

**APPENDIX C. SPREADSHEET PROGRAM AND USER  
MANUAL**

## INTRODUCTION

The safety prediction models developed in NCHRP Project 17-58 (1, 2) apply to two-way urban and suburban arterials with six or more lanes, one-way urban and suburban arterials, and intersections on these types of arterials. These models were developed for possible inclusion in a future edition of the *Highway Safety Manual* (HSM) (3). Because the models are complex in form and require numerous calculations to implement, an Excel®-based spreadsheet program was developed to assist analysts in implementing the safety prediction models.

This *User Guide* provides instructions for using the spreadsheet program to implement the calculations in the revised HSM Chapter 12 (2). All variable names and definitions in the spreadsheet program are consistent with those in the revised HSM Chapter 12. Hence, it is recommended that the analyst read the revised HSM Chapter 12 before using the spreadsheet program, and refer back to the Chapter when clarification is needed on variable definitions and procedures for measuring or counting variable values.

## BASIC OPERATION

The spreadsheet program can be used on a computer with Microsoft Office® 2007 or newer versions. This User Guide provides instructions on using the spreadsheet program to analyze individual sites (arterial segments or intersections), tabulate results for a facility consisting of multiple sites, and conduct an empirical Bayes (EB) analysis.

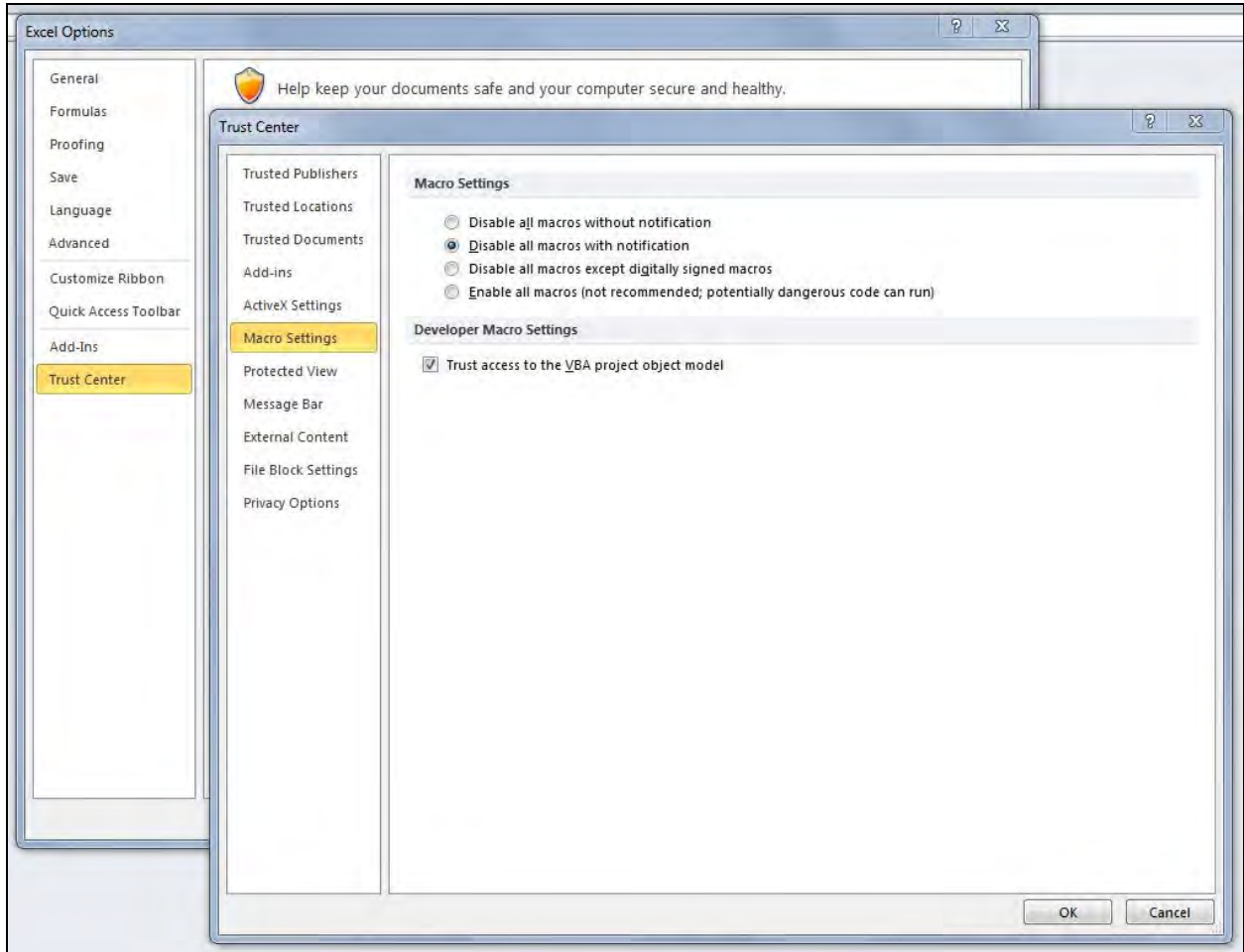
### Enabling Macro Content

The spreadsheet program uses macros for several of its calculation and organization tasks. Hence, it is essential that Excel be configured such that macros are not always disabled. Macro security settings are located in the Trust Center (see Figure 1), which is accessed by choosing the File tab on the upper-left portion of the Excel screen and choosing “Options”. The spreadsheet program will not function properly if the highest macro security setting, “Disable all macros without notification”, is chosen. If “Disable all macros with notification” or “Disable all macros except digitally signed macros” is chosen, the yellow bar shown in Figure 2 will appear when the program is opened. Click on the “Enable Content” button to enable macros. If the last macro security option, “Enable all macros”, is chosen, the yellow bar will not appear and macros will function.

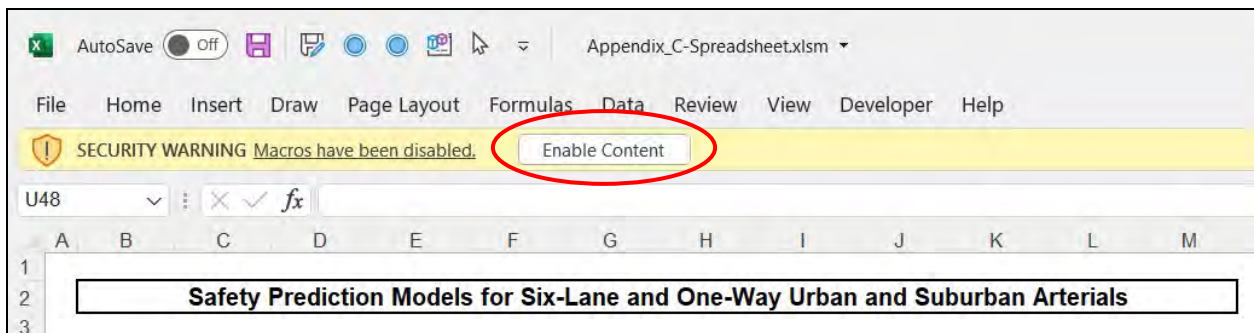
### Worksheet Organization

When the spreadsheet program is opened, the Welcome screen shown in Figure 3 will appear. This screen provides a basic overview of the program and brief description of the color scheme used for the cells. The five tabs below the Welcome message are used to access the five worksheets that are provided in the program. The first of these worksheets is the Welcome screen. The next three worksheets, “Two-way segments”, “One-way segments”, and “Intersections”, are the input data worksheets that are used to analyze individual sites on the urban or suburban arterial facility of interest. The last worksheet, “Totals”, is used to obtain

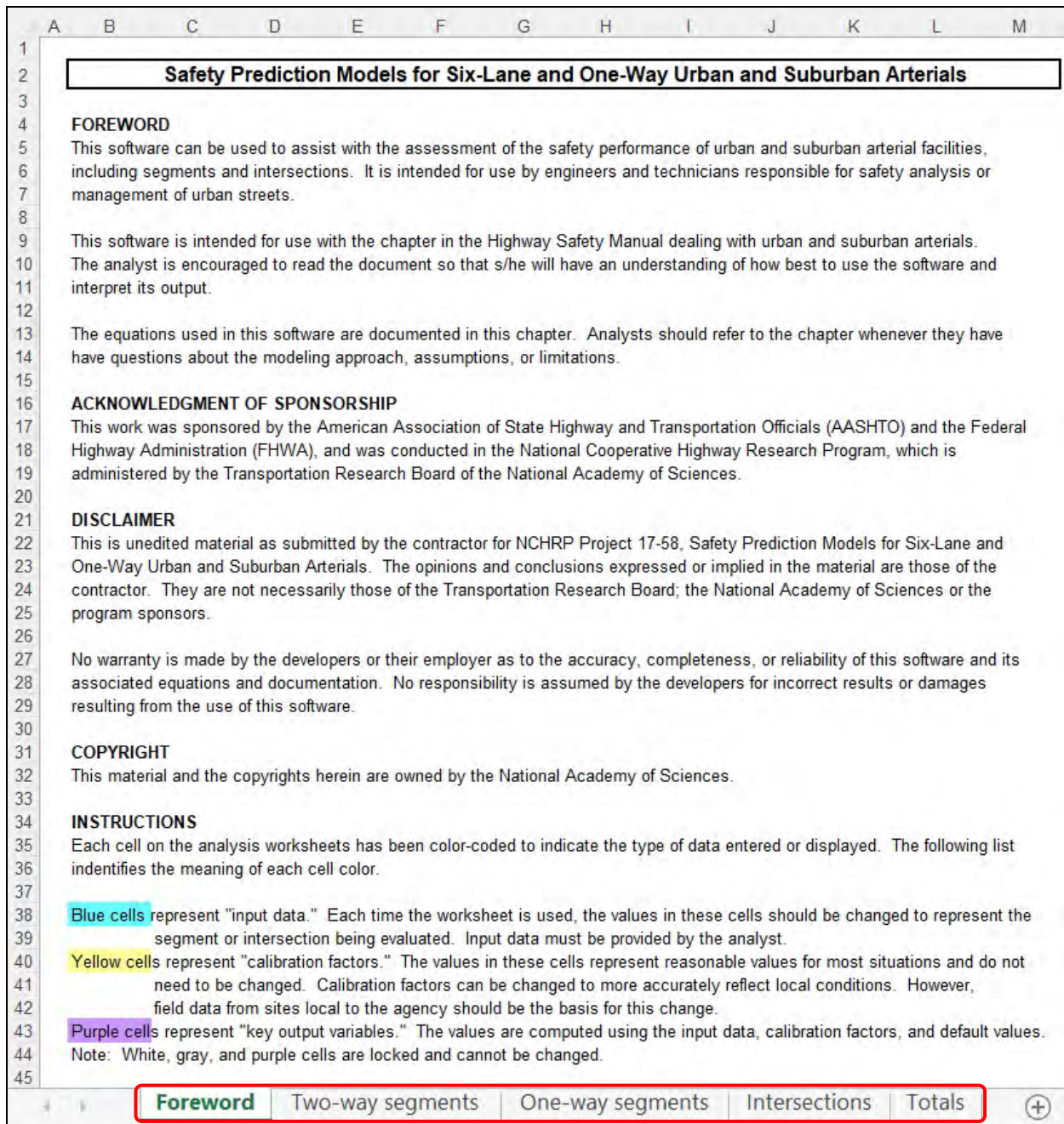
crash totals for the entire facility as well as to conduct a site-specific or project-level EB analysis based on the procedures described in Appendix A of the HSM.



**Figure 1. Macro Security Settings in Excel**



**Figure 2. Enabling Macros in Excel**



**Figure 3. Foreword Screen**

### Cell Color Scheme

In the various worksheets, color shading is used to assist the analyst in understanding which cells may be manipulated and which cannot be disrupted. The spreadsheet program uses numerous equations and macros to perform the calculations needed to implement the safety prediction models, and cells containing these calculations are locked to prevent inadvertent alteration that would lead to erroneous results.

#### *Input Data Cells*

Input data cells are shaded blue, like the “General Information” and “Site Information” cells shown in Figure 4. The analyst will routinely change the values in these cells to describe the site being analyzed and to examine changes in predicted crash frequency that may occur if input parameters are altered. The required content for these cells is described in greater detail in the next section of this Guide.

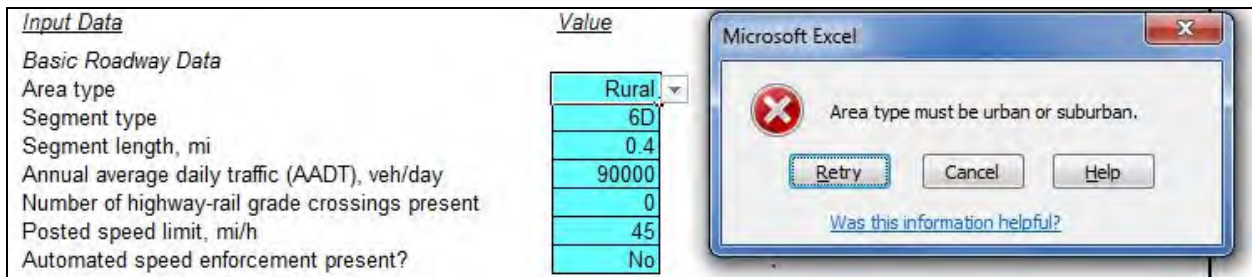
| <i>Safety Prediction Worksheet for Two-Way Urban and Suburban Arterial Segments</i> |                  |                         |             |
|---|------------------|-------------------------|-------------|
| <i>General Information</i>  |                  | <i>Site Information</i> |             |
| Analyst   | MPP              | Street number           | SH 1        |
| Agency  | TTI              | Street name             | Main Street |
| Date  | 12/8/2015        | Segment number          | 1           |
| Location  | City of Fillmore | Analysis year           | 2011        |

**Figure 4. Input Data Cells – Blue Shading**

Some input data cells describe characteristics that can only be described in discrete quantities. For example, area type can only be described as urban or suburban for the facilities included in the scope of the safety prediction models contained in the spreadsheet program. When the analyst selects one of these cells, a drop-down menu will appear as shown in Figure 5. The analyst may choose one of the options in the menu or type one of the allowed options into the cell. If the analyst enters a value that is not valid for the input data cell, an error message will appear as shown in Figure 6.



**Figure 5. Drop-Down Menus**



**Figure 6. Input Data Cell Error Message**

Some input data cells are accompanied by advisory messages that will appear in red to the right of the cell. These messages may provide clarifications on certain data inputs, warnings if model parameter ranges have been exceeded, or warnings if an invalid value has been entered into the input data cell. All three of these situations are visible in Figure 7. For the described two-way arterial segment, the segment type was entered as “8D”, or eight-lane divided. The analyst indicated that the segment length is 0.4 mi and there are 18 roadside fixed objects present, so an advisory message explains that the object density is “45 objects per mile”. The analyst entered a median width of 0 ft, which is not consistent with an eight-lane divided cross



section, so a warning message indicates that the analyst “must enter nonzero median width”. The posted speed limit is 30 mi/h, and the pedestrian and bicyclist adjustment factors ( $f_{ped}$  and  $f_{bike}$ ) that are needed for some calculations are not available for that speed, so the advisory message indicates that the factors must be estimated (“Estimated ped/bike factors”).

| <u>Input Data</u>                              | <u>Value</u> | <u>Advisory Messages</u>         |
|--|--------------|----------------------------------|
| <i>Basic Roadway Data</i>                      |              |                                  |
| Area type                                      | Suburban     | .                                |
| Segment type                                   | 8D           | .                                |
| Segment length, mi                             | 0.4          | .                                |
| Annual average daily traffic (AADT), veh/day   | 90000        | .                                |
| Number of highway-rail grade crossings present | 0            | .                                |
| Posted speed limit, mi/h                       | 30           | Estimated ped/bike factors.      |
| Automated speed enforcement present?           | No           | .                                |
| <i>Access Data</i>                             |              |                                  |
| Driveway count                                 |              |                                  |
| Major commercial                               | 0            | .                                |
| Major industrial                               | 0            | .                                |
| Minor  | 0            | .                                |
| <i>Cross Section Data</i>                      |              |                                  |
| Lane width, ft                                 | 11           | .                                |
| Outside shoulder width, ft                     | 1.5          | .                                |
| Median width, ft                               | 0            | Must enter nonzero median width. |
| Median barrier present?                        | Yes          | .                                |
| <i>Roadside Data</i>                           |              |                                  |
| Roadside fixed object count                    | 18           | 45 objects per mile.             |
| Average roadside fixed object offset, ft       | 7            | .                                |

**Figure 7. Advisory Messages for Input Data Cells**

### Calibration Factor Cells

Calibration factor cells are shaded yellow as shown in Figure 8. These cells contain parameters like the local calibration factor  $C$  and the pedestrian and bicyclist adjustment factors  $f_{ped}$  and  $f_{bike}$ . These calibration factors affect key calculation results in each of the input data worksheets. The analyst can change the values entered into calibration factor cells, but should do so only based on analysis of field data from the jurisdiction containing the sites of interest. The original values in the calibration factor cells are the factors and model coefficients that were derived from the research conducted in NCHRP Project 17-58. It is expected that these cells may need to be altered on occasion based on a jurisdiction’s data trends, but they should not need to be altered during the course of a routine analysis exercise.

| <u>Calibration Factors</u>                                 | <u>Value</u> |
|--|--------------|
| Local calibration factor ( $C$ )                           | 1.000        |
| Adjustment factor for pedestrians ( $f_{ped}$ )            | 0.029        |
| Adjustment factor for bicyclists ( $f_{bike}$ )            | 0.007        |
| Severity distribution calibration factor ( $C_{sdf,tws}$ ) | 1.000        |

**Figure 8. Calibration Factor Cells**

### Key Output Variable Cells

Key output variable cells are shaded purple as shown in Figure 9. These cells contain key output quantities, such as the total predicted crash frequency, combined CMF (product of all individual CMFs), and severity distribution for fatal-and-injury crashes. These cells are locked and cannot be altered, but are shaded to denote their importance.

| <u>Output Summary</u>      | <i>Predicted crash frequency, crashes / year</i> |            |              |
|----------------------------|--|------------|--------------|
|                            | <i>F+I</i>                                       | <i>PDO</i> | <i>Total</i> |
| Total crashes              | 4.145  | 5.039      | 9.184        |
| Multiple-vehicle crashes   | 2.878  | 3.872      |              |
| Single-vehicle crashes     | 0.948  | 1.167      |              |
| Vehicle-pedestrian crashes | 0.257  |            |              |
| Vehicle-bicycle crashes    | 0.062  |            |              |

**Figure 9. Key Output Variable Cells**

### Other Types of Cell Shading

Some cells are shaded white or gray as shown in Figure 10. These cells contain intermediate calculations that may be of interest to the analyst, but do not represent the final analysis result. The white cells in Figure 10 contain the computed values for each individual CMF on a two-way segment. The analyst may need to inspect these values to determine which site characteristics contribute most to a high or low predicted crash frequency. White cells are also visible in Figure 9, showing the tabulation of predicted crash frequency by severity (fatal-and-injury or property-damage-only) and crash type (multiple-vehicle, single-vehicle, vehicle-pedestrian, or vehicle-bicycle).

| <u>Crash Modification Factors</u> | <i>F+I</i>      |               | <i>PDO</i>      |               |
|-----------------------------------|-----------------|---------------|-----------------|---------------|
|                                   | <i>Multiple</i> | <i>Single</i> | <i>Multiple</i> | <i>Single</i> |
| Lane width                        | 1.022           | 1.022         | 1.022           | 1.022         |
| Outside shoulder width            | 1.000           | 1.000         | 1.000           | 1.000         |
| Median width                      | 1.011           | 1.011         | 1.011           | 1.011         |
| Median barrier                    | 0.600           | 1.967         | 0.600           | 1.967         |
| Highway-rail grade crossing       | 1.000           | 1.000         | 1.000           | 1.000         |
| Major commercial driveways        | 0.932           |               | 0.932           |               |
| Major industrial driveways        | 0.989           |               | 0.989           |               |
| Minor driveways                   | 0.947           |               | 0.947           |               |
| Automated speed enforcement       | 1.000           | 1.000         | 1.000           | 1.000         |
| Roadside fixed objects            |                 | 1.180         |                 | 1.180         |

**Figure 10. Other Cells**

A small number of gray cells exist in the spreadsheet program. These cells are shaded gray to indicate that they are not applicable. For example, Figure 10 shows that the cells for single-vehicle driveway CMFs and the multiple-vehicle roadside fixed object CMF are gray.

These cells are not applicable because the driveway CMFs do not apply to single-vehicle crashes and the roadside fixed object CMF does not apply to multiple-vehicle crashes.

Some input data cells are configured to be shaded different colors depending on whether they are needed. For example, as shown in Figure 11, the input data cell for average roadside fixed object offset is typically shaded blue. However, if the analyst enters 0 for roadside fixed object count, the average roadside fixed object offset cell shading turns white and its text turns gray. This change denotes the fact that an average roadside fixed object offset need not be provided if no such objects are present.

|  |    |
|--|----|
| <i>Roadside Data</i>                     |    |
| Roadside fixed object count              | 18 |
| Average roadside fixed object offset, ft | 7  |
| <i>Roadside Data</i>                     |    |
| Roadside fixed object count              | 0  |
| Average roadside fixed object offset, ft | 7  |

**Figure 11. Automated Cell Shading**

## Analysis Sequence

To conduct a safety analysis of an urban or suburban arterial facility, the analyst would complete the following steps:

1. Identify the facility of interest. The facility will likely consist of multiple sites, where a site is a homogeneous two-way arterial street segment, a homogeneous one-way arterial street segment, or a signalized or stop-controlled intersection of two streets.
2. Determine the analysis period of interest. The analysis period will consist of one or more years.
3. Analyze the first site on the facility using the relevant input data worksheet.
4. Transfer the data and calculations from the input data worksheet to the Totals worksheet.
5. Repeat steps 3 and 4 for each year in the analysis period (if there are multiple years).
6. Repeat steps 3-5 for each site on the facility (if there are multiple sites).
7. Enter crash count data into the Totals worksheet (if an EB adjustment is desired).
8. Calculate the predicted crash frequency (if EB adjustment is not applied) or expected crash frequency (if EB adjustment is applied) for the entire facility using the Totals worksheet.

The analysis procedure is described in greater detail in the next parts of this Guide, which describe the input data worksheets and the Totals worksheet.

## Input Data Worksheets

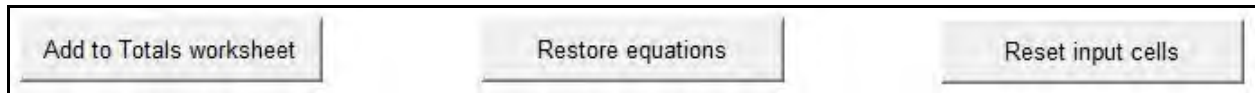
The spreadsheet program contains input data worksheets for describing and analyzing individual sites. There are three worksheets, which correspond to the three facility types that were addressed in NCHRP Project 17-58. These facility types include two-way urban and



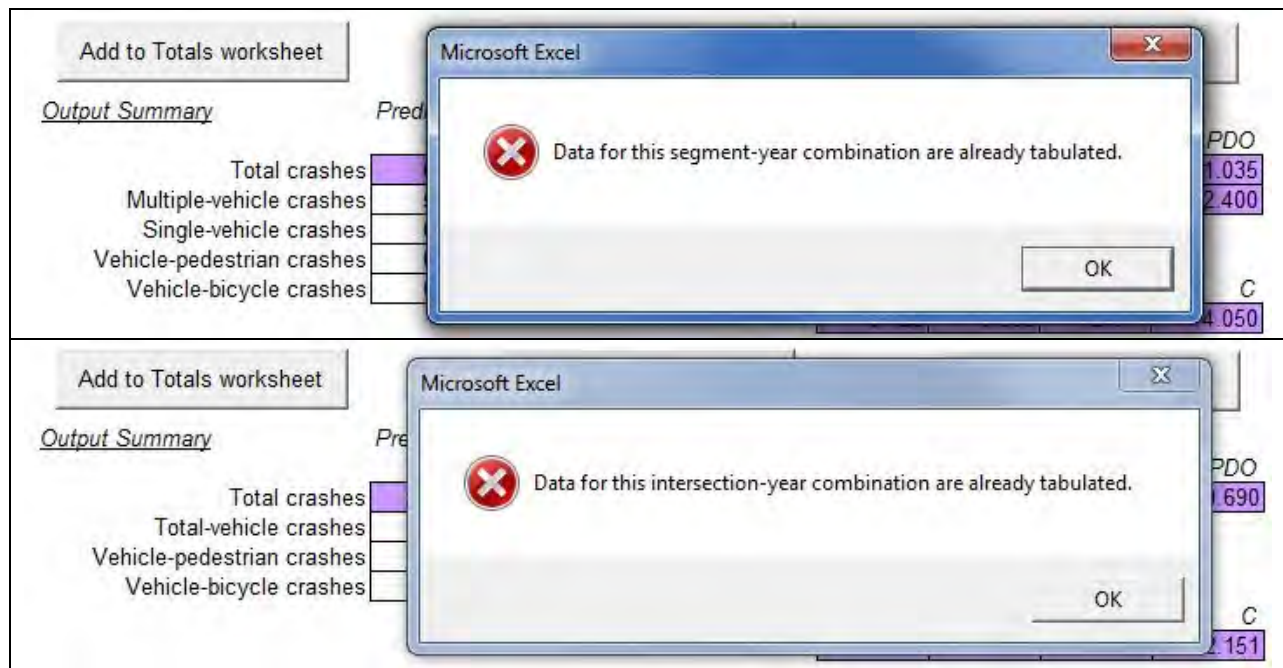
suburban arterial street segments with six or more lanes, one-way urban and suburban arterial streets, and intersections on these streets.

All three input data worksheets have the three command buttons that are shown in Figure 12. These buttons serve the following purposes:

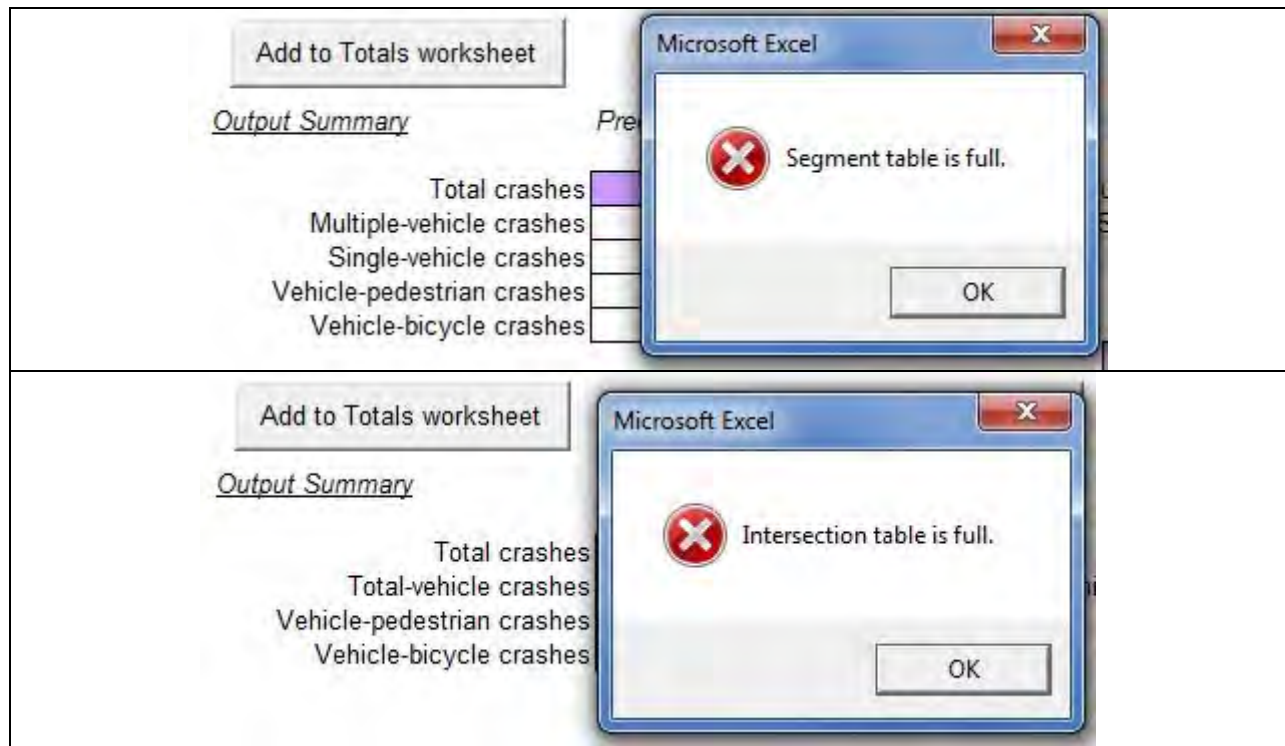
- Add to Totals worksheet: Click this button to transfer the data and calculations from the input data worksheet to the Totals worksheet. If the site has already been described for the specified year, and the data and calculations have already been transferred to the Totals worksheet, an error message will appear (see Figure 13) and the data will not transfer. The data will be added to the bottommost empty row in the relevant data table (segment or intersection) on the Totals worksheet; if this row is filled, an error message will appear (see Figure 14) to indicate that the data table is full, and the data will not transfer.
- Restore equations: Some of the input data cells and calibration factor cells contain equations, though these cells are unlocked. For example, the Date cell in the General Information input data cells contains an equation that gives today's date, but the analyst can overwrite the equation-computed date with a different date if desired. Click this button to restore the equations in the cells.
- Reset input cells: Click this button to populate the input data cells with a set of pre-chosen values. These values describe a fictitious site. This function is useful if the analyst is finished analyzing a site and desires to start a new analysis without retaining data describing the previous site.



**Figure 12. Command Buttons on Input Data Worksheets**



**Figure 13. Data Transfer Error Messages – Duplicate Data**



**Figure 14. Data Transfer Error Messages – Full Data Table**

Each of the input data worksheets consists of a main work area that is denoted by a bold-bordered box. The main work area contains all input data cells, calibration factor cells, and output cells. The worksheets also have numerous boxes containing calibration coefficients and some intermediate calculations in the space to the right of the main work area. It is not anticipated that the analyst would need to use the boxes to the right of the main work area. Some of these boxes contain cells that are shaded yellow because they are populated with calibration coefficients for the various equations. These coefficients were derived in NCHRP Project 17-58, and the analyst should not alter them without significant justification based on detailed analysis of field data from the jurisdiction of interest.

#### *Two-Way Segments*

The general information and site information input data cells are shown in the top portion of Figure 15. Cells are provided for the analyst to enter analyst's name, agency, date (this cell is populated with an equation that computes the current date), location, street number, street name, segment number, and analysis year. To avoid the error message shown in Figure 13, it is essential to change the segment number every time a new site at a facility is being analyzed, and to change the analysis year every time a new year is being analyzed.

The input data cells on the Two-Way Segments worksheet are shown in Figure 16. The analyst must provide data to describe the basic roadway characteristics, access characteristics, cross-sectional characteristics, and roadside characteristics.

| <b>Safety Prediction Worksheet for Two-Way Urban and Suburban Arterial Segments</b> |  |                   |  |                     |            |
|---|--|-------------------|--|---------------------|------------|
| <u>General Information</u>  |  |                   | <u>Site Information</u>                      |                     |            |
| Analyst   | MPP  |                   | Street number                                | SH 1                |            |
| Agency  | TTI  |                   | Street name                                  | Main Street         |            |
| Date  | 12/9/2015  |                   | Segment number                               | 1                   |            |
| Location  | City of Fillmore                                 |                   | Analysis year                                | 2011                |            |
| Add to Totals worksheet   |  | Restore equations |  | Reset input cells   |            |
| <u>Output Summary</u>   |  |                   | <u>Severity distribution for F+I crashes</u> |                     |            |
|   | <i>Predicted crash frequency, crashes / year</i> |                   |  | <i>Combined CMF</i> |            |
|   | <i>F+I</i>                                       | <i>PDO</i>        | <i>Total</i>                                 | <i>F+I</i>          | <i>PDO</i> |
| Total crashes   | 6.785  | 8.556             | 15.341                                       | 1.035               | 1.035      |
| Multiple-vehicle crashes  | 5.492  | 7.389             |  | 2.400               | 2.400      |
| Single-vehicle crashes  | 0.948  | 1.167             |  |                     |            |
| Vehicle-pedestrian crashes  | 0.225  |                   |  |                     |            |
| Vehicle-bicycle crashes   | 0.120  |                   |  |                     |            |
|   | <i>K</i>   | <i>A</i>          | <i>B</i>                                     | <i>C</i>            |            |
|   | 0.128  | 0.533             | 2.074  | 4.050               |            |

**Figure 15. Two-Way Segments General Information Cells and Output Summary**

| <u>Input Data</u>                              | <u>Value</u>        | <u>Advisory Messages</u>  |
|--|---------------------|---|
| <i>Basic Roadway Data</i>                      |                     |   |
| Area type                                      | Suburban            | .   |
| Segment type                                   | 6D                  | .   |
| Segment length, mi                             | 0.4                 | .   |
| Annual average daily traffic (AADT), veh/day   | 90000               | .   |
| Number of highway-rail grade crossings present | 0                   | .   |
| Posted speed limit, mi/h                       | 45                  | .   |
| Automated speed enforcement present?           | No                  | .   |
| <i>Access Data</i>                             |                     |   |
| Driveway count                                 | Major commercial: 6 | <b>15 major comm. driveways per mile.<br/>3 major industrial driveways per mile.<br/>18 minor driveways per mile.</b> |
|  | Major industrial: 1 |   |
|  | Minor: 7            |   |
| <i>Cross Section Data</i>                      |                     |   |
| Lane width, ft                                 | 11                  | .   |
| Outside shoulder width, ft                     | 1.5                 | .   |
| Median width, ft                               | 13                  | .   |
| Median barrier present?                        | Yes                 | .   |
| <i>Roadside Data</i>                           |                     |   |
| Roadside fixed object count                    | 18                  | <b>45 objects per mile.</b>   |
| Average roadside fixed object offset, ft       | 7                   | .   |

**Figure 16. Two-Way Segments Input Data Cells**

The following basic roadway characteristics are needed:

- Area type: Specify if the area surrounding the site is urban or suburban.

- Segment type: Select the appropriate code – 6U for six-lane undivided segments, 6D for six-lane divided segments, 7T for six-lane segments with a two-way left-turn lane, or 8D for eight-lane divided segments. These codes are consistent with those used in the HSM.
- Segment length: Enter the segment length, in miles.
- Annual average daily traffic: Enter the AADT, in vehicles per day.
- Number of highway-rail grade crossings present: Enter the number of highway-rail grade crossings that are present on the segment.
- Posted speed limit: Select the posted speed limit, in miles per hour.
- Automated speed enforcement: Indicate whether automated speed enforcement is used on the segment.

The following access characteristics are needed:

- Driveway count – major commercial: Enter the count of major commercial driveways on the segment.
- Driveway count – major industrial: Enter the count of major industrial driveways on the segment.
- Driveway count – minor: Enter the count of minor driveways (of any land use type) on the segment.

All driveway counts represent the number of full driveways, which are driveways that accommodate all entering and exiting turning movements. Driveways that are channelized to allow only right-turn entry and exit movements should be counted as half-driveway.

The following cross-sectional characteristics are needed:

- Lane width: Enter the lane width, in feet.
- Outside shoulder width: Enter the outside shoulder width, in feet. The outside shoulder is the shoulder to the right of drivers with respect to the direction of travel.
- Median width: Enter the median width, in feet. This quantity is not needed if an undivided or two-way left-turn lane segment type (6U or 7T) is specified.
- Median barrier present: Indicate whether a non-traversable median barrier is present. This quantity is not needed if an undivided or two-way left-turn lane segment type (6U or 7T) is specified.

The following roadside characteristics are needed:

- Roadside fixed object count: Enter the number of fixed objects that are present on the roadside (not including the median). Fixed objects that are located within 70 feet of one another longitudinally along the street are counted as a single object.
- Average roadside fixed object offset: Enter the average offset between travel lanes and fixed objects, in feet. The edge of the travel lanes is defined as the marked edgeline, or a line 2 feet from the face of the curb if no marked edgeline exists. This quantity is not needed if no roadside fixed objects are present.

If necessary, the analyst can enter values for the following calibration factors:

- Local calibration factor.
- Adjustment factor for pedestrians.
- Adjustment factor for bicyclists.
- Severity distribution calibration factor.

Computed values for the individual CMFs are provided in the lower portion of the worksheet (see Figure 17). The output summary on the top portion of the worksheet (see Figure 15) provides the predicted crash frequency, combined CMFs (product of individual CMFs), and severity distribution for the segment in the analysis year.

| <u>Calibration Factors</u>                                 | <u>Value</u>                  | <u>Default Values</u>         |
|--|-------------------------------|-------------------------------|
| Local calibration factor ( $C$ )                           | 1.000                         | 1.000                         |
| Adjustment factor for pedestrians ( $f_{ped}$ )            | 0.015                         | 0.015                         |
| Adjustment factor for bicyclists ( $f_{bike}$ )            | 0.008                         | 0.008                         |
| Severity distribution calibration factor ( $C_{sdf,tws}$ ) | 1.000                         | 1.000                         |
| <u>Crash Modification Factors</u>                          | <u>F+I</u>                    | <u>PDO</u>                    |
|  | <u>Multiple</u> <u>Single</u> | <u>Multiple</u> <u>Single</u> |
| Lane width   | 1.022                         | 1.022                         |
| Outside shoulder width                                     | 1.000                         | 1.000                         |
| Median width   | 1.011                         | 1.011                         |
| Median barrier   | 0.600                         | 1.967                         |
| Highway-rail grade crossing                                | 1.000                         | 1.000                         |
| Major commercial driveways                                 | 1.576                         |                               |
| Major industrial driveways                                 | 1.016                         |                               |
| Minor driveways  | 1.041                         |                               |
| Automated speed enforcement                                | 1.000                         | 1.000                         |
| Roadside fixed objects                                     |                               | 1.180                         |

**Figure 17. Two-Way Segments Calibration Factor Cells and CMF Calculations**

### *One-Way Segments*

The general information and site information input data cells are shown in the top portion of Figure 18. Cells are provided for the analyst to enter analyst's name, agency, date (this cell is populated with an equation that computes the current date), location, street number, street name, segment number, and analysis year. To avoid the error message shown in Figure 13, it is essential to change the segment number every time a new site at a facility is being analyzed, and to change the analysis year every time a new year is being analyzed.

The input data cells on the One-Way Segments worksheet are shown in Figure 19. The analyst must provide data to describe the basic roadway characteristics, access characteristics, cross-sectional characteristics, and roadside characteristics.



| <b>Safety Prediction Worksheet for One-Way Urban and Suburban Arterial Segments</b> |                  |                   |  |                   |              |          |
|---|------------------|-------------------|--|-------------------|--------------|----------|
| <u>General Information</u>  |                  |                   | <u>Site Information</u>                          |                   |              |          |
| Analyst   | MPP              |                   | Street number                                    | SH 1              |              |          |
| Agency  | TTI              |                   | Street name                                      | Main Street       |              |          |
| Date  | 12/9/2015        |                   | Segment number                                   | 1                 |              |          |
| Location  | City of Fillmore |                   | Analysis year                                    | 2011              |              |          |
| Add to Totals worksheet   |                  | Restore equations |  | Reset input cells |              |          |
| <u>Output Summary</u>   |                  |                   | <u>Predicted crash frequency, crashes / year</u> |                   |              |          |
|   |                  |                   | <i>F+I</i>                                       | <i>PDO</i>        | <i>Total</i> |          |
| Total crashes   |                  |                   | 1.638  | 3.295             | 4.933        |          |
| Multiple-vehicle crashes  |                  |                   | 1.244  | 2.986             |              |          |
| Single-vehicle crashes  |                  |                   | 0.227  | 0.309             |              |          |
| Vehicle-pedestrian crashes  |                  |                   | 0.114  |                   |              |          |
| Vehicle-bicycle crashes   |                  |                   | 0.052  |                   |              |          |
|   |                  |                   | <u>Combined CMF</u>                              |                   |              |          |
|   |                  |                   | <i>F+I</i>                                       | <i>PDO</i>        |              |          |
| Multiple-vehicle crashes  |                  |                   | 1.370  | 1.370             |              |          |
| Single-vehicle crashes  |                  |                   | 1.297  | 1.297             |              |          |
|   |                  |                   | <u>Severity distribution for F+I crashes</u>     |                   |              |          |
|   |                  |                   | <i>K</i>   | <i>A</i>          | <i>B</i>     | <i>C</i> |
|   |                  |                   | 0.024  | 0.222             | 0.536        | 0.856    |

**Figure 18. One-Way Segments General Information Cells and Output Summary**

| <u>Input Data</u>                                   |                  | <u>Value</u> | <u>Advisory Messages</u>                  |
|---|------------------|--------------|---|
| <i>Basic Roadway Data</i>                           |                  |              |   |
| Area type   |                  | Suburban     | .   |
| Segment type  |                  | 30           | .   |
| Segment length, mi                                  |                  | 0.4          | .   |
| Bicycle lanes present?                              |                  | No           | .   |
| Annual average daily traffic (AADT), veh/day        |                  | 17500        | .   |
| Posted speed limit, mi/h                            |                  | 30           | .   |
| Automated speed enforcement present?                |                  | No           | .   |
| <i>Access Data</i>                                  |                  |              |   |
| Driveway count                                      | Major commercial | 6            | <b>15 major comm. driveways per mile.</b> |
|   | Minor            | 7            |   |
| <i>Cross Section Data</i>                           |                  |              |   |
| Lane width, ft                                      |                  | 11           | .   |
| Right shoulder width, ft                            |                  | 1.5          | .   |
| <i>Roadside Data</i>                                |                  |              |   |
| On-street parallel parking length on right side, mi |                  | 0            | .   |
| On-street angle parking length on right side, mi    |                  | 0            | .   |
| On-street parallel parking length on left side, mi  |                  | 0            | .   |
| On-street angle parking length on left side, mi     |                  | 0            | .   |
| Roadside fixed object count                         |                  | 18           | <b>45 objects per mile.</b>               |
| Average roadside fixed object offset, ft            |                  | 7            |   |

**Figure 19. One-Way Segments Input Data Cells**

The following basic roadway characteristics are needed:

- Area type: Specify if the area surrounding the site is urban or suburban.
- Segment type: Select the appropriate code – 20, 30, or 40 for two-lane, three-lane, or four-lane segments, respectively. These codes are consistent with those used in the HSM.
- Segment length: Enter the segment length, in miles.

- Bicycle lanes present: Indicate if bicycle lanes are present on the segment.
- Annual average daily traffic: Enter the AADT, in vehicles per day.
- Posted speed limit: Select the posted speed limit, in miles per hour.
- Automated speed enforcement: Indicate whether automated speed enforcement is used on the segment.

The following access characteristics are needed:

- Driveway count – major commercial: Enter the count of major commercial driveways on the segment.
- Driveway count – minor: Enter the count of minor driveways (of any land use type) on the segment.

All driveway counts represent the number of full driveways, which are driveways that accommodate all entering and exiting turning movements. Driveways that are channelized to allow only right-turn entry and exit movements should be counted as half-driveway.

The following cross-sectional characteristics are needed:

- Lane width: Enter the lane width, in feet.
- Right shoulder width: Enter the right shoulder width, in feet.

The following roadside characteristics are needed:

- On-street parallel parking length on right side: Enter the length of parallel parking present on the right side of the segment in the direction of travel, in miles.
- On-street angle parking length on right side: Enter the length of angle parking present on the right side of the segment in the direction of travel, in miles.
- On-street parallel parking length on left side: Enter the length of parallel parking present on the left side of the segment in the direction of travel, in miles.
- On-street angle parking length on left side: Enter the length of angle parking present on the left side of the segment in the direction of travel, in miles.
- Roadside fixed object count: Enter the number of fixed objects that are present on the roadside (not including the median). Fixed objects that are located within 70 feet of one another longitudinally along the street are counted as a single object.
- Average roadside fixed object offset: Enter the average offset between travel lanes and fixed objects, in feet. The edge of the travel lanes is defined as the marked edgeline, or a line 2 feet from the face of the curb if no marked edgeline exists. This quantity is not needed if no roadside fixed objects are present.

If necessary, the analyst can enter values for the following calibration factors:

- Local calibration factor.
- Adjustment factor for pedestrians.
- Adjustment factor for bicyclists.

- Severity distribution calibration factor.
- Probability of fatality given a crash involving fatality or incapacitating injury has occurred.

Computed values for the individual CMFs are provided in the lower portion of the worksheet (see Figure 20). The output summary on the top portion of the worksheet (see Figure 18) provides the predicted crash frequency, combined CMFs (product of individual CMFs), and severity distribution for the segment in the analysis year.

| <u>Calibration Factors</u>                                 | <u>Value</u>    |               | <u>Default Values</u> |               |
|--|-----------------|---------------|-----------------------|---------------|
| Local calibration factor ( $C$ )                           | 1.000           |               | 1.000                 |               |
| Adjustment factor for pedestrians ( $f_{ped}$ )            | 0.024           |               | 0.024                 |               |
| Adjustment factor for bicyclists ( $f_{bike}$ )            | 0.011           |               | 0.011                 |               |
| Severity distribution calibration factor ( $C_{sdf,ows}$ ) | 1.000           |               | 1.000                 |               |
| Probability of fatality given K+A severity ( $P_{K K+A}$ ) | 0.099           |               | 0.099                 |               |
| <u>Crash Modification Factors</u>                          | <u>F+I</u>      |               | <u>PDO</u>            |               |
|  | <u>Multiple</u> | <u>Single</u> | <u>Multiple</u>       | <u>Single</u> |
| Right shoulder width                                       | 1.052           | 1.052         | 1.052                 | 1.052         |
| On-street parallel parking                                 | 1.000           | 1.000         | 1.000                 | 1.000         |
| On-street angle parking                                    | 1.000           | 1.000         | 1.000                 | 1.000         |
| Major commercial driveways                                 | 1.259           |               | 1.259                 |               |
| Minor driveways  | 1.035           |               | 1.035                 |               |
| Automated speed enforcement                                | 1.000           | 1.000         | 1.000                 | 1.000         |
| Roadside fixed objects                                     |                 | 1.233         |                       | 1.233         |

**Figure 20. One-Way Segments Calibration Factor Cells and CMF Calculations**

### Intersections

The general information and site information input data cells are shown in the top portion of Figure 21. Cells are provided for the analyst to enter analyst's name, agency, date (this cell is populated with an equation that computes the current date), location, major street name, minor street name, intersection number, and analysis year. To avoid the error message shown in Figure 13, it is essential to change the intersection number every time a new site at a facility is being analyzed, and to change the analysis year every time a new year is being analyzed.

For intersections, the major street is defined based on the following rules:

- For 2x2 intersections (intersections of two two-way streets), the major street is the street with the higher volume.
- For 1x2 or 1x1 intersections (intersections where one or both of the streets are one-way), the major street is the one-way street.
- Note that in the case of 3-leg intersections, it is possible for the major street to be the one that ends at the intersection.

| <b>Safety Prediction Worksheet for Urban and Suburban Arterial Intersections</b> |                  |                   |  |                   |  |
|--|------------------|-------------------|--|-------------------|--|
| <u>General Information</u>   |                  |                   | <u>Site Information</u>                      |                   |  |
| Analyst  | MPP              |                   | Major street name                            | Main Street       |  |
| Agency   | TTI              |                   | Minor street name                            | Cross Street      |  |
| Date   | 12/9/2015        |                   | Intersection number                          | 1                 |  |
| Location   | City of Fillmore |                   | Analysis year                                | 2011              |  |
| Add to Totals worksheet  |                  | Restore equations |  | Reset input cells |  |
| <u>Output Summary</u>  |                  |                   | <u>Severity distribution for F+I crashes</u> |                   |  |
|  |                  |                   | K      A      B      C                       |                   |  |
|  |                  |                   | 0.015    0.149    0.748    2.151             |                   |  |
|  |                  |                   | Total-vehicle crashes    0.690    0.690      |                   |  |
|  |                  |                   | Vehicle-pedestrian crashes    1.000          |                   |  |
|  |                  |                   | Total crashes    3.064    2.774    5.837     |                   |  |
|  |                  |                   | Total-vehicle crashes    2.862    2.774      |                   |  |
|  |                  |                   | Vehicle-pedestrian crashes    0.095          |                   |  |
|  |                  |                   | Vehicle-bicycle crashes    0.107             |                   |  |
|  |                  |                   | Total-vehicle crashes    0.690    0.690      |                   |  |
|  |                  |                   | Vehicle-pedestrian crashes    1.000          |                   |  |
|  |                  |                   | Total crashes    3.064    2.774    5.837     |                   |  |
|  |                  |                   | Total-vehicle crashes    2.862    2.774      |                   |  |
|  |                  |                   | Vehicle-pedestrian crashes    0.095          |                   |  |
|  |                  |                   | Vehicle-bicycle crashes    0.107             |                   |  |

**Figure 21. Intersections General Information Cells and Output Summary**

The input data cells on the Intersections worksheet are shown in Figure 22. The analyst must provide data to describe characteristics of the intersection as a whole as well as both intersecting streets.

| <u>Input Data</u>                                    | <u>Value</u>                     | <u>Advisory Messages</u>       |
|--|----------------------------------|--------------------------------|
| <u>Intersection Data</u>                             |                                  |                                |
| Area type  | Urban                            | .                              |
| Number of legs                                       | 4                                | 4SG intersection type          |
| Traffic control type                                 | Signalized                       | .                              |
| Lighting present?                                    | Yes                              | .                              |
| Red-light cameras present?                           | No                               | .                              |
| Daily pedestrian volume crossing all legs (peds/day) | 700                              | .                              |
| Maximum number of lanes crossed by a pedestrian      | 7                                | .                              |
| Number of bus stops within 1,000 ft of intersection  | 0                                | .                              |
| School(s) present within 1,000 ft of intersection?   | No                               | .                              |
| Alcohol sales establishments within 1,000 ft         | 0                                | .                              |
| <u>Street Data</u>                                   |                                  |                                |
| Street configuration                                 | Major: Two-way    Minor: Two-way | 2x2 intersection configuration |
| Annual average daily traffic (AADT), veh/day         | 20000    10000                   | .                              |
| Number of lanes                                      | 6    4                           | .                              |
| Number of approaches with left-turn lanes            | 2    2                           | .                              |
| Number of left-turn movements with protected phasing | 2    0                           | .                              |
| Number of right-turn movements prohibited on red     | 2    0                           | .                              |
| Number of U-turn movements prohibited                | 0    2                           | .                              |
| Number of approaches with right-turn channelization  | 0    2                           | .                              |

**Figure 22. Intersections Input Data Cells**

The following intersection characteristics are needed:

- Area type: Specify if the area surrounding the site is urban or suburban.
- Number of legs: Enter the number of street legs at the intersection (3 or 4).
- Traffic control type: Specify if the traffic control is signalized or two-way stop. Note that an advisory message will provide the intersection category code (3ST, 3SG, 4ST, or 4SG) that is used in the HSM to describe the four combinations of number of legs and traffic control.
- Lighting present: Indicate whether lighting is present at the intersection.
- Red-light cameras present: Indicate whether red-light cameras are used at the intersection. This quantity is not needed for two-way stop-controlled intersections. This quantity is not needed for a two-way stop-controlled intersection.
- Daily pedestrian volume crossing all legs: Enter the daily pedestrian volume, in pedestrians per day. Include all pedestrians crossing at all intersection legs. Note that the HSM refers to this quantity as “PedVol” and provides default values for 3SG and 4SG intersections based on qualitative general levels of pedestrian activity (high, medium-high, medium, medium-low, and low). This quantity is not needed for two-way stop-controlled intersections. This quantity is not needed for a two-way stop-controlled intersection.
- Maximum number of lanes crossed by a pedestrian: Count the total number of lanes (all through lanes plus turn lanes) at each intersection leg, and enter the highest number of lanes observed on the legs. This quantity is not needed for two-way stop-controlled intersections. This quantity is not needed for a two-way stop-controlled intersection.
- Number of bus stops within 1,000 ft. of intersection: Enter the number of bus stops present within 1,000 feet of the center of the intersection, across all legs. This quantity is not needed for two-way stop-controlled intersections. This quantity is not needed for a two-way stop-controlled intersection.
- School(s) present within 1,000 ft. of intersection: Indicate whether one or more schools are present within 1,000 ft. of the center of the intersection. This quantity is not needed for two-way stop-controlled intersections. This quantity is not needed for a two-way stop-controlled intersection.
- Alcohol sales establishments within 1,000 ft.: Enter the number of alcohol sales establishments present within 1,000 ft. of the center of the intersection, across all legs. This quantity is not needed for two-way stop-controlled intersections. This quantity is not needed for a two-way stop-controlled intersection.

The following street characteristics are needed for each street:

- Street configuration: Specify the street configuration as two-way or one-way. For a 1x2 intersection, the one-way street is defined as the major street.
- Annual average daily traffic: Enter the AADT, in vehicles per day. This quantity is a two-way total, including both arriving and departing vehicles. If different AADTs are present on the two legs of a street, enter the average of the two values. For 2x2 and 1x1 intersections, the major street must have equal or greater AADT than the minor street.
- Number of lanes: Enter the number of lanes (arriving plus departing) present on the street, not including turn lanes that are added by taper in the vicinity of the intersection.



- Number of approaches with left-turn lanes: Indicate the number of approaches on the street that have left-turn lanes. Count a leg if it has one or more left-turn lanes; the number of left-turn lanes on the leg does not matter. This quantity is not needed for the minor street at a signalized intersection or the major street at a two-way stop-controlled intersection.
- Number of left-turn movements with protected phasing: Enter the number of left-turn movements on the street that have protected-only phasing. This quantity is needed only for signalized 2x2 intersections.
- Number of right-turn movements prohibited on red: Enter the number of right-turn movements on the street that are prohibited when the signal indication is red. This quantity is not needed for a two-way stop-controlled intersection.
- Number of U-turn movements prohibited: Enter the number of U-turn movements on the street that are prohibited. This quantity is needed only for signalized 2x2 intersections.
- Number of approaches with right-turn channelization: Enter the number of approaches on the street that have right-turn channelization, or provision of free or yield-controlled right-turn movement. This quantity is not needed for a two-way stop-controlled intersection.

If necessary, the analyst can enter values for the following calibration factors:

- Local calibration factor.
- Adjustment factor for pedestrians for stop-controlled intersections.
- Adjustment factor for bicyclists.
- Severity distribution calibration factors for 2x2 intersections.
- Severity distribution calibration factors for 1x2 and 1x1 intersections.
- Probability of fatality given a crash involving fatality or incapacitating injury has occurred.

Computed values for the individual CMFs are provided in the lower portion of the worksheet (see Figure 23). The output summary on the top portion of the worksheet (see Figure 21) provides the predicted crash frequency, combined CMFs (product of individual CMFs), and severity distribution for the segment in the analysis year.

### **Totals Worksheet**

After the analyst uses the input data worksheets to describe each site on the facility of interest, the Totals worksheet is available to tabulate the predicted crash frequency for the overall facility and also to conduct a site-specific or project-level EB analysis. The analyst transfers data from the input data worksheets to the Totals worksheet by clicking the “Add to Totals worksheet” button near the top of each input data worksheet.

| <u>Calibration Factors</u>  | <u>Value</u> | <u>Default Values</u> |
|---|--------------|-----------------------|
| Local calibration factor ( $C$ )                                  | 1.000        | 1.000                 |
| Adjustment factor for pedestrians for stop control ( $f_{ped}$ )  | 0.049        | 0.049                 |
| Adjustment factor for bicyclists ( $f_{bike}$ )                   | 0.019        | 0.019                 |
| Severity distribution calibration factor, 2-way ( $C_{saf,twi}$ ) | 1.000        | 1.000                 |
| Severity distribution calibration factor, 1-way ( $C_{saf,owi}$ ) | 1.000        | 1.000                 |
| Probability of fatality given K+A severity ( $P_{K K+A}$ )        | 0.094        | 0.094                 |

|                                 | <u>Manner of Collision Proportions</u> |          |          |          |          |          |          |          |
|---------------------------------|--|----------|----------|----------|----------|----------|----------|----------|
|                                 | 3ST, F+I                               | 3ST, PDO | 3SG, F+I | 3SG, PDO | 4ST, F+I | 4ST, PDO | 4SG, F+I | 4SG, PDO |
| <i>2x2 intersections</i>        |  |          |          |          |          |          |          |          |
| Rear-end collision proportion   | 0.094                                  | 0.154    | 0.120    | 0.189    | 0.079    | 0.098    | 0.083    | 0.148    |
| Angle collision proportion      | 0.764                                  | 0.629    | 0.676    | 0.554    | 0.806    | 0.707    | 0.746    | 0.552    |
| <i>1x2 or 1x1 intersections</i> |  |          |          |          |          |          |          |          |
| Rear-end collision proportion   | 0.100                                  | 0.100    | 0.111    | 0.143    | 0.047    | 0.065    | 0.030    | 0.059    |
| Angle collision proportion      | 0.300                                  | 0.250    | 0.889    | 0.571    | 0.822    | 0.706    | 0.837    | 0.733    |

| <u>Crash Modification Factors</u>    | <u>F+I</u> | <u>PDO</u> |
|--------------------------------------|------------|------------|
| <i>Total-vehicle crash CMFs</i>      |            |            |
| Lighting                             | 0.911      | 0.911      |
| Red-light cameras                    | 1.000      | 1.000      |
| Left-turn signal phasing             | 0.740      | 0.740      |
| Right-turn-on-red                    | 0.960      | 0.960      |
| U-turn prohibition                   | 0.922      | 0.922      |
| Right-turn channelization            | 1.000      | 1.000      |
| Number of lanes                      | 1.158      | 1.158      |
| <i>Vehicle-pedestrian crash CMFs</i> |            |            |
| Bus stops                            | 1.000      |            |
| Schools                              | 1.000      |            |
| Alcohol sales establishments         | 1.000      |            |

**Figure 23. Intersections Calibration Factor Cells and CMF Calculations**

*Worksheet Organization*

The Totals worksheet is organized with two large data tables like the one shown in Figure 24. The top table is labeled “Segment Site Information” and accommodates up to 15 segment-year combinations. The bottom table is labeled “Intersection Site Information” and accommodates up to 15 intersection-year combinations. For example, if the facility of interest consists of five segments and five intersections, and the analysis period is three years, all 15 rows in each table would be filled. Each table contains the following data:

- Site identification information like site number, analysis year, and site type.
- Predicted crash frequency, which was obtained from the relevant input data worksheet. These cells are shaded white.
- Site-specific observed crash totals. These cells are grayed out if no EB analysis or a project-level EB analysis is conducted, and are shaded blue if a site-specific EB analysis is conducted.
- Predicted or expected crash frequency. These cells are labeled with “Predicted crash frequency” and shown with purple shading in Figure 24 for the case of no EB analysis being conducted. The cells are shaded purple and labeled with “Expected crash

frequency” if a site-specific EB analysis is chosen, and grayed out if a project-level EB analysis is chosen.

- Combined CMF (not shown in Figure 24).
- Site location information (not shown in Figure 24).

| <i>Segment Site Information</i> |      |      |               | Predicted crash frequency, crashes / year |       |                |       |                    |       | Site-specific observed crash totals |     |                  |     | Predicted crash frequency, crashes / year |     |                    |     |                 |     |
|---------------------------------|------|------|---------------|---|-------|----------------|-------|--------------------|-------|-------------------------------------|-----|------------------|-----|---|-----|--------------------|-----|-----------------|-----|
| Number                          | Year | Type | Street number | Multiple-vehicle                          |       | Single-vehicle |       | Vehicle-pedestrian |       | Vehicle-bicycle                     |     | Multiple-vehicle |     | Single-vehicle                            |     | Vehicle-pedestrian |     | Vehicle-bicycle |     |
|                                 |      |      |               | F+I                                       | PDO   | F+I            | PDO   | F+I                | F+I   | F+I                                 | PDO | F+I              | PDO | F+I                                       | PDO | F+I                | PDO | F+I             | F+I |
| ■                               | 1    | 2011 | 6D            | SH 1                                      | 5.492 | 7.389          | 0.948 | 1.167              | 0.225 | 0.120                               |     |                  |     |   |     |                    |     |                 |     |
| ■                               | 1    | 2011 | 30            | SH 1                                      | 1.244 | 2.986          | 0.227 | 0.309              | 0.114 | 0.052                               |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |
| ■                               |      |      |               |   |       |                |       |                    |       |                                     |     |                  |     |   |     |                    |     |                 |     |

**Figure 24. Totals Worksheet, Segments Data Table**

The controls for the Totals worksheet are shown in Figure 25. The blue cell contains a drop-down menu where the analyst specifies the type of EB analysis to be conducted (none, site-specific, or project-level). Both EB analysis options can be applied to past periods for which crash counts are available. A site-specific EB analysis requires crashes to be assigned to the appropriate site and year, while a project-level EB analysis allows a facility-wide crash total across all analysis years to be provided. The site-specific EB analysis is more precise but requires more detailed crash data.

*Crash Totals Tabulation*

Empirical Bayes adjustment type: None Clear tables

None  
Site-specific  
Project-level

Sort rows

Calculate

---

*Segment Site Information*

| Number | Year | Type | Street number |      |
|--------|------|------|---------------|------|
| ■      | 1    | 2011 | 6D            | SH 1 |
| ■      | 1    | 2011 | 30            | SH 1 |

**Figure 25. Totals Worksheet Controls**

The following three command buttons are provided near the upper-left corner of the Totals worksheet (see Figure 25):

- **Clear tables:** Click this button to clear all data from the Totals worksheet.
- **Sort rows:** Click this button to sort the rows in each data table by year, site number, and site type code. This function is particularly useful when the data table is mostly full but has an empty row in the middle of the table that must be reclaimed because the bottom row was filled (see the error message in Figure 14).
- **Calculate:** Click this button to perform the calculations needed to aggregate crash totals and perform an EB analysis (if chosen).

Each row in the data tables has a square red button in the leftmost cell of the row. Clicking these buttons allows the analyst to (1) return the data in that table row to its origin worksheet (Two-way segments, One-way segments, or Intersections) and/or (2) delete the data in that row of the table.

The Totals worksheet consists of the main data tables that were discussed above; a second set of tables to the right of the main data tables, which contain intermediate calculations; two boxes that contain inverse dispersion parameters that are used for the EB analysis calculations and were derived along with the model coefficients in NCHRP Project 17-58; and an archived data area that contains all relevant site data in case the analyst needs to return these data to the input data worksheets for revision. The boxes for the inverse dispersion parameters contain yellow-shaded cells, as these parameters can be changed, but they should not be changed without significant justification based on detailed analysis of field data from the jurisdiction of interest.

### *Analysis Options*

The Totals worksheet can perform three different types of analysis, which are described in the following paragraphs.

**No Empirical Bayes Analysis.** This option is denoted as “None” in the drop-down menu shown in Figure 25. With this analysis option, the Totals worksheet provides the predicted crash frequency for the facility as a simple summation of the predicted crash frequencies across the sites. The analyst need not provide crash counts. The crash totals tables on the top of the Totals worksheet will be populated with crash summations as shown in Figure 26. The “Facility Totals” table provides the total crash frequency for the facility, and aggregated by crash type (multiple-vehicle + single-vehicle, vehicle-pedestrian + vehicle-bicycle), severity (fatal-and-injury, property-damage-only). The “Total Predicted Crash Frequency” table provides a more detailed aggregation of crash frequency, broken down by site type (segment or intersection) in addition to crash type and severity. The “Project-Level Observed Crash Totals” table is not used when an EB analysis is not conducted.

**Site-Specific Empirical Bayes Analysis.** This option is denoted as “Site-specific” in the drop-down menu shown in Figure 25. With this analysis option, the Totals worksheet provides the expected crash frequency for each site-year combination, and also computes the total

expected crash frequency for the facility as a summation across all sites and analysis years. The analyst must provide crash counts for every site, as indicated by the blue cells for the columns in the middle portion of the data tables (see Figure 27). Vehicle-pedestrian crash counts need not be provided for stop-controlled intersections because the pedestrian-vehicle crash frequency model applies only to signalized intersections, so the relevant cells for these crash counts are shaded white accordingly. The crash totals tables on the top of the Totals worksheet will be populated with EB-adjusted crash totals, and the “Total Expected Crash Frequency” table will be populated with a more detailed aggregation of crash frequency. The “Project-Level Observed Crash Totals” table is not used when a site-specific EB analysis is conducted.

| Facility Totals |        | Project-Level Observed Crash Totals                     |  |     |     | Total Predicted Crash Frequency, crashes / year |                  |        |                |       |               |        |         |          |
|-----------------|--------|---|--|-----|-----|---|------------------|--------|----------------|-------|---------------|--------|---------|----------|
| MV+SV:          | 32,422 | Crash type  |  | F+I | PDO | Site type                                       | Multiple-vehicle |        | Single-vehicle |       | Total-vehicle |        | Veh-ped | Veh-bike |
| VP+VB:          | 1,425  | Multiple-vehicle crashes on segments:                   |  |     |     |   | F+I              | PDO    | F+I            | PDO   | F+I           | PDO    | F+I     | F+I      |
| F+I:            | 14,989 | Single-vehicle crashes on segments:                     |  |     |     | Segments:                                       | 6,737            | 10,375 | 1,175          | 1,476 | 7,912         | 11,850 | 0,339   | 0,172    |
| PDO:            | 18,858 | Total-vehicle crashes at all intersections:             |  |     |     | Intersections:                                  |                  |        |                |       | 5,653         | 7,007  | 0,505   | 0,408    |
| Total:          | 33,846 | Vehicle-pedestrian crashes at signalized intersections: |  |     |     | Total:  | 6,737            | 10,375 | 1,175          | 1,476 | 13,564        | 18,858 | 0,844   | 0,580    |

Figure 26. Crash Totals Tables – No Empirical Bayes Analysis

| Facility Totals |        | Project-Level Observed Crash Totals                     |  |     |     | Total Expected Crash Frequency, crashes / year |                  |        |                |       |               |        |         |          |
|-----------------|--------|---|--|-----|-----|--|------------------|--------|----------------|-------|---------------|--------|---------|----------|
| MV+SV:          | 38,068 | Crash type  |  | F+I | PDO | Site type                                      | Multiple-vehicle |        | Single-vehicle |       | Total-vehicle |        | Veh-ped | Veh-bike |
| VP+VB:          | 2,176  | Multiple-vehicle crashes on segments:                   |  |     |     |  | F+I              | PDO    | F+I            | PDO   | F+I           | PDO    | F+I     | F+I      |
| F+I:            | 18,079 | Single-vehicle crashes on segments:                     |  |     |     | Segments:                                      | 7,845            | 11,560 | 1,597          | 2,061 | 9,442         | 13,621 | 0,391   | 0,200    |
| PDO:            | 22,165 | Total-vehicle crashes at all intersections:             |  |     |     | Intersections:                                 |                  |        |                |       | 6,461         | 8,544  | 1,106   | 0,478    |
| Total:          | 40,243 | Vehicle-pedestrian crashes at signalized intersections: |  |     |     | Total:   | 7,845            | 11,560 | 1,597          | 2,061 | 15,903        | 22,165 | 1,498   | 0,678    |

| Predicted crash frequency, crashes / year |       |                |       |                    |       | Site-specific observed crash totals |     |                |     | Expected crash frequency, crashes / year |       |                |       |                    |       | Combine         |       |                  |     |
|---|-------|----------------|-------|--------------------|-------|-------------------------------------|-----|----------------|-----|--|-------|----------------|-------|--------------------|-------|-----------------|-------|------------------|-----|
| Multiple-vehicle                          |       | Single-vehicle |       | Vehicle-pedestrian |       | Multiple-vehicle                    |     | Single-vehicle |     | Multiple-vehicle                         |       | Single-vehicle |       | Vehicle-pedestrian |       | Vehicle-bicycle |       | Multiple-vehicle |     |
| F+I                                       | PDO   | F+I            | PDO   | F+I                | PDO   | F+I                                 | PDO | F+I            | PDO | F+I                                      | PDO   | F+I            | PDO   | F+I                | PDO   | F+I             | PDO   | F+I              | PDO |
| 5,492                                     | 7,389 | 0,948          | 1,167 | 0,225              | 0,120 | 7                                   | 9   | 2              | 3   | 6,455                                    | 8,569 | 1,312          | 1,686 | 0,270              | 0,144 | 1,035           | 1,035 |                  |     |
| 1,244                                     | 2,986 | 0,227          | 0,309 | 0,114              | 0,052 | 2                                   | 3   | 1              | 1   | 1,390                                    | 2,991 | 0,285          | 0,375 | 0,121              | 0,055 | 1,370           | 1,370 |                  |     |

Figure 27. Crash Totals Tables – Site-Specific Empirical Bayes Analysis

**Project-Level Empirical Bayes Analysis.** This option is denoted as “Project-level” in the drop-down menu shown in Figure 25. With this analysis option, the Totals worksheet provides the expected crash frequency for the facility across all analysis years. The analyst must provide crash counts for the facility, as indicated by the blue cells in the “Project-Level Observed Crash Totals” table (see Figure 28). These crash counts are aggregated by crash type and severity and summed across all analysis years. The crash totals tables on the top of the Totals worksheet will be populated with EB-adjusted crash totals. The “Total Predicted Crash Frequency” table is not used when an EB analysis is not conducted.

| Facility Totals |        | Project-Level Observed Crash Totals                     |  |     |     | Total Expected Crash Frequency, crashes / year |                  |     |                |     |               |     |         |          |
|-----------------|--------|---|--|-----|-----|--|------------------|-----|----------------|-----|---------------|-----|---------|----------|
| MV+SV:          | 41,911 | Crash type  |  | F+I | PDO | Site type                                      | Multiple-vehicle |     | Single-vehicle |     | Total-vehicle |     | Veh-ped | Veh-bike |
| VP+VB:          | 1,330  | Multiple-vehicle crashes on segments:                   |  | 9   | 12  |  | F+I              | PDO | F+I            | PDO | F+I           | PDO | F+I     | F+I      |
| F+I:            | 18,864 | Single-vehicle crashes on segments:                     |  | 3   | 4   | Segments:                                      |                  |     |                |     |               |     |         |          |
| PDO:            | 24,377 | Total-vehicle crashes at all intersections:             |  |     |     | Intersections:                                 |                  |     |                |     |               |     |         |          |
| Total:          | 43,241 | Vehicle-pedestrian crashes at signalized intersections: |  |     |     | Total:   |                  |     |                |     |               |     |         |          |

Figure 28. Crash Totals Tables – Project-Level Empirical Bayes Analysis

## REFERENCES

1. Lord, D., S. Geedipally, M. P. Pratt, E. S. Park, S. H. Khazraee, and K. Fitzpatrick. *Safety Prediction Models for Six-Lane and One-Way Urban and Suburban Arterials*. NCHRP Report 17-58. Transportation Research Board, National Academy of Sciences, Washington, D.C., 2016 (forthcoming).
2. Draft Chapter 12 of the *Highway Safety Manual*. NCHRP Project 17-58.
3. *Highway Safety Manual, 1st Edition*. Volume 2. American Association of State Highway and Transportation Officials, Washington, D.C., 2010.