<sup>st</sup> Street

### **Technical Memo**

| Date:    | April 12, 2017   |
|----------|--|
| Project: | I-29 Exit 77 (41 <sup>st</sup> Street) Interchange Modification Justification Report<br>Project # PL0100(84) 3616P, PCN 05MH |
| To:      | Study Advisory Team  |
| From:    | HDR  |
| Subject: | Technical Memo 4 – Predictive Crash Analysis for I-29 Interchange at 41  |

#### 1. Introduction

The South Dakota Department of Transportation (SDDOT) is proposing to reconstruct the existing I-29 / 41<sup>st</sup> Street interchange in Sioux Falls. The build alternatives are a Single-Point Interchange (SPI) and a Diverging Diamond Interchange (DDI), which would replace the existing diamond interchange. In accordance with The Federal Highway Administration (FHWA) requirements, a change in Interstate access requires an Interchange Modification Justification Report (IMJR), including a safety analysis assessing the no build and proposed build interchange alternatives. This memorandum presents a summary of the methodology and findings for the predicted safety performance analysis for the no-build and build alternatives for the I-29 / 41<sup>st</sup> Street project.

The analysis limits for this study are focused on the immediate interchange area as shown in **Figure 1**. On I-29, the limits extend from the interchange of I-29 /  $26^{th}$  Street to approximately 0.4 miles south of  $41^{st}$  Street, for a total distance of 1 mile. In addition to the freeway, the four interchange ramps and the two ramp terminals were analyzed.

The predictive crash analysis presented in this memorandum is based on the principles and methods of the Highway Safety Manual (HSM) as discussed in detail below. It presents a comparative analysis of the predicted crashes anticipated within the interchange area for the "No-Build" future condition (maintain diamond interchange) and the planned build alternatives (SPI and DDI). The results are intended to verify the assumption that the construction of a SPI or DDI at this location will not result in a decrease in overall safety performance in the interchange area.

Appendix A provides the concept layouts for the no-build condition and the build alternatives.

Appendix B provides the Interactive Highway Safety Design Model (IHSDM) worksheets.

#### 2. <u>Methodology</u>

This predictive safety analysis was completed using the American Association of State Highway and Transportation Officials (AASHTO) HSM method, including the National Cooperative Highway Research Program (NCHRP) Report 17-45 method for evaluating freeways and interchanges, which is now part of the HSM as a supplemental volume published in 2014.





Source: Google Earth, September 2016

6300 S. Old Village PI., Suite 100, Sioux Falls, SD 57108 P 605-977-7740

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FHWA supports, and in many cases now requires, the use of the method for the evaluation of proposed freeway facility improvements, including new or modified Interstate access. According to the HSM preface: "The focus of the HSM is to provide quantitative information for decision making. The HSM assembles currently available information and methodologies on measuring, estimating, and evaluating roadways in terms of crash frequency (number of crashes per year) and crash severity (level of injures due to crashes). The HSM presents tools and methodologies for consideration of 'safety' across the range of highway activities ..."

For this study, the HSM predictive method was used. "The predictive method provides a quantitative measure of expected crash frequency under both existing conditions and conditions which have not yet occurred. This allows proposed roadway conditions to be quantitatively assessed ..." (HSM, 2010)

The HSM method crash prediction estimates are developed using safety performance functions (SPFs) for specific facility types. The SPFs take into account the daily traffic volume information, but they assume that other geometric and traffic control features match a theoretical base condition for that facility type. Therefore, crash modification factors (CMFs) are used to make adjustments to the initial SPF results, to account for differences between the actual analysis condition and the theoretical base condition. A CMF of 1 means the analysis condition and the theoretical base condition will predict the same number of crashes. Thus, if a CMF is greater than 1 that will increase the number of predicted crashes while if it is less than 1 it will decrease the number of predicted crashes. For example, if a depressed freeway median is narrower than the assumed 60-foot base condition, then a CMF of less than 1 is applied to adjust the SPF results for the segment.

The HSM methodology has been in development for many years and is rapidly advancing; however, there are still many limitations where the available tools do not yet offer SPFs and/or CMFs for certain conditions. Where this is the case, recent research and crash data were also considered to refine the results as described later in this section.

#### 2.1 Facilities, Segmentation and Data Inputs:

In keeping with the site based HSM analysis approach, each type of facility was examined separately. This involved segmenting the I-29 mainline and the I-29 ramps into functional elements. The Interactive Highway Safety Design Model (IHSDM) software automatically segments highways (including freeway segments, ramps and C-D roads) following HSM guidance. The ramp terminal intersections were also considered individually. IHSDM reports provided in the **Appendix** list all freeway, ramp, and ramp terminal intersection sites that were reviewed.

The HSM method requires several geometric and operational inputs to accurately compute the SPFs and apply the correct CMFs. This includes information such as segment length, daily traffic volume, ramp locations, merge distances, and horizontal curvature. The geometric inputs were primarily obtained from the conceptual design files and aerial photography. The traffic volume data was based on data and design year volume forecasts from the 2045 Sioux Falls Travel Demand Model.

#### 2.2 I-29 Mainline Segments

The I-29 mainline segments were evaluated using HSM methods implemented using the Interactive Highway Safety Design Model (IHSDM) version 11.1.0 software provided by FHWA.

#### 2.3 I-29 Entrance and Exit Ramps

The I-29 entrance and exit ramps were also evaluated using HSM methods in the IHSDM software. Consistent with this method, each ramp was evaluated as one or more specific ramp segments, taking into account the ramp geometry. Some of the ramps were subdivided into multiple segments to account for changes in number of lanes or shoulder widths.

#### 2.4 <u>41<sup>st</sup> Street Ramp Terminals</u>

For the No-Build and Build options, the ramps connect to 41<sup>st</sup> Street at signalized intersections. Interchange ramp terminals are evaluated using the HSM ramp terminal procedure in IHSDM. The IHSDM ramp terminal method does not, however, address SPIs or DDIs. It only predicts crashes for a variety of more typical diamond and partial cloverleaf interchange ramp terminals. Therefore, it was necessary to develop an estimate for an "operationally-similar" diamond interchange design and then use CMFs from HDR's "Crash Prediction Analysis Procedures for Diverging Diamond Interchange (DDI), Single-Point Urban Interchange (SPI), and Two-Lane Loop Ramp" memo dated November 4<sup>th</sup>, 2015 to modify the results to estimate the predictions for a SPI and DDI design. Based on available SDDOT data, the preliminary CMF for conversion of a traditional diamond interchange to a SPI is 0.63 for ramp terminal intersection crashes. Based on research done in Missouri on safety evaluations of DDIs, the preliminary CMF for conversion at ramp terminal intersections and 0.49 for Property Damage Only (PDO) crashes at ramp terminal intersections.

#### 2.5 <u>41<sup>st</sup> Street Segments</u>

Crash prediction for an interchange study area can be almost entirely described by evaluating the crashes from the freeway, freeway ramps, and ramp terminal intersections due to how the HSM estimates crashes for those types of sites. However, some crashes near the interchange may be due to roadway segment characteristics of the arterial cross street. If these segment-related crashes are to be included, then HSM methods for urban and suburban arterials would need to be applied. In this study, the primary area for crash prediction evaluation was focused on the interchange, and no arterial segment crashes were evaluated between scenarios.

#### 2.6 Calibration Factors:

According to the HSM, "the predictive models were developed from the most complete and consistent data sets available." However, the report also recommends that the equations be calibrated for each jurisdiction because "the general level of crash frequencies may vary substantially from one jurisdiction to another." However, SDDOT has not yet conducted the extensive analyses required to develop a complete set of HSM related calibration factors.



Therefore, using the national HSM equations is proposed as the best approach for this current analysis.

#### 2.7 Empirical Bayes Approach: Considering Historical Crash Data:

The HSM method includes an optional step called the Empirical Bayes (EB) approach, which combines "the estimate from a predictive model with observed crash data to obtain a more reliable estimate of the expected average crash frequency." (HSM, 2010) Essentially, the historical crash data is used to adjust the future crash prediction. Typically, the EB method is only used when it can be applied equally to all of the alternatives under consideration. Thus the improvements being considered must be moderate, so that the historical crash data is reasonable to consider for the No-Build and Build conditions. When major alignment or traffic control changes are proposed (such as the proposed SPI or DDI), it is not used because "there is typically a small difference in the results obtained from the predictive method when it is used with and without the EB Method." Therefore, "if the EB Method is not applied consistently, such differences will likely introduce a small bias in the comparison of expected crash frequency among alternatives." (HSM Supplement, 2014) Therefore, the results are presented without the EB method adjustment.

#### 3. Analysis Results

The No-Build and Build interchange alternatives were evaluated and the predicted number of crashes was compared for the 2021 to 2045 analysis period. (Although construction completion is not likely until year 2023, it was determined reasonable to include years 2021 to 2045 as the time of analysis if the project goes back to its initial schedule. The overall results are virtually identical whether the analysis time period is 2021 to 2045 or 2023 to 2045). As mentioned previously, the required inputs were derived from design plans, aerial photography, and traffic volume data from the 2045 Sioux Falls Travel Demand Model. The following sections present the details of the analyses.

#### 3.1 Build and No-Build Crash Frequency Comparison:

The predicted annual crash frequencies for the No-Build and Build scenarios (2021 to 2045) are presented in **Table 1** along with the breakdown of Fatal + Injury (F+I) and Property Damage Only (PDO) crashes. The No-Build and Build detailed IHSDM results sheets are provided in **Appendix B**. As shown, the majority of predicted crashes for all scenarios occur at the ramp terminal intersections. The freeway crashes for the Build scenarios are assumed to stay the same when compared to No-Build because the build scenarios do not change anything on the freeway. The ramp crashes are expected to increase slightly due to added lanes to some of the ramps. Focusing on the ramp terminals, the SPI ramp terminal crashes are expected to be reduced by 37% and the DDI ramp terminal crashes are expected to be reduced by 56%. This is consistent with what would be expected from consolidating two ramp terminals to one ramp terminal with the SPI concept and eliminating left-turns with the DDI concept.



#### Table 1: 2021 to 2045 Predicted Build and No-Build Annual Crash Frequencies

The resulting total number of annual predicted crashes is 41.2 for the SPI concept and 32.9 for the DDI concept which are both less than 57.0 predicted crashes for the No-Build condition.

Considering predicted crash severity, the DDI concept may decrease the number of F+I crashes at the ramp terminals by 63% and the SPI concept by 37%. In addition, the DDI concept may decrease the number of PDO crashes at the ramp terminals by 51% and the SPI concept by 37%. This result took into account the significant reduction in F+I crashes observed at DDIs compared to standard diamond interchanges in the Missouri research (63% reduction).

#### 4. Conclusions

Based on the preceding HSM analysis, it is concluded that both the proposed SPI and DDI are likely to exhibit significantly less overall crash frequencies than the existing diamond interchange, the DDI more so than the SPI. The freeway crashes are not expected to change and ramp crashes are expected to increase slightly based on the conceptual designs which focus on the ramp terminals. The ramp terminal crashes are expected to be reduced by 56% for the DDI and 37% for the SPI. The DDI has an even better crash benefit when looking at F+I crashes. The DDI reduces F+I crashes at the ramp terminals by 63%, compared to 37% for the SPI. The PDO crashes at the ramp terminals are reduced by 51% for the DDI and 37% for the SPI. Therefore, both proposed build options provide safety benefits compared to the No-Build option, with the DDI providing more safety benefits than the SPI.

## **APPENDIX A**

**Interchange Alternatives** 







## **APPENDIX B**

### **Crash Prediction Evaluation Reports**

# I-29 / 41<sup>st</sup> Street Interchange No-Build

Interactive Highway Safety Design Model

### **Crash Prediction Evaluation Report**

I-29 Segments

September 27, 2016

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### **Report Overview**

Report Generated: Sep 27, 2016 3:04 PM Report Template: System: Multi-Page [System] (mlcpm2, Aug 1, 2016 2:10 PM)

**Evaluation Date:** Tue Sep 27 15:03:48 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: I-29 Highway Comment: Created Wed Jul 06 08:59:58 CDT 2016 Highway Version: 2

Evaluation Title: Evaluation 16Evaluation Comment: Created Tue Sep 27 15:03:42 CDT 2016

Minimum Station: 0.000 Maximum Station: 52+38.000 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Section 1 Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 52+38.000 Functional Class: Freeway Type of Alignment: Divided, Multilane Model Category: Freeway Segment Calibration Factor: FI\_EN=1.0; FI\_EX=1.0; FI\_MV=1.0; FI\_SV=1.0; PDO\_EN=1.0; PDO\_EX=1.0; PDO\_MV=1.0; PDO\_SV=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   | Median<br>Width (ft) | Туре               | Effective Median<br>Width (ft) |
|----------|------|-----------|----------------|--------------|-------------|------------|--|----------------------|--------------------|--------------------------------|
| 1        | 6F   | Urban     | 0.000          | 20+43.470    | 2,043.47    | 0.3870     | 2021: 54,400; 2022: 55,270; 2023: 56,141; 2024: 57,012; 2025: 57,883; 2026: 58,754; 2027: 59,625; 2028: 60,495; 2029: 61,366; 2030: 62,237; 2031: 63,108; 2032: 63,979; 2033: 64,850; 2034: 65,720; 2035: 66,591; 2036: 67,462; 2037: 68,333; 2038: 69,204; 2039: 70,075; 2044: 70,945; 2041: 71,816; 2042: 72,687; 2043: 73,558; 2044: 74,429; 2045: 75,300 | 40.00                | Traversable Median | 60.00                          |
| 2        | 6F   | Urban     | 20+43.470      | 21+79.300    | 135.83      | 0.0257     | 2021: 54,400; 2022: 55,270; 2023: 56,141; 2024: 57,012; 2025: 57,883; 2026: 58,754; 2027: 59,625; 2028: 60,495; 2029: 61,366; 2030: 62,237; 2031: 63,108; 2032: 63,979; 2033: 64,850; 2034: 65,720; 2035: 66,591; 2036: 67,462; 2037: 68,333; 2038: 69,204; 2039: 70,075; 2044: 70,945; 2041: 71,816; 2042: 72,687; 2043: 73,558; 2044: 74,429; 2045: 75,300 | 40.00                | Traversable Median | 60.00                          |
| 3        | 6F   | Urban     | 21+79.300      | 39+23.470    | 1,744.17    | 0.3303     | 2021: 45,100; 2022: 45,854; 2023: 46,608; 2024: 47,362; 2025: 48,116; 2026: 48,870; 2027: 49,625; 2028: 50,379; 2029: 51,133; 2030: 51,887; 2031: 52,641; 2032: 53,395; 2033: 54,150; 2034: 54,904; 2035: 55,658; 2036: 56,412; 2037: 57,166; 2038: 57,920; 2039: 58,675; 2040: 59,429; 2041: 60,183; 2042: 60,937; 2043: 61,691; 2044: 62,445; 2045: 63,200 | 40.00                | Traversable Median | 60.00                          |
| 4        | 6F   | Urban     | 39+23.470      | 40+44.240    | 120.77      | 0.0229     | 2021: 48,100; 2022: 49,033; 2023: 49,966; 2024: 50,900; 2025: 51,833; 2026: 52,766; 2027: 53,700; 2028: 54,633; 2029: 55,566; 2030: 56,500; 2031: 57,433; 2032: 58,366; 2033: 59,300; 2034: 60,233; 2035: 61,166; 2036: 62,100; 2037: 63,033; 2038: 63,966; 2039: 64,900; 2040: 65,833; 2041: 66,766; 2042: 67,700; 2043: 68,633; 2044: 69,566; 2045: 70,500 | 40.00                | Traversable Median | 60.00                          |
| 6        | 6F   | Urban     | 40+44.240      | 52+38.000    | 1,193.76    | 0.2261     | 2021: 48,100; 2022: 49,033; 2023: 49,966; 2024: 50,900; 2025: 51,833; 2026: 52,766; 2027: 53,700; 2028: 54,633; 2029: 55,566; 2030: 56,500; 2031: 57,433; 2032: 58,366; 2033: 59,300; 2034: 60,233; 2035: 61,166; 2036: 62,100; 2037: 63,033; 2038: 63,966; 2039: 64,900; 2040: 65,833; 2041: 66,766; 2042: 67,700; 2043: 68,633; 2044: 69,566; 2045: 70,500 | 40.00                | Traversable Median | 60.00                          |

 Table 1. Evaluation Freeway - Homogeneous Segments (Section 1)

| Seg. No. | Туре | Ramp Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |       | Туре               | Effective Median<br>Width (ft) |
|----------|------|-----------|----------------|--------------|-------------|------------|--|-------|--------------------|--------------------------------|
| 5        | 6SC  | Exit      | 39+23.470      | 40+44.240    | 120.77      | 0.0229     | 2021: 48,100; 2022: 49,033; 2023: 49,966; 2024: 50,900; 2025: 51,833; 2026: 52,766; 2027: 53,700; 2028: 54,633; 2029: 55,566; 2030: 56,500; 2031: 57,433; 2032: 58,366; 2033: 59,300; 2034: 60,233; 2035: 61,166; 2036: 62,100; 2037: 63,033; 2038: 63,966; 2039: 64,900; 2040: 65,833; 2041: 66,766; 2042: 67,700; 2043: 68,633; 2044: 69,566; 2045: 70,500 | 40.00 | Traversable Median | 60.00                          |
| 7        | 6SC  | Exit      | 40+44.240      | 46+43.470    | 599.23      | 0.1135     | 2021: 48,100; 2022: 49,033; 2023: 49,966; 2024: 50,900; 2025: 51,833; 2026: 52,766; 2027: 53,700; 2028: 54,633; 2029: 55,566; 2030: 56,500; 2031: 57,433; 2032: 58,366; 2033: 59,300; 2034: 60,233; 2035: 61,166; 2036: 62,100; 2037: 63,033; 2038: 63,966; 2039: 64,900; 2040: 65,833; 2041: 66,766; 2042: 67,700; 2043: 68,633; 2044: 69,566; 2045: 70,500 | 40.00 | Traversable Median | 60.00                          |
| 8        | 6SC  | Entrance  | 40+44.240      | 52+38.000    | 1,193.76    | 0.2261     | 2021: 48,100; 2022: 49,033; 2023: 49,966; 2024: 50,900; 2025: 51,833; 2026: 52,766; 2027: 53,700; 2028: 54,633; 2029: 55,566; 2030: 56,500; 2031: 57,433; 2032: 58,366; 2033: 59,300; 2034: 60,233; 2035: 61,166; 2036: 62,100; 2037: 63,033; 2038: 63,966; 2039: 64,900; 2040: 65,833; 2041: 66,766; 2042: 67,700; 2043: 68,633; 2044: 69,566; 2045: 70,500 | 40.00 | Traversable Median | 60.00                          |

 Table 2. Evaluation Freeway - Speed Change Lanes (Speed Change)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Vear of Analysis   | 2045   |
|   | 2043   |
| Evaluated Length (mi)   | 0.9920 |
| Average Future Road AADT (vpd)                                  | 59,894 |
| Expected Crashes  |        |
| Total Crashes   | 241.60 |
| Fatal and Injury Crashes  | 81.98  |
| Property-Damage-Only Crashes                                    | 159.62 |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 34     |
| Percent Property-Damage-Only Crashes (%)                        | 66     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 9.7417 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 3.3057 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 6.4360 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 542.18 |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.45   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.15   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.29   |

#### Table 3. Expected Freeway Crash Rates and Frequencies (Section 1)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.3625 |
| Average Future Road AADT (vpd)                                  | 29,650 |
| Expected Crashes  |        |
| Total Crashes   | 46.68  |
| Fatal and Injury Crashes  | 14.10  |
| Property-Damage-Only Crashes                                    | 32.58  |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 30     |
| Percent Property-Damage-Only Crashes (%)                        | 70     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 5.1518 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 1.5563 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 3.5954 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 98.06  |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.48   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.14   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.33   |

## Table 4. Expected Freeway Speed Change Lane Crash Rates and Frequencies (Speed Change)

**Note:** *Total Travel and Crash Rates/Million Vehicle Miles* for *Speed Change Lanes* reflect AADTs that are **half of the Freeway Segment AADTs** based on the assumption of 50/50 directional distribution.

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Effective<br>Length (mi) | Expected No.<br>Crashes for<br>Evaluation<br>Period | Crash Rate<br>(crashes/mi<br>/yr) | Travel<br>Crash Rate<br>(crashes/mi<br>llion veh-<br>mi) |
|---|----------------|--------------|--------------------------|---|-----------------------------------|--|
| 1   | 0.000          | 20+43.470    | 0.3870                   | 136.377   | 14.0951                           | 0.59   |
| 2   | 20+43.470      | 21+79.300    | 0.0257                   | 7.776   | 12.0906                           | 0.51   |
| 3   | 21+79.300      | 39+23.470    | 0.3303                   | 79.263  | 9.5979                            | 0.49   |
| 4   | 39+23.470      | 40+44.240    | 0.0114                   | 3.405   | 11.9102                           | 0.55   |
| 6   | 40+44.240      | 52+38.000    | 0.0563                   | 14.783  | 10.5031                           | 0.48   |

Table 5. Expected Crash Frequencies and Rates by Freeway Segment (Section 1)

Note: Effective Length is the segment length minus the length of the speed change lanes if present.

## Table 6. Expected Crash Frequencies and Rates by Freeway Speed Change Lane (Speed Change)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mil<br>lion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 5   | 39+23.470      | 40+44.240    | 0.0229         | 3.200  | 5.5969                            | 0.52   |
| 7   | 40+44.240      | 46+43.470    | 0.1135         | 15.880   | 5.5969                            | 0.52   |
| 8   | 40+44.240      | 52+38.000    | 0.2261         | 27.602   | 4.8833                            | 0.45   |

**Note:** *Travel Crash Rates/Million Vehicle Miles* for *Speed Change Lanes* reflect AADTs that are **half of the Freeway Segment AADTs** based on the assumption of 50/50 directional distribution.

| Table 7.   | Expected | <b>Crash Free</b> | nuencies and | l Rates by  | Horizontal ]   | Design Elen | nent (Section 1) |
|------------|----------|-------------------|--------------|-------------|----------------|-------------|------------------|
| I UDIC / I | Lapecteu |                   | queneres and | i itutto by | II OI IZOIItui | Design Lien | neme (beetion I) |

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Tangent        | 0.000          | 33+31.850    | 0.6310         | 196.530  | 12.4577                           | 0.55   |
| Simple Curve 1 | 33+31.850      | 46+69.920    | 0.2534         | 71.586   | 15.5249                           | 0.98   |
| Tangent        | 46+69.920      | 52+38.000    | 0.1076         | 20.170   | 15.3865                           | 0.94   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury (O)<br>Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.9323                               | 2.3448  | 16.0581   | 27.3434  | 89.6988                                  |
| 2        | 0.0544                               | 0.1350  | 0.9114  | 1.4781   | 5.1970                                   |
| 3        | 0.5580                               | 1.4202  | 9.3640  | 15.2547  | 52.6657                                  |
| 4        | 0.0277                               | 0.0713  | 0.4300  | 0.6117   | 2.2646                                   |
| 6        | 0.1058                               | 0.2634  | 1.7686  | 2.8518   | 9.7936                                   |
| Total    | 1.6783                               | 4.2347  | 28.5320   | 47.5399  | 159.6198                                 |

 Table 8. Expected Crash Severity by Freeway Segment (Section 1)

 Table 9. Expected Crash Severity by Speed Change Lane (Speed Change)

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |  |
|----------|--------------------------------------|---|---|--|--|--|
| 5        | 0.0219                               | 0.0564  | 0.3403  | 0.4841   | 2.2977                                   |  |
| 7        | 0.1088                               | 0.2798  | 1.6884  | 2.4022   | 11.4005                                  |  |
| 8        | 0.1981                               | 0.5013  | 3.1903  | 4.8309   | 18.8812                                  |  |
| Total    | 0.3288                               | 0.8375  | 5.2190  | 7.7173   | 32.5794                                  |  |

|                    |                                     | Fatal an | d Injury       | Property<br>Or | Damage<br>lly  | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.15     | 0.1            | 1.75           | 0.7            | 1.90    | 0.8            |  |
| Highway<br>Segment | Collision with Fixed Object         | 26.30    | 10.9           | 56.97          | 23.6           | 83.28   | 34.5           |  |
| Highway<br>Segment | Collision with Other Object         | 1.86     | 0.8            | 11.06          | 4.6            | 12.92   | 5.3            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 7.58     | 3.1            | 8.51           | 3.5            | 16.09   | 6.7            |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.55     | 0.2            | 1.27           | 0.5            | 1.82    | 0.8            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 36.43    | 15.1           | 79.57          | 32.9           | 116.00  | 48.0           |  |
| Highway<br>Segment | Right-Angle Collision               | 1.41     | 0.6            | 1.44           | 0.6            | 2.85    | 1.2            |  |
| Highway<br>Segment | Head-on Collision                   | 0.36     | 0.2            | 0.16           | 0.1            | 0.53    | 0.2            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 1.41     | 0.6            | 1.92           | 0.8            | 3.33    | 1.4            |  |
| Highway<br>Segment | Rear-end Collision                  | 34.16    | 14.1           | 55.23          | 22.9           | 89.40   | 37.0           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 8.20     | 3.4            | 21.29          | 8.8            | 29.49   | 12.2           |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 45.55    | 18.9           | 80.05          | 33.1           | 125.60  | 52.0           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 81.98    | 33.9           | 159.62         | 66.1           | 241.60  | 100.0          |  |
|                    | Total Crashes                       | 81.98    | 33.9           | 159.62         | 66.1           | 241.60  | 100.0          |  |

 Table 10. Expected Segment Crash Type Distribution (Section 1)

**Note:** *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

|                    |                                     | Fatal an | d Injury       | Property<br>Or | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.00     | 0.0            | 0.10           | 0.5            | 0.10    | 0.5            |  |
| Highway<br>Segment | Collision with Fixed Object         | 1.05     | 5.5            | 2.84           | 14.9           | 3.89    | 20.4           |  |
| Highway<br>Segment | Collision with Other Object         | 0.09     | 0.5            | 0.41           | 2.2            | 0.50    | 2.6            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.26     | 1.4            | 0.32           | 1.7            | 0.58    | 3.0            |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.00     | 0.0            | 0.00           | 0.0            | 0.00    | 0.0            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 1.41     | 7.4            | 3.66           | 19.2           | 5.06    | 26.5           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.06     | 0.3            | 0.16           | 0.9            | 0.22    | 1.2            |  |
| Highway<br>Segment | Head-on Collision                   | 0.03     | 0.1            | 0.03           | 0.1            | 0.05    | 0.3            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.09     | 0.5            | 0.22           | 1.1            | 0.30    | 1.6            |  |
| Highway<br>Segment | Rear-end Collision                  | 2.96     | 15.5           | 7.74           | 40.6           | 10.69   | 56.0           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.85     | 4.5            | 1.89           | 9.9            | 2.74    | 14.4           |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 3.98     | 20.8           | 10.04          | 52.6           | 14.02   | 73.5           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 5.38     | 28.2           | 13.70          | 71.8           | 19.08   | 100.0          |  |
|                    | Total Crashes                       | 5.38     | 28.2           | 13.70          | 71.8           | 19.08   | 100.0          |  |

#### Table 11. Expected Exit Speed Change Lane Crash Type Distribution (Speed Change)

**Note:** *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.00     | 0.0            | 0.04           | 0.1            | 0.04    | 0.1            |  |
| Highway<br>Segment | Collision with Fixed Object         | 1.69     | 6.1            | 2.44           | 8.8            | 4.13    | 15.0           |  |
| Highway<br>Segment | Collision with Other Object         | 0.17     | 0.6            | 0.68           | 2.5            | 0.84    | 3.1            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.58     | 2.1            | 0.30           | 1.1            | 0.89    | 3.2            |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.04     | 0.1            | 0.06           | 0.2            | 0.09    | 0.3            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 2.48     | 9.0            | 3.51           | 12.7           | 5.99    | 21.7           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.17     | 0.6            | 0.30           | 1.1            | 0.47    | 1.7            |  |
| Highway<br>Segment | Head-on Collision                   | 0.04     | 0.1            | 0.02           | 0.1            | 0.05    | 0.2            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.15     | 0.5            | 0.28           | 1.0            | 0.43    | 1.6            |  |
| Highway<br>Segment | Rear-end Collision                  | 4.74     | 17.2           | 10.01          | 36.3           | 14.74   | 53.4           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 1.16     | 4.2            | 4.76           | 17.2           | 5.92    | 21.4           |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 6.24     | 22.6           | 15.37          | 55.7           | 21.61   | 78.3           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 8.72     | 31.6           | 18.88          | 68.4           | 27.60   | 100.0          |  |
|                    | Total Crashes                       | 8.72     | 31.6           | 18.88          | 68.4           | 27.60   | 100.0          |  |

## Table 12. Expected Entrance Speed Change Lane Crash Type Distribution (Speed Change)

**Note:** *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## Crash Prediction Evaluation Report NB Off Ramp

September 27, 2016

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### **Report Overview**

Report Generated: Sep 27, 2016 11:33 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 12 09:42:07 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: NB Off Ramp Highway Comment: Created Fri Jul 08 12:36:35 CDT 2016 Highway Version: 1

Evaluation Title: Evaluation 7Evaluation Comment: Created Mon Sep 12 09:41:56 CDT 2016

Minimum Station: 0.000 Maximum Station: 808.520 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 808.520 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: EX\_RAMP\_MV\_FI=1.0; EX\_RAMP\_MV\_PDO=1.0; EX\_RAMP\_SV\_FI=1.0; EX\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |
|----------|------|-----------|----------------|--------------|-------------|------------|--|
| 1        | 1EX  | Urban     | 0.000          | 590.000      | 590.00      | 0.1117     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |
| 2        | 1EX  | Urban     | 590.000        | 602.000      | 12.00       | 0.0023     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 3        | IEX  | Urban     | 602.000        | 625.000      | 23.00       | 0.0044     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,570; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |
| 4        | 1EX  | Urban     | 625.000        | 649.000      | 24.00       | 0.0046     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 5        | 1EX  | Urban     | 649.000        | 672.000      | 23.00       | 0.0044     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 6        | 1EX  | Urban     | 672.000        | 695.000      | 23.00       | 0.0044     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 7        | 1EX  | Urban     | 695.000        | 719.000      | 24.00       | 0.0046     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 8        | 1EX  | Urban     | 719.000        | 730.000      | 11.00       | 0.0021     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 9        | 1EX  | Urban     | 730.000        | 808.520      | 78.52       | 0.0149     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |

| Table 1.  | Evaluation | Freeway - | Homogeneous | Segments | (Freeway    | Ramp | Sections)      |
|-----------|------------|-----------|-------------|----------|-------------|------|----------------|
| I abit II | L'aluation | Incomag   | mogeneous   | Segments | (I I CC may | ramp | <i>beenons</i> |

| First Voor of Analysis  | 2021   |
|---|--------|
|   | 2021   |
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1531 |
| Average Future Road AADT (vpd)                                  | 5,950  |
| Expected Crashes  |        |
| Total Crashes   | 6.71   |
| Fatal and Injury Crashes  | 3.15   |
| Property-Damage-Only Crashes                                    | 3.56   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 47     |
| Percent Property-Damage-Only Crashes (%)                        | 53     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 1.7537 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.8231 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 0.9307 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 8.31   |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.81   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.38   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.43   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 590.000      | 0.1117         | 4.683  | 1.6764                            | 0.77   |
| 2   | 590.000        | 602.000      | 0.0023         | 0.092  | 1.6217                            | 0.75   |
| 3   | 602.000        | 625.000      | 0.0044         | 0.182  | 1.6696                            | 0.77   |
| 4   | 625.000        | 649.000      | 0.0045         | 0.197  | 1.7364                            | 0.80   |
| 5   | 649.000        | 672.000      | 0.0044         | 0.197  | 1.8062                            | 0.83   |
| 6   | 672.000        | 695.000      | 0.0044         | 0.204  | 1.8777                            | 0.86   |
| 7   | 695.000        | 719.000      | 0.0045         | 0.222  | 1.9540                            | 0.90   |
| 8   | 719.000        | 730.000      | 0.0021         | 0.105  | 2.0131                            | 0.93   |
| 9   | 730.000        | 808.520      | 0.0149         | 0.831  | 2.2356                            | 1.03   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

## Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Simple Curve 1 | 0.000          | 180.000      | 0.0341         | 1.429  | 1.6764                            | 0.77   |
| Tangent        | 180.000        | 808.520      | 0.1190         | 5.285  | 1.7759                            | 0.82   |
| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0664                               | 0.2013  | 0.8370  | 1.0213   | 2.5573                                   |
| 2        | 0.0013                               | 0.0040  | 0.0166  | 0.0203   | 0.0499                                   |
| 3        | 0.0026                               | 0.0080  | 0.0332  | 0.0405   | 0.0976                                   |
| 4        | 0.0029                               | 0.0088  | 0.0365  | 0.0446   | 0.1045                                   |
| 5        | 0.0029                               | 0.0089  | 0.0370  | 0.0451   | 0.1028                                   |
| 6        | 0.0031                               | 0.0094  | 0.0390  | 0.0476   | 0.1055                                   |
| 7        | 0.0034                               | 0.0103  | 0.0429  | 0.0524   | 0.1130                                   |
| 8        | 0.0016                               | 0.0049  | 0.0205  | 0.0250   | 0.0528                                   |
| 9        | 0.0141                               | 0.0428  | 0.1779  | 0.2171   | 0.3792                                   |
| Total    | 0.0984                               | 0.2984  | 1.2405  | 1.5137   | 3.5628                                   |

### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.2            | 0.07           | 1.1            | 0.08    | 1.2            |  |
| Highway<br>Segment | Collision with Fixed Object         | 2.19     | 32.6           | 2.33           | 34.7           | 4.52    | 67.4           |  |
| Highway<br>Segment | Collision with Other Object         | 0.15     | 2.3            | 0.45           | 6.7            | 0.61    | 9.0            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.63     | 9.4            | 0.35           | 5.2            | 0.98    | 14.6           |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.05     | 0.7            | 0.05           | 0.8            | 0.10    | 1.5            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 3.04     | 45.2           | 3.25           | 48.5           | 6.29    | 93.7           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.00     | 0.1            | 0.01           | 0.1            | 0.01    | 0.1            |  |
| Highway<br>Segment | Head-on Collision                   | 0.00     | 0.0            | 0.00           | 0.0            | 0.00    | 0.0            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.00     | 0.1            | 0.01           | 0.1            | 0.01    | 0.2            |  |
| Highway<br>Segment | Rear-end Collision                  | 0.09     | 1.3            | 0.21           | 3.2            | 0.30    | 4.4            |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.02     | 0.3            | 0.08           | 1.2            | 0.10    | 1.5            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.12     | 1.7            | 0.31           | 4.6            | 0.42    | 6.3            |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 3.15     | 46.9           | 3.56           | 53.1           | 6.71    | 100.0          |  |
|                    | Total Crashes                       | 3.15     | 46.9           | 3.56           | 53.1           | 6.71    | 100.0          |  |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

NB On Ramp

September 27, 2016

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## **Report Overview**

Report Generated: Sep 27, 2016 11:32 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Fri Sep 09 15:20:54 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st StProject Comment: Created Wed Jul 06 08:57:12 CDT 2016Project Unit System: U.S. Customary

Highway Title: NB On Ramp Highway Comment: Created Fri Jul 08 14:06:37 CDT 2016 Highway Version: 1

**Evaluation Title:** NB On Ramp 2021-2045 **Evaluation Comment:** Created Fri Sep 09 15:19:44 CDT 2016

Minimum Station: 0.000 Maximum Station: 989.060 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

## **Freeway Ramp Evaluation**

Section: Section 1 **Evaluation Start Location: 0.000 Evaluation End Location:** 989.060 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: ENT\_RAMP\_MV\_FI=1.0; ENT\_RAMP\_MV\_PDO=1.0; ENT\_RAMP\_SV\_FI=1.0; ENT\_RAMP\_SV\_PDO=1.0;



Crash Prediction Summary, Section 1 (One Direction; Urban; Freeway Ramp) Project: I-29 and 41 st St, Evaluation: NB On Ramp 2021-2045



| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT  |
|----------|------|-----------|----------------|--------------|-------------|------------|---|
| 1        | 2EN  | Urban     | 0.000          | 92.000       | 92.00       | 0.0174     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700       |
| 2        | 1EN  | Urban     | 92.000         | 97.000       | 5.00        | 0.0009     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700       |
| 3        | 1EN  | Urban     | 97.000         | 106.000      | 9.00        | 0.0017     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2044: 8,697; 2045: 8,700                    |
| 4        | 1EN  | Urban     | 106.000        | 115.000      | 9.00        | 0.0017     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032:<br>8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695;<br>2044: 8,697; 2045: 8,700 |
| 5        | 1EN  | Urban     | 115.000        | 123.000      | 8.00        | 0.0015     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032:<br>8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695;<br>2044: 8,697; 2045: 8,700 |
| 6        | 1EN  | Urban     | 123.000        | 132.000      | 9.00        | 0.0017     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032:<br>8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695;<br>2044: 8,697; 2045: 8,700 |
| 7        | 1EN  | Urban     | 132.000        | 141.000      | 9.00        | 0.0017     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700       |
| 8        | 1EN  | Urban     | 141.000        | 989.060      | 848.06      | 0.1606     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700       |

| Table 1. | Evaluation | Freeway - | Homogeneous | Segments | (Freeway    | Ramp | Sections) |
|----------|------------|-----------|-------------|----------|-------------|------|-----------|
|          |            |           |             |          | <pre></pre> |      |           |

|   | []     |
|---|--------|
| First Year of Analysis  | 2021   |
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1873 |
| Average Future Road AADT (vpd)                                  | 8,675  |
| Expected Crashes  |        |
| Total Crashes   | 11.05  |
| Fatal and Injury Crashes  | 4.51   |
| Property-Damage-Only Crashes                                    | 6.54   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 41     |
| Percent Property-Damage-Only Crashes (%)                        | 59     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 2.3588 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.9623 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 1.3965 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 14.83  |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.74   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.30   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.44   |

### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 92.000       | 0.0174         | 1.555  | 3.5697                            | 1.13   |
| 2   | 92.000         | 97.000       | 0.0009         | 0.060  | 2.5279                            | 0.80   |
| 3   | 97.000         | 106.000      | 0.0017         | 0.104  | 2.4518                            | 0.77   |
| 4   | 106.000        | 115.000      | 0.0017         | 0.101  | 2.3578                            | 0.74   |
| 5   | 115.000        | 123.000      | 0.0015         | 0.086  | 2.2727                            | 0.72   |
| 6   | 123.000        | 132.000      | 0.0017         | 0.093  | 2.1911                            | 0.69   |
| 7   | 132.000        | 141.000      | 0.0017         | 0.090  | 2.1083                            | 0.67   |
| 8   | 141.000        | 989.060      | 0.1606         | 8.957  | 2.2307                            | 0.70   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Tangent        | 0.000          | 591.260      | 0.1120         | 6.845  | 2.4449                            | 0.77   |
| Simple Curve 1 | 591.260        | 989.060      | 0.0753         | 4.202  | 2.2307                            | 0.70   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0114                               | 0.0344  | 0.1783  | 0.3361   | 0.9948                                   |
| 2        | 0.0006                               | 0.0018  | 0.0112  | 0.0137   | 0.0326                                   |
| 3        | 0.0010                               | 0.0030  | 0.0193  | 0.0236   | 0.0575                                   |
| 4        | 0.0009                               | 0.0029  | 0.0183  | 0.0223   | 0.0560                                   |
| 5        | 0.0008                               | 0.0024  | 0.0154  | 0.0188   | 0.0486                                   |
| 6        | 0.0009                               | 0.0026  | 0.0165  | 0.0201   | 0.0533                                   |
| 7        | 0.0008                               | 0.0025  | 0.0156  | 0.0190   | 0.0519                                   |
| 8        | 0.0792                               | 0.2401  | 1.5282  | 1.8647   | 5.2449                                   |
| Total    | 0.0955                               | 0.2896  | 1.8029  | 2.3184   | 6.5397                                   |

### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage         | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.1            | 0.10           | 0.9            | 0.12    | 1.0            |  |
| Highway<br>Segment | Collision with Fixed Object         | 2.57     | 23.3           | 3.30           | 29.8           | 5.87    | 53.1           |  |
| Highway<br>Segment | Collision with Other Object         | 0.18     | 1.6            | 0.64           | 5.8            | 0.82    | 7.4            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.74     | 6.7            | 0.49           | 4.5            | 1.23    | 11.2           |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.05     | 0.5            | 0.07           | 0.7            | 0.13    | 1.2            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 3.56     | 32.2           | 4.60           | 41.7           | 8.17    | 73.9           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.03     | 0.3            | 0.04           | 0.3            | 0.06    | 0.6            |  |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.1            | 0.00           | 0.0            | 0.01    | 0.1            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.03     | 0.3            | 0.05           | 0.4            | 0.08    | 0.7            |  |
| Highway<br>Segment | Rear-end Collision                  | 0.71     | 6.4            | 1.33           | 12.1           | 2.04    | 18.5           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.17     | 1.5            | 0.52           | 4.7            | 0.69    | 6.2            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.94     | 8.6            | 1.94           | 17.5           | 2.88    | 26.1           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 4.51     | 40.8           | 6.54           | 59.2           | 11.05   | 100.0          |  |
|                    | Total Crashes                       | 4.51     | 40.8           | 6.54           | 59.2           | 11.05   | 100.0          |  |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

SB Off Ramp

September 27, 2016

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## **Report Overview**

Report Generated: Sep 27, 2016 11:31 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 12 09:41:32 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st StProject Comment: Created Wed Jul 06 08:57:12 CDT 2016Project Unit System: U.S. Customary

Highway Title: SB Off Ramp Highway Comment: Created Thu Jul 07 14:54:22 CDT 2016 Highway Version: 2

**Evaluation Title:** Evaluation 4 **Evaluation Comment:** Created Mon Sep 12 09:41:16 CDT 2016

Minimum Station: 0.000 Maximum Station: 1+142.460 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 **Evaluation Start Location: 0.000 Evaluation End Location:** 1+142.460 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: EX\_RAMP\_MV\_FI=1.0; EX\_RAMP\_MV\_PDO=1.0; EX\_RAMP\_SV\_FI=1.0; EX\_RAMP\_SV\_PDO=1.0;



Crash Prediction Summary, Section 1 (One Direction; Urban; Freeway Ramp) Project: I-29 and 41st St, Evaluation: Evaluation 4



| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |
|----------|------|-----------|----------------|--------------|-------------|------------|--|
| 1        | 2EX  | Urban     | 0.000          | 446.950      | 446.95      | 0.0847     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 2        | 2EX  | Urban     | 446.950        | 457.000      | 10.05       | 0.0019     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 3        | 2EX  | Urban     | 457.000        | 475.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 4        | 2EX  | Urban     | 475.000        | 494.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 5        | 2EX  | Urban     | 494.000        | 512.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 6        | 2EX  | Urban     | 512.000        | 531.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 7        | 2EX  | Urban     | 531.000        | 549.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 8        | 2EX  | Urban     | 549.000        | 568.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 9        | 2EX  | Urban     | 568.000        | 587.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 10       | 2EX  | Urban     | 587.000        | 733.000      | 146.00      | 0.0277     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 11       | 2EX  | Urban     | 733.000        | 1+006.000    | 273.00      | 0.0517     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 12       | 2EX  | Urban     | 1+006.000      | 1+142.460    | 136.46      | 0.0258     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |

| Table 1. | Evaluation | Freeway - | Homogeneous | Segments ( | (Freeway | Ramp | Sections) |
|----------|------------|-----------|-------------|------------|----------|------|-----------|
|          |            |           |             |            | (        |      |           |

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.2164 |
| Average Future Road AADT (vpd)                                  | 11,850 |
| Expected Crashes  |        |
| Total Crashes   | 27.52  |
| Fatal and Injury Crashes  | 11.02  |
| Property-Damage-Only Crashes                                    | 16.49  |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 40     |
| Percent Property-Damage-Only Crashes (%)                        | 60     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 5.0865 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 2.0378 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 3.0487 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 23.40  |
| Travel Crash Rate (crashes/million veh-mi)                      | 1.18   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.47   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.70   |

### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mil<br>lion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 446.950      | 0.0846         | 11.183   | 5.2843                            | 1.22   |
| 2   | 446.950        | 457.000      | 0.0019         | 0.151  | 3.1702                            | 0.73   |
| 3   | 457.000        | 475.000      | 0.0034         | 0.278  | 3.2590                            | 0.75   |
| 4   | 475.000        | 494.000      | 0.0036         | 0.304  | 3.3804                            | 0.78   |
| 5   | 494.000        | 512.000      | 0.0034         | 0.299  | 3.5070                            | 0.81   |
| 6   | 512.000        | 531.000      | 0.0036         | 0.327  | 3.6390                            | 0.84   |
| 7   | 531.000        | 549.000      | 0.0034         | 0.322  | 3.7766                            | 0.87   |
| 8   | 549.000        | 568.000      | 0.0036         | 0.353  | 3.9203                            | 0.91   |
| 9   | 568.000        | 587.000      | 0.0036         | 0.366  | 4.0743                            | 0.94   |
| 10  | 587.000        | 733.000      | 0.0277         | 3.963  | 5.7332                            | 1.33   |
| 11  | 733.000        | 1+006.000    | 0.0517         | 7.133  | 5.5184                            | 1.28   |
| 12  | 1+006.000      | 1+142.460    | 0.0258         | 2.836  | 4.3887                            | 1.01   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Simple Curve 1 | 0.000          | 242.760      | 0.0460         | 6.074  | 5.2843                            | 1.22   |
| Simple Curve 2 | 242.760        | 436.860      | 0.0368         | 4.856  | 5.2843                            | 1.22   |
| Tangent        | 436.860        | 630.150      | 0.0366         | 3.824  | 4.1782                            | 0.97   |
| Simple Curve 3 | 630.150        | 872.350      | 0.0459         | 6.433  | 5.6096                            | 1.30   |
| Tangent        | 872.350        | 1+142.460    | 0.0512         | 6.328  | 4.9477                            | 1.14   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.1130                               | 0.3427  | 1.1739  | 2.4804   | 7.0729                                   |
| 2        | 0.0017                               | 0.0051  | 0.0173  | 0.0327   | 0.0941                                   |
| 3        | 0.0032                               | 0.0096  | 0.0323  | 0.0609   | 0.1718                                   |
| 4        | 0.0035                               | 0.0106  | 0.0360  | 0.0679   | 0.1861                                   |
| 5        | 0.0035                               | 0.0106  | 0.0360  | 0.0678   | 0.1809                                   |
| 6        | 0.0039                               | 0.0119  | 0.0401  | 0.0756   | 0.1960                                   |
| 7        | 0.0039                               | 0.0119  | 0.0401  | 0.0755   | 0.1905                                   |
| 8        | 0.0044                               | 0.0132  | 0.0446  | 0.0841   | 0.2064                                   |
| 9        | 0.0046                               | 0.0140  | 0.0472  | 0.0889   | 0.2119                                   |
| 10       | 0.0495                               | 0.1500  | 0.5071  | 0.9559   | 2.3008                                   |
| 11       | 0.0909                               | 0.2756  | 0.9315  | 1.7560   | 4.0792                                   |
| 12       | 0.0367                               | 0.1114  | 0.3765  | 0.7098   | 1.6013                                   |
| Total    | 0.3187                               | 0.9665  | 3.2825  | 6.4555   | 16.4918                                  |

### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    | Crash Type                          | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       |                                     | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.04     | 0.1            | 0.30           | 1.1            | 0.35    | 1.3            |  |
| Highway<br>Segment | Collision with Fixed Object         | 7.41     | 26.9           | 9.92           | 36.1           | 17.33   | 63.0           |  |
| Highway<br>Segment | Collision with Other Object         | 0.52     | 1.9            | 1.93           | 7.0            | 2.45    | 8.9            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 2.13     | 7.8            | 1.48           | 5.4            | 3.62    | 13.1           |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.15     | 0.6            | 0.22           | 0.8            | 0.38    | 1.4            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 10.27    | 37.3           | 13.86          | 50.4           | 24.12   | 87.7           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.02     | 0.1            | 0.05           | 0.2            | 0.07    | 0.3            |  |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.0            | 0.01           | 0.0            | 0.01    | 0.0            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.02     | 0.1            | 0.06           | 0.2            | 0.09    | 0.3            |  |
| Highway<br>Segment | Rear-end Collision                  | 0.57     | 2.1            | 1.82           | 6.6            | 2.38    | 8.7            |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.14     | 0.5            | 0.70           | 2.5            | 0.84    | 3.0            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.76     | 2.8            | 2.63           | 9.6            | 3.39    | 12.3           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 11.02    | 40.1           | 16.49          | 59.9           | 27.52   | 100.0          |  |
|                    | Total Crashes                       | 11.02    | 40.1           | 16.49          | 59.9           | 27.52   | 100.0          |  |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

SB On Ramp

September 27, 2016

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## **Report Overview**

Report Generated: Sep 27, 2016 11:30 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Fri Sep 09 15:30:23 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: SB On Ramp Highway Comment: Created Fri Jul 08 09:10:58 CDT 2016 Highway Version: 1

**Evaluation Title:** SB On Ramp **Evaluation Comment:** Created Fri Sep 09 15:30:08 CDT 2016

Minimum Station: 0.000 Maximum Station: 889.000 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

## **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 889.000 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: ENT\_RAMP\_MV\_FI=1.0; ENT\_RAMP\_MV\_PDO=1.0; ENT\_RAMP\_SV\_FI=1.0; ENT\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT  |
|----------|------|-----------|----------------|--------------|-------------|------------|---|
| 1        | 1EN  | Urban     | 0.000          | 889.000      | 889.00      | 0.1684     | 2021: 4,700; 2022: 4,787; 2023: 4,875; 2024: 4,962; 2025: 5,050; 2026: 5,137; 2027: 5,225; 2028: 5,312; 2029: 5,400; 2030: 5,487; 2031: 5,575; 2032: 5,662; 2033: 5,750; 2034: 5,837; 2035: 5,925; 2036: 6,012; 2037: 6,100; 2038: 6,187; 2039: 6,275; 2040: 6,362; 2041: 6,450; 2042: 6,537; 2043: 6,625; 2044: 6,712; 2045: 6,800 |

### Table 1. Evaluation Freeway - Homogeneous Segments (Freeway Ramp Sections)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1684 |
| Average Future Road AADT (vpd)                                  | 5,750  |
| Expected Crashes  |        |
| Total Crashes   | 6.95   |
| Fatal and Injury Crashes  | 2.98   |
| Property-Damage-Only Crashes                                    | 3.97   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 43     |
| Percent Property-Damage-Only Crashes (%)                        | 57     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 1.6510 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.7083 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 0.9427 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 8.83   |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.79   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.34   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.45   |

### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

# Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 889.000      | 0.1684         | 6.949  | 1.6510                            | 0.79   |

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location Length (mi) |        | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------------------|--------|--|-----------------------------------|--|
| Tangent        | 0.000          | 545.950                  | 0.1034 | 4.268  | 1.6510                            | 0.79   |
| Simple Curve 1 | 545.950        | 889.000                  | 0.0650 | 2.682  | 1.6510                            | 0.79   |

### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

| Seg.<br>No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury (O)<br>Crashes<br>(crashes/yr) |  |
|-------------|--------------------------------------|---|---|--|--|--|
| 1           | 0.0636                               | 0.1928  | 1.2273  | 1.4976   | 3.9681                                   |  |

|                    | a 1 <b>m</b>                        | Fatal an | d Injury       | Property<br>O1                             | Damage<br>ly | Total          |       |  |
|--------------------|-------------------------------------|----------|----------------|--|--------------|----------------|-------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes<br>(%)CrashesCrashes<br>(%)Crashes |              | Crashes<br>(%) |       |  |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.1            | 0.07                                       | 1.0          | 0.08           | 1.1   |  |
| Highway<br>Segment | Collision with Fixed Object         | 1.77     | 25.5           | 2.20                                       | 31.6         | 3.97           | 57.1  |  |
| Highway<br>Segment | Collision with Other Object         | 0.12     | 1.8            | 0.43                                       | 6.1          | 0.55           | 7.9   |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.51     | 7.4            | 0.33                                       | 4.7          | 0.84           | 12.1  |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.04     | 0.5            | 0.05                                       | 0.7          | 0.09           | 1.2   |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 2.46     | 35.4           | 3.07                                       | 44.1         | 5.53           | 79.5  |  |
| Highway<br>Segment | Right-Angle Collision               | 0.02     | 0.2            | 0.02                                       | 0.2          | 0.03           | 0.5   |  |
| Highway<br>Segment | Head-on Collision                   | 0.00     | 0.1            | 0.00                                       | 0.0          | 0.01           | 0.1   |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.02     | 0.2            | 0.02                                       | 0.3          | 0.04           | 0.5   |  |
| Highway<br>Segment | Rear-end Collision                  | 0.39     | 5.6            | 0.62                                       | 8.9          | 1.01           | 14.6  |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.09     | 1.4            | 0.24                                       | 3.4          | 0.33           | 4.8   |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.52     | 7.5            | 0.90                                       | 13.0         | 1.42           | 20.5  |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 2.98     | 42.9           | 3.97                                       | 57.1         | 6.95           | 100.0 |  |
|                    | Total Crashes                       | 2.98     | 42.9           | 3.97                                       | 57.1         | 6.95           | 100.0 |  |

| Table 6. | Expected S | Segment Cras | n Type | Distribution | (Freeway | Ramp | Sections) |
|----------|------------|--------------|--------|--------------|----------|------|-----------|
|----------|------------|--------------|--------|--------------|----------|------|-----------|

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

NB Ramp Terminal

September 27, 2016

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## **Report Overview**

Report Generated: Sep 27, 2016 11:29 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Fri Sep 09 15:31:04 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st StProject Comment: Created Wed Jul 06 08:57:12 CDT 2016Project Unit System: U.S. Customary

Intersection Title: NB Terminal Intersection Comment: Created Mon Jul 11 07:47:16 CDT 2016 Intersection Version: v1

**Evaluation Title:** Evaluation 1 **Evaluation Comment:** Created Fri Sep 09 15:30:49 CDT 2016

Minimum Station: 0.000 Maximum Station: 1+410.410 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

## **NB** Terminal Evaluation

Intersection: Evaluation Start Location: 0.000 Evaluation End Location: 1+410.410 Calibration Factor: RT\_SG\_FI=1.0; RT\_SG\_PDO=1.0;

| Table 1. | <b>Evaluation</b> | Ramp | Terminal - | - Site | (NB | <b>Terminal</b> ) |
|----------|-------------------|------|------------|--------|-----|-------------------|
|          |                   |      |            | ~      | (   |                   |

| Inter. No. | Ramp Terminal Type                               | Area Type | Legs | Location  | Traffic Control | AADT   |
|------------|--|-----------|------|-----------|-----------------|--|
| 1          | D4-Four-Leg Ramp Terminal with Diagonal<br>Ramps | Urban     | 4    | 1+012.270 | Signalized      | Inside: 2021: 36.000; 2022: 36.587; 2023: 37,175; 2024: 37,762; 2025: 38,350; 2026: 38,937; 2027: 39,525; 2028: 40,112; 2029: 40,700;<br>2030: 41,287; 2031: 41,875; 2032: 42,462; 2033: 43,050; 2034: 43,637; 2035: 44,252; 2036: 44,812; 2037: 45,400; 2038: 45,987; 2039-<br>64,575; 2040: 47,162; 2041: 47,750; 2042: 48,337; 2043: 48,952; 2044: 49,212; 2045: 50,100; Outside: 2021: 28,900; 2022: 92,288;<br>2023: 29,616; 2024: 29,975; 2025: 30,333; 2026: 30,691; 2027: 31,050; 2028: 31,408; 2029: 31,766; 2030: 32,125; 2031: 32,483; 2032:<br>32,841; 2033: 33,200; 2034: 33,558; 2045: 33,916; 2036: 34,275; 2037: 34,633; 2038: 34,991; 2039: 52,350; 2040: 35,708; 2041:<br>36,066; 2042: 36,452; 2043: 36,783; 2044: 37,141; 2045: 37,500: = Intrance: 2021: 8,865; 2022: 8,652; 2023: 8,664; 2022: 8,665; 2025:<br>8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035:<br>8,679; 2036: 6,861; 2037: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2011: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035:<br>8,799; 2036: 6,861; 2037: 8,662; 2028: 5,1039: 8,687; 2031: 8,670; 2032: 8,652; 2027: 8,662; 2044: 8,697; 2045:<br>8,799; 2036: 6,861; 2037: 8,662; 2042: 5,198; 2034: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030:<br>5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,129; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040:<br>5,694; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,802; 2045: 6,900 |

#### Table 2. Expected Ramp Terminal Crash Rates and Frequencies (NB Terminal)

| First Year of Analysis                   | 2021   |
|--|--------|
| Last Year of Analysis                    | 2045   |
| Evaluated Length (mi)                    | 0.0000 |
| Expected Crashes                         |        |
| Total Crashes                            | 464.32 |
| Fatal and Injury Crashes                 | 195.64 |
| Property-Damage-Only Crashes             | 268.68 |
| Percent of Total Expected Crashes        |        |
| Percent Fatal and Injury Crashes (%)     | 42     |
| Percent Property-Damage-Only Crashes (%) | 58     |

| Segment<br>Number/Intersection<br>Name/Cross Road | Location  | Expected No.<br>Crashes for<br>Evaluation Period | Expected No.<br>Crashes/Year<br>(crashes/million<br>veh) | Expected Crash<br>Rate<br>(crashes/yr) |
|---|-----------|--|--|--|
| NB Terminal                                       | 1+012.270 | 464.315  | 1.12   | 18.5726                                |

#### Table 3. Expected Crash Frequencies and Rates by Ramp Terminal (NB Terminal)

#### Table 4. Expected Crash Severity by Ramp Terminal (NB Terminal)

| Seg.<br>No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury (O)<br>Crashes<br>(crashes/yr) |
|-------------|--------------------------------------|---|---|--|--|
| 1           | 0.2466                               | 6.1582  | 38.5882   | 150.6480                                       | 268.6745                                 |

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |
| Highway<br>Segment | Collision with Animal               | 0.00     | 0.0            | 0.00           | 0.0            | 0.00    | 0.0            |
| Highway<br>Segment | Collision with Fixed Object         | 6.46     | 1.4            | 13.43          | 2.9            | 19.89   | 4.3            |
| Highway<br>Segment | Collision with Other Object         | 0.20     | 0.0            | 0.54           | 0.1            | 0.73    | 0.2            |
| Highway<br>Segment | Other Single-vehicle Collision      | 3.52     | 0.8            | 1.88           | 0.4            | 5.40    | 1.2            |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.20     | 0.0            | 0.54           | 0.1            | 0.73    | 0.2            |
| Highway<br>Segment | Total Single Vehicle Crashes        | 10.37    | 2.2            | 16.39          | 3.5            | 26.76   | 5.8            |
| Highway<br>Segment | Right-Angle Collision               | 50.87    | 11.0           | 59.11          | 12.7           | 109.97  | 23.7           |
| Highway<br>Segment | Head-on Collision                   | 2.15     | 0.5            | 1.88           | 0.4            | 4.03    | 0.9            |
| Highway<br>Segment | Other Multi-vehicle Collision       | 1.76     | 0.4            | 5.37           | 1.2            | 7.13    | 1.5            |
| Highway<br>Segment | Rear-end Collision                  | 122.28   | 26.3           | 145.89         | 31.4           | 268.17  | 57.8           |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 8.22     | 1.8            | 40.03          | 8.6            | 48.25   | 10.4           |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 185.27   | 39.9           | 252.28         | 54.3           | 437.56  | 94.2           |
| Highway<br>Segment | Total Highway Segment Crashes       | 195.64   | 42.1           | 268.68         | 57.9           | 464.32  | 100.0          |
|                    | Total Crashes                       | 195.64   | 42.1           | 268.68         | 57.9           | 464.32  | 100.0          |

 Table 5. Expected Segment Crash Type Distribution (NB Terminal)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

| Table 6. | Evaluation Message |  |
|----------|--------------------|--|
|----------|--------------------|--|

| Start Location | End Location | Message   |
|----------------|--------------|---|
| 1+012.270      | 1+012.270    | for intersection #1 (10+12.270 to 10+12.270 ), inside crossroad traffic volume (47,162 vpd) for 2040 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |
| 1+012.270      | 1+012.270    | for intersection #1 (10+12.270 to 10+12.270 ), inside crossroad traffic volume (47,750 vpd) for 2041 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |
| 1+012.270      | 1+012.270    | for intersection #1 (10+12.270 to 10+12.270 ), inside crossroad traffic volume (48,337 vpd) for 2042 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |
| 1+012.270      | 1+012.270    | for intersection #1 (10+12.270 to 10+12.270 ), inside crossroad traffic volume (48,925 vpd) for 2043 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |
| 1+012.270      | 1+012.270    | for intersection #1 (10+12.270 to 10+12.270 ), inside crossroad traffic volume (49,512 vpd) for 2044 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |
| 1+012.270      | 1+012.270    | for intersection #1 (10+12.270 to 10+12.270 ), inside crossroad traffic volume (50,100 vpd) for 2045 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |

Interactive Highway Safety Design Model

# **Crash Prediction Evaluation Report**

SB Ramp Terminal

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## **Report Overview**

Report Generated: Sep 27, 2016 11:28 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Fri Sep 09 15:34:31 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Intersection Title: SB Terminal Intersection Comment: Created Mon Jul 11 07:40:30 CDT 2016 Intersection Version: v1

**Evaluation Title:** Evaluation 2 **Evaluation Comment:** Created Fri Sep 09 15:34:21 CDT 2016

Minimum Station: 0.000 Maximum Station: 1+410.410 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

# **SB** Terminal Evaluation

Intersection: Evaluation Start Location: 0.000 Evaluation End Location: 1+410.410 Calibration Factor: RT\_SG\_FI=1.0; RT\_SG\_PDO=1.0;

| Table 1. | Evaluation | Ramp | Terminal | - Site | (SB | Terminal) |
|----------|------------|------|----------|--------|-----|-----------|
|----------|------------|------|----------|--------|-----|-----------|

| Inter. No. | Ramp Terminal Type                               | Area Type | Legs | Location | Traffic Control | AADT  |
|------------|--|-----------|------|----------|-----------------|---|
| 1          | D4-Four-Leg Ramp Terminal with Diagonal<br>Ramps | Urban     | 4    | 496.330  | Signalized      | Inside: 2021: 36.000; 2022: 36.587; 2023: 37,175; 2024: 37,762; 2025: 38,350; 2026: 38,937; 2027: 39,525; 2028: 40,112; 2029: 40,700;<br>2030: 41,287; 2031: 41,875; 2032: 42,462; 2033: 43,050; 2034: 43,637; 2035: 44,282; 2010; Ouro Cutside: 2011: 34,600; 2022: 53,086; 45,987; 2039:<br>46,575; 2040: 47,162; 2041: 47,750; 2042: 44,337; 2043: 48,952; 2044: 49,151; 2045: 50,100; Outside: 2011: 34,600; 2022: 53,086;<br>2023: 36,016; 2024: 36,725; 2025: 37,433; 2026: 38,141; 2027: 38,850; 2028: 39,588; 2029: 40,266; 2030: 40,975; 2031: 41,683; 2032:<br>42,391; 2033: 43,100; 2034: 43,808; 2055: 44,516; 2036: 45,225; 2037: 45,933; 2038: 46,641; 2039: 47,350; 2040: 48,058; 2041:<br>48,766; 2042: 49,475; 2043: 50,183; 2044: 50,891; 2045: 51,600: : Entrance: 2021: 4,700; 2022: 4,787; 2023: 4,785; 2024: 4,962; 2025:<br>5,050; 2026: 5,137; 2027: 5,225; 2028: 5,312; 2029: 5,400; 2040: 546; 2040: 16,450; 2042: -6,537; 2044: 6,752; 2044: 6,712; 2045:<br>6,800; Exit: 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029:<br>11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,202; 2051: 12,470; 2037: 12,533; 2038:<br>12,704; 2039: 12,875; 2040: 11,3045; 2041: 13,216; 2042: 11,837; 2033: 11,203; 2055: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029:<br>11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,202; 2051; 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029:<br>11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,202; 2051; 12,101; 2036: 12,307; 12,533; 2038:<br>12,704; 2039; 12,875; 2040: 11,305; 2041: 13,216; 2042: 13,387; 2043: 13,387; 2043: 13,585; 2044: 13,792; 2045: 13,900 |

#### Table 2. Expected Ramp Terminal Crash Rates and Frequencies (SB Terminal)

| First Year of Analysis                   | 2021   |
|--|--------|
| Last Year of Analysis                    | 2045   |
| Evaluated Length (mi)                    | 0.0000 |
| Expected Crashes                         |        |
| Total Crashes                            | 619.00 |
| Fatal and Injury Crashes                 | 264.37 |
| Property-Damage-Only Crashes             | 354.64 |
| Percent of Total Expected Crashes        |        |
| Percent Fatal and Injury Crashes (%)     | 43     |
| Percent Property-Damage-Only Crashes (%) | 57     |

| Segment<br>Number/Intersection<br>Name/Cross Road | Location | Expected No. Crashes<br>for Evaluation Period | Expected No.<br>Crashes/Year<br>(crashes/million<br>veh) | Expected Crash<br>Rate (crashes/yr) |
|---|----------|---|--|-------------------------------------|
| SB Terminal                                       | 496.330  | 619.005                                       | 1.31   | 24.7602                             |

 Table 3. Expected Crash Frequencies and Rates by Ramp Terminal (SB Terminal)

#### Table 4. Expected Crash Severity by Ramp Terminal (SB Terminal)

| Seg.<br>No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury (O)<br>Crashes<br>(crashes/yr) |  |
|-------------|--------------------------------------|---|---|--|--|--|
| 1           | 0.3112                               | 7.7727  | 46.3339   | 209.9508                                       | 354.6368                                 |  |

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>nly  | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.00     | 0.0            | 0.00           | 0.0            | 0.00    | 0.0            |  |
| Highway<br>Segment | Collision with Fixed Object         | 8.72     | 1.4            | 17.73          | 2.9            | 26.46   | 4.3            |  |
| Highway<br>Segment | Collision with Other Object         | 0.26     | 0.0            | 0.71           | 0.1            | 0.97    | 0.2            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 4.76     | 0.8            | 2.48           | 0.4            | 7.24    | 1.2            |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.26     | 0.0            | 0.71           | 0.1            | 0.97    | 0.2            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 14.01    | 2.3            | 21.63          | 3.5            | 35.64   | 5.8            |  |
| Highway<br>Segment | Right-Angle Collision               | 68.74    | 11.1           | 78.02          | 12.6           | 146.76  | 23.7           |  |
| Highway<br>Segment | Head-on Collision                   | 2.91     | 0.5            | 2.48           | 0.4            | 5.39    | 0.9            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 2.38     | 0.4            | 7.09           | 1.1            | 9.47    | 1.5            |  |
| Highway<br>Segment | Rear-end Collision                  | 165.23   | 26.7           | 192.57         | 31.1           | 357.80  | 57.8           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 11.10    | 1.8            | 52.84          | 8.5            | 63.94   | 10.3           |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 250.36   | 40.4           | 333.00         | 53.8           | 583.36  | 94.2           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 264.37   | 42.7           | 354.64         | 57.3           | 619.00  | 100.0          |  |
|                    | Total Crashes                       | 264.37   | 42.7           | 354.64         | 57.3           | 619.00  | 100.0          |  |

 Table 5. Expected Segment Crash Type Distribution (SB Terminal)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

| Start Location | End Location | Message  |
|----------------|--------------|--|
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), outside crossroad traffic volume (47,350 vpd) for 2039 exceeds model limit (47,000 vpd) for reliable results for intersection type D4 |
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), inside crossroad traffic volume (47,162 vpd) for 2040 exceeds model limit (47,000 vpd) for reliable results for intersection type D4  |
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), inside crossroad traffic volume (47,750 vpd) for 2041 exceeds model limit (47,000 vpd) for reliable results for intersection type D4  |
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), inside crossroad traffic volume (48,337 vpd) for 2042 exceeds model limit (47,000 vpd) for reliable results for intersection type D4  |
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), inside crossroad traffic volume (48,925 vpd) for 2043 exceeds model limit (47,000 vpd) for reliable results for intersection type D4  |
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), inside crossroad traffic volume (49,512 vpd) for 2044 exceeds model limit (47,000 vpd) for reliable results for intersection type D4  |
| 496.330        | 496.330      | for intersection #1 (4+96.330 to 4+96.330 ), inside crossroad traffic volume (50,100 vpd) for 2045 exceeds model limit (47,000 vpd) for reliable results for intersection type D4  |

#### Table 6. Evaluation Message

# I-29 / 41<sup>st</sup> Street Interchange Single Point Urban Interchange (SPUI)

Interactive Highway Safety Design Model

# **Crash Prediction Evaluation Report**

NB Off Ramp

September 27, 2016

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## **Report Overview**

Report Generated: Sep 27, 2016 11:38 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 26 14:58:05 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St - SPUI Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: NB Off Ramp Highway Comment: Created Fri Jul 08 12:36:35 CDT 2016 Highway Version: 1

**Evaluation Title:** Evaluation 11 **Evaluation Comment:** Created Mon Sep 26 14:57:50 CDT 2016

Minimum Station: 0.000 Maximum Station: 808.520 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 808.520 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: EX\_RAMP\_MV\_FI=1.0; EX\_RAMP\_MV\_PDO=1.0; EX\_RAMP\_SV\_FI=1.0; EX\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |
|----------|------|-----------|----------------|--------------|-------------|------------|--|
| 1        | 1EX  | Urban     | 0.000          | 400.000      | 400.00      | 0.0758     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 2        | 1EX  | Urban     | 400.000        | 409.000      | 9.00        | 0.0017     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 3        | 1EX  | Urban     | 409.000        | 425.000      | 16.00       | 0.0030     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 4        | 1EX  | Urban     | 425.000        | 442.000      | 17.00       | 0.0032     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 5        | 1EX  | Urban     | 442.000        | 459.000      | 17.00       | 0.0032     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 6        | 1EX  | Urban     | 459.000        | 475.000      | 16.00       | 0.0030     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |
| 7        | 1EX  | Urban     | 475.000        | 492.000      | 17.00       | 0.0032     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |
| 8        | 1EX  | Urban     | 492.000        | 808.520      | 316.52      | 0.0600     | 2021: 5,000: 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870: 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |

| Table 1. | <b>Evaluation</b> | Freeway - | Homogeneous | Segments | (Freeway | Ramp | Sections) |
|----------|-------------------|-----------|-------------|----------|----------|------|-----------|
|          |                   |           |             |          |          |      |           |

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1531 |
| Average Future Road AADT (vpd)                                  | 5,950  |
| Expected Crashes  |        |
| Total Crashes   | 7.45   |
| Fatal and Injury Crashes  | 3.75   |
| Property-Damage-Only Crashes                                    | 3.70   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 50     |
| Percent Property-Damage-Only Crashes (%)                        | 50     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 1.9460 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.9795 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 0.9665 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 8.31   |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.90   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.45   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.45   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 400.000      | 0.0758         | 3.308  | 1.7464                            | 0.80   |
| 2   | 400.000        | 409.000      | 0.0017         | 0.071  | 1.6621                            | 0.77   |
| 3   | 409.000        | 425.000      | 0.0030         | 0.131  | 1.7258                            | 0.80   |
| 4   | 425.000        | 442.000      | 0.0032         | 0.146  | 1.8146                            | 0.84   |
| 5   | 442.000        | 459.000      | 0.0032         | 0.154  | 1.9121                            | 0.88   |
| 6   | 459.000        | 475.000      | 0.0030         | 0.152  | 2.0131                            | 0.93   |
| 7   | 475.000        | 492.000      | 0.0032         | 0.171  | 2.1208                            | 0.98   |
| 8   | 492.000        | 808.520      | 0.0599         | 3.317  | 2.2135                            | 1.02   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Simple Curve 1 | 0.000          | 180.000      | 0.0341         | 1.488  | 1.7464                            | 0.80   |
| Tangent        | 180.000        | 808.520      | 0.1190         | 5.961  | 2.0031                            | 0.92   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0480                               | 0.1454  | 0.6046  | 0.7378   | 1.7718                                   |
| 2        | 0.0010                               | 0.0032  | 0.0131  | 0.0160   | 0.0375                                   |
| 3        | 0.0020                               | 0.0059  | 0.0247  | 0.0302   | 0.0679                                   |
| 4        | 0.0022                               | 0.0068  | 0.0284  | 0.0346   | 0.0740                                   |
| 5        | 0.0024                               | 0.0074  | 0.0307  | 0.0374   | 0.0760                                   |
| 6        | 0.0025                               | 0.0075  | 0.0311  | 0.0380   | 0.0734                                   |
| 7        | 0.0028                               | 0.0086  | 0.0357  | 0.0436   | 0.0800                                   |
| 8        | 0.0561                               | 0.1703  | 0.7079  | 0.8638   | 1.5192                                   |
| Total    | 0.1171                               | 0.3550  | 1.4762  | 1.8013   | 3.6999                                   |

#### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    |  | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|--|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                             | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal                  | 0.01     | 0.2            | 0.07           | 1.0            | 0.09    | 1.2            |  |
| Highway<br>Segment | Collision with Fixed Object            | 2.61     | 35.0           | 2.42           | 32.5           | 5.03    | 67.5           |  |
| Highway<br>Segment | Collision with Other Object            | 0.18     | 2.5            | 0.47           | 6.3            | 0.65    | 8.8            |  |
| Highway<br>Segment | Other Single-vehicle Collision         | 0.75     | 10.1           | 0.36           | 4.9            | 1.11    | 14.9           |  |
| Highway<br>Segment | ay<br>nt Collision with Parked Vehicle |          | 0.7            | 0.05           | 0.7            | 0.11    | 1.5            |  |
| Highway<br>Segment | Total Single Vehicle Crashes           | 3.61     | 48.5           | 3.38           | 45.4           | 6.99    | 93.9           |  |
| Highway<br>Segment | Right-Angle Collision                  | 0.00     | 0.1            | 0.01           | 0.1            | 0.01    | 0.1            |  |
| Highway<br>Segment | Head-on Collision                      | 0.00     | 0.0            | 0.00           | 0.0            | 0.00    | 0.0            |  |
| Highway<br>Segment | Other Multi-vehicle Collision          | 0.00     | 0.1            | 0.01           | 0.1            | 0.01    | 0.2            |  |
| Highway<br>Segment | Rear-end Collision                     | 0.10     | 1.4            | 0.22           | 3.0            | 0.32    | 4.3            |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision    | 0.03     | 0.3            | 0.09           | 1.1            | 0.11    | 1.5            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes         | 0.14     | 1.8            | 0.32           | 4.3            | 0.46    | 6.1            |  |
| Highway<br>Segment | Total Highway Segment Crashes          | 3.75     | 50.3           | 3.70           | 49.7           | 7.45    | 100.0          |  |
|                    | Total Crashes                          | 3.75     | 50.3           | 3.70           | 49.7           | 7.45    | 100.0          |  |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

# **Crash Prediction Evaluation Report**

NB On Ramp

September 27, 2016

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## **Report Overview**

Report Generated: Sep 27, 2016 11:39 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 26 15:13:04 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St - SPUI Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: NB On Ramp Highway Comment: Created Fri Jul 08 14:06:37 CDT 2016 Highway Version: 1

**Evaluation Title:** Evaluation 5 **Evaluation Comment:** Created Mon Sep 26 15:12:56 CDT 2016

Minimum Station: 0.000 Maximum Station: 989.060 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

## **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 989.060 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: ENT\_RAMP\_MV\_FI=1.0; ENT\_RAMP\_MV\_PDO=1.0; ENT\_RAMP\_SV\_FI=1.0; ENT\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT  |
|----------|------|-----------|----------------|--------------|-------------|------------|---|
| 1        | 2EN  | Urban     | 0.000          | 800.000      | 800.00      | 0.1515     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700 |
| 2        | 1EN  | Urban     | 800.000        | 989.060      | 189.06      | 0.0358     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700 |

### Table 1. Evaluation Freeway - Homogeneous Segments (Freeway Ramp Sections)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1873 |
| Average Future Road AADT (vpd)                                  | 8,675  |
| Expected Crashes  |        |
| Total Crashes   | 14.49  |
| Fatal and Injury Crashes  | 5.47   |
| Property-Damage-Only Crashes                                    | 9.01   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 38     |
| Percent Property-Damage-Only Crashes (%)                        | 62     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 3.0936 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 1.1692 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 1.9244 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 14.83  |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.98   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.37   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.61   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

# Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 800.000      | 0.1515         | 12.148   | 3.2071                            | 1.01   |
| 2   | 800.000        | 989.060      | 0.0358         | 2.339  | 2.6131                            | 0.82   |
# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Tangent        | 0.000          | 591.260      | 0.1120         | 8.979  | 3.2071                            | 1.01   |
| Simple Curve 1 | 591.260        | 989.060      | 0.0753         | 5.509  | 2.9248                            | 0.92   |

 Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0894                               | 0.2712  | 1.4036  | 2.6460   | 7.7380                                   |
| 2        | 0.0227                               | 0.0689  | 0.4385  | 0.5350   | 1.2741                                   |
| Total    | 0.1121                               | 0.3401  | 1.8421  | 3.1810   | 9.0121                                   |

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.02     | 0.1            | 0.12           | 0.9            | 0.14    | 1.0            |  |
| Highway<br>Segment | Collision with Fixed Object         | 2.87     | 19.8           | 4.01           | 27.7           | 6.88    | 47.5           |  |
| Highway<br>Segment | Collision with Other Object         | 0.20     | 1.4            | 0.78           | 5.4            | 0.98    | 6.8            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.83     | 5.7            | 0.60           | 4.1            | 1.43    | 9.8            |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.06     | 0.4            | 0.09           | 0.6            | 0.15    | 1.0            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 3.98     | 27.4           | 5.60           | 38.7           | 9.58    | 66.1           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.05     | 0.3            | 0.06           | 0.4            | 0.11    | 0.7            |  |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.1            | 0.01           | 0.0            | 0.02    | 0.1            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.05     | 0.3            | 0.08           | 0.6            | 0.13    | 0.9            |  |
| Highway<br>Segment | Rear-end Collision                  | 1.12     | 7.8            | 2.35           | 16.2           | 3.48    | 24.0           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.27     | 1.9            | 0.91           | 6.3            | 1.18    | 8.1            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 1.50     | 10.4           | 3.41           | 23.5           | 4.91    | 33.9           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 5.47     | 37.8           | 9.01           | 62.2           | 14.49   | 100.0          |  |
|                    | Total Crashes                       | 5.47     | 37.8           | 9.01           | 62.2           | 14.49   | 100.0          |  |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## Crash Prediction Evaluation Report SB Off Ramp

September 27, 2016

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### **Report Overview**

Report Generated: Sep 27, 2016 11:39 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 12 09:41:32 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st StProject Comment: Created Wed Jul 06 08:57:12 CDT 2016Project Unit System: U.S. Customary

Highway Title: SB Off Ramp Highway Comment: Created Thu Jul 07 14:54:22 CDT 2016 Highway Version: 2

**Evaluation Title:** Evaluation 4 **Evaluation Comment:** Created Mon Sep 12 09:41:16 CDT 2016

Minimum Station: 0.000 Maximum Station: 1+142.460 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 **Evaluation Start Location: 0.000 Evaluation End Location:** 1+142.460 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: EX\_RAMP\_MV\_FI=1.0; EX\_RAMP\_MV\_PDO=1.0; EX\_RAMP\_SV\_FI=1.0; EX\_RAMP\_SV\_PDO=1.0;



Crash Prediction Summary, Section 1 (One Direction; Urban; Freeway Ramp) Project: I-29 and 41st St, Evaluation: Evaluation 4



| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |
|----------|------|-----------|----------------|--------------|-------------|------------|--|
| 1        | 2EX  | Urban     | 0.000          | 446.950      | 446.95      | 0.0847     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 2        | 2EX  | Urban     | 446.950        | 457.000      | 10.05       | 0.0019     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 3        | 2EX  | Urban     | 457.000        | 475.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 4        | 2EX  | Urban     | 475.000        | 494.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 5        | 2EX  | Urban     | 494.000        | 512.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 6        | 2EX  | Urban     | 512.000        | 531.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 7        | 2EX  | Urban     | 531.000        | 549.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 8        | 2EX  | Urban     | 549.000        | 568.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 9        | 2EX  | Urban     | 568.000        | 587.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 10       | 2EX  | Urban     | 587.000        | 733.000      | 146.00      | 0.0277     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 11       | 2EX  | Urban     | 733.000        | 1+006.000    | 273.00      | 0.0517     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 12       | 2EX  | Urban     | 1+006.000      | 1+142.460    | 136.46      | 0.0258     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |

| Table 1. | <b>Evaluation</b> | Freeway - | Homogeneous | Segments ( | (Freeway | Ramp | Sections) |
|----------|-------------------|-----------|-------------|------------|----------|------|-----------|
|          |                   |           |             |            | (        |      |           |

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.2164 |
| Average Future Road AADT (vpd)                                  | 11,850 |
| Expected Crashes  |        |
| Total Crashes   | 27.52  |
| Fatal and Injury Crashes  | 11.02  |
| Property-Damage-Only Crashes                                    | 16.49  |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 40     |
| Percent Property-Damage-Only Crashes (%)                        | 60     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 5.0865 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 2.0378 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 3.0487 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 23.40  |
| Travel Crash Rate (crashes/million veh-mi)                      | 1.18   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.47   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.70   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mil<br>lion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 446.950      | 0.0846         | 11.183   | 5.2843                            | 1.22   |
| 2   | 446.950        | 457.000      | 0.0019         | 0.151  | 3.1702                            | 0.73   |
| 3   | 457.000        | 475.000      | 0.0034         | 0.278  | 3.2590                            | 0.75   |
| 4   | 475.000        | 494.000      | 0.0036         | 0.304  | 3.3804                            | 0.78   |
| 5   | 494.000        | 512.000      | 0.0034         | 0.299  | 3.5070                            | 0.81   |
| 6   | 512.000        | 531.000      | 0.0036         | 0.327  | 3.6390                            | 0.84   |
| 7   | 531.000        | 549.000      | 0.0034         | 0.322  | 3.7766                            | 0.87   |
| 8   | 549.000        | 568.000      | 0.0036         | 0.353  | 3.9203                            | 0.91   |
| 9   | 568.000        | 587.000      | 0.0036         | 0.366  | 4.0743                            | 0.94   |
| 10  | 587.000        | 733.000      | 0.0277         | 3.963  | 5.7332                            | 1.33   |
| 11  | 733.000        | 1+006.000    | 0.0517         | 7.133  | 5.5184                            | 1.28   |
| 12  | 1+006.000      | 1+142.460    | 0.0258         | 2.836  | 4.3887                            | 1.01   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Simple Curve 1 | 0.000          | 242.760      | 0.0460         | 6.074  | 5.2843                            | 1.22   |
| Simple Curve 2 | 242.760        | 436.860      | 0.0368         | 4.856  | 5.2843                            | 1.22   |
| Tangent        | 436.860        | 630.150      | 0.0366         | 3.824  | 4.1782                            | 0.97   |
| Simple Curve 3 | 630.150        | 872.350      | 0.0459         | 6.433  | 5.6096                            | 1.30   |
| Tangent        | 872.350        | 1+142.460    | 0.0512         | 6.328  | 4.9477                            | 1.14   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.1130                               | 0.3427  | 1.1739  | 2.4804   | 7.0729                                   |
| 2        | 0.0017                               | 0.0051  | 0.0173  | 0.0327   | 0.0941                                   |
| 3        | 0.0032                               | 0.0096  | 0.0323  | 0.0609   | 0.1718                                   |
| 4        | 0.0035                               | 0.0106  | 0.0360  | 0.0679   | 0.1861                                   |
| 5        | 0.0035                               | 0.0106  | 0.0360  | 0.0678   | 0.1809                                   |
| 6        | 0.0039                               | 0.0119  | 0.0401  | 0.0756   | 0.1960                                   |
| 7        | 0.0039                               | 0.0119  | 0.0401  | 0.0755   | 0.1905                                   |
| 8        | 0.0044                               | 0.0132  | 0.0446  | 0.0841   | 0.2064                                   |
| 9        | 0.0046                               | 0.0140  | 0.0472  | 0.0889   | 0.2119                                   |
| 10       | 0.0495                               | 0.1500  | 0.5071  | 0.9559   | 2.3008                                   |
| 11       | 0.0909                               | 0.2756  | 0.9315  | 1.7560   | 4.0792                                   |
| 12       | 0.0367                               | 0.1114  | 0.3765  | 0.7098   | 1.6013                                   |
| Total    | 0.3187                               | 0.9665  | 3.2825  | 6.4555   | 16.4918                                  |

#### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | То      | tal            |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |
| Highway<br>Segment | Collision with Animal               | 0.04     | 0.1            | 0.30           | 1.1            | 0.35    | 1.3            |
| Highway<br>Segment | Collision with Fixed Object         | 7.41     | 26.9           | 9.92           | 36.1           | 17.33   | 63.0           |
| Highway<br>Segment | Collision with Other Object         | 0.52     | 1.9            | 1.93           | 7.0            | 2.45    | 8.9            |
| Highway<br>Segment | Other Single-vehicle Collision      | 2.13     | 7.8            | 1.48           | 5.4            | 3.62    | 13.1           |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.15     | 0.6            | 0.22           | 0.8            | 0.38    | 1.4            |
| Highway<br>Segment | Total Single Vehicle Crashes        | 10.27    | 37.3           | 13.86          | 50.4           | 24.12   | 87.7           |
| Highway<br>Segment | Right-Angle Collision               | 0.02     | 0.1            | 0.05           | 0.2            | 0.07    | 0.3            |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.0            | 0.01           | 0.0            | 0.01    | 0.0            |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.02     | 0.1            | 0.06           | 0.2            | 0.09    | 0.3            |
| Highway<br>Segment | Rear-end Collision                  | 0.57     | 2.1            | 1.82           | 6.6            | 2.38    | 8.7            |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.14     | 0.5            | 0.70           | 2.5            | 0.84    | 3.0            |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.76     | 2.8            | 2.63           | 9.6            | 3.39    | 12.3           |
| Highway<br>Segment | Total Highway Segment Crashes       | 11.02    | 40.1           | 16.49          | 59.9           | 27.52   | 100.0          |
|                    | Total Crashes                       | 11.02    | 40.1           | 16.49          | 59.9           | 27.52   | 100.0          |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

SB On Ramp

September 27, 2016

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| rigule Clash rieulcuon Summary (rieeway Kamp Sections)    |   |

### **Report Overview**

Report Generated: Sep 27, 2016 11:39 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 26 15:14:32 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St - SPUI Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: SB On Ramp Highway Comment: Created Fri Jul 08 09:10:58 CDT 2016 Highway Version: 1

**Evaluation Title:** Evaluation 4 **Evaluation Comment:** Created Mon Sep 26 15:14:27 CDT 2016

Minimum Station: 0.000 Maximum Station: 889.000 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 889.000 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: ENT\_RAMP\_MV\_FI=1.0; ENT\_RAMP\_MV\_PDO=1.0; ENT\_RAMP\_SV\_FI=1.0; ENT\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT  |
|----------|------|-----------|----------------|--------------|-------------|------------|---|
| 1        | 2EN  | Urban     | 0.000          | 650.000      | 650.00      | 0.1231     | 2021: 4,700; 2022: 4,787; 2023: 4,875; 2024: 4,962; 2025: 5,050; 2026: 5,137; 2027: 5,225; 2028: 5,312; 2029: 5,400; 2030: 5,487; 2031: 5,575; 2032: 5,662; 2033: 5,750; 2034: 5,837; 2035: 5,925; 2036: 6,012; 2037: 6,100; 2038: 6,187; 2039: 6,275; 2040: 6,362; 2041: 6,450; 2042: 6,537; 2043: 6,625; 2044: 6,712; 2045: 6,600 |
| 2        | 1EN  | Urban     | 650.000        | 889.000      | 239.00      | 0.0453     | 2021: 4,700; 2022: 4,787; 2023: 4,875; 2024: 4,962; 2025: 5,050; 2026: 5,137; 2027: 5,225; 2028: 5,312; 2029: 5,400; 2030: 5,487; 2031: 5,575; 2032: 5,662; 2033: 5,750; 2034: 5,837; 2035: 5,925; 2036: 6,012; 2037: 6,100; 2038: 6,187; 2039: 6,275; 2040: 6,362; 2041: 6,450; 2042: 6,537; 2043: 6,625; 2044: 6,712; 2045: 6,800 |

### Table 1. Evaluation Freeway - Homogeneous Segments (Freeway Ramp Sections)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1684 |
| Average Future Road AADT (vpd)                                  | 5,750  |
| Expected Crashes  |        |
| Total Crashes   | 9.21   |
| Fatal and Injury Crashes  | 3.62   |
| Property-Damage-Only Crashes                                    | 5.58   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 39     |
| Percent Property-Damage-Only Crashes (%)                        | 61     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 2.1868 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.8608 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 1.3260 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 8.83   |
| Travel Crash Rate (crashes/million veh-mi)                      | 1.04   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.41   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.63   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

# Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 650.000      | 0.1231         | 6.897  | 2.2411                            | 1.07   |
| 2   | 650.000        | 889.000      | 0.0453         | 2.308  | 2.0393                            | 0.97   |

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Tangent        | 0.000          | 545.950      | 0.1034         | 5.793  | 2.2411                            | 1.07   |
| Simple Curve 1 | 545.950        | 889.000      | 0.0650         | 3.412  | 2.1005                            | 1.00   |

#### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0521                               | 0.1579  | 0.8171  | 1.5403   | 4.3299                                   |
| 2        | 0.0225                               | 0.0683  | 0.4348  | 0.5306   | 1.2516                                   |
| Total    | 0.0746                               | 0.2262  | 1.2519  | 2.0709   | 5.5815                                   |

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.1            | 0.08           | 0.9            | 0.10    | 1.0            |  |
| Highway<br>Segment | Collision with Fixed Object         | 1.99     | 21.6           | 2.75           | 29.8           | 4.74    | 51.4           |  |
| Highway<br>Segment | Collision with Other Object         | 0.14     | 1.5            | 0.53           | 5.8            | 0.67    | 7.3            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.57     | 6.2            | 0.41           | 4.5            | 0.98    | 10.7           |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.04     | 0.4            | 0.06           | 0.7            | 0.10    | 1.1            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 2.76     | 30.0           | 3.83           | 41.6           | 6.59    | 71.6           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.03     | 0.3            | 0.03           | 0.3            | 0.06    | 0.6            |  |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.1            | 0.00           | 0.0            | 0.01    | 0.1            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.03     | 0.3            | 0.04           | 0.5            | 0.07    | 0.7            |  |
| Highway<br>Segment | Rear-end Collision                  | 0.65     | 7.1            | 1.21           | 13.1           | 1.86    | 20.2           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.16     | 1.7            | 0.47           | 5.1            | 0.62    | 6.7            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.87     | 9.4            | 1.75           | 19.0           | 2.61    | 28.4           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 3.62     | 39.4           | 5.58           | 60.6           | 9.21    | 100.0          |  |
|                    | Total Crashes                       | 3.62     | 39.4           | 5.58           | 60.6           | 9.21    | 100.0          |  |

| Table 6. | Expected S | Segment Cras | n Type | Distribution | (Freeway | Ramp | Sections) |
|----------|------------|--------------|--------|--------------|----------|------|-----------|
|----------|------------|--------------|--------|--------------|----------|------|-----------|

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

# I-29 / 41<sup>st</sup> Street Interchange Diverging Diamond Interchange (DDI)

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

NB Off Ramp

September 27, 2016

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### **Report Overview**

Report Generated: Sep 27, 2016 11:40 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 26 15:15:28 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St - DDI Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: NB Off Ramp Highway Comment: Created Fri Jul 08 12:36:35 CDT 2016 Highway Version: 1

**Evaluation Title:** Evaluation 11 **Evaluation Comment:** Created Mon Sep 26 15:15:23 CDT 2016

Minimum Station: 0.000 Maximum Station: 808.520 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 808.520 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: EX\_RAMP\_MV\_FI=1.0; EX\_RAMP\_MV\_PDO=1.0; EX\_RAMP\_SV\_FI=1.0; EX\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |
|----------|------|-----------|----------------|--------------|-------------|------------|--|
| 1        | 1EX  | Urban     | 0.000          | 550.000      | 550.00      | 0.1042     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900              |
| 2        | 1EX  | Urban     | 550.000        | 563.000      | 13.00       | 0.0025     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,5870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900   |
| 3        | 1EX  | Urban     | 563.000        | 588.000      | 25.00       | 0.0047     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900              |
| 4        | 1EX  | Urban     | 588.000        | 613.000      | 25.00       | 0.0047     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 5        | 1EX  | Urban     | 613.000        | 638.000      | 25.00       | 0.0047     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,587; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900 |
| 6        | 1EX  | Urban     | 638.000        | 663.000      | 25.00       | 0.0047     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |
| 7        | 1EX  | Urban     | 663.000        | 688.000      | 25.00       | 0.0047     | 2021: 5,000; 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870; 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |
| 8        | 1EX  | Urban     | 688.000        | 808.520      | 120.52      | 0.0228     | 2021: 5,000: 2022: 5,079; 2023: 5,158; 2024: 5,237; 2025: 5,316; 2026: 5,395; 2027: 5,475; 2028: 5,554; 2029: 5,633; 2030: 5,712; 2031: 5,791; 2032: 5,870: 2033: 5,950; 2034: 6,029; 2035: 6,108; 2036: 6,187; 2037: 6,266; 2038: 6,345; 2039: 6,425; 2040: 6,504; 2041: 6,583; 2042: 6,662; 2043: 6,741; 2044: 6,820; 2045: 6,900  |

| Table 1. | Evaluation | Freeway -  | Homogeneous | Segments  | (Freeway    | Ram   | Sections)        |
|----------|------------|------------|-------------|-----------|-------------|-------|------------------|
| Lable L. | L'aluation | Fict way - | nonogeneous | orginents | (I'I'ce may | mannp | <i>becubilis</i> |

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1531 |
| Average Future Road AADT (vpd)                                  | 5,950  |
| Expected Crashes  |        |
| Total Crashes   | 6.84   |
| Fatal and Injury Crashes  | 3.26   |
| Property-Damage-Only Crashes                                    | 3.58   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 48     |
| Percent Property-Damage-Only Crashes (%)                        | 52     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 1.7879 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.8517 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 0.9361 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 8.31   |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.82   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.39   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.43   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 550.000      | 0.1042         | 4.472  | 1.7173                            | 0.79   |
| 2   | 550.000        | 563.000      | 0.0025         | 0.102  | 1.6567                            | 0.76   |
| 3   | 563.000        | 588.000      | 0.0047         | 0.202  | 1.7067                            | 0.79   |
| 4   | 588.000        | 613.000      | 0.0047         | 0.210  | 1.7751                            | 0.82   |
| 5   | 613.000        | 638.000      | 0.0047         | 0.219  | 1.8465                            | 0.85   |
| 6   | 638.000        | 663.000      | 0.0047         | 0.227  | 1.9213                            | 0.89   |
| 7   | 663.000        | 688.000      | 0.0047         | 0.237  | 1.9994                            | 0.92   |
| 8   | 688.000        | 808.520      | 0.0228         | 1.175  | 2.0596                            | 0.95   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

## Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Simple Curve 1 | 0.000          | 180.000      | 0.0341         | 1.464  | 1.7173                            | 0.79   |
| Tangent        | 180.000        | 808.520      | 0.1190         | 5.381  | 1.8081                            | 0.83   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0650                               | 0.1970  | 0.8190  | 0.9994   | 2.3919                                   |
| 2        | 0.0015                               | 0.0045  | 0.0188  | 0.0230   | 0.0541                                   |
| 3        | 0.0030                               | 0.0091  | 0.0378  | 0.0461   | 0.1061                                   |
| 4        | 0.0032                               | 0.0096  | 0.0398  | 0.0486   | 0.1089                                   |
| 5        | 0.0033                               | 0.0101  | 0.0420  | 0.0513   | 0.1118                                   |
| 6        | 0.0035                               | 0.0107  | 0.0444  | 0.0541   | 0.1147                                   |
| 7        | 0.0037                               | 0.0113  | 0.0468  | 0.0571   | 0.1177                                   |
| 8        | 0.0186                               | 0.0565  | 0.2350  | 0.2867   | 0.5785                                   |
| Total    | 0.1018                               | 0.3087  | 1.2837  | 1.5663   | 3.5837                                   |

#### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    | Crash Type                          | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|
| Element Type       |                                     | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.2            | 0.07           | 1.1            | 0.09    | 1.2            |
| Highway<br>Segment | Collision with Fixed Object         | 2.27     | 33.1           | 2.34           | 34.3           | 4.61    | 67.4           |
| Highway<br>Segment | Collision with Other Object         | 0.16     | 2.3            | 0.46           | 6.7            | 0.61    | 9.0            |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.65     | 9.5            | 0.35           | 5.1            | 1.00    | 14.7           |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.05     | 0.7            | 0.05           | 0.8            | 0.10    | 1.5            |
| Highway<br>Segment | Total Single Vehicle Crashes        | 3.14     | 45.9           | 3.27           | 47.8           | 6.42    | 93.7           |
| Highway<br>Segment | Right-Angle Collision               | 0.00     | 0.1            | 0.01           | 0.1            | 0.01    | 0.1            |
| Highway<br>Segment | Head-on Collision                   | 0.00     | 0.0            | 0.00           | 0.0            | 0.00    | 0.0            |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.00     | 0.1            | 0.01           | 0.1            | 0.01    | 0.2            |
| Highway<br>Segment | Rear-end Collision                  | 0.09     | 1.3            | 0.21           | 3.1            | 0.30    | 4.4            |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.02     | 0.3            | 0.08           | 1.2            | 0.10    | 1.5            |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.12     | 1.7            | 0.31           | 4.5            | 0.43    | 6.3            |
| Highway<br>Segment | Total Highway Segment Crashes       | 3.26     | 47.6           | 3.58           | 52.4           | 6.84    | 100.0          |
|                    | Total Crashes                       | 3.26     | 47.6           | 3.58           | 52.4           | 6.84    | 100.0          |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

NB On Ramp

September 27, 2016
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### **Report Overview**

Report Generated: Sep 27, 2016 11:40 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 26 15:16:19 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St - DDI Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: NB On Ramp Highway Comment: Created Fri Jul 08 14:06:37 CDT 2016 Highway Version: 1

**Evaluation Title:** Evaluation 4 **Evaluation Comment:** Created Mon Sep 26 15:16:14 CDT 2016

Minimum Station: 0.000 Maximum Station: 989.060 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

## **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 989.060 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: ENT\_RAMP\_MV\_FI=1.0; ENT\_RAMP\_MV\_PDO=1.0; ENT\_RAMP\_SV\_FI=1.0; ENT\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT  |
|----------|------|-----------|----------------|--------------|-------------|------------|---|
| 1        | 2EN  | Urban     | 0.000          | 800.000      | 800.00      | 0.1515     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700 |
| 2        | 1EN  | Urban     | 800.000        | 989.060      | 189.06      | 0.0358     | 2021: 8,650; 2022: 8,652; 2023: 8,654; 2024: 8,656; 2025: 8,658; 2026: 8,660; 2027: 8,662; 2028: 8,664; 2029: 8,666; 2030: 8,668; 2031: 8,670; 2032: 8,672; 2033: 8,675; 2034: 8,677; 2035: 8,679; 2036: 8,681; 2037: 8,683; 2038: 8,685; 2039: 8,687; 2040: 8,689; 2041: 8,691; 2042: 8,693; 2043: 8,695; 2044: 8,697; 2045: 8,700 |

### Table 1. Evaluation Freeway - Homogeneous Segments (Freeway Ramp Sections)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1873 |
| Average Future Road AADT (vpd)                                  | 8,675  |
| Expected Crashes  |        |
| Total Crashes   | 13.79  |
| Fatal and Injury Crashes  | 4.77   |
| Property-Damage-Only Crashes                                    | 9.01   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 35     |
| Percent Property-Damage-Only Crashes (%)                        | 65     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 2.9435 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 1.0191 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 1.9244 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 14.83  |
| Travel Crash Rate (crashes/million veh-mi)                      | 0.93   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.32   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.61   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

# Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 800.000      | 0.1515         | 11.582   | 3.0577                            | 0.97   |
| 2   | 800.000        | 989.060      | 0.0358         | 2.202  | 2.4603                            | 0.78   |

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Tangent        | 0.000          | 591.260      | 0.1120         | 8.560  | 3.0577                            | 0.97   |
| Simple Curve 1 | 591.260        | 989.060      | 0.0753         | 5.224  | 2.7738                            | 0.88   |

#### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0780                               | 0.2364  | 1.2234  | 2.3063   | 7.7380                                   |
| 2        | 0.0198                               | 0.0600  | 0.3822  | 0.4663   | 1.2741                                   |
| Total    | 0.0977                               | 0.2964  | 1.6056  | 2.7727   | 9.0121                                   |

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.1            | 0.12           | 0.9            | 0.14    | 1.0            |  |
| Highway<br>Segment | Collision with Fixed Object         | 2.50     | 18.1           | 4.01           | 29.1           | 6.51    | 47.3           |  |
| Highway<br>Segment | Collision with Other Object         | 0.18     | 1.3            | 0.78           | 5.7            | 0.96    | 6.9            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.72     | 5.2            | 0.60           | 4.3            | 1.32    | 9.6            |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.05     | 0.4            | 0.09           | 0.7            | 0.14    | 1.0            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 3.46     | 25.1           | 5.60           | 40.6           | 9.07    | 65.8           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.04     | 0.3            | 0.06           | 0.4            | 0.10    | 0.7            |  |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.1            | 0.01           | 0.0            | 0.02    | 0.1            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.04     | 0.3            | 0.08           | 0.6            | 0.12    | 0.9            |  |
| Highway<br>Segment | Rear-end Collision                  | 0.98     | 7.1            | 2.35           | 17.1           | 3.33    | 24.2           |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.23     | 1.7            | 0.91           | 6.6            | 1.14    | 8.3            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 1.31     | 9.5            | 3.41           | 24.7           | 4.72    | 34.2           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 4.77     | 34.6           | 9.01           | 65.4           | 13.79   | 100.0          |  |
|                    | Total Crashes                       | 4.77     | 34.6           | 9.01           | 65.4           | 13.79   | 100.0          |  |

| Table 6. | Expected S | Segment Cras | n Type | Distribution | (Freeway | Ramp | Sections) |
|----------|------------|--------------|--------|--------------|----------|------|-----------|
|----------|------------|--------------|--------|--------------|----------|------|-----------|

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

SB Off Ramp

September 27, 2016

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### **Report Overview**

Report Generated: Sep 27, 2016 11:41 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 12 09:41:32 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st StProject Comment: Created Wed Jul 06 08:57:12 CDT 2016Project Unit System: U.S. Customary

Highway Title: SB Off Ramp Highway Comment: Created Thu Jul 07 14:54:22 CDT 2016 Highway Version: 2

**Evaluation Title:** Evaluation 4 **Evaluation Comment:** Created Mon Sep 12 09:41:16 CDT 2016

Minimum Station: 0.000 Maximum Station: 1+142.460 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

### **Freeway Ramp Evaluation**

Section: Section 1 **Evaluation Start Location: 0.000 Evaluation End Location:** 1+142.460 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: EX\_RAMP\_MV\_FI=1.0; EX\_RAMP\_MV\_PDO=1.0; EX\_RAMP\_SV\_FI=1.0; EX\_RAMP\_SV\_PDO=1.0;



Crash Prediction Summary, Section 1 (One Direction; Urban; Freeway Ramp) Project: I-29 and 41st St, Evaluation: Evaluation 4



| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT   |
|----------|------|-----------|----------------|--------------|-------------|------------|--|
| 1        | 2EX  | Urban     | 0.000          | 446.950      | 446.95      | 0.0847     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 2        | 2EX  | Urban     | 446.950        | 457.000      | 10.05       | 0.0019     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 3        | 2EX  | Urban     | 457.000        | 475.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 4        | 2EX  | Urban     | 475.000        | 494.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 5        | 2EX  | Urban     | 494.000        | 512.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 6        | 2EX  | Urban     | 512.000        | 531.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 7        | 2EX  | Urban     | 531.000        | 549.000      | 18.00       | 0.0034     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 8        | 2EX  | Urban     | 549.000        | 568.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 9        | 2EX  | Urban     | 568.000        | 587.000      | 19.00       | 0.0036     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 10       | 2EX  | Urban     | 587.000        | 733.000      | 146.00      | 0.0277     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 11       | 2EX  | Urban     | 733.000        | 1+006.000    | 273.00      | 0.0517     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |
| 12       | 2EX  | Urban     | 1+006.000      | 1+142.460    | 136.46      | 0.0258     | 2021: 9,800; 2022: 9,970; 2023: 10,141; 2024: 10,312; 2025: 10,483; 2026: 10,654; 2027: 10,825; 2028: 10,995; 2029: 11,166; 2030: 11,337; 2031: 11,508; 2032: 11,679; 2033: 11,850; 2034: 12,020; 2035: 12,191; 2036: 12,362; 2037: 12,533; 2038: 12,704; 2039: 12,875; 2040: 13,045; 2041: 13,216; 2042: 13,387; 2043: 13,558; 2044: 13,729; 2045: 13,900 |

| Table 1. | Evaluation | Freeway - | Homogeneous | Segments ( | (Freeway | Ramp | Sections) |
|----------|------------|-----------|-------------|------------|----------|------|-----------|
|          |            |           |             |            | (        |      |           |

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.2164 |
| Average Future Road AADT (vpd)                                  | 11,850 |
| Expected Crashes  |        |
| Total Crashes   | 27.52  |
| Fatal and Injury Crashes  | 11.02  |
| Property-Damage-Only Crashes                                    | 16.49  |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 40     |
| Percent Property-Damage-Only Crashes (%)                        | 60     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 5.0865 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 2.0378 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 3.0487 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 23.40  |
| Travel Crash Rate (crashes/million veh-mi)                      | 1.18   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.47   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.70   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mil<br>lion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 446.950      | 0.0846         | 11.183   | 5.2843                            | 1.22   |
| 2   | 446.950        | 457.000      | 0.0019         | 0.151  | 3.1702                            | 0.73   |
| 3   | 457.000        | 475.000      | 0.0034         | 0.278  | 3.2590                            | 0.75   |
| 4   | 475.000        | 494.000      | 0.0036         | 0.304  | 3.3804                            | 0.78   |
| 5   | 494.000        | 512.000      | 0.0034         | 0.299  | 3.5070                            | 0.81   |
| 6   | 512.000        | 531.000      | 0.0036         | 0.327  | 3.6390                            | 0.84   |
| 7   | 531.000        | 549.000      | 0.0034         | 0.322  | 3.7766                            | 0.87   |
| 8   | 549.000        | 568.000      | 0.0036         | 0.353  | 3.9203                            | 0.91   |
| 9   | 568.000        | 587.000      | 0.0036         | 0.366  | 4.0743                            | 0.94   |
| 10  | 587.000        | 733.000      | 0.0277         | 3.963  | 5.7332                            | 1.33   |
| 11  | 733.000        | 1+006.000    | 0.0517         | 7.133  | 5.5184                            | 1.28   |
| 12  | 1+006.000      | 1+142.460    | 0.0258         | 2.836  | 4.3887                            | 1.01   |

 Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Simple Curve 1 | 0.000          | 242.760      | 0.0460         | 6.074  | 5.2843                            | 1.22   |
| Simple Curve 2 | 242.760        | 436.860      | 0.0368         | 4.856  | 5.2843                            | 1.22   |
| Tangent        | 436.860        | 630.150      | 0.0366         | 3.824  | 4.1782                            | 0.97   |
| Simple Curve 3 | 630.150        | 872.350      | 0.0459         | 6.433  | 5.6096                            | 1.30   |
| Tangent        | 872.350        | 1+142.460    | 0.0512         | 6.328  | 4.9477                            | 1.14   |

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.1130                               | 0.3427  | 1.1739  | 2.4804   | 7.0729                                   |
| 2        | 0.0017                               | 0.0051  | 0.0173  | 0.0327   | 0.0941                                   |
| 3        | 0.0032                               | 0.0096  | 0.0323  | 0.0609   | 0.1718                                   |
| 4        | 0.0035                               | 0.0106  | 0.0360  | 0.0679   | 0.1861                                   |
| 5        | 0.0035                               | 0.0106  | 0.0360  | 0.0678   | 0.1809                                   |
| 6        | 0.0039                               | 0.0119  | 0.0401  | 0.0756   | 0.1960                                   |
| 7        | 0.0039                               | 0.0119  | 0.0401  | 0.0755   | 0.1905                                   |
| 8        | 0.0044                               | 0.0132  | 0.0446  | 0.0841   | 0.2064                                   |
| 9        | 0.0046                               | 0.0140  | 0.0472  | 0.0889   | 0.2119                                   |
| 10       | 0.0495                               | 0.1500  | 0.5071  | 0.9559   | 2.3008                                   |
| 11       | 0.0909                               | 0.2756  | 0.9315  | 1.7560   | 4.0792                                   |
| 12       | 0.0367                               | 0.1114  | 0.3765  | 0.7098   | 1.6013                                   |
| Total    | 0.3187                               | 0.9665  | 3.2825  | 6.4555   | 16.4918                                  |

#### Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

|                    |                                     | Fatal and Injury |                |         | Damage<br>ly   | Total   |                |  |
|--------------------|-------------------------------------|------------------|----------------|---------|----------------|---------|----------------|--|
| Element Type       | Crash Type                          | Crashes          | Crashes<br>(%) | Crashes | Crashes<br>(%) | Crashes | Crashes<br>(%) |  |
| Highway<br>Segment | Collision with Animal               | 0.04             | 0.1            | 0.30    | 1.1            | 0.35    | 1.3            |  |
| Highway<br>Segment | Collision with Fixed Object         | 7.41             | 26.9           | 9.92    | 36.1           | 17.33   | 63.0           |  |
| Highway<br>Segment | Collision with Other Object         | 0.52             | 1.9            | 1.93    | 7.0            | 2.45    | 8.9            |  |
| Highway<br>Segment | Other Single-vehicle Collision      | 2.13             | 7.8            | 1.48    | 5.4            | 3.62    | 13.1           |  |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.15             | 0.6            | 0.22    | 0.8            | 0.38    | 1.4            |  |
| Highway<br>Segment | Total Single Vehicle Crashes        | 10.27            | 37.3           | 13.86   | 50.4           | 24.12   | 87.7           |  |
| Highway<br>Segment | Right-Angle Collision               | 0.02             | 0.1            | 0.05    | 0.2            | 0.07    | 0.3            |  |
| Highway<br>Segment | Head-on Collision                   | 0.01             | 0.0            | 0.01    | 0.0            | 0.01    | 0.0            |  |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.02             | 0.1            | 0.06    | 0.2            | 0.09    | 0.3            |  |
| Highway<br>Segment | Rear-end Collision                  | 0.57             | 2.1            | 1.82    | 6.6            | 2.38    | 8.7            |  |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.14             | 0.5            | 0.70    | 2.5            | 0.84    | 3.0            |  |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.76             | 2.8            | 2.63    | 9.6            | 3.39    | 12.3           |  |
| Highway<br>Segment | Total Highway Segment Crashes       | 11.02            | 40.1           | 16.49   | 59.9           | 27.52   | 100.0          |  |
|                    | Total Crashes                       | 11.02            | 40.1           | 16.49   | 59.9           | 27.52   | 100.0          |  |

 Table 6. Expected Segment Crash Type Distribution (Freeway Ramp Sections)

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

## **Crash Prediction Evaluation Report**

SB On Ramp

September 27, 2016

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### **Report Overview**

Report Generated: Sep 27, 2016 11:41 AM Report Template: System: Multi-Page [System] (mlcpm2, Oct 22, 2015 8:30 AM)

**Evaluation Date:** Mon Sep 26 15:19:52 CDT 2016 **IHSDM Version:** v11.1.0 (Mar 11, 2016) **Crash Prediction Module:** v6.1.0 (Mar 10, 2016)

User Name: gmenard Organization Name: Phone: E-Mail:

Project Title: I-29 and 41st St - DDI Project Comment: Created Wed Jul 06 08:57:12 CDT 2016 Project Unit System: U.S. Customary

Highway Title: SB On Ramp Highway Comment: Created Fri Jul 08 09:10:58 CDT 2016 Highway Version: 1

**Evaluation Title:** Evaluation 4 **Evaluation Comment:** Created Mon Sep 26 15:19:46 CDT 2016

Minimum Station: 0.000 Maximum Station: 889.000 Policy for Superelevation: AASHTO 2011 U.S. Customary Calibration: HSM Configuration Crash Distribution: HSM Configuration Model/CMF: HSM Configuration Empirical-Bayes Analysis: None First Year of Analysis: 2021 Last Year of Analysis: 2045

## **Freeway Ramp Evaluation**

Section: Section 1 Evaluation Start Location: 0.000 Evaluation End Location: 889.000 Functional Class: Freeway Ramp Type of Alignment: One Direction Model Category: Freeway Ramp Calibration Factor: ENT\_RAMP\_MV\_FI=1.0; ENT\_RAMP\_MV\_PDO=1.0; ENT\_RAMP\_SV\_FI=1.0; ENT\_RAMP\_SV\_PDO=1.0;





| Seg. No. | Туре | Area Type | Start Location | End Location | Length (ft) | Length(mi) | AADT  |
|----------|------|-----------|----------------|--------------|-------------|------------|---|
| 1        | 2EN  | Urban     | 0.000          | 700.000      | 700.00      | 0.1326     | 2021: 4,700; 2022: 4,787; 2023: 4,875; 2024: 4,962; 2025: 5,050; 2026: 5,137; 2027: 5,225; 2028: 5,312; 2029: 5,400; 2030: 5,487; 2031: 5,575; 2032: 5,662; 2033: 5,750; 2034: 5,837; 2035: 5,925; 2036: 6,012; 2037: 6,100; 2038: 6,187; 2039: 6,275; 2040: 6,362; 2041: 6,450; 2042: 6,537; 2043: 6,625; 2044: 6,712; 2045: 6,800 |
| 2        | 1EN  | Urban     | 700.000        | 889.000      | 189.00      | 0.0358     | 2021: 4,700; 2022: 4,787; 2023: 4,875; 2024: 4,962; 2025: 5,050; 2026: 5,137; 2027: 5,225; 2028: 5,312; 2029: 5,400; 2030: 5,487; 2031: 5,575; 2032: 5,662; 2033: 5,750; 2034: 5,837; 2035: 5,925; 2036: 6,012; 2037: 6,100; 2038: 6,187; 2039: 6,275; 2040: 6,362; 2041: 6,450; 2042: 6,537; 2043: 6,625; 2044: 6,712; 2045: 6,800 |

### Table 1. Evaluation Freeway - Homogeneous Segments (Freeway Ramp Sections)

| First Year of Analysis  | 2021   |
|---|--------|
| Last Year of Analysis   | 2045   |
| Evaluated Length (mi)   | 0.1684 |
| Average Future Road AADT (vpd)                                  | 5,750  |
| Expected Crashes  |        |
| Total Crashes   | 9.37   |
| Fatal and Injury Crashes  | 3.64   |
| Property-Damage-Only Crashes                                    | 5.73   |
| Percent of Total Expected Crashes                               |        |
| Percent Fatal and Injury Crashes (%)                            | 39     |
| Percent Property-Damage-Only Crashes (%)                        | 61     |
| Expected Crash Rate   |        |
| Crash Rate (crashes/mi/yr)                                      | 2.2254 |
| Fatal and Injury Crash Rate (crashes/mi/yr)                     | 0.8647 |
| Property-Damage-Only Crash Rate (crashes/mi/yr)                 | 1.3608 |
| Expected Travel Crash Rate                                      |        |
| Total Travel (million veh-mi)                                   | 8.83   |
| Travel Crash Rate (crashes/million veh-mi)                      | 1.06   |
| Travel Fatal and Injury Crash Rate (crashes/million veh-mi)     | 0.41   |
| Travel Property-Damage-Only Crash Rate (crashes/million veh-mi) | 0.65   |

#### Table 2. Expected Ramp Crash Rates and Frequencies (Freeway Ramp Sections)

# Table 3. Expected Crash Frequencies and Rates by Ramp Segment (Freeway Ramp Sections)

| Segment<br>Number/Intersection<br>Name/Cross Road | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|---|----------------|--------------|----------------|--|-----------------------------------|--|
| 1   | 0.000          | 700.000      | 0.1326         | 7.543  | 2.2757                            | 1.08   |
| 2   | 700.000        | 889.000      | 0.0358         | 1.825  | 2.0393                            | 0.97   |

# Table 4. Expected Crash Frequencies and Rates by Horizontal Design Element (Freeway Ramp Sections)

| Title          | Start Location | End Location | Length<br>(mi) | Expected No.<br>Crashes for<br>Evaluation Period | Crash Rate<br>(crashes/mi/<br>yr) | Travel<br>Crash Rate<br>(crashes/mill<br>ion veh-mi) |
|----------------|----------------|--------------|----------------|--|-----------------------------------|--|
| Tangent        | 0.000          | 545.950      | 0.1034         | 5.883  | 2.2757                            | 1.08   |
| Simple Curve 1 | 545.950        | 889.000      | 0.0650         | 3.485  | 2.1455                            | 1.02   |

 Table 5. Expected Crash Severity by Ramp Segment (Freeway Ramp Sections)

| Seg. No. | Fatal (K)<br>Crashes<br>(crashes/yr) | Incapacitating Injury (A)<br>Crashes (crashes/yr) | Non-Incapacitating Injury<br>(B) Crashes (crashes/yr) | Possible Injury<br>(C) Crashes<br>(crashes/yr) | No Injury<br>(O) Crashes<br>(crashes/yr) |
|----------|--------------------------------------|---|---|--|--|
| 1        | 0.0569                               | 0.1724  | 0.8925  | 1.6826   | 4.7381                                   |
| 2        | 0.0178                               | 0.0540  | 0.3438  | 0.4196   | 0.9897                                   |
| Total    | 0.0747                               | 0.2265  | 1.2364  | 2.1021   | 5.7278                                   |

|                    |                                     | Fatal an | d Injury       | Property<br>O1 | Damage<br>ly   | Total   |                |
|--------------------|-------------------------------------|----------|----------------|----------------|----------------|---------|----------------|
| Element Type       | Crash Type                          | Crashes  | Crashes<br>(%) | Crashes        | Crashes<br>(%) | Crashes | Crashes<br>(%) |
| Highway<br>Segment | Collision with Animal               | 0.01     | 0.1            | 0.09           | 0.9            | 0.10    | 1.0            |
| Highway<br>Segment | Collision with Fixed Object         | 1.99     | 21.2           | 2.80           | 29.9           | 4.79    | 51.1           |
| Highway<br>Segment | Collision with Other Object         | 0.14     | 1.5            | 0.54           | 5.8            | 0.68    | 7.3            |
| Highway<br>Segment | Other Single-vehicle Collision      | 0.57     | 6.1            | 0.42           | 4.5            | 0.99    | 10.6           |
| Highway<br>Segment | Collision with Parked Vehicle       | 0.04     | 0.4            | 0.06           | 0.7            | 0.10    | 1.1            |
| Highway<br>Segment | Total Single Vehicle Crashes        | 2.75     | 29.4           | 3.91           | 41.7           | 6.66    | 71.1           |
| Highway<br>Segment | Right-Angle Collision               | 0.03     | 0.3            | 0.03           | 0.3            | 0.06    | 0.6            |
| Highway<br>Segment | Head-on Collision                   | 0.01     | 0.1            | 0.00           | 0.0            | 0.01    | 0.1            |
| Highway<br>Segment | Other Multi-vehicle Collision       | 0.03     | 0.3            | 0.04           | 0.5            | 0.07    | 0.8            |
| Highway<br>Segment | Rear-end Collision                  | 0.67     | 7.1            | 1.25           | 13.4           | 1.92    | 20.5           |
| Highway<br>Segment | Sideswipe, Same Direction Collision | 0.16     | 1.7            | 0.48           | 5.2            | 0.64    | 6.9            |
| Highway<br>Segment | Total Multiple Vehicle Crashes      | 0.89     | 9.5            | 1.82           | 19.4           | 2.71    | 28.9           |
| Highway<br>Segment | Total Highway Segment Crashes       | 3.64     | 38.9           | 5.73           | 61.1           | 9.37    | 100.0          |
|                    | Total Crashes                       | 3.64     | 38.9           | 5.73           | 61.1           | 9.37    | 100.0          |

| Table 6. | Expected S | Segment Cras | n Type | Distribution | (Freeway | Ramp | Sections) |
|----------|------------|--------------|--------|--------------|----------|------|-----------|
|----------|------------|--------------|--------|--------------|----------|------|-----------|

**Note:***Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.