850	1800	1940	1912	1531	1807
120	4659	4976	4530	4515	4451	4626
121	6264	6455	6612	7337	6913	6716
121	6264	6455	6612	7337	6913	6716
122	976	966	1062	1053	1093	1030
123	2734	2771	2962	2978	3025	2894
124	6161	6302	6183	6248	6722	6323
125	181	104	181	181	137	157
126	2008	642	647	707	2001	1201
126	2008	642	647	707	2001	1201
126	2008	642	647	707	2001	1201
127	104	97	124	120	273	144
128	2815	2470	2517	2484	2593	2576
129	4659	4976	4530	4515	4451	4626
130	7322	6302	6183	6248	6722	6555
131	332	5384	332	332	169	1310
131	332	5384	332	332	169	1310
131	332	5384	332	332	169	1310
132	1679	1671	1736	1718	1734	1708
133	5384	5268	5100	4412	4596	4952
134	6439	7772	6432	8209	8467	7464
134	6439	7772	6432	8209	8467	7464
134	6439	7772	6432	8209	8467	7464
134	6439	7772	6432	8209	8467	7464
134	6439	7772	6432	8209	8467	7464
134	6439	7772	6432	8209	8467	7464
135	2531	2341	1600	1660	2531	2133
136	3073	3184	3055	2769	4358	3288
137	1906	1645	1684	1671	1679	1717
137	1906	1645	1684	1671	1679	1717
137	1906	1645	1684	1671	1679	1717

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
138	1731	1737	1770	1900	1753	1778
138	1731	1737	1770	1900	1753	1778
138	1731	1737	1770	1900	1753	1778
139	1731	1737	1770	1900	1753	1778
139	1731	1737	1770	1900	1753	1778
139	1731	1737	1770	1900	1753	1778
139	1731	1737	1770	1900	1753	1778
140	1149	977	768	729	827	890
140	1149	977	768	729	827	890
140	1149	977	768	729	827	890
140	1149	977	768	729	827	890
140	1149	977	768	729	827	890
141	947	983	1026	964	954	975
142	4122	806	1939	3265	5915	3209
143	181	181	181	181	137	172
144	2899	2951	2356	2507	2605	2664
144	2899	2951	2356	2507	2605	2664
145	3058	6466	5850	5792	5920	5417
145	3058	6466	5850	5792	5920	5417
145	3058	6466	5850	5792	5920	5417
146	1934	1851	1466	1500	1558	1662
147	2365	2458	2522	2380	2462	2437
147	2365	2458	2522	2380	2462	2437
147	2365	2458	2522	2380	2462	2437
147	2365	2458	2522	2380	2462	2437
147	2365	2458	2522	2380	2462	2437
148	605	609	615	617	700	629
148	605	609	615	617	700	629
148	605	609	615	617	700	629
148	605	609	615	617	700	629
148	605	609	615	617	700	629
149	1307	1232	1239	1211	1203	1238
149	1307	1232	1239	1211	1203	1238
150	1757	1728	1893	2014	1999	1878
151	322	292	292	322	312	308
151	322	292	292	322	312	308
151	322	292	292	322	312	308
151	322	292	292	322	312	308
151	322	292	292	322	312	308
152	81	79	82	80	84	81
152	81	79	82	80	84	81
152	81	79	82	80	84	81
152	81	79	82	80	84	81
152	81	79	82	80	84	81
152	81	79	82	80	84	81
152	81	79	82	80	84	81
152	81	79	82	80	84	81
153	292	296	291	409	409	339
154	5793	5821	5972	5751	4693	5606

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
154	5793	5821	5972	5751	4693	5606
154	5793	5821	5972	5751	4693	5606
155	4066	3737	4118	3989	3602	3902
155	4066	3737	4118	3989	3602	3902
155	4066	3737	4118	3989	3602	3902
156	5216	5389	5353	5062	5255	5255
157	2335	1525	1576	1660	1629	1745
158	6459	4976	4530	4515	4451	4986
158	6459	4976	4530	4515	4451	4986
159	2365	2458	2522	2380	2462	2437
159	2365	2458	2522	2380	2462	2437
159	2365	2458	2522	2380	2462	2437
160	2481	2088	2535	2483	1506	2219
160	2481	2088	2535	2483	1506	2219
160	2481	2088	2535	2483	1506	2219
160	2481	2088	2535	2483	1506	2219
160	2481	2088	2535	2483	1506	2219
161	3272	3890	3966	3971	3452	3710
161	3272	3890	3966	3971	3452	3710
161	3272	3890	3966	3971	3452	3710
162	940	975	988	940	1038	976
162	940	975	988	940	1038	976
162	940	975	988	940	1038	976
163	5294	5317	5166	4498	4645	4984
163	5294	5317	5166	4498	4645	4984
164	699	701	638	542	950	706
165	5260	5404	5489	5619	5824	5519
166	2815	2470	2517	2484	2593	2576
167	1288	1306	1385	1315	1247	1308
168	2576	2395	2640	3003	2576	2638
168	2576	2395	2640	3003	2576	2638
169	1200	1251	1287	1307	1279	1265
169	1200	1251	1287	1307	1279	1265
169	1200	1251	1287	1307	1279	1265
169	1200	1251	1287	1307	1279	1265
169	1200	1251	1287	1307	1279	1265
169	1200	1251	1287	1307	1279	1265
169	1200	1251	1287	1307	1279	1265
170	1780	1783	1808	1941	1925	1847
170	1780	1783	1808	1941	1925	1847
170	1780	1783	1808	1941	1925	1847
170	1780	1783	1808	1941	1925	1847
171	1160	1167	1193	1516	1625	1332
172	2051	1971	2570	2573	2546	2342
173	3455	3523	3693	3665	3684	3604
173	3455	3523	3693	3665	3684	3604
173	3455	3523	3693	3665	3684	3604
174	7423	5199	5374	5280	2344	5124
175	981	1193	1124	1112	1148	1112

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
176	946	941	1249	1230	1319	1137
176	946	941	1249	1230	1319	1137
176	946	941	1249	1230	1319	1137
176	946	941	1249	1230	1319	1137
177	7019	2669	2722	2682	2766	3572
177	7019	2669	2722	2682	2766	3572
177	7019	2669	2722	2682	2766	3572
177	7019	2669	2722	2682	2766	3572
177	7019	2669	2722	2682	2766	3572
177	7019	2669	2722	2682	2766	3572
178	4187	3931	4088	4286	4601	4219
179	1149	977	768	729	827	890
179	1149	977	768	729	827	890
179	1149	977	768	729	827	890
179	1149	977	768	729	827	890
179	1149	977	768	729	827	890
179	1149	977	768	729	827	890
180	665	630	626	694	550	633
181	5224	5642	5488	6708	5919	5796
181	5224	5642	5488	6708	5919	5796
181	5224	5642	5488	6708	5919	5796
182	1906	1645	1684	1671	1679	1717
182	1906	1645	1684	1671	1679	1717
182	1906	1645	1684	1671	1679	1717
182	1906	1645	1684	1671	1679	1717
183	1780	1783	1808	1941	1925	1847
183	1780	1783	1808	1941	1925	1847
183	1780	1783	1808	1941	1925	1847
183	1780	1783	1808	1941	1925	1847
184	1059	1068	1089	4254	4209	2336
184	1059	1068	1089	4254	4209	2336
184	1059	1068	1089	4254	4209	2336
184	1059	1068	1089	4254	4209	2336
185	2137	4062	4076	4081	3849	3641
185	2137	4062	4076	4081	3849	3641
186	81	79	82	80	84	81
186	81	79	82	80	84	81
186	81	79	82	80	84	81
186	81	79	82	80	84	81
187	564	588	592	691	670	621
188	1396	1414	1940	1920	1851	1704
188	1396	1414	1940	1920	1851	1704
188	1396	1414	1940	1920	1851	1704
188	1396	1414	1940	1920	1851	1704
189	3272	3890	3966	3971	3452	3710
189	3272	3890	3966	3971	3452	3710
189	3272	3890	3966	3971	3452	3710
189	3272	3890	3966	3971	3452	3710
189	3272	3890	3966	3971	3452	3710

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
190	1307	1232	1239	1211	1203	1238
190	1307	1232	1239	1211	1203	1238
190	1307	1232	1239	1211	1203	1238
190	1307	1232	1239	1211	1203	1238
191	1239	1288	1239	1239	1369	1275
191	1239	1288	1239	1239	1369	1275
191	1239	1288	1239	1239	1369	1275
191	1239	1288	1239	1239	1369	1275
191	1239	1288	1239	1239	1369	1275
192	4398	4742	4700	4112	4596	4510
193	1937	1917	1966	1972	1724	1903

Table E- 2. Predictive Crash Analysis Data

	AADT					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**Avg**
193	1937	1917	1966	1972	1724	1903
193	1937	1917	1966	1972	1724	1903
194	664	584	625	618	611	620
194	664	584	625	618	611	620
195	1243	1240	1002	1003	1013	1100
195	1243	1240	1002	1003	1013	1100
195	1243	1240	1002	1003	1013	1100
196	894	584	625	618	611	666

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	1	0	0	0	1	2
2	1	0	1	0	0	2
3	0	0	0	0	0	0
4	1	0	0	0	1	2
4	0	0	0	0	0	0
4	0	2	1	0	0	3
5	0	0	0	0	0	0
5	0	0	0	0	0	0
5	0	0	0	0	0	0
5	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	1	1	1	3
6	0	0	1	0	0	1
6	0	0	1	0	1	2
6	0	0	0	0	0	0
6	0	0	0	0	0	0
6	0	0	0	0	0	0
6	0	0	1	0	0	1
7	0	2	0	0	0	2
8	0	0	2	0	0	2
9	0	0	0	0	0	0
9	0	0	0	0	0	0
9	0	0	0	0	0	0
10	1	0	1	2	0	4
11	0	0	0	0	0	0
11	0	0	0	0	0	0
11	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
12	0	1	0	0	0	1

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
13	0	0	0	0	0	0
13	0	0	0	0	0	0
13	0	0	0	0	0	0
13	0	0	0	0	0	0
13	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
14	0	0	0	0	0	0
14	1	0	0	0	0	1
15	0	1	0	0	0	1
15	0	0	0	0	0	0
15	0	0	0	0	0	0
15	0	0	0	2	0	2
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	1	1
17	1	0	0	0	0	1
18	1	1	2	0	5	9
19	0	2	1	0	0	3
20	0	0	0	0	0	0
20	0	0	0	0	0	0
20	0	0	0	0	0	0
20	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
20	0	0	0	0	0	0
20	0	0	0	0	0	0
20	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	1	0	3	1	5
22	0	0	0	1	0	1
22	1	2	0	2	1	6
23	1	0	1	0	0	2
23	1	2	0	0	0	3
23	0	0	0	0	0	0
24	1	0	0	0	2	3
25	0	0	1	0	0	1
25	0	1	0	1	0	2
25	2	1	0	0	1	4
26	0	0	1	0	0	1
26	0	0	0	0	0	0
26	0	0	0	0	0	0
26	0	0	0	0	0	0
26	0	0	0	0	0	0
27	1	0	0	1	2	4
28	0	0	0	0	0	0
28	1	0	0	0	0	1
28	1	0	1	1	0	3
29	1	0	0	0	0	1
30	0	0	0	0	0	0
30	0	0	0	0	0	0
30	0	0	0	0	0	0
30	0	0	0	0	0	0
31	1	0	1	1	4	7
32	1	1	10	1	2	15
33	0	3	1	1	0	5
33	1	3	0	2	1	7
33	0	0	2	1	0	3
34	0	1	0	0	0	1
34	0	0	0	0	0	0
34	0	0	1	2	0	3
34	0	0	0	0	0	0
34	0	0	0	0	0	0
34	0	1	0	0	1	2
35	0	0	0	0	0	0
35	0	0	0	0	1	1
35	0	1	1	0	0	2
36	0	0	0	0	0	0
36	0	0	0	1	0	1
36	0	0	0	0	0	0
36	0	0	0	0	0	0
36	1	0	0	0	0	1
37	0	0	0	1	0	1
37	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
37	0	0	0	0	0	0
37	0	0	0	0	0	0
37	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
38	0	0	0	0	1	1
39	1	0	0	0	0	1
40	0	0	0	0	0	0
40	0	0	0	0	0	0
40	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	1	1
42	0	0	0	0	0	0
42	0	0	0	0	0	0
42	0	0	0	0	0	0
42	0	0	0	0	0	0
42	0	0	0	0	0	0
42	0	0	0	0	0	0
42	1	0	0	0	0	1
42	0	0	0	0	0	0
42	0	0	0	0	0	0
43	1	2	2	0	1	6
44	0	0	0	0	0	0
44	0	0	0	0	0	0
44	0	1	0	0	0	1
44	0	0	0	1	0	1
44	0	0	0	0	0	0
45	0	2	1	0	1	4
45	0	1	1	1	1	4
46	1	0	0	0	1	2
47	1	0	0	1	0	2
47	0	0	0	0	1	1
47	0	0	0	0	0	0
47	0	1	0	0	1	2
48	1	0	0	0	1	2
49	0	1	2	2	1	6
50	0	0	0	0	0	0
50	0	0	0	0	0	0
50	0	0	0	0	0	0
50	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	1	0	0	1	0	2
53	0	0	1	3	2	6
54	0	1	0	1	0	2
54	1	0	0	0	1	2
54	0	0	0	0	0	0
55	0	5	1	2	0	8
56	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
57	0	0	0	0	0	0
57	0	0	0	0	0	0
57	0	0	0	0	0	0
57	0	0	0	1	0	1
57	0	0	0	0	0	0
57	0	0	0	0	0	0
57	0	0	0	0	0	0
58	0	0	0	1	1	2
59	0	0	0	0	0	0
59	0	0	0	0	1	1
59	1	0	0	0	0	1
60	1	0	0	2	1	4
60	2	1	2	4	1	10
61	0	0	1	0	1	2
61	0	0	0	0	0	0
61	1	0	1	0	0	2
61	0	0	1	0	1	2
61	1	0	1	0	1	3
62	0	0	0	0	0	0
63	1	0	2	0	2	5
64	0	0	0	0	1	1
64	0	1	0	1	0	2
64	0	0	0	1	1	2
65	1	1	0	1	0	3
65	0	1	1	1	0	3
66	0	0	1	0	1	2
66	1	0	0	1	1	3
67	0	0	0	2	0	2
67	0	0	1	0	0	1
67	0	0	2	0	2	4
67	2	4	1	1	1	9
68	1	1	4	1	0	7
69	0	0	0	0	0	0
70	1	1	1	0	1	4
70	0	2	2	2	1	7
71	0	0	0	1	0	1
71	0	0	1	1	0	2
71	0	0	0	0	0	0
71	0	0	0	0	0	0
71	0	0	0	0	0	0
71	0	0	0	0	0	0
72	0	0	0	0	0	0
73	0	0	0	0	0	0
74	0	1	0	1	0	2
75	1	0	1	0	0	2
75	0	0	0	0	0	0
75	0	0	0	0	0	0
75	0	0	0	0	0	0
76	1	0	0	0	0	1

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
77	0	0	1	0	0	1
77	0	0	0	1	0	1
77	0	0	0	1	0	1
78	0	1	0	2	0	3
78	1	0	1	2	0	4
78	1	0	2	0	1	4
79	0	0	0	0	0	0
79	0	0	0	0	0	0
79	0	0	0	0	0	0
79	0	0	0	1	0	1
79	0	0	0	0	0	0
79	0	0	0	0	0	0
80	0	0	0	2	0	2
80	0	0	0	0	0	0
81	1	0	2	2	1	6
82	0	0	1	0	0	1
82	0	1	0	0	0	1
82	0	0	0	0	0	0
82	0	0	0	0	0	0
82	0	0	0	1	0	1
82	0	0	0	0	0	0
83	0	0	0	0	0	0
83	0	0	0	0	0	0
83	0	0	0	0	0	0
83	0	1	0	0	0	1
84	0	1	1	1	0	3
85	0	0	0	0	0	0
86	0	1	0	0	1	2
86	0	1	0	1	0	2
87	2	2	3	2	1	10
88	1	0	0	0	0	1
89	1	0	0	0	0	1
90	0	0	0	0	1	1
90	1	1	0	2	2	6
91	2	0	0	0	0	2
91	0	0	0	0	0	0
91	0	0	0	0	0	0
91	0	1	0	0	0	1
91	0	0	0	0	0	0
92	0	0	1	1	0	2
93	1	0	0	0	0	1
94	2	0	0	1	1	4
94	1	0	0	0	0	1
95	1	0	0	0	1	2
95	0	0	0	0	0	0
95	0	0	0	0	0	0
95	0	1	0	0	0	1
96	0	2	0	0	1	3
96	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
96	0	0	0	2	0	2
97	1	0	2	1	1	5
98	0	1	1	2	2	6
98	1	1	3	0	2	7
99	2	0	0	0	0	2
99	0	0	0	0	1	1
99	1	0	2	0	0	3
99	0	0	0	0	0	0
99	0	0	0	0	0	0
99	0	0	0	0	0	0
100	0	2	0	0	0	2
101	0	0	1	1	0	2
102	0	0	0	1	3	4
103	0	1	1	0	0	2
104	0	0	0	0	0	0
105	0	0	2	0	0	2
106	0	0	0	0	0	0
107	0	0	0	0	0	0
107	0	0	0	0	0	0
107	0	0	0	0	0	0
108	1	1	0	1	0	3
108	0	0	0	0	0	0
109	0	0	0	0	0	0
110	0	0	2	0	0	2
111	1	0	1	0	0	2
111	0	1	0	0	0	1
111	0	0	0	1	0	1
111	1	1	0	3	1	6
112	0	0	1	0	1	2
113	0	0	0	0	0	0
113	0	0	1	0	0	1
113	0	0	0	0	0	0
114	0	0	0	0	0	0
114	0	0	1	0	0	1
114	0	0	0	0	1	1
115	0	1	0	1	0	2
115	0	0	0	0	0	0
115	0	0	0	0	0	0
115	0	0	0	0	0	0
115	0	0	0	0	0	0
115	0	0	0	0	0	0
115	0	0	0	0	0	0
115	0	0	0	0	0	0
116	0	0	1	0	1	2
116	0	0	0	0	0	0
117	0	0	0	0	0	0
118	0	0	2	0	0	2
118	0	0	1	0	0	1
118	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
118	0	0	0	0	0	0
118	1	1	1	0	0	3
119	0	0	0	1	0	1
119	1	0	0	0	2	3
120	1	0	1	0	1	3
121	1	0	1	0	3	5
121	2	0	1	1	2	6
122	0	0	0	0	0	0
123	2	0	1	2	0	5
124	0	2	1	3	3	9
125	0	1	0	0	1	2
126	0	0	0	1	0	1
126	0	0	0	0	0	0
126	0	0	0	0	0	0
127	0	0	0	0	1	1
128	0	2	2	3	1	8
129	0	0	1	0	0	1
130	1	2	2	0	0	5
131	0	0	1	0	0	1
131	0	0	0	0	0	0
131	0	0	0	0	1	1
132	1	1	1	1	2	6
133	1	1	3	0	2	7
134	2	1	1	1	0	5
134	1	1	2	1	0	5
134	1	2	1	2	1	7
134	0	0	0	1	1	2
134	2	2	0	1	1	6
134	1	1	0	0	1	3
135	1	0	0	1	0	2
136	0	1	1	0	1	3
137	0	0	0	1	1	2
137	0	0	0	0	0	0
137	0	0	0	0	0	0
138	0	0	0	0	0	0
138	0	0	0	0	0	0
138	0	0	0	0	0	0
139	0	0	0	0	0	0
139	0	0	0	0	0	0
139	0	0	0	0	0	0
139	0	0	0	1	1	2
140	0	0	0	1	0	1
140	0	0	0	0	0	0
140	1	0	0	0	0	1
140	0	1	0	0	0	1
140	1	0	1	0	0	2
141	0	2	1	0	3	6
142	5	5	10	4	11	35
143	0	0	0	0	2	2

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
144	0	1	0	0	1	2
144	0	0	0	0	0	0
145	0	0	0	0	0	0
145	0	0	0	0	0	0
145	0	0	0	0	0	0
146	1	1	0	0	1	3
147	1	2	0	0	0	3
147	0	0	1	1	3	5
147	0	0	0	0	0	0
147	2	0	0	0	0	2
147	2	2	1	1	0	6
148	0	0	0	0	0	0
148	0	0	0	0	0	0
148	0	0	0	0	0	0
148	0	0	0	0	0	0
148	0	0	0	0	0	0
149	0	0	0	1	1	2
149	1	3	2	0	0	6
150	0	0	0	1	0	1
151	0	0	0	0	0	0
151	0	0	0	0	0	0
151	0	0	0	0	0	0
151	0	0	0	0	0	0
151	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
152	0	0	0	0	0	0
153	1	0	2	0	0	3
154	1	1	2	2	1	7
154	3	0	1	3	3	10
154	0	0	1	0	1	2
155	1	0	1	0	0	2
155	1	0	0	0	0	1
155	0	0	1	0	0	1
156	3	0	1	2	1	7
157	0	0	0	0	0	0
158	0	0	1	1	0	2
158	0	0	1	1	1	3
159	0	0	0	0	1	1
159	0	0	0	0	0	0
159	0	0	0	0	0	0
160	1	0	0	0	0	1
160	0	1	0	0	0	1
160	1	0	0	0	0	1

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
160	0	0	0	0	1	1
160	0	0	0	0	0	0
161	1	1	2	0	1	5
161	0	0	0	0	1	1
161	0	0	0	0	0	0
162	0	0	0	0	0	0
162	0	1	0	0	0	1
162	2	0	0	0	0	2
163	0	0	0	0	0	0
163	0	0	0	0	1	1
164	1	0	0	0	1	2
165	0	0	0	0	0	0
166	2	0	1	0	2	5
167	0	0	0	0	1	1
168	0	0	0	0	0	0
168	0	0	0	0	0	0
169	0	0	0	0	0	0
169	0	0	0	0	0	0
169	0	0	0	0	0	0
169	0	0	0	0	0	0
169	0	0	0	0	0	0
169	0	0	0	0	0	0
169	0	0	0	0	2	2
170	0	1	0	0	0	1
170	0	0	0	0	0	0
170	0	0	0	0	0	0
170	0	0	0	0	0	0
171	0	0	0	1	1	2
172	1	0	1	0	0	2
173	1	2	0	2	1	6
173	0	0	0	1	0	1
173	1	0	0	0	0	1
174	0	1	2	0	0	3
175	0	1	0	0	0	1
176	0	0	0	0	0	0
176	0	1	1	0	1	3
176	0	0	1	0	0	1
176	0	0	0	0	0	0
177	0	1	0	0	0	1
177	1	1	0	0	0	2
177	0	0	1	0	0	1
177	0	0	0	0	0	0
177	0	0	0	0	0	0
177	0	0	0	1	2	3
178	1	2	2	1	3	9
179	0	0	0	0	0	0
179	0	0	0	0	0	0
179	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
179	0	0	0	0	0	0
179	0	0	0	0	0	0
180	0	0	1	0	0	1
181	1	2	2	1	1	7
181	0	2	0	0	1	3
181	0	0	0	0	0	0
182	0	0	1	0	0	1
182	0	1	0	0	1	2
182	0	0	0	0	0	0
182	0	0	0	0	2	2
183	0	0	0	0	0	0
183	0	0	0	0	0	0
183	0	0	0	0	0	0
183	0	0	0	0	0	0
184	0	0	0	1	0	1
184	0	1	2	1	0	4
184	0	0	0	0	0	0
184	0	0	0	0	1	1
185	0	0	0	0	0	0
185	0	0	0	0	0	0
186	0	0	0	0	0	0
186	0	0	0	0	0	0
186	0	0	0	0	0	0
186	0	0	0	0	0	0
187	0	0	0	0	0	0
188	1	2	0	0	2	5
188	0	1	0	0	1	2
188	0	0	0	0	0	0

Table E- 3. Predictive Crash Data

	Observed Crashes					
Site	**2012**	**2011**	**2010**	**2009**	**2008**	**TOT**
188	2	1	0	0	0	3
189	0	0	0	1	0	1
189	0	0	0	0	0	0
189	0	0	0	0	0	0
189	0	0	0	0	0	0
189	0	1	0	0	1	2
190	0	0	1	0	1	2
190	0	1	0	0	1	2
190	1	0	0	0	1	2
190	1	0	0	0	0	1
191	0	0	0	1	0	1
191	0	0	0	0	1	1
191	0	0	1	0	0	1
191	0	0	0	1	0	1
191	0	0	0	0	0	0
192	0	0	0	1	2	3
193	0	0	0	0	1	1
193	0	0	0	0	0	0
193	0	0	0	1	1	2
194	0	0	0	1	0	1
194	0	0	0	0	0	0
195	1	0	1	1	1	4
195	0	1	0	0	0	1
195	0	1	0	0	1	2
196	0	0	0	0	0	0

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
1	H	0.260	M	5	1876.94
1	T	0.218	M	5	0.00
1	H	0.515	M	5	1876.94
2	T	1.002	D	2	0.00
3	T	0.992	M	1	0.00
4	T	0.207	M	6	0.00
4	H	0.274	M	6	3400.96
4	T	0.535	M	6	0.00
5	H	0.128	D	2	1492.98
5	T	0.392	D	2	0.00
5	H	0.094	D	2	1095.05
5	H	0.084	D	2	863.63
5	T	0.213	D	2	0.00
6	T	0.117	D	5	0.00
6	H	0.119	D	5	6236.19
6	T	0.177	D	5	0.00

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
6	H	0.141	D	5	3279.63
6	T	0.164	D	5	0.00
6	H	0.117	D	5	2206.47
6	T	0.166	D	5	0.00
7	T	0.166	M	5	0.00
8	T	0.178	D	2	0.00
9	T	0.137	D	0	0.00
9	H	0.100	D	0	208.94
9	T	0.779	D	0	0.00
10	T	1.004	M	0	0.00
11	T	0.253	M	1	0.00
11	H	0.253	M	1	3449.49
11	T	0.472	M	1	0.00
11	H	0.174	M	1	3449.49
12	T	0.691	D	2	0.00
12	H	0.309	D	2	4976.54

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
13	H	0.125	D	5	1977.85
13	H	0.203	D	5	1217.72
13	T	0.171	D	5	0.00
13	H	0.155	D	5	1073.37
13	H	0.109	D	5	797.75
13	T	0.237	D	5	0.00
14	T	0.339	M	2	0.00
14	H	0.354	M	2	3729.24
14	T	0.266	M	2	0.00
15	T	0.564	M	5	0.00
15	H	0.133	M	5	1688.62
15	T	0.103	M	5	0.00
15	H	0.169	M	5	298.00
16	T	0.090	M	0	0.00
16	H	0.082	M	0	281.93
16	H	0.103	M	0	924.88
16	T	0.101	M	0	0.00
16	H	0.092	M	0	315.71
16	T	0.086	M	0	0.00
16	H	0.119	M	0	534.30
16	H	0.100	M	0	289.49
16	T	0.083	M	0	0.00
16	H	0.049	M	0	834.96
16	T	0.128	M	0	0.00
17	T	0.329	M	5	0.00
17	H	0.670	M	5	4436.55
18	T	0.999	D	1	0.00
19	T	0.998	D	1	0.00
20	T	0.146	D	0	0.00
20	H	0.120	D	0	148.79
20	T	0.091	D	0	0.00
20	H	0.147	D	0	102.61
20	T	0.114	D	0	0.00
20	H	0.112	D	0	204.36
20	T	0.117	D	0	0.00
20	H	0.109	D	0	113.63
21	T	0.957	M	5	0.00
22	T	0.680	M	0	0.00
22	H	0.172	M	0	849.39
23	T	0.370	D	8	0.00
23	T	0.252	D	6	0.00
23	T	0.360	D	8	0.00
24	T	1.000	D	8	0.00
25	T	0.405	M	5	0.00
25	H	0.254	M	5	6271.33
25	T	0.339	M	5	0.00
26	H	0.147	M	1	1362.65
26	H	0.244	M	1	953.65
26	T	0.158	M	1	0.00
26	H	0.197	M	1	1306.71
26	T	0.211	M	1	0.00
27	T	0.994	M	1	0.00
28	T	0.345	M	8	0.00
28	H	0.290	M	8	2775.72
28	T	0.400	M	8	0.00
29	T	0.209	D	8	0.00
30	T	0.236	M	1	0.00
30	H	0.303	M	1	2578.68
30	T	0.115	M	1	0.00
30	H	0.345	M	1	1089.66
31	T	0.998	D	2	0.00
32	T	1.002	D	5	0.00
33	T	0.085	D	4	0.00
33	H	0.107	D	6	529.31
33	T	0.124	D	6	0.00
34	T	0.230	M	6	0.00
34	H	0.154	M	6	4142.66
34	T	0.153	M	6	0.00
34	H	0.170	M	6	1685.66
34	T	0.113	M	6	0.00
34	H	0.202	M	6	2067.00
35	H	0.186	M	2	667.08
35	T	0.235	M	2	0.00
35	H	0.278	M	2	1096.47
36	T	0.237	D	5	0.00
36	H	0.312	D	5	814.28
36	H	0.196	D	5	697.76
36	H	0.112	D	5	840.08
36	H	0.144	D	5	742.57
37	T	0.120	M	1	0.00
37	H	0.125	M	1	259.58
37	H	0.311	M	1	1034.86
37	T	0.136	M	1	0.00
37	H	0.125	M	1	691.85
37	H	0.167	M	1	1150.01
38	T	0.400	D	2	0.00
38	T	0.598	D	8	0.00
39	T	0.998	D	3	0.00
40	T	0.113	M	2	0.00
40	H	0.419	M	2	1401.20
40	H	0.269	M	2	511.35
40	T	0.205	M	2	0.00
41	T	1.009	D	0	0.00
42	H	0.097	D	2	299.39
42	H	0.123	D	2	445.89
42	H	0.102	D	2	455.39

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
42	T	0.087	D	2	0.00
42	H	0.121	D	2	252.70
42	H	0.091	D	2	484.17
42	H	0.100	D	2	236.66
42	T	0.064	D	2	0.00
42	H	0.151	D	2	270.59
43	T	0.993	D	8	0.00
44	T	0.309	D	0	0.00
44	H	0.170	D	0	504.19
44	H	0.158	D	0	197.46
44	H	0.254	D	0	1075.78
44	H	0.128	D	0	315.89
45	T	0.280	D	5	0.00
45	T	0.706	D	5	0.00
46	T	0.964	D	1	0.00
47	H	0.177	M	1	1172.99
47	T	0.184	M	1	0.00
47	H	0.273	M	1	1768.44
47	T	0.360	M	1	0.00
48	T	1.002	M	1	0.00
49	T	1.006	M	8	0.00
50	H	0.147	M	2	929.39
50	H	0.190	M	2	928.77
50	T	0.377	M	2	0.00
50	H	0.194	M	2	1247.21
50	T	0.094	M	2	0.00
51	T	0.974	D	5	0.00
52	T	0.982	M	5	0.00
53	T	0.596	M	5	0.00
54	T	0.490	D	2	0.00
54	T	0.200	D	1	0.00
54	T	0.319	D	2	0.00
55	T	0.998	D	8	0.00
56	T	1.001	M	1	0.00
57	T	0.136	D	2	0.00
57	H	0.119	D	2	380.82
57	T	0.086	D	2	0.00
57	H	0.105	D	2	485.44
57	T	0.181	D	2	0.00
57	H	0.119	D	2	996.28
57	T	0.113	D	2	0.00
58	T	0.989	M	5	0.00
59	T	0.361	D	8	0.00
59	H	0.293	D	4	1000.00
59	T	0.343	D	4	0.00
60	T	0.259	M	5	0.00
60	H	0.746	M	5	7192.07
61	T	0.225	D	2	0.00
61	H	0.194	D	2	3551.23
61	T	0.174	D	2	0.00
61	H	0.187	D	2	1643.73
61	T	0.211	D	2	0.00
62	T	0.985	D	5	0.00
63	T	0.175	D	8	0.00
64	T	0.201	D	3	0.00
64	H	0.406	D	3	4328.62
64	T	0.396	D	3	0.00
65	T	0.751	D	5	0.00
65	H	0.248	D	5	2307.46
66	T	0.644	M	8	0.00
66	H	0.365	M	8	8389.83
67	T	0.298	M	8	0.00
67	T	0.168	M	4	0.00
67	H	0.367	M	8	6189.99
67	T	0.164	M	8	0.00
68	T	0.999	M	4	0.00
69	T	1.010	M	5	0.00
70	T	0.634	D	1	0.00
70	H	0.367	D	1	5926.79
71	H	0.173	M	1	277.51
71	H	0.152	M	1	203.86
71	H	0.106	M	1	207.06
71	H	0.144	M	1	182.79
71	T	0.161	M	1	0.00
71	H	0.245	M	1	229.36
72	T	0.970	M	1	0.00
73	T	0.989	M	2	0.00
74	T	0.730	M	1	0.00
75	T	0.544	M	0	0.00
75	H	0.127	M	0	1322.34
75	T	0.136	M	0	0.00
75	H	0.169	M	0	656.75
76	T	0.987	M	0	0.00
77	T	0.217	D	0	0.00
77	H	0.217	D	8	2039.09
77	T	0.530	D	8	0.00
78	T	0.210	D	5	0.00
78	T	0.210	D	5	0.00
78	T	0.567	D	5	0.00
79	H	0.111	D	0	645.11
79	T	0.131	D	0	0.00
79	H	0.204	D	0	482.57
79	H	0.197	D	0	466.98
79	H	0.192	D	0	494.80
79	H	0.157	D	0	721.84
80	T	0.576	D	2	0.00

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
80	H	0.430	D	2	1000.00
81	T	1.002	M	1	0.00
82	T	0.090	M	2	0.00
82	H	0.125	M	2	357.00
82	H	0.146	M	2	447.73
82	T	0.124	M	2	0.00
82	H	0.143	M	2	476.59
82	T	0.393	M	2	0.00
83	H	0.246	M	5	2329.02
83	T	0.369	M	5	0.00
83	H	0.207	M	5	4859.96
83	T	0.162	M	5	0.00
84	T	0.986	M	1	0.00
85	T	0.826	D	1	0.00
86	T	0.630	D	8	0.00
86	H	0.349	D	8	5012.53
87	T	1.001	D	8	0.00
88	T	0.658	M	5	0.00
89	T	1.007	D	5	0.00
90	H	0.270	M	2	1241.09
90	T	0.726	M	8	0.00
91	T	0.154	M	8	0.00
91	H	0.237	M	8	3649.88
91	T	0.311	M	8	0.00
91	H	0.311	M	8	2624.31
91	T	0.122	M	8	0.00
92	T	1.021	M	5	0.00
93	T	1.001	D	0	0.00
94	T	0.753	D	5	0.00
94	H	0.256	D	5	2200.00
95	T	0.187	M	8	0.00
95	H	0.178	M	8	1313.93
95	H	0.183	M	8	1228.33
95	T	0.455	M	8	0.00
96	H	0.221	M	3	1044.38
96	H	0.231	M	3	1931.11
96	T	0.550	M	8	0.00
97	T	1.001	D	5	0.00
98	T	0.596	D	7	0.00
98	H	0.417	D	7	1949.54
99	H	0.202	D	1	4180.85
99	T	0.148	D	1	0.00
99	H	0.199	D	1	2285.80
99	T	0.189	D	1	0.00
99	T	0.130	D	8	0.00
99	H	0.164	D	8	914.39
100	T	1.009	D	5	0.00
101	T	1.007	D	8	0.00
102	T	0.988	D	8	0.00
103	T	1.001	D	2	0.00
104	T	0.999	D	5	0.00
105	T	0.999	D	2	0.00
106	T	1.007	M	1	0.00
107	T	0.417	M	2	0.00
107	H	0.404	M	2	10225.54
107	T	0.237	M	2	0.00
108	H	0.770	M	8	10670.55
108	T	0.235	M	8	0.00
109	T	0.241	D	8	0.00
110	T	1.026	M	1	0.00
111	H	0.198	D	6	1689.34
111	T	0.133	D	6	0.00
111	H	0.502	D	6	2127.96
111	T	0.200	D	6	0.00
112	T	0.996	M	5	0.00
113	T	0.516	D	2	0.00
113	H	0.311	D	2	12773.21
113	T	0.168	D	2	0.00
114	T	0.248	M	5	0.00
114	H	0.417	M	5	7314.13
114	T	0.323	M	5	0.00
115	H	0.112	M	0	267.81
115	T	0.152	M	0	0.00
115	H	0.114	M	0	255.15
115	H	0.095	M	0	99.35
115	H	0.125	M	0	240.26
115	H	0.124	M	0	199.56
115	H	0.123	M	0	143.20
115	H	0.150	M	0	172.61
116	T	0.319	D	5	0.00
116	H	0.679	D	5	3734.47
117	T	0.991	M	0	0.00
118	T	0.225	M	0	0.00
118	H	0.135	M	0	2142.07
118	T	0.119	M	0	0.00
118	H	0.130	M	0	2102.49
118	T	0.373	M	0	0.00
119	T	0.213	D	2	0.00
119	H	0.798	D	2	11502.47
120	T	0.991	M	1	0.00
121	T	0.422	M	8	0.00
121	H	0.611	M	8	12306.35
122	T	1.003	D	5	0.00
123	T	1.001	M	8	0.00
124	T	0.996	D	8	0.00
125	T	0.996	M	8	0.00

Table E- 4. Predictive Crash Data

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
126	T	0.608	D	8	0.00
126	H	0.245	D	4	1627.55
126	T	0.145	D	8	0.00
127	T	0.985	M	1	0.00
128	T	0.995	D	2	0.00
129	T	1.003	M	2	0.00
130	T	1.003	D	8	0.00
131	T	0.266	M	2	0.00
131	H	0.200	M	2	6314.96
131	T	0.524	M	2	0.00
132	T	0.989	M	0	0.00
133	H	0.982	D	8	11852.87
134	H	0.361	M	1	2319.82
134	H	0.127	M	1	1990.30
134	H	0.126	M	1	1291.13
134	T	0.139	M	1	0.00
134	H	0.169	M	1	928.78
134	T	0.135	M	1	0.00
135	T	0.195	D	8	0.00
136	T	1.005	D	5	0.00
137	T	0.525	M	5	0.00
137	H	0.212	M	5	3429.74
137	T	0.300	M	5	0.00
138	T	0.284	M	1	0.00
138	H	0.236	M	1	1820.35
138	T	0.524	M	1	0.00
139	H	0.285	M	1	2664.46
139	H	0.257	M	1	5004.20
139	T	0.330	M	1	0.00
139	H	0.097	M	1	1105.87
140	T	0.234	D	1	0.00
140	H	0.206	D	1	2415.20
140	T	0.238	D	1	0.00
140	H	0.175	D	1	1986.15
140	T	0.151	D	1	0.00
141	T	0.999	M	1	0.00
142	T	0.999	D	1	0.00
143	T	0.999	M	1	0.00
144	T	0.602	D	1	0.00
144	H	0.400	D	1	5013.31
145	T	0.413	D	4	0.00
145	H	0.187	D	3	5186.92
145	T	0.402	D	5	0.00
146	T	0.999	D	5	0.00
147	T	0.132	M	3	0.00
147	H	0.316	M	3	904.16
147	T	0.134	M	3	0.00
147	H	0.263	M	3	2833.77
147	T	0.263	M	8	0.00
148	H	0.212	M	2	3353.43
148	T	0.178	M	2	0.00
148	H	0.274	M	2	2681.10
148	T	0.156	M	2	0.00
148	H	0.180	M	2	2606.91
149	H	0.153	M	8	483.66
149	T	0.619	M	1	0.00
150	T	0.996	D	1	0.00
151	H	0.108	D	1	2822.67
151	T	0.214	D	1	0.00
151	H	0.290	D	1	3598.44
151	T	0.290	D	1	0.00
151	H	0.126	D	1	537.27
152	H	0.160	M	1	515.43
152	H	0.134	M	1	96.03
152	H	0.148	M	1	871.23
152	T	0.100	M	1	0.00
152	H	0.138	M	1	423.81
152	T	0.117	M	1	0.00
152	H	0.110	M	1	947.51
152	H	0.091	M	1	419.71
153	T	1.001	M	8	0.00
154	T	0.173	M	5	0.00
154	H	0.449	M	5	9324.10
154	T	0.309	M	5	0.00
155	T	0.188	M	5	0.00
155	H	0.416	M	5	7899.78
155	T	0.385	M	5	0.00
156	T	1.084	D	2	0.00
157	T	1.000	D	8	0.00
158	T	0.781	M	1	0.00
158	H	0.230	M	1	1163.09
159	H	0.165	M	5	2081.45
159	T	0.624	M	5	0.00
159	H	0.229	M	5	1493.43
160	H	0.159	M	8	1531.46
160	H	0.181	M	8	3200.54
160	T	0.236	M	8	0.00
160	H	0.229	M	8	5441.78
160	H	0.192	M	8	2670.22
161	T	0.329	M	8	0.00
161	H	0.290	M	8	4578.37
161	T	0.326	M	8	0.00
162	T	0.617	M	2	0.00
162	H	0.210	M	2	3466.52
162	T	0.165	M	2	0.00
163	H	0.105	M	10	922.58

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
163	H	0.123	M	10	769.88
164	T	0.495	D	8	0.00
165	T	1.000	D	8	0.00
166	T	0.996	D	1	0.00
167	T	1.043	D	0	0.00
168	T	0.550	D	5	0.00
168	H	0.438	D	5	4384.36
169	H	0.123	M	2	512.63
169	H	0.111	M	2	756.28
169	H	1.000	M	2	1235.08
169	H	0.145	M	2	688.03
169	H	0.206	M	2	580.05
169	H	0.138	M	2	596.01
169	T	0.124	M	2	0.00
170	H	0.143	M	1	3648.59
170	T	0.421	M	1	0.00
170	H	0.118	M	1	1999.12
170	T	0.319	M	1	0.00
171	T	0.399	M	1	0.00
172	T	0.981	M	1	0.00
173	T	0.381	D	5	0.00
173	H	0.172	D	5	3761.93
173	T	0.452	D	5	0.00
174	T	1.026	M	5	0.00
175	T	1.000	M	1	0.00
176	T	0.124	D	5	0.00
176	H	0.125	D	5	1282.40
176	T	0.213	D	5	0.00
176	H	0.201	D	5	848.98
177	T	0.086	D	6	0.00
177	H	0.155	D	6	1766.32
177	H	0.314	D	6	1251.05
177	T	0.123	D	6	0.00
177	H	0.134	D	6	1124.87
177	T	0.174	D	6	0.00
178	T	1.000	D	7	0.00
179	H	0.155	D	2	2659.28
179	T	0.203	D	2	0.00
179	H	0.138	D	2	2506.41
179	T	0.170	D	2	0.00
179	H	0.152	D	2	855.75
179	H	0.168	D	2	1341.68
180	T	0.952	M	8	0.00
181	H	0.418	D	5	4669.56
181	T	0.198	D	5	0.00
181	H	0.387	D	5	9346.79
182	T	0.327	D	5	0.00
182	H	0.280	D	5	4982.08

Table E- 4. Predictive Crash Data

Site	Tangent/ Curve	Length	Region	Shoulder Width	Horizontal Curve Radius
182	T	0.159	D	5	0.00
182	H	0.242	D	5	2988.46
183	T	0.258	M	1	0.00
183	H	0.295	M	1	1402.10
183	T	0.185	M	1	0.00
183	H	0.267	M	1	1643.21
184	H	0.253	D	8	1063.02
184	T	0.356	D	8	0.00
184	H	0.233	D	8	1341.97
184	H	0.157	D	8	1482.46
185	H	0.276	M	5	2815.19
185	T	0.721	M	5	0.00
186	H	0.391	M	1	602.09
186	H	0.153	M	1	721.44
186	H	0.139	M	1	994.89
186	H	0.301	M	1	586.18
187	T	0.990	M	1	0.00
188	T	0.550	M	1	0.00
188	H	0.204	M	1	1243.48
188	T	0.133	M	1	0.00
188	H	0.114	M	1	1069.89
189	T	0.183	M	8	0.00
189	H	0.246	M	8	26601.42
189	T	0.182	M	8	0.00
189	H	0.170	M	8	12106.77
189	T	0.211	M	8	0.00
190	T	0.148	M	8	0.00
190	H	0.154	M	8	1130.49
190	T	0.557	M	8	0.00
190	H	0.156	M	8	2144.69
191	T	0.359	D	0	0.00
191	H	0.199	D	0	682.61
191	T	0.228	D	0	0.00
191	H	0.124	D	0	1213.34
191	H	0.113	D	0	661.67
192	T	1.010	D	8	0.00
193	T	0.285	M	0	0.00
193	H	0.338	M	0	4675.85
193	T	0.377	M	0	0.00
194	T	0.998	D	0	0.00
194	H	0.300	D	0	5379.97
195	H	0.180	D	8	2018.82
195	T	0.327	D	8	0.00
195	H	0.461	D	8	4840.75
196	T	1.000	D	2	0.00

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
1	0.00	N	N	3.00	N
1	0.00	N	N	3.00	N
1	0.00	N	N	3.00	N
2	0.00	N	N	3.00	N
3	0.00	N	N	3.00	N
4	0.00	N	N	3.00	N
4	0.00	N	N	3.00	N
4	3.74	N	N	3.00	N
5	0.00	N	N	3.00	N
5	0.00	N	N	3.00	N
5	0.00	N	N	3.00	N
5	0.00	N	N	3.00	N
5	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
6	0.00	N	N	3.00	N
7	0.00	N	N	3.00	N
8	0.00	N	N	5.00	N
9	0.00	N	N	3.00	N
9	0.00	N	N	3.00	N
9	2.57	N	N	3.00	N
10	1.99	N	N	3.00	N
11	19.52	N	N	3.00	N
11	19.78	N	N	3.00	N
11	14.84	N	N	3.00	N
11	11.49	N	N	3.00	N
12	0.00	N	N	3.00	N
12	0.00	N	N	3.00	N
13	0.00	N	N	3.00	N
13	0.00	N	N	3.00	N
13	0.00	N	N	3.00	N
13	0.00	N	N	3.00	N
13	0.00	N	N	3.00	N
13	0.00	N	N	3.00	N
14	0.00	N	N	3.00	N
14	0.00	N	N	3.00	N
14	0.00	N	N	3.00	N
15	30.13	N	N	3.00	N
15	30.05	N	N	3.00	N
15	19.40	N	N	3.00	N
15	0.00	N	N	4.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
16	0.00	N	N	3.00	N
17	0.00	N	N	3.00	N
17	0.00	N	N	3.00	N
18	1.00	N	N	3.00	N
19	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
20	0.00	N	N	3.00	N
21	0.00	N	N	3.00	N
22	0.00	N	N	3.00	N
22	0.00	N	N	3.00	N
23	0.00	N	N	3.00	N
23	0.00	N	N	3.00	N
23	5.56	N	N	3.00	N
24	0.00	N	N	3.00	N
25	0.00	N	N	3.00	N
25	0.00	N	N	3.00	N
25	0.00	N	N	3.00	N
26		N	N	3.00	N
26	8.21	N	N	3.00	N
26	12.62	N	N	3.00	N
26	10.15	N	N	3.00	N
26	9.49	N	N	3.00	N
27	0.00	N	N	3.00	N
28	0.00	N	N	3.00	N
28	0.00	N	N	3.00	N
28	0.00	N	N	3.00	N
29	21.05	Y	Y	3.00	N
30		N	N	3.00	N
30		N	N	3.00	N
30	8.66	N	N	3.00	N
30		N	N	3.00	N
31	0.00	N	N	3.00	N
32	1.00	N	N	3.00	N
33	0.00	N	N	3.00	N
33	0.00	N	N	3.00	N
33	0.00	N	N	3.00	N
34	0.00	N	N	3.00	N

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
34	0.00	N	N	3.00	N
34	0.00	N	N	3.00	N
34	0.00	N	N	3.00	N
34	0.00	N	N	3.00	N
34	0.00	N	N	3.00	N
35	10.76	N	N	3.00	N
35	8.51	N	N	3.00	N
35		N	N	3.00	N
36	8.43	N	N	3.00	N
36		N	N	3.00	N
36		N	N	3.00	N
36	8.90	N	N	3.00	N
36	13.86	N	N	3.00	N
37	0.00	N	N	3.00	N
37	0.00	N	N	3.00	N
37	0.00	N	N	3.00	N
37	0.00	N	N	3.00	N
37	0.00	N	N	3.00	N
37	0.00	N	N	3.00	N
38	5.00	N	N	3.00	N
38	0.00	N	N	3.00	N
39	1.00	N	N	3.00	N
40	0.00	N	N	3.00	N
40	0.00	N	N	3.00	N
40	0.00	N	N	3.00	N
40	0.00	N	N	3.00	N
41	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
42	0.00	N	N	3.00	N
43	0.00	N	N	3.00	N
44	0.00	N	N	3.00	N
44	0.00	N	N	3.00	N
44	0.00	N	N	3.00	N
44	0.00	N	N	3.00	N
44	0.00	N	N	3.00	N
45	0.00	N	Y	3.00	N
45	0.00	N	N	3.00	N
46	0.00	N	N	3.00	N
47	0.00	N	N	3.00	N
47	0.00	N	N	3.00	N
47	0.00	N	N	3.00	N
47	0.00	N	N	3.00	N
48	0.00	N	N	3.00	N
49	0.00	N	N	3.00	N
50	0.00	N	N	3.00	N
50	0.00	N	N	3.00	N
50	0.00	N	N	3.00	N
50	0.00	N	N	3.00	N
50	0.00	N	N	3.00	N
51	0.00	N	N	3.00	N
52	0.00	N	N	3.00	N
53	0.00	N	N	3.00	N
54	0.00	N	N	3.00	N
54	5.00	N	N	3.00	N
54	0.00	N	N	3.00	N
55	6.00	N	N	3.00	N
56	2.00	N	N	3.00	N
57	0.00	N	N	3.00	N
57	0.00	N	N	3.00	N
57	0.00	N	N	3.00	N
57	0.00	N	N	3.00	N
57	0.00	N	N	3.00	N
57	0.00	N	N	3.00	N
57	0.00	N	N	3.00	N
58	0.00	N	N	3.00	N
59		N	N	3.00	N
59	6.84	Y	N	3.00	N
59	8.74	Y	N	3.00	N
60	7.72	N	N	3.00	N
60		N	N	3.00	N
61	0.00	N	N	3.00	N
61	0.00	N	N	3.00	N
61	0.00	N	N	3.00	N
61	0.00	N	N	3.00	N
61	0.00	N	N	3.00	N
62	0.00	N	N	3.00	N
63	5.70	N	N	3.00	N
64	0.00	N	N	3.00	N
64	0.00	N	N	3.00	N
64	0.00	N	N	3.00	N
65	0.00	N	N	3.00	N
65	0.00	N	N	3.00	N
66	0.00	N	N	3.00	N
66	0.00	N	N	3.00	N
67	6.71	N	N	3.00	N
67	5.95	N	N	3.00	N
67	8.17	N	N	3.00	N
67	6.10	N	N	3.00	N
68	3.00	N	N	3.00	N
69	2.00	N	N	3.00	N
70	1.58	N	N	3.00	N

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
70		N	N	3.00	N
71	0.00	N	N	3.00	N
71	0.00	N	N	3.00	N
71	0.00	N	N	3.00	N
71	0.00	N	N	3.00	N
71	0.00	N	N	3.00	N
71	0.00	N	N	3.00	N
72	0.00	N	N	3.00	N
73	0.00	N	N	3.00	N
74	4.10	N	N	3.00	N
75	12.88	N	N	3.00	N
75	7.87	N	N	3.00	N
75	7.36	N	N	3.00	N
75	17.78	N	N	3.00	N
76	0.00	N	N	3.00	N
77		N	N	3.00	N
77		N	N	3.00	N
77	16.99	Y	N	3.00	N
78		N	N	3.00	N
78		N	Y	3.00	N
78	8.82	N	N	3.00	N
79	0.00	N	N	3.00	N
79	0.00	N	N	3.00	N
79	0.00	N	N	3.00	N
79	0.00	N	N	3.00	N
79	0.00	N	N	3.00	N
79	0.00	N	N	3.00	N
80		N	N	3.00	N
80	4.65	N	N	3.00	N
81	0.00	N	N	3.00	N
82	0.00	N	N	3.00	N
82	0.00	N	N	3.00	N
82	0.00	N	N	3.00	N
82	0.00	N	N	3.00	N
82	0.00	N	N	3.00	N
82	0.00	N	N	3.00	N
83	24.41	N	N	3.00	N
83	29.85	N	N	3.00	N
83	14.47	N	N	3.00	N
83	12.32	N	N	3.00	N
84	0.00	N	N	3.00	N
85	0.00	N	N	3.00	N
86	11.11	N	N	3.00	N
86	8.61	N	N	3.00	N
87	0.00	N	N	3.00	N
88	4.50	N	N	3.00	Y
89	0.00	N	N	3.00	Y
90		N	N	3.00	Y
90	4.13	N	N	3.00	Y

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
91		N	N	3.00	N
91		N	N	3.00	N
91	6.44	N	N	3.00	N
91		N	N	3.00	N
91		N	N	3.00	N
92	0.00	N	N	3.00	Y
93	0.00	N	N	3.00	N
94	0.00	N	N	3.00	N
94	0.00	N	N	3.00	N
95	26.70	Y	N	3.00	N
95		N	N	3.00	N
95		N	N	3.00	N
95	8.79	N	N	3.00	N
96	0.00	N	N	3.00	N
96	0.00	N	N	3.00	N
96	0.00	N	N	3.00	N
97	0.00	N	N	3.00	N
98	0.00	N	N	3.00	N
98	0.00	N	N	3.00	N
99	4.96	N	N	3.00	N
99	13.47	N	N	3.00	N
99		N	N	3.00	N
99	5.29	N	N	3.00	N
99		N	N	3.00	N
99		N	N	3.00	N
100	0.00	N	N	3.00	N
101	0.00	N	N	3.00	N
102	0.00	N	N	3.00	N
103	0.00	N	N	3.00	N
104	1.00	N	N	3.00	N
105	0.00	N	N	3.00	N
106	0.00	N	N	3.00	N
107	2.40	N	N	3.00	N
107		N	N	3.00	N
107		N	N	3.00	N
108	0.00	N	N	3.00	N
108	0.00	N	N	3.00	N
109	0.00	N	N	3.00	N
110	0.00	N	N	3.00	N
111	0.00	N	N	3.00	N
111	0.00	N	N	3.00	N
111	0.00	N	N	3.00	N
111	0.00	N	N	3.00	N
112	0.00	N	N	3.00	N
113	0.00	N	N	3.00	N
113	0.00	N	N	3.00	N
113	0.00	N	N	3.00	N
114	0.00	N	N	3.00	N
114	0.00	N	N	3.00	N

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
114	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
115	0.00	N	N	3.00	N
116	0.00	N	N	3.00	N
116	0.00	N	N	3.00	N
117	0.00	N	N	3.00	N
118	8.88	N	N	3.00	N
118	7.38	N	N	3.00	N
118	25.20	N	N	3.00	N
118	23.05	N	N	3.00	N
118	0.00	N	N	3.00	N
119	0.00	N	N	3.00	N
119	0.00	N	N	3.00	N
120	0.00	N	N	3.00	N
121	0.00	N	N	3.00	N
121	0.00	N	N	3.00	N
122	0.00	N	N	3.00	N
123	0.00	N	N	3.00	N
124	0.00	N	N	3.00	N
125	0.00	N	N	3.00	N
126	3.29	N	N	3.00	N
126	12.22	N	N	3.00	N
126	34.40	N	N	3.00	N
127	4.10	N	N	3.00	N
128	0.00	N	N	3.00	N
129	3.00	N	N	3.00	N
130	6.00	N	N	3.00	N
131	0.00	N	N	3.00	N
131	0.00	N	N	3.00	N
131	0.00	N	N	3.00	N
132	0.00	N	N	3.00	N
133	0.00	N	N	3.00	N
134	0.00	N	N	3.00	N
134	0.00	N	N	3.00	N
134	0.00	N	N	3.00	N
134	0.00	N	N	3.00	N
134	0.00	N	N	3.00	N
134	0.00	N	N	3.00	N
135	10.24	N	N	3.00	N
136	0.00	N	N	3.00	N
137	0.00	N	N	3.00	N
137	0.00	N	N	3.00	N
137	0.00	N	N	3.00	N
138	0.00	N	N	3.00	N
138	0.00	N	N	3.00	N
138	0.00	N	N	3.00	N
139	0.00	N	N	3.00	N
139	0.00	N	N	3.00	N
139	0.00	N	N	3.00	N
139	0.00	N	N	3.00	N
140	0.00	N	N	3.00	N
140	0.00	N	N	3.00	N
140	0.00	N	N	3.00	N
140	0.00	N	N	3.00	N
140	0.00	N	N	3.00	N
141	0.00	N	N	3.00	N
142	0.00	N	N	3.00	N
143	0.00	N	N	3.00	N
144	0.00	N	N	3.00	N
144	0.00	N	N	3.00	N
145	0.00	N	N	3.00	N
145	0.00	N	N	3.00	N
145	0.00	N	N	3.00	N
146	0.00	N	N	3.00	N
147	0.00	N	N	3.00	N
147	0.00	N	N	3.00	N
147	0.00	N	N	3.00	N
147	0.00	N	N	3.00	N
147	0.00	N	N	3.00	N
148	0.00	N	N	3.00	N
148	0.00	N	N	3.00	N
148	0.00	N	N	3.00	N
148	0.00	N	N	3.00	N
148	0.00	N	N	3.00	N
149	0.00	N	N	3.00	N
149	0.00	N	N	3.00	N
150	0.00	N	N	3.00	N
151	0.00	N	N	3.00	N
151	0.00	N	N	3.00	N
151	0.00	N	N	3.00	N
151	0.00	N	N	3.00	N
151	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
152	0.00	N	N	3.00	N
153	0.00	N	N	3.00	N
154	0.00	N	N	3.00	N

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
154	0.00	N	N	3.00	N
154	0.00	N	N	3.00	N
155	0.00	N	N	3.00	N
155	0.00	N	N	3.00	N
155	0.00	N	N	3.00	N
156	0.00	N	N	3.00	N
157	0.00	N	N	3.00	N
158	0.00	N	N	3.00	N
158	0.00	N	N	3.00	N
159	0.00	N	N	3.00	N
159	0.00	N	N	3.00	N
159	0.00	N	N	3.00	N
160	0.00	N	N	3.00	N
160	0.00	N	N	3.00	N
160	0.00	N	N	3.00	N
160	0.00	N	N	3.00	N
160	0.00	N	N	3.00	N
161	0.00	N	N	3.00	N
161	0.00	N	N	3.00	N
161	0.00	N	N	3.00	N
162	0.00	N	N	3.00	N
162	0.00	N	N	3.00	N
162	0.00	N	N	3.00	N
163	0.00	N	N	3.00	N
163	0.00	N	N	3.00	N
164	0.00	N	N	3.00	N
165	0.00	N	N	3.00	N
166	0.00	N	N	3.00	N
167	0.00	N	N	3.00	N
168	0.00	N	N	3.00	N
168	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
169	0.00	N	N	3.00	N
170	0.00	N	N	3.00	N
170	0.00	N	N	3.00	N
170	0.00	N	N	3.00	N
170	0.00	N	N	3.00	N
171	0.00	N	N	3.00	N
172	0.00	N	N	3.00	N
173	0.00	N	N	3.00	N
173	0.00	N	N	3.00	N
173	0.00	N	N	3.00	N
174	0.00	N	N	3.00	N
175	0.00	N	N	3.00	N

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
176	0.00	N	N	3.00	N
176	0.00	N	N	3.00	N
176	0.00	N	N	3.00	N
176	0.00	N	N	3.00	N
177	0.00	N	N	3.00	N
177	0.00	N	N	3.00	N
177	0.00	N	N	3.00	N
177	0.00	N	N	3.00	N
177	0.00	N	N	3.00	N
177	0.00	N	N	3.00	N
178	0.00	N	N	3.00	N
179	0.00	N	N	3.00	N
179	0.00	N	N	3.00	N
179	0.00	N	N	3.00	N
179	0.00	N	N	3.00	N
179	0.00	N	N	3.00	N
179	0.00	N	N	3.00	N
180	0.00	N	N	3.00	N
181	0.00	N	N	3.00	N
181	0.00	N	N	3.00	N
181	0.00	N	N	3.00	N
182	0.00	N	N	3.00	N
182	0.00	N	N	3.00	N
182	0.00	N	N	3.00	N
182	0.00	N	N	3.00	N
183	0.00	N	N	3.00	N
183	0.00	N	N	3.00	N
183	0.00	N	N	3.00	N
183	0.00	N	N	3.00	N
184	0.00	N	N	3.00	N
184	0.00	N	N	3.00	N
184	0.00	N	N	3.00	N
184	0.00	N	N	3.00	N
185	0.00	N	N	3.00	N
185	0.00	N	N	3.00	N
186	0.00	N	N	3.00	N
186	0.00	N	N	3.00	N
186	0.00	N	N	3.00	N
186	0.00	N	N	3.00	N
187	0.00	N	N	3.00	N
188	0.00	N	N	3.00	N
188	0.00	N	N	3.00	N
188	0.00	N	N	3.00	N
188	0.00	N	N	3.00	N
189	0.00	N	N	3.00	N
189	0.00	N	N	3.00	N
189	0.00	N	N	3.00	N
189	0.00	N	N	3.00	N
189	0.00	N	N	3.00	N

Table E-5. Predictive Crash Data

Site	Driveway Density	TWLT	Passing Lane	Roadside Design	Lighting
190	0.00	N	N	3.00	N
190	0.00	N	N	3.00	N
190	0.00	N	N	3.00	N
190	0.00	N	N	3.00	N
191	0.00	N	N	3.00	N
191	0.00	N	N	3.00	N
191	0.00	N	N	3.00	N
191	0.00	N	N	3.00	N
191	0.00	N	N	3.00	N
192	0.00	N	N	3.00	N
193	0.00	N	N	3.00	N
193	0.00	N	N	3.00	N
193	0.00	N	N	3.00	N
194	0.00	N	N	3.00	N
194	0.00	N	N	3.00	N
195	0.00	N	N	3.00	N
195	0.00	N	N	3.00	N
195	0.00	N	N	3.00	N
196	0.00	N	N	3.00	N

Table E-6. Predictive Crash Data (Crash Modification Factors)

Site	Crash Modification Factors											
	CMF1	CMF2	CMF3	CMF4	CMF5	CMF6	CMF7	CMF8	CMF9	CMF10	CMF11	CMF12
1	1.00	1.08	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	1.00	1.08	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.04	1.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.04	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.04	1.71	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.14	1.00	1.00
9	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.05	3.48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.20	1.00	1.00	1.00	2.36	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.20	1.06	1.00	1.00	2.38	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.20	1.00	1.00	1.00	1.92	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.20	1.09	1.00	1.00	1.61	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.12	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.02	1.21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.02	1.21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.02	1.31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.02	1.59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.09	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.02	1.00	1.00	1.00	3.33	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.02	1.23	1.00	1.00	3.33	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.02	1.00	1.00	1.00	3.32	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.02	2.03	1.00	1.00	1.00	1.00	1.00	1.00	1.07	1.00	1.00
16	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	3.24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	1.54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	2.78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	1.81	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	2.78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
16	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	2.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17	1.00	1.07	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	3.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	4.43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	3.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.05	5.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.25	1.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	0.93	1.00	1.00	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00
24	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.08	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.05	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.05	1.22	1.00	1.00	1.29	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.05	1.00	1.00	1.00	1.69	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.05	1.20	1.00	1.00	1.47	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.05	1.00	1.00	1.00	1.41	1.00	1.00	1.00	1.00	1.00	1.00
27	1.00	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
28	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
28	1.00	1.03	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
28	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
29	1.00	0.93	1.00	1.00	1.00	2.51	1.00	0.75	1.00	1.00	1.00	1.00
30	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	1.00	1.09	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	1.00	1.09	1.00	1.00	1.00	1.34	1.00	1.00	0.78	1.00	1.00	1.00
30	1.00	1.09	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
31	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
33	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
33	1.00	1.00	1.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
35	1.00	1.09	1.42	1.00	1.00	1.54	1.00	1.00	1.00	1.00	1.00	1.00
35	1.00	1.09	1.00	1.00	1.00	1.33	1.00	1.00	1.00	1.00	1.00	1.00
35	1.00	1.09	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
36	1.00	1.03	1.00	1.00	1.00	1.32	1.00	1.00	1.00	1.00	1.00	1.00
36	1.00	1.03	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
36	1.00	1.03	1.38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
36	1.00	1.03	1.55	1.00	1.00	0.63	1.00	1.00	0.99	1.00	1.00	1.00
36	1.00	1.03	1.48	1.00	1.00	0.72	1.00	1.00	0.96	1.00	1.00	1.00
37	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
37	1.00	1.05	2.59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
37	1.00	1.05	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
37	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
37	1.00	1.05	1.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
37	1.00	1.05	1.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
38	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
38	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
39	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	1.00	1.04	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	1.00	1.04	1.38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
41	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	2.78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	1.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	2.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	2.69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	2.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	3.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	1.00	1.04	2.27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
43	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	1.00	1.05	1.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	1.00	1.05	2.65	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	1.00	1.05	1.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	1.00	1.05	2.28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
45	1.00	1.06	1.00	1.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00
45	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
46	1.00	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
47	1.00	1.26	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
47	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
47	1.00	1.26	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
47	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
48	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
49	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.04	1.38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.04	1.29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.04	1.21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
51	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
52	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
53	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
54	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
54	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
54	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
55	1.00	0.93	1.00	1.00	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00
56	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	2.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	2.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	1.44	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
57	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
58	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
59	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
59	1.00	1.08	1.05	1.00	1.00	1.17	1.00	1.00	1.00	1.00	1.00	1.00
59	1.00	1.08	1.00	1.00	1.00	1.35	1.00	1.00	1.00	1.00	1.00	1.00
60	1.00	1.08	1.00	1.00	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00
60	1.00	1.08	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	1.00	1.16	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	1.00	1.16	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
62	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
63	1.00	0.93	1.00	1.00	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00
64	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
64	1.00	1.16	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
64	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
65	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
65	1.00	1.07	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
66	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
66	1.00	1.05	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
67	1.00	0.93	1.00	1.00	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00
67	1.00	1.08	1.00	1.00	1.00	1.30	1.00	1.00	1.00	1.00	1.00	1.00
67	1.00	0.93	1.02	1.00	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00
67	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
68	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
69	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
70	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
70	1.00	1.26	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71	1.00	1.05	2.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71	1.00	1.05	2.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71	1.00	1.05	3.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71	1.00	1.05	2.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71	1.00	1.05	1.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
72	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
73	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
74	1.00	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
75	1.00	1.09	1.00	1.00	1.00	1.73	1.00	1.00	1.00	1.00	1.00	1.00
75	1.00	1.09	1.31	1.00	1.00	1.27	1.00	1.00	1.00	1.00	1.00	1.00
75	1.00	1.09	1.00	1.00	1.00	1.22	1.00	1.00	1.00	1.00	1.00	1.00
75	1.00	1.02	1.47	1.00	1.00	2.19	1.00	1.00	1.00	1.00	1.00	1.00
76	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
77	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

Site	Crash Modification Factors											
	CMF1	CMF2	CMF3	CMF4	CMF5	CMF6	CMF7	CMF8	CMF9	CMF10	CMF11	CMF12
77	1.00	0.93	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
77	1.00	0.93	1.00	1.00	1.00	2.12	1.00	1.00	0.73	1.00	1.00	1.00
78	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
78	1.00	1.08	1.00	1.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00
78	1.00	1.08	1.00	1.00	1.00	1.36	1.00	1.00	1.00	1.00	1.00	1.00
79	1.00	1.05	1.72	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
79	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
79	1.00	1.05	1.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
79	1.00	1.05	1.56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
79	1.00	1.05	1.55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
79	1.00	1.05	1.46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	1.00	1.16	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
81	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
82	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
82	1.00	1.16	2.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
82	1.00	1.16	1.79	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
82	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
82	1.00	1.16	1.76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
82	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
83	1.00	1.08	1.09	1.00	1.00	2.82	1.00	1.00	1.00	1.00	1.00	1.00
83	1.00	1.08	1.00	1.00	1.00	3.33	1.00	1.00	1.00	1.00	1.00	1.00
83	1.00	1.08	1.05	1.00	1.00	1.89	1.00	1.00	1.00	1.00	1.00	1.00
83	1.00	1.08	1.00	1.00	1.00	1.69	1.00	1.00	1.00	1.00	1.00	1.00
84	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
85	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
86	1.00	0.93	1.00	1.00	1.00	1.58	1.00	1.00	1.00	1.00	1.00	1.00
86	1.00	0.93	1.03	1.00	1.00	1.34	1.00	1.00	1.00	1.00	1.00	1.00
87	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
88	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	1.00
89	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	1.00
90	1.00	1.04	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	1.00
90	1.00	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	1.00
91	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
91	1.00	1.02	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
91	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
91	1.00	1.02	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
91	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
92	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	1.00
93	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
94	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
94	1.00	1.08	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
95	1.00	1.00	1.00	1.00	1.00	3.01	1.00	1.00	0.58	1.00	1.00	1.00
95	1.00	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
95	1.00	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
95	1.00	1.00	1.00	1.00	1.00	1.35	1.00	1.00	1.00	1.00	1.00	1.00
96	1.00	1.16	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
96	1.00	1.16	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
96	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
97	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
98	1.00	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
99	1.00	1.20	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
99	1.00	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
99	1.00	1.20	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
99	1.00	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
99	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
99	1.00	1.03	1.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
101	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
102	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
104	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
105	1.00	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
106	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
107	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
107	1.00	1.13	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
107	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
108	1.00	0.93	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
108	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
110	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
111	1.00	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
111	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
111	1.00	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
111	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
112	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
113	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
113	1.00	1.04	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
113	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
114	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
114	1.00	1.08	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
114	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	2.72	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	2.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	6.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	2.72	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	3.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	3.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
115	1.00	1.26	2.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
116	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
116	1.00	1.08	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
117	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
118	1.00	1.09	1.00	1.00	1.00	1.36	1.00	1.00	1.00	1.00	1.00	1.00
118	1.00	1.09	1.18	1.00	1.00	1.36	1.00	1.00	1.00	1.00	1.00	1.00
118	1.00	1.09	1.00	1.00	1.00	2.87	1.00	1.00	1.00	1.00	1.00	1.00
118	1.00	1.09	1.19	1.00	1.00	2.67	1.00	1.00	1.00	1.00	1.00	1.00
118	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
119	1.00	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
119	1.00	1.14	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
120	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
121	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
121	1.00	0.93	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
122	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
123	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
124	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
125	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
126	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
126	1.00	1.08	1.13	1.00	1.00	1.68	1.00	1.00	1.00	1.00	1.00	1.00
126	1.00	0.93	1.00	1.00	1.00	3.75	1.00	1.00	1.00	1.00	1.00	1.00
127	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
128	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
129	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
130	1.00	0.93	1.00	1.00	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00
131	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
131	1.00	1.04	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
131	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
132	1.00	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
133	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	1.26	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	1.26	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	1.26	1.32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	1.26	1.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
134	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
135	1.00	0.93	1.00	1.00	1.00	1.49	1.00	1.00	1.00	1.00	1.00	1.00
136	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
137	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
137	1.00	1.07	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
137	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
138	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
138	1.00	1.23	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
138	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
139	1.00	1.23	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
139	1.00	1.23	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
139	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
139	1.00	1.23	1.48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
140	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
140	1.00	1.15	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
140	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
140	1.00	1.15	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
140	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
141	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
142	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
143	1.00	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
144	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
144	1.00	1.26	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
145	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
145	1.00	1.16	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
145	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
146	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
147	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
147	1.00	1.16	1.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
147	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
147	1.00	1.16	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
147	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
148	1.00	1.05	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
148	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
148	1.00	1.05	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
148	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
148	1.00	1.05	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
149	1.00	1.02	1.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
149	1.00	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
150	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
151	1.00	1.05	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
151	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
151	1.00	1.05	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
151	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
151	1.00	1.05	1.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	1.63	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	5.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	1.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	1.89	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
152	1.00	1.05	2.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
153	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
154	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
154	1.00	1.08	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
154	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
155	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
155	1.00	1.08	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
155	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
156	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
157	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
158	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
158	1.00	1.26	1.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
159	1.00	1.08	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
159	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
159	1.00	1.08	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
160	1.00	0.93	1.21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
160	1.00	0.93	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
160	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
160	1.00	0.93	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
160	1.00	0.93	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
161	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
161	1.00	0.93	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
161	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
162	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
162	1.00	1.08	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
162	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
163	1.00	0.93	1.54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
163	1.00	0.93	1.54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
164	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
165	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
166	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
167	1.00	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
168	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
168	1.00	1.08	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
169	1.00	1.10	1.82	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

Site	Crash Modification Factors											
	CMF1	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
169	1.00	1.10	1.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
169	1.00	1.10	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
169	1.00	1.10	1.52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
169	1.00	1.10	1.43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
169	1.00	1.10	1.63	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
169	1.00	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
170	1.00	1.23	1.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
170	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
170	1.00	1.23	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
170	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
171	1.00	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
172	1.00	1.26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
173	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
173	1.00	1.08	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
173	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
174	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
175	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
176	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
176	1.00	1.03	1.32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
176	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
176	1.00	1.03	1.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
177	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
177	1.00	1.00	1.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
177	1.00	1.00	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
177	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
177	1.00	1.00	1.34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
177	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
178	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
179	1.00	1.09	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
179	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
179	1.00	1.09	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
179	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
179	1.00	1.09	1.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
179	1.00	1.09	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
181	1.00	1.08	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
181	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
181	1.00	1.08	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
182	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
182	1.00	1.07	1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
182	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
182	1.00	1.07	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
183	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
183	1.00	1.23	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
183	1.00	1.23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
183	1.00	1.23	1.12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
184	1.00	1.01	1.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
184	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
184	1.00	1.01	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
184	1.00	1.01	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
185	1.00	1.08	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
185	1.00	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
186	1.00	1.05	1.22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-6. Predictive Crash Data (Crash Modification Factors)

	Crash Modification Factors											
Site	**CMF1**	**CMF2**	**CMF3**	**CMF4**	**CMF5**	**CMF6**	**CMF7**	**CMF8**	**CMF9**	**CMF10**	**CMF11**	**CMF12**
186	1.00	1.05	1.47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
186	1.00	1.05	1.37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
186	1.00	1.05	1.29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
187	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
188	1.00	1.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
188	1.00	1.18	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
188	1.00	1.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
188	1.00	1.18	1.43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
189	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
189	1.00	0.93	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
189	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
189	1.00	0.93	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
189	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
190	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
190	1.00	1.02	1.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
190	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
190	1.00	1.02	1.15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
191	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
191	1.00	1.16	1.38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
191	1.00	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
191	1.00	1.16	1.34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
191	1.00	1.16	1.69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
192	1.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
193	1.00	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
193	1.00	1.25	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
193	1.00	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
194	1.00	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
194	1.00	1.09	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
195	1.00	1.02	1.14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
195	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
195	1.00	1.02	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
196	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
1	1.199	0.193	0.190	0.185	0.197	0.195	0.961
1	1.080	0.146	0.144	0.140	0.149	0.148	0.727
1	1.134	0.362	0.356	0.348	0.370	0.366	1.801
2	1.130	0.494	0.494	0.777	0.425	0.649	2.839
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	1.000	0.085	0.087	0.088	0.087	0.080	0.428
4	1.060	0.120	0.123	0.123	0.123	0.113	0.601
4	1.000	0.221	0.226	0.227	0.226	0.208	1.108
5	1.321	0.031	0.032	0.029	0.024	0.043	0.159
5	1.040	0.076	0.076	0.069	0.059	0.103	0.384
5	1.560	0.028	0.028	0.025	0.021	0.037	0.139
5	1.778	0.028	0.028	0.026	0.022	0.038	0.142
5	1.040	0.041	0.042	0.038	0.032	0.056	0.209
6	1.070	0.064	0.055	0.056	0.056	0.056	0.287
6	1.145	0.069	0.060	0.061	0.061	0.061	0.312
6	1.070	0.096	0.083	0.085	0.084	0.085	0.434
6	1.188	0.085	0.074	0.075	0.075	0.075	0.384
6	1.070	0.089	0.077	0.079	0.078	0.079	0.402
6	1.284	0.077	0.066	0.068	0.067	0.068	0.346
6	1.070	0.090	0.078	0.080	0.079	0.080	0.407
7	0.990	0.140	0.134	0.136	0.146	0.120	0.677
8	1.322	0.019	0.019	0.019	0.019	0.015	0.091
9	1.050	0.004	0.004	0.004	0.004	0.004	0.019
9	3.654	0.010	0.009	0.010	0.010	0.010	0.048
9	1.050	0.022	0.021	0.022	0.022	0.022	0.108
10	1.250	0.649	0.642	0.659	0.661	0.578	3.189
11	2.832	0.298	0.136	0.154	0.154	0.320	1.061
11	3.027	0.319	0.145	0.164	0.164	0.342	1.134
11	2.304	0.453	0.206	0.233	0.233	0.486	1.611
11	2.106	0.153	0.069	0.079	0.079	0.164	0.543
12	1.120	0.308	0.265	0.348	0.329	0.401	1.652
12	1.154	0.142	0.122	0.161	0.152	0.185	0.761
13	1.234	0.025	0.025	0.020	0.019	0.028	0.116
13	1.234	0.040	0.040	0.032	0.032	0.045	0.189
13	1.020	0.028	0.028	0.023	0.022	0.031	0.132
13	1.336	0.033	0.033	0.027	0.026	0.037	0.156
13	1.622	0.028	0.028	0.023	0.022	0.032	0.134
13	1.020	0.039	0.039	0.031	0.031	0.044	0.183
14	1.090	0.113	0.115	0.114	0.113	0.104	0.559
14	1.134	0.123	0.125	0.124	0.123	0.113	0.608
14	1.090	0.089	0.090	0.089	0.088	0.082	0.439
15	3.397	0.369	0.369	0.369	0.369	0.046	1.522
15	4.178	0.107	0.107	0.107	0.107	0.013	0.442
15	3.386	0.067	0.067	0.067	0.067	0.008	0.277
15	2.216	0.072	0.072	0.072	0.072	0.009	0.298
16	1.050	0.007	0.007	0.007	0.007	0.008	0.037
16	3.402	0.022	0.022	0.022	0.022	0.023	0.109
16	1.617	0.013	0.013	0.013	0.013	0.013	0.065
16	1.050	0.008	0.008	0.008	0.008	0.009	0.042
16	2.919	0.021	0.021	0.021	0.021	0.022	0.106
16	1.050	0.007	0.007	0.007	0.007	0.007	0.036
16	1.901	0.018	0.018	0.018	0.018	0.018	0.089
16	2.919	0.023	0.023	0.023	0.023	0.024	0.115
16	1.050	0.007	0.007	0.007	0.007	0.007	0.034

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
16	2.363	0.009	0.009	0.009	0.009	0.009	0.046
16	1.050	0.011	0.011	0.011	0.011	0.011	0.053
17	1.070	0.178	0.174	0.178	0.220	0.218	0.968
17	1.091	0.370	0.362	0.369	0.456	0.453	2.010
18	1.260	0.956	0.947	0.938	0.925	0.923	4.689
19	1.150	0.352	0.300	0.236	0.224	0.254	1.365
20	1.050	0.007	0.007	0.007	0.007	0.006	0.035
20	4.095	0.024	0.024	0.024	0.024	0.018	0.113
20	1.050	0.005	0.005	0.005	0.005	0.003	0.022
20	4.652	0.033	0.033	0.033	0.033	0.025	0.157
20	1.050	0.006	0.006	0.006	0.006	0.004	0.028
20	3.434	0.019	0.019	0.019	0.019	0.014	0.088
20	1.050	0.006	0.006	0.006	0.006	0.005	0.028
20	5.418	0.029	0.029	0.029	0.029	0.022	0.136
21	1.080	1.438	1.314	1.325	1.344	1.232	6.653
22	1.250	0.439	0.435	0.446	0.448	0.391	2.160
22	1.688	0.150	0.149	0.153	0.153	0.134	0.738
23	0.930	0.661	0.672	0.666	0.657	0.623	3.280
23	1.000	0.485	0.493	0.488	0.481	0.456	2.403
23	0.977	0.676	0.687	0.681	0.671	0.636	3.351
24	0.930	1.048	0.783	0.699	0.696	0.685	3.911
25	1.080	0.584	0.582	0.584	0.531	0.533	2.812
25	1.112	0.377	0.376	0.378	0.343	0.344	1.818
25	1.080	0.489	0.487	0.489	0.445	0.446	2.356
26	1.323	0.004	0.004	0.004	0.004	0.004	0.021
26	1.652	0.009	0.008	0.009	0.009	0.008	0.043
26	1.775	0.006	0.006	0.006	0.006	0.006	0.030
26	1.852	0.008	0.008	0.008	0.008	0.008	0.039
26	1.481	0.007	0.007	0.007	0.007	0.007	0.033
27	1.170	0.399	0.390	0.404	0.413	0.442	2.048
28	1.030	0.137	0.137	0.138	0.147	0.135	0.694
28	1.092	0.122	0.122	0.123	0.131	0.120	0.618
28	1.030	0.159	0.159	0.160	0.170	0.156	0.805
29	1.751	0.280	0.282	0.293	0.414	0.411	1.680
30	1.090	0.049	0.049	0.055	0.055	0.052	0.260
30	1.166	0.067	0.067	0.076	0.076	0.072	0.357
30	1.139	0.025	0.025	0.028	0.028	0.027	0.133
30	1.243	0.081	0.081	0.092	0.092	0.087	0.434
31	1.040	0.133	0.132	0.097	0.096	0.103	0.562
32	1.080	2.268	2.074	2.199	2.010	2.079	10.629
33	1.080	0.298	0.259	0.223	0.223	0.284	1.287
33	1.920	0.667	0.580	0.498	0.499	0.635	2.878
33	1.000	0.404	0.352	0.302	0.303	0.385	1.747
34	1.000	0.095	0.098	0.098	0.097	0.090	0.477
34	1.080	0.069	0.070	0.070	0.070	0.065	0.344
34	1.000	0.063	0.065	0.065	0.065	0.059	0.316
34	1.180	0.083	0.085	0.085	0.085	0.078	0.414
34	1.000	0.046	0.048	0.048	0.048	0.044	0.233
34	1.120	0.093	0.096	0.096	0.096	0.088	0.468
35	2.384	0.136	0.138	0.137	0.135	0.125	0.671
35	1.450	0.105	0.106	0.105	0.104	0.096	0.516
35	1.275	0.109	0.110	0.109	0.108	0.100	0.536
36	1.360	0.068	0.068	0.069	0.070	0.070	0.344
36	1.236	0.081	0.081	0.082	0.083	0.084	0.412

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
36	1.421	0.058	0.058	0.059	0.060	0.061	0.297
36	0.996	0.023	0.023	0.024	0.024	0.024	0.119
36	1.054	0.032	0.032	0.032	0.033	0.033	0.162
37	1.050	0.011	0.011	0.011	0.011	0.011	0.054
37	2.720	0.029	0.029	0.029	0.029	0.028	0.145
37	1.218	0.033	0.033	0.033	0.033	0.032	0.162
37	1.050	0.012	0.012	0.012	0.012	0.012	0.061
37	1.680	0.018	0.018	0.018	0.018	0.018	0.090
37	1.334	0.019	0.019	0.019	0.019	0.019	0.095
38	1.040	0.036	0.290	0.172	0.188	0.165	0.851
38	0.990	0.051	0.413	0.245	0.267	0.236	1.211
39	1.160	0.852	0.868	0.880	0.960	0.919	4.479
40	1.040	0.010	0.009	0.010	0.010	0.009	0.048
40	1.134	0.040	0.038	0.041	0.039	0.037	0.195
40	1.435	0.032	0.031	0.033	0.032	0.030	0.159
40	1.040	0.018	0.017	0.018	0.018	0.017	0.088
41	1.050	0.065	0.063	0.065	0.065	0.126	0.384
42	2.891	0.015	0.011	0.015	0.015	0.020	0.076
42	2.028	0.013	0.009	0.013	0.013	0.018	0.067
42	2.205	0.012	0.008	0.012	0.012	0.016	0.061
42	1.040	0.005	0.003	0.005	0.005	0.007	0.024
42	2.798	0.018	0.013	0.018	0.018	0.025	0.092
42	2.267	0.011	0.008	0.011	0.011	0.015	0.056
42	3.318	0.018	0.012	0.018	0.018	0.024	0.089
42	1.040	0.004	0.002	0.004	0.004	0.005	0.018
42	2.361	0.019	0.013	0.019	0.019	0.026	0.096
43	0.930	2.156	2.188	2.265	2.298	2.246	11.153
44	1.050	0.013	0.013	0.013	0.112	0.063	0.212
44	1.680	0.011	0.011	0.011	0.099	0.055	0.187
44	2.783	0.017	0.017	0.017	0.152	0.085	0.288
44	1.250	0.012	0.012	0.012	0.109	0.061	0.208
44	2.394	0.012	0.012	0.012	0.106	0.059	0.201
45	0.795	0.090	0.159	0.162	0.160	0.165	0.735
45	1.060	0.304	0.534	0.544	0.536	0.553	2.470
46	1.170	0.388	0.394	0.417	0.396	0.376	1.972
47	1.575	0.153	0.147	0.192	0.192	0.190	0.873
47	1.260	0.127	0.122	0.159	0.159	0.157	0.724
47	1.399	0.209	0.201	0.262	0.263	0.260	1.195
47	1.260	0.249	0.239	0.311	0.312	0.309	1.419
48	1.260	1.687	1.700	1.384	1.486	1.445	7.703
49	0.930	0.793	0.794	0.847	0.852	0.823	4.108
50	1.435	0.005	0.004	0.005	0.005	0.004	0.023
50	1.342	0.005	0.005	0.006	0.006	0.005	0.027
50	1.040	0.008	0.008	0.009	0.008	0.008	0.042
50	1.258	0.005	0.005	0.005	0.005	0.005	0.026
50	1.040	0.002	0.002	0.002	0.002	0.002	0.010
51	1.050	0.340	0.339	0.274	0.274	0.277	1.503
52	1.080	0.760	0.790	0.888	1.012	0.968	4.418
53	1.080	0.404	0.425	0.463	0.454	0.469	2.214
54	1.160	0.394	0.409	0.414	0.384	0.378	1.979
54	1.260	0.175	0.181	0.184	0.170	0.168	0.877
54	1.160	0.256	0.266	0.269	0.250	0.246	1.287
55	1.023	1.681	1.719	1.687	1.705	1.834	8.626
56	1.260	0.691	0.664	0.866	0.867	0.858	3.948

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
57	1.060	0.027	0.027	0.025	0.021	0.037	0.136
57	2.279	0.050	0.051	0.046	0.039	0.069	0.255
57	1.060	0.017	0.017	0.016	0.013	0.023	0.086
57	2.131	0.042	0.042	0.038	0.032	0.057	0.211
57	1.060	0.036	0.036	0.033	0.028	0.049	0.181
57	1.526	0.034	0.034	0.031	0.026	0.046	0.171
57	1.060	0.022	0.022	0.020	0.017	0.030	0.113
58	1.080	0.779	0.805	0.770	0.794	0.678	3.826
59	0.930	0.257	0.259	0.269	0.380	0.377	1.543
59	1.327	0.297	0.300	0.311	0.440	0.436	1.785
59	1.458	0.383	0.387	0.401	0.568	0.563	2.303
60	1.361	0.346	0.340	0.397	0.405	0.383	1.870
60	1.091	0.798	0.785	0.917	0.934	0.884	4.318
61	1.160	0.163	0.233	0.235	0.233	0.241	1.105
61	1.253	0.152	0.217	0.219	0.217	0.225	1.030
61	1.160	0.126	0.180	0.182	0.180	0.186	0.854
61	1.357	0.159	0.227	0.229	0.227	0.235	1.078
61	1.160	0.153	0.218	0.220	0.218	0.226	1.035
62	1.010	0.128	0.126	0.093	0.092	0.099	0.539
63	0.995	0.169	0.158	0.177	0.174	0.178	0.856
64	1.160	0.164	0.172	0.179	0.195	0.185	0.894
64	1.195	0.341	0.357	0.372	0.405	0.385	1.861
64	1.160	0.323	0.338	0.352	0.384	0.365	1.763
65	1.070	0.404	0.396	0.399	0.412	0.466	2.078
65	1.166	0.146	0.143	0.144	0.148	0.168	0.749
66	1.050	0.359	0.254	0.416	0.414	0.498	1.941
66	1.071	0.208	0.147	0.240	0.239	0.288	1.123
67	1.014	0.636	0.635	0.773	0.820	0.820	3.685
67	1.404	0.497	0.496	0.604	0.640	0.640	2.877
67	1.043	0.807	0.805	0.980	1.040	1.040	4.672
67	0.930	0.321	0.320	0.390	0.414	0.414	1.859
68	1.080	1.059	1.041	1.217	1.239	1.172	5.728
69	1.080	1.212	1.245	1.260	1.262	1.182	6.161
70	1.260	0.607	0.601	0.595	0.587	0.586	2.977
70	1.285	0.358	0.355	0.352	0.347	0.346	1.758
71	2.184	0.008	0.008	0.008	0.008	0.008	0.040
71	2.804	0.009	0.009	0.009	0.009	0.009	0.046
71	3.518	0.008	0.008	0.008	0.008	0.008	0.040
71	3.119	0.010	0.009	0.010	0.010	0.009	0.048
71	1.050	0.004	0.004	0.004	0.004	0.004	0.018
71	2.016	0.011	0.010	0.011	0.011	0.010	0.053
72	1.230	0.552	0.554	0.564	0.606	0.559	2.835
73	1.080	0.270	0.280	0.293	0.275	0.272	1.390
74	1.170	0.293	0.287	0.297	0.303	0.325	1.505
75	1.886	0.197	0.197	0.197	0.197	0.024	0.814
75	1.813	0.044	0.044	0.044	0.044	0.005	0.183
75	1.330	0.035	0.035	0.035	0.035	0.004	0.144
75	3.284	0.107	0.107	0.107	0.107	0.013	0.440
76	1.070	0.154	0.154	0.172	0.227	0.174	0.882
77	1.260	0.157	0.158	0.128	0.128	0.126	0.696
77	1.042	0.129	0.130	0.106	0.105	0.104	0.575
77	1.439	0.436	0.439	0.356	0.355	0.351	1.938
78	1.080	0.177	0.176	0.183	0.183	0.138	0.858
78	0.810	0.133	0.132	0.137	0.138	0.104	0.644

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
78	1.469	0.651	0.647	0.671	0.674	0.509	3.152
79	1.806	0.010	0.127	0.010	0.127	0.007	0.280
79	1.050	0.007	0.087	0.007	0.087	0.005	0.192
79	1.607	0.016	0.207	0.016	0.207	0.012	0.458
79	1.638	0.016	0.203	0.016	0.203	0.012	0.449
79	1.628	0.015	0.197	0.015	0.197	0.011	0.435
79	1.533	0.012	0.152	0.012	0.152	0.009	0.335
80	1.160	0.368	0.545	0.561	0.558	0.578	2.611
80	1.299	0.308	0.456	0.469	0.467	0.483	2.183
81	1.260	0.796	0.841	0.883	0.886	0.875	4.282
82	1.160	0.061	0.061	0.078	0.078	0.074	0.351
82	2.506	0.181	0.181	0.233	0.233	0.220	1.049
82	2.076	0.175	0.176	0.226	0.226	0.213	1.017
82	1.160	0.083	0.083	0.107	0.107	0.101	0.483
82	2.042	0.170	0.170	0.218	0.219	0.206	0.982
82	1.160	0.264	0.264	0.340	0.340	0.321	1.529
83	3.320	0.431	0.430	0.444	0.430	0.434	2.169
83	3.596	0.700	0.698	0.722	0.698	0.705	3.522
83	2.143	0.235	0.234	0.242	0.234	0.236	1.180
83	1.825	0.157	0.156	0.161	0.156	0.158	0.788
84	1.070	0.159	0.166	0.167	0.195	0.189	0.875
85	1.070	0.043	0.830	0.043	0.043	0.032	0.991
86	1.469	1.007	0.710	0.697	0.691	0.910	4.015
86	1.284	0.487	0.343	0.337	0.334	0.440	1.941
87	0.930	0.874	0.838	0.949	0.937	0.951	4.550
88	0.863	0.151	0.147	0.156	0.131	0.131	0.716
89	0.880	0.363	0.349	0.360	0.348	0.352	1.771
90	0.993	0.085	0.083	0.089	0.102	0.094	0.454
90	0.813	0.188	0.184	0.196	0.225	0.207	1.000
91	1.020	0.049	0.049	0.068	0.068	0.044	0.279
91	1.081	0.080	0.080	0.112	0.111	0.073	0.455
91	1.020	0.098	0.099	0.138	0.137	0.090	0.563
91	1.122	0.108	0.109	0.152	0.151	0.099	0.619
91	1.020	0.039	0.039	0.054	0.054	0.035	0.221
92	0.896	0.994	0.993	0.996	0.998	0.941	4.922
93	1.150	0.353	0.300	0.236	0.224	0.254	1.368
94	1.080	1.626	1.702	1.302	1.250	1.094	6.975
94	1.177	0.603	0.631	0.483	0.464	0.406	2.587
95	1.746	0.052	0.051	0.052	0.073	0.067	0.295
95	1.040	0.030	0.029	0.030	0.041	0.038	0.167
95	1.020	0.030	0.029	0.030	0.041	0.038	0.168
95	1.350	0.098	0.096	0.098	0.136	0.125	0.554
96	1.415	0.197	0.205	0.211	0.199	0.206	1.017
96	1.299	0.189	0.197	0.202	0.190	0.197	0.975
96	0.930	0.323	0.336	0.345	0.325	0.336	1.665
97	1.080	1.903	1.760	1.770	1.728	1.688	8.848
98	1.000	0.863	0.840	0.813	0.738	0.742	3.996
98	1.060	0.640	0.622	0.602	0.547	0.549	2.960
99	1.272	0.104	0.183	0.187	0.184	0.190	0.847
99	1.200	0.072	0.127	0.130	0.128	0.132	0.588
99	1.332	0.108	0.189	0.193	0.190	0.196	0.876
99	1.200	0.092	0.162	0.165	0.163	0.168	0.749
99	1.030	0.054	0.095	0.097	0.096	0.099	0.442
99	1.391	0.092	0.162	0.166	0.163	0.168	0.752

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
100	1.080	1.960	1.966	2.072	2.051	2.116	10.166
101	0.930	0.726	0.719	0.705	0.700	0.715	3.564
102	0.930	2.612	2.726	2.668	1.947	2.237	12.191
103	1.130	0.494	0.494	0.777	0.425	0.649	2.838
104	1.080	0.743	0.690	0.761	0.866	0.885	3.944
105	1.060	0.188	0.165	0.177	0.175	0.173	0.878
106	1.260	1.603	1.631	1.447	1.435	1.432	7.548
107	1.130	0.205	0.204	0.213	0.220	0.215	1.057
107	1.141	0.200	0.200	0.208	0.215	0.210	1.033
107	1.130	0.116	0.116	0.121	0.125	0.122	0.599
108	0.939	1.356	1.266	1.302	1.358	1.268	6.549
108	0.930	0.409	0.382	0.393	0.410	0.383	1.977
109	0.930	0.439	0.454	0.590	0.374	0.403	2.259
110	1.230	0.584	0.586	0.597	0.641	0.591	2.999
111	1.150	0.318	0.343	0.334	0.408	0.360	1.763
111	1.000	0.185	0.200	0.194	0.238	0.210	1.027
111	1.050	0.736	0.795	0.773	0.945	0.834	4.083
111	1.000	0.279	0.301	0.293	0.358	0.316	1.547
112	1.080	1.498	1.368	1.380	1.399	1.283	6.928
113	1.040	0.043	0.043	0.043	0.043	0.034	0.206
113	1.050	0.026	0.026	0.026	0.026	0.021	0.126
113	1.040	0.014	0.014	0.014	0.014	0.011	0.067
114	1.080	0.195	0.202	0.193	0.199	0.170	0.959
114	1.102	0.335	0.346	0.331	0.341	0.292	1.644
114	1.080	0.254	0.263	0.251	0.259	0.221	1.249
115	3.427	0.019	0.079	0.019	0.019	0.014	0.149
115	1.260	0.009	0.040	0.009	0.009	0.007	0.075
115	3.490	0.019	0.082	0.019	0.019	0.015	0.155
115	8.190	0.038	0.160	0.038	0.038	0.028	0.301
115	3.427	0.021	0.089	0.021	0.021	0.016	0.167
115	3.881	0.023	0.100	0.023	0.023	0.018	0.188
115	4.964	0.030	0.126	0.030	0.030	0.022	0.237
115	3.767	0.027	0.117	0.027	0.027	0.021	0.220
116	1.080	0.231	0.232	0.195	0.205	0.229	1.092
116	1.102	0.500	0.503	0.423	0.445	0.498	2.369
117	1.100	0.225	0.226	0.291	0.367	0.270	1.380
118	1.482	0.064	0.064	0.064	0.064	0.008	0.265
118	1.749	0.046	0.046	0.046	0.046	0.006	0.188
118	3.128	0.072	0.072	0.072	0.072	0.009	0.296
118	3.463	0.087	0.087	0.087	0.087	0.011	0.358
118	1.090	0.078	0.078	0.078	0.078	0.010	0.323
119	1.140	0.120	0.117	0.126	0.124	0.099	0.586
119	1.151	0.454	0.442	0.476	0.469	0.376	2.217
120	1.260	1.554	1.660	1.511	1.506	1.485	7.717
121	0.930	0.657	0.677	0.693	0.769	0.725	3.522
121	0.939	0.961	0.990	1.015	1.126	1.061	5.153
122	1.030	0.269	0.267	0.293	0.291	0.302	1.422
123	0.930	0.680	0.689	0.737	0.741	0.752	3.599
124	0.930	1.525	1.560	1.531	1.547	1.664	7.827
125	0.930	0.045	0.026	0.045	0.045	0.034	0.194
126	0.930	0.303	0.097	0.098	0.107	0.302	0.907
126	2.050	0.270	0.086	0.087	0.095	0.269	0.807
126	3.488	0.272	0.087	0.088	0.096	0.271	0.813
127	1.050	0.029	0.027	0.034	0.033	0.075	0.198

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
128	1.160	0.868	0.761	0.776	0.766	0.799	3.970
129	1.160	1.449	1.547	1.408	1.404	1.384	7.192
130	1.014	1.988	1.711	1.679	1.697	1.825	8.901
131	1.040	0.025	0.398	0.025	0.025	0.012	0.484
131	1.082	0.019	0.311	0.019	0.019	0.010	0.378
131	1.040	0.048	0.784	0.048	0.048	0.025	0.954
132	1.220	0.541	0.539	0.560	0.554	0.559	2.753
133	0.930	1.314	1.285	1.244	1.077	1.121	6.042
134	1.336	0.828	1.000	0.827	1.056	1.089	4.801
134	1.512	0.330	0.399	0.330	0.421	0.435	1.915
134	1.663	0.359	0.434	0.359	0.458	0.473	2.083
134	1.260	0.302	0.364	0.301	0.385	0.397	1.749
134	1.676	0.486	0.587	0.485	0.620	0.639	2.816
134	1.260	0.292	0.352	0.292	0.372	0.384	1.693
135	1.386	0.183	0.169	0.116	0.120	0.183	0.771
136	1.080	0.891	0.923	0.886	0.803	1.264	4.767
137	1.070	0.286	0.247	0.253	0.251	0.252	1.289
137	1.145	0.124	0.107	0.109	0.109	0.109	0.558
137	1.070	0.164	0.141	0.144	0.143	0.144	0.737
138	1.230	0.162	0.162	0.165	0.177	0.164	0.830
138	1.378	0.150	0.151	0.154	0.165	0.152	0.773
138	1.230	0.298	0.299	0.305	0.327	0.302	1.532
139	1.316	0.174	0.174	0.177	0.190	0.176	0.891
139	1.279	0.152	0.153	0.156	0.167	0.154	0.782
139	1.230	0.188	0.188	0.192	0.206	0.190	0.964
139	1.820	0.082	0.082	0.084	0.090	0.083	0.420
140	1.150	0.083	0.070	0.055	0.052	0.059	0.320
140	1.265	0.080	0.068	0.053	0.051	0.058	0.310
140	1.150	0.084	0.071	0.056	0.053	0.060	0.325
140	1.323	0.071	0.060	0.048	0.045	0.051	0.275
140	1.150	0.053	0.045	0.036	0.034	0.038	0.207
141	1.120	0.283	0.294	0.307	0.288	0.285	1.457
142	1.120	1.232	0.241	0.580	0.976	1.768	4.797
143	1.120	0.054	0.054	0.054	0.054	0.041	0.257
144	1.260	0.587	0.598	0.477	0.508	0.528	2.699
144	1.298	0.402	0.409	0.327	0.348	0.361	1.847
145	1.080	0.364	0.770	0.697	0.690	0.705	3.226
145	1.218	0.186	0.394	0.357	0.353	0.361	1.651
145	1.080	0.355	0.750	0.679	0.672	0.687	3.143
146	1.080	0.558	0.534	0.423	0.433	0.449	2.396
147	1.160	0.097	0.100	0.103	0.097	0.101	0.498
147	1.369	0.273	0.284	0.291	0.275	0.284	1.407
147	1.160	0.098	0.102	0.105	0.099	0.102	0.507
147	1.241	0.206	0.214	0.220	0.207	0.215	1.062
147	0.930	0.154	0.160	0.165	0.155	0.161	0.796
148	1.124	0.039	0.039	0.039	0.039	0.045	0.200
148	1.050	0.030	0.030	0.031	0.031	0.035	0.157
148	1.124	0.050	0.050	0.051	0.051	0.058	0.259
148	1.050	0.026	0.027	0.027	0.027	0.031	0.138
148	1.166	0.034	0.034	0.034	0.035	0.039	0.176
149	1.734	0.093	0.087	0.088	0.086	0.085	0.440
149	1.170	0.253	0.238	0.240	0.234	0.233	1.197
150	1.230	0.575	0.566	0.620	0.659	0.654	3.074
151	1.229	0.011	0.010	0.010	0.011	0.011	0.055

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
151	1.050	0.019	0.017	0.017	0.019	0.019	0.092
151	1.103	0.028	0.025	0.025	0.028	0.027	0.132
151	1.050	0.026	0.024	0.024	0.026	0.025	0.125
151	1.859	0.020	0.018	0.018	0.020	0.019	0.096
152	1.712	0.006	0.006	0.006	0.006	0.006	0.030
152	5.282	0.015	0.015	0.015	0.015	0.016	0.077
152	1.470	0.005	0.005	0.005	0.005	0.005	0.024
152	1.050	0.002	0.002	0.002	0.002	0.002	0.011
152	1.985	0.006	0.006	0.006	0.006	0.006	0.030
152	1.050	0.003	0.003	0.003	0.003	0.003	0.013
152	1.575	0.004	0.004	0.004	0.004	0.004	0.019
152	2.468	0.005	0.005	0.005	0.005	0.005	0.024
153	0.990	0.077	0.078	0.077	0.108	0.108	0.449
154	1.080	0.289	0.290	0.298	0.287	0.234	1.399
154	1.091	0.757	0.761	0.781	0.752	0.614	3.665
154	1.080	0.517	0.519	0.533	0.513	0.419	2.501
155	1.080	0.221	0.203	0.224	0.217	0.196	1.061
155	1.102	0.498	0.457	0.504	0.488	0.441	2.388
155	1.080	0.452	0.415	0.458	0.443	0.400	2.168
156	1.160	1.753	1.811	1.799	1.701	1.766	8.829
157	0.930	0.580	0.379	0.392	0.413	0.405	2.169
158	1.260	1.698	1.308	1.191	1.187	1.170	6.552
158	1.499	0.595	0.459	0.418	0.416	0.410	2.298
159	1.242	0.130	0.135	0.138	0.130	0.135	0.668
159	1.080	0.426	0.443	0.454	0.429	0.443	2.194
159	1.242	0.180	0.187	0.192	0.181	0.187	0.926
160	1.125	0.119	0.100	0.121	0.119	0.072	0.532
160	1.014	0.122	0.103	0.125	0.122	0.074	0.545
160	0.930	0.145	0.122	0.148	0.145	0.088	0.650
160	0.967	0.147	0.124	0.150	0.147	0.089	0.657
160	1.023	0.130	0.110	0.133	0.130	0.079	0.582
161	0.930	0.267	0.318	0.324	0.324	0.282	1.515
161	0.967	0.245	0.291	0.297	0.297	0.259	1.390
161	0.930	0.265	0.315	0.322	0.322	0.280	1.504
162	1.080	0.167	0.173	0.176	0.167	0.185	0.868
162	1.156	0.061	0.063	0.064	0.061	0.067	0.316
162	1.080	0.045	0.046	0.047	0.045	0.049	0.232
163	1.432	0.212	0.213	0.207	0.180	0.186	0.998
163	1.432	0.250	0.251	0.244	0.212	0.219	1.176
164	1.000	0.092	0.093	0.084	0.072	0.126	0.467
165	0.930	1.307	1.343	1.364	1.396	1.447	6.856
166	1.260	0.944	0.828	0.844	0.833	0.869	4.318
167	1.170	0.420	0.426	0.451	0.429	0.406	2.132
168	1.080	0.409	0.380	0.419	0.476	0.409	2.093
168	1.112	0.335	0.312	0.344	0.391	0.335	1.717
169	2.002	0.079	0.082	0.085	0.086	0.084	0.416
169	1.782	0.063	0.066	0.068	0.069	0.068	0.334
169	1.144	0.367	0.382	0.393	0.399	0.391	1.933
169	1.672	0.078	0.081	0.083	0.084	0.083	0.409
169	1.573	0.104	0.108	0.111	0.113	0.111	0.547
169	1.793	0.079	0.083	0.085	0.086	0.085	0.418
169	1.100	0.044	0.046	0.047	0.048	0.047	0.230
170	1.353	0.092	0.092	0.094	0.101	0.100	0.478
170	1.230	0.246	0.247	0.250	0.269	0.266	1.279

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
170	1.501	0.084	0.084	0.085	0.092	0.091	0.437
170	1.230	0.186	0.187	0.189	0.203	0.202	0.967
171	1.150	0.142	0.143	0.146	0.186	0.199	0.816
172	1.260	0.677	0.651	0.849	0.850	0.841	3.867
173	1.080	0.380	0.387	0.406	0.403	0.405	1.979
173	1.166	0.185	0.189	0.198	0.197	0.198	0.967
173	1.080	0.451	0.460	0.482	0.478	0.481	2.352
174	1.080	2.198	1.540	1.591	1.564	0.694	7.587
175	1.130	0.296	0.360	0.339	0.336	0.346	1.677
176	1.030	0.032	0.032	0.043	0.042	0.045	0.194
176	1.360	0.043	0.043	0.057	0.056	0.060	0.258
176	1.030	0.055	0.055	0.073	0.072	0.077	0.333
176	1.339	0.068	0.068	0.090	0.088	0.095	0.408
177	1.000	0.161	0.061	0.063	0.062	0.064	0.410
177	1.190	0.346	0.132	0.134	0.132	0.136	0.881
177	1.130	0.665	0.253	0.258	0.254	0.262	1.692
177	1.000	0.231	0.088	0.089	0.088	0.091	0.587
177	1.340	0.337	0.128	0.131	0.129	0.133	0.858
177	1.000	0.326	0.124	0.126	0.125	0.128	0.829
178	1.000	1.119	1.051	1.093	1.146	1.230	5.638
179	1.232	0.059	0.050	0.039	0.037	0.042	0.227
179	1.090	0.068	0.058	0.045	0.043	0.049	0.263
179	1.254	0.053	0.045	0.036	0.034	0.038	0.206
179	1.090	0.057	0.048	0.038	0.036	0.041	0.220
179	1.526	0.071	0.060	0.048	0.045	0.051	0.276
179	1.341	0.069	0.059	0.046	0.044	0.050	0.268
180	1.000	0.169	0.160	0.159	0.177	0.140	0.805
181	1.112	0.648	0.700	0.681	0.833	0.735	3.597
181	1.080	0.298	0.322	0.313	0.383	0.338	1.653
181	1.091	0.589	0.636	0.619	0.756	0.667	3.267
182	1.070	0.178	0.154	0.157	0.156	0.157	0.802
182	1.113	0.159	0.137	0.140	0.139	0.140	0.715
182	1.070	0.087	0.075	0.077	0.076	0.076	0.391
182	1.145	0.141	0.122	0.125	0.124	0.124	0.636
183	1.230	0.151	0.151	0.153	0.165	0.163	0.784
183	1.390	0.195	0.195	0.198	0.213	0.211	1.011
183	1.230	0.109	0.109	0.110	0.118	0.117	0.563
183	1.378	0.175	0.175	0.178	0.191	0.189	0.907
184	1.202	0.086	0.087	0.088	0.346	0.342	0.949
184	1.010	0.102	0.103	0.105	0.408	0.404	1.121
184	1.182	0.078	0.078	0.080	0.313	0.309	0.858
184	1.232	0.055	0.055	0.056	0.219	0.217	0.602
185	1.156	0.182	0.346	0.347	0.348	0.328	1.552
185	1.080	0.444	0.845	0.847	0.848	0.800	3.785
186	1.281	0.011	0.011	0.011	0.011	0.011	0.054
186	1.544	0.005	0.005	0.005	0.005	0.005	0.026
186	1.439	0.004	0.004	0.004	0.004	0.004	0.022
186	1.355	0.009	0.009	0.009	0.009	0.009	0.044
187	1.070	0.160	0.166	0.167	0.195	0.190	0.878
188	1.180	0.242	0.245	0.337	0.333	0.321	1.478
188	1.416	0.108	0.109	0.149	0.148	0.143	0.656
188	1.180	0.058	0.059	0.081	0.080	0.077	0.356
188	1.687	0.071	0.072	0.099	0.098	0.095	0.436
189	0.930	0.149	0.177	0.180	0.181	0.157	0.844

Table E-7. Predictive Crash Data (Crash Modification Factors)

Site	All_CMFs	Pred2012	Pred2011	Pred2010	Pred2009	Pred2008	Pred_tot
189	0.939	0.202	0.241	0.245	0.246	0.213	1.147
189	0.930	0.148	0.176	0.180	0.180	0.156	0.840
189	0.958	0.143	0.170	0.173	0.173	0.150	0.809
189	0.930	0.172	0.204	0.208	0.209	0.181	0.975
190	1.020	0.053	0.050	0.050	0.049	0.049	0.250
190	1.326	0.071	0.067	0.068	0.066	0.066	0.338
190	1.020	0.199	0.187	0.188	0.184	0.183	0.941
190	1.173	0.064	0.060	0.061	0.059	0.059	0.303
191	1.160	0.138	0.143	0.138	0.138	0.152	0.710
191	1.601	0.105	0.109	0.105	0.105	0.116	0.541
191	1.160	0.088	0.091	0.088	0.088	0.097	0.451
191	1.554	0.064	0.066	0.064	0.064	0.071	0.328
191	1.960	0.074	0.077	0.074	0.074	0.081	0.379
192	0.930	1.103	1.189	1.179	1.031	1.153	5.656
193	1.250	0.184	0.183	0.187	0.188	0.164	0.906
193	1.288	0.225	0.223	0.229	0.229	0.201	1.107
193	1.250	0.244	0.241	0.248	0.248	0.217	1.198
194	1.090	0.193	0.170	0.182	0.180	0.177	0.901
194	1.123	0.060	0.053	0.056	0.056	0.055	0.279
195	1.163	0.069	0.069	0.056	0.056	0.057	0.307
195	1.020	0.111	0.110	0.089	0.089	0.090	0.490
195	1.040	0.159	0.159	0.129	0.129	0.130	0.706
196	1.070	0.256	0.167	0.179	0.177	0.175	0.952

APPENDIX F: PROCEDURES FOR ESTIMATING CALIBRATION FUNCTIONS

Appendix F provides a brief overview of the procedure that was used for estimating the calibration functions in Microsoft Excel. More details about these procedures are available in Hauer (2015). The procedure is illustrated using an example, (e.g., estimating the Type 1 calibration function.

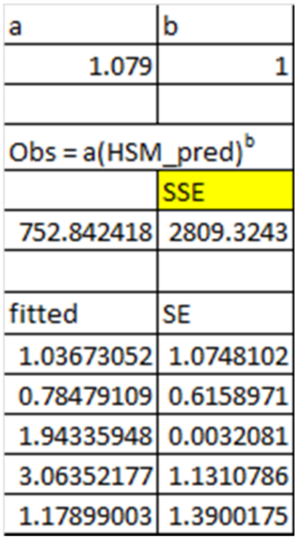
As discussed in Section 5, the Type 1 calibration function is the following:

$$N_p = a \times (HSM\ Pred)^b$$

Where Np = predicted number of crashes after calibration
HSM Pred = predicted number of crashes based on the HSM (AASHTO 2010) procedure before calibration
a = factor determined by statistical analysis
b = factor determined by statistical analysis

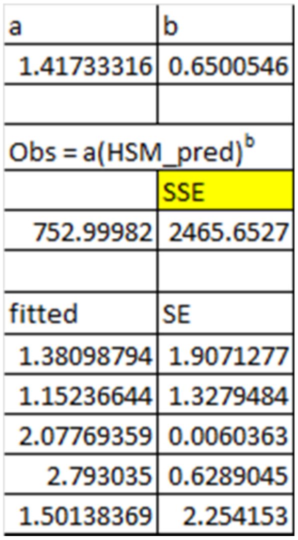
For the Type 1 calibration function, the estimation was done using ordinary least squares (OLS), poisson (P) regression, and negative binomial (NB) regression. Here are the steps that were followed for estimating the function using OLS.

- Create a data file where each row represents the data for one segment. At a minimum, data are needed on AADT, segment length, all CMFs, the observed crashes (Obs), and the predicted crashes from the HSM (HSM Pred).
- Insert spaces above the data so that there is space to enter information for parameters a and b and for other statistics.
- Enter starting values for a and b. A reasonable starting value will be 1.079 for a (which is the same as the calibration factor), and 1 for b.
- Calculate the fitted value for each segment based on the RHS of Equation 1 using a, b, and HSM Pred. For example, if HSM Pred is 0.96, then the fitted value will be $1.079 \times (0.96)^1$ = 1.036.
- Calculate the total fitted value of crashes and the total observed crashes for all the segments.
- For each segment, calculate the square of the difference between the observed and fitted values. For example, if a segment experienced 3 crashes, and the fitted value was 2.3, then square of the difference will be $(3 – 2.3)^2$ = 0.49. Calculate the total square of the difference for all the segments (call this SSE). Figure F-1 shows an extract of the excel file that was used. It shows the cells with the initial values for a and b, the total fitted value (752.84), and the SSE (2809.3).
- After this, click on data and then solver. The goal is minimize the total of the SSE by varying a and b with the constraint that the total observed crashes is equal to the total fitted crashes. Figure F-2 shows values after using Solver. The values a and b that minimize the SSE are a = 1.417 and b = 0.650.



a	b
1.079	1
Obs = a(HSM_pred)^b	
	SSE
752.842418	2809.3243
fitted	SE
1.03673052	1.0748102
0.78479109	0.6158971
1.94335948	0.0032081
3.06352177	1.1310786
1.17899003	1.3900175

Figure F-1. Extract from Excel Sheet for Ordinary Least Squares Before Using Solver.



a	b
1.41733316	0.6500546
Obs = a(HSM_pred)^b	
	SSE
752.99982	2465.6527
fitted	SE
1.38098794	1.9071277
1.15236644	1.3279484
2.07769359	0.0060363
2.793035	0.6289045
1.50138369	2.254153

Figure F-2. Extract from Excel Sheet for Ordinary Least Squares After Using Solver.

The steps for estimating the P regression and the NB regression are quite similar. The main difference is that in P and NB regression, when Solver is used, the goal is to *maximize* the log-likelihood (LL) instead of *minimizing* the SSE.

The abbreviated[5] LL for the P regression is as follows:

$$= -\hat{\mu} + X\ln(\hat{\mu}) \tag{Eq. 8}$$

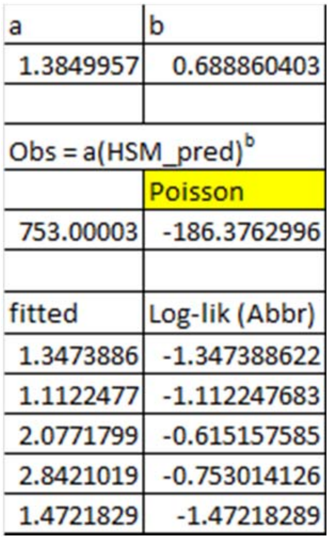
Where $\hat{\mu}$ = the fitted value
X = the observed number of crashes

The abbreviated LL for the NB regression is as follows:

$$= GAMMALN(X + \varphi L) - GAMMALN(\varphi L) + \varphi L\ln(\varphi L) + X\ln(\hat{\mu}) - (\varphi L + X) \times \ln(\varphi L + \hat{\mu}) \tag{Eq. 9}$$

Where GAMMALN = the log gamma function in Microsoft Excel
L = the length of a segment
φ = the inverse overdispersion parameter for the negative binomial regression model

Figure F-3 and Figure F-4 show the results obtained after using Solver for P and NB regression.



a	b
1.3849957	0.688860403
Obs = a(HSM_pred)^{b}	
	Poisson
753.00003	-186.3762996
fitted	Log-lik (Abbr)
1.3473886	-1.347388622
1.1122477	-1.112247683
2.0771799	-0.615157585
2.8421019	-0.753014126
1.4721829	-1.47218289

Figure F-3. Extract from Excel sheet for Poisson Regression After using Solver.

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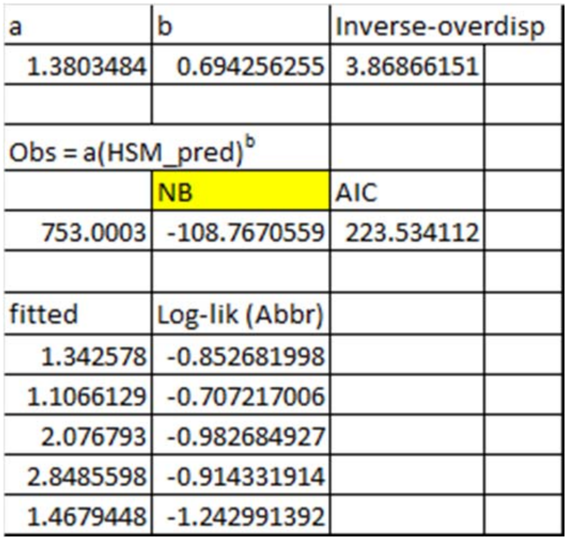
[5] Reference Section 5 for a discussion regarding the reason for using abbreviated log likelihood.



a	b	Inverse-overdisp	
1.3803484	0.694256255	3.86866151	
Obs = a(HSM_pred)^b			
	NB	AIC	
753.0003	-108.7670559	223.534112	
fitted	Log-lik (Abbr)		
1.342578	-0.852681998		
1.1066129	-0.707217006		
2.076793	-0.982684927		
2.8485598	-0.914331914		
1.4679448	-1.242991392		

Figure F-4. Extract from Excel Sheet for Negative Binomial Regression After using Solver.