Alabama Department of Transportation

# West South Boulevard Redesign Safety Assessment

## SAFETY DATA CASE STUDY

FHWA-SA-21-075

Federal Highway Administration Office of Safety

Roadway Safety Data Program

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U.S. Department of Transportation
Federal Highway Administration

ALDOT
Alabama Department of Transportation

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# Acronyms

| Acronym | Description |
|---|---|
| **AADT** | annual average daily traffic |
| **AASHTO** | American Association of State Highway and Transportation Officials |
| **ALDOT** | Alabama Department of Transportation |
| **ATAP** | Alabama Transportation Assistance Program |
| **CPM** | Crash Prediction Module |
| **FHWA** | Federal Highway Administration |
| **FI** | fatal and injury |
| **GDL** | Geometric Design Laboratory |
| **HSM** | Highway Safety Manual |
| **IHSDM** | Interactive Highway Safety Design Model |
| **mph** | miles per hour |
| **NCHRP** | National Cooperative Highway Research Program |
| **PDO** | property damage only |
| **TWLTL** | two-way left-turn lane |
| **vpd** | vehicles per day |

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# Executive Summary

This case study summarizes a safety analysis conducted by the Federal Highway Administration (FHWA) Geometric Design Lab (GDL), in collaboration with the Alabama Department of Transportation (ALDOT) and the FHWA Alabama Division. GDL used the Interactive Highway Safety Design Model (IHSDM) software to assess the safety performance of W South Boulevard, a high-volume, high-speed suburban arterial in Montgomery, Alabama. This analysis supported a proposed access management design that included pedestrian improvements. The existing corridor lacked pedestrian accommodations but exhibited notable pedestrian activity and informal worn paths. The corridor also experienced a higher-than-expected number of crashes in recent years, particularly pedestrian crashes. GDL used the IHSDM's Crash Prediction Model to predict annual crashes and compare the existing condition of W South Boulevard with the proposed redesign that included pedestrian safety improvements. The results of the data-driven analysis informed ALDOT's decision-making on the project and increased confidence in the pedestrian safety elements selected for the final design. W South Boulevard represents a facility type that is common throughout the United States, especially where suburban and rural areas interface and mixed land uses are adjacent to major freeway corridors. This example showcases one way that data-driven safety analysis and crash prediction available through IHSDM can enable agencies to make informed investments in road user safety.

# Introduction

The Transportation Research Board's Safety Performance and Analysis (ACS20) User Liaison Subcommittee has an on-going initiative focused on practical application of the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) (i.e., "using the HSM in the real world"). The Federal Highway Administration (FHWA) also administers the HSM Implementation Pooled Fund, which includes 22 States focused on projects to help further HSM implementation. Development of HSM case studies will assist practitioners in performing data-driven safety analysis using the advanced methods described in the HSM. The primary purpose of the HSM case studies is to highlight noteworthy applications of HSM methods, focus on common challenges, and feature agencies that overcame those challenges. These case studies serve as a source of lessons learned and noteworthy practices to help guide practitioners applying the HSM.

## Background

This case study presents a collaboration between the FHWA Geometric Design Lab (GDL), FHWA Alabama Division, and the Alabama Department of Transportation (ALDOT). ALDOT identified W South Boulevard in Montgomery, Alabama as an opportunity to demonstrate how a suburban arterial could be retrofitted to accommodate pedestrians and vulnerable users more safely. In support, GDL used the Interactive Highway Safety Design Model (IHSDM) software as part of the redesign process. Figure 1 shows the location and extent of the project.



Note: The white location pins and dashed line were added by the authors to delineate the project bounds.

Figure 1. Graphic. W South Boulevard project location.

Prior to the completed redesign in 2020, W South Boulevard between I-65 and Davenport Drive represented a common high-speed, high-volume arterial seen throughout the United States. W South Boulevard existed as an undivided suburban facility with three through lanes in each direction and a two-way left-turn lane (TWLTL), as shown in figure 2. It carried an annual average daily traffic (AADT) of 34,150 vehicles per day (vpd), with a posted speed limit of 50 miles per hour (mph). The section that was the focus of this analysis is just over a half a mile in length, with a signalized diamond interchange on the west end at the intersection of W South Boulevard and I-65 and a four-leg signalized intersection on the east end at the intersection of W South Boulevard and Davenport Drive. On both ends of the corridor, the cross-section transitions from three through lanes in each direction to two.

The corridor is primarily commercial, and contains several gas stations, hotels, fast food restaurants, and other businesses. There are numerous driveways providing access between these businesses and W South Boulevard. There is a truck stop on the north side of W South Boulevard (as well as a Greyhound bus station that closed in 2019), and all of the restaurants are located on the south side of the road. This leads to many cases of pedestrians crossing the high-speed, high-volume seven-lane road at mid-block, uncontrolled locations.


Figure 2. Photo. Aerial photo of the prior condition of W South Boulevard between I-65 and Davenport Drive.

## Purpose and Need

The study area on W South Boulevard experienced a higher-than-expected number of crashes, particularly pedestrian crashes, over several years prior to a 2017 analysis. This prompted ALDOT to propose a redesign that included pedestrian accommodations. The existing segment did not include any notable pedestrian facilities, such as sidewalks or pedestrian countdown timers. In the absence of sidewalks, the pedestrian traffic had produced well-worn footpaths along both sides of W South Boulevard. Figure 3 shows the existing corridor, including the footpaths next to the roadway.


Figure 3. Photo. Well-worn footpaths along the side of W South Boulevard.

ALDOT reviewed the corridor's crash history to diagnose the issues and identify potential treatments to address them. The proposed access management and pedestrian designs integrated several improvements along the length of the corridor including:

- Implementing a road diet on the westbound direction of W South Boulevard, reducing it to two through lanes.
- Installing sidewalks along both sides of W South Boulevard.
- Installing a raised median with occasional left-turn pockets along the length of the segment.

- Installing two high-visibility pedestrian crosswalks (one at a newly signalized intersection and one mid-block with a pedestrian-actuated traffic signal).
- Improving lighting along the corridor, specifically at the marked pedestrian crosswalks.
- Consolidating some driveway access points.

The FHWA GDL conducted an analysis and used the Crash Prediction Module (CPM) within IHSDM to assess the predicted safety performance of both the existing condition and proposed redesign. ALDOT then reviewed the safety performance of the two conditions and selected the proposed improvements.

### Project Description

- **Sponsoring agency:** ALDOT.
- **Project location:** Montgomery, AL.
- **Project bounds and length of project:** W South Boulevard from I-65 to Davenport Drive (approximately 0.5 miles).
- **Facility type(s):** 7-lane, undivided major arterial.
- **Area type:** Suburban.
- **Project status (as of October 2021):** Analysis completed, and redesign constructed, incorporating the proposed design improvements.

## Safety Performance Analysis

This section provides an overview of the analysis methods, results, and the outcomes of the analysis.

### Analysis Overview

The GDL used the IHSDM CPM to apply HSM Part C predictive methods to estimate the expected number of crashes for the W South Boulevard study corridor, including the interchange with I-65 on the west end and the intersection with Davenport Drive on the east end. The project team estimated expected crash counts for both the existing and proposed scenarios, to provide for a comparison. Comparing the design results to the existing results instead of the observed crash data was necessary because the models used in the CPM are not calibrated for use in Alabama. This is discussed in more detail in the *Challenges* section.

HSM Part C (and subsequently IHSDM) models the different project components separately, meaning that the analysis involved the following elements:

- Highways:
  - W South Boulevard.
  - I-65.
  - Davenport Drive.

- Interchange components:
    - I-65 northbound entrance ramp.
    - I-65 northbound exit ramp.
    - Ramp terminal (I-65 ramps and W South Boulevard).
- Intersections:
    - W South Boulevard and Davenport Drive.

The treatments addressed in the analysis included:

- Changing the number of through lanes from six to five.
- Addition of a raised median.
- Addition of a continuous, paved inside shoulder.
- Addition of lighting.

The analysts used the location-based method to enter data into IHSDM, allowing the segment to be viewed using the IHSDM Highway Viewer as shown in figure 4. The analysts estimated the horizontal alignment using aerial and streetview imagery to show an accurate representation of the geometry.

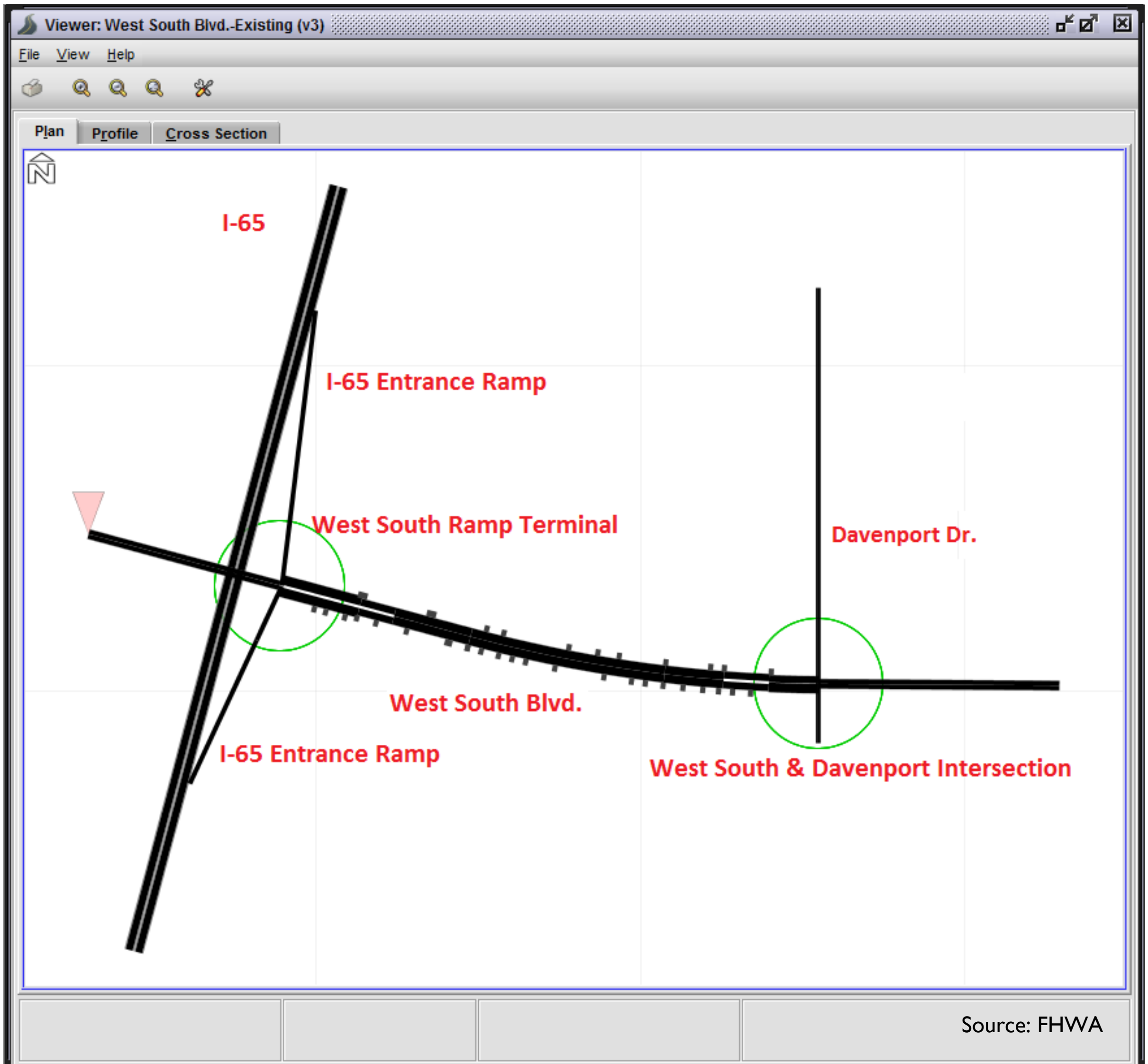


Figure 4. Graphic. W South Boulevard as seen in the IHSDM Highway Viewer.

Table 1 summarizes the model inputs for the W South Boulevard segment in both the existing and proposed scenarios. In the existing scenario, analysts estimated lane widths to be 12-ft for through lanes and 14-ft for the TWLTL using aerial imagery. The analysis included the TWLTL for the entire length of the corridor, except for short segments on both the west and east end where the median was either crosshatched or existed as a raised concrete median. A 2-ft paved outside shoulder was used along the entire length of the segment. A cumulative AADT of 34,150 vpd combined both directions of travel based on previous data collection. The posted speed limit of 50 mph corresponded to the IHSDM speed category of “Intermediate/High.”

The analysis identified 33 driveways in total along the corridor. Two driveways in the westbound direction were categorized as "Major Industrial" and one in the eastbound direction was categorized "Major Commercial," while the remainder were categorized as "Minor Commercial." The density of fixed objects along the segment was set at 10 objects per mile and the offset was set at 20-ft, based on observations of Google Maps™.

For the proposed redesign, the number of through lanes in the westbound direction on W South Boulevard was reduced to 2, with 12-ft lane widths. The proposed design removed the TWLTL, and a 2-ft paved inside shoulder was added in addition to the existing outside shoulder. The proposed design also consolidated one of the "Minor Commercial" driveways in the eastbound direction with other existing access points and added lighting along the entire length of the segment. All other inputs for W South Boulevard remained the same in both the existing and proposed redesign scenarios.

**Table 1. W South Boulevard segment inputs for the existing scenario and proposed redesign.**

| Item | Existing | Redesign |
|---|---|---|
| Number of thru lanes | 6 | 5 |
| Divided vs. undivided | Undivided | Divided |
| Type and width of median | TWLTL | Raised; varies from 20 ft to 24 ft |
| Presence of TWLTL | Yes | No |
| AADT | 34,150 vpd | - |
| Traffic or posted speed range | Intermediate/high speed | - |
| Left and right turn lanes | Left- and right-turn lanes at both intersection | Added left-turn lane into truck stop on EB |
| Roadside fixed object density | Very low | - |
| Offset to fixed objects | High | - |
| Average lane width | 12 ft | - |
| Average outside shoulder width | 2 ft | - |
| Density of railroad crossings (crossings/mi) | 0 | - |
| Number of driveways | 33 | 32 |
| Automated speed enforcement | None | - |
| Presence of on-street parking | None | - |
| Presence of lighting | None | Yes |

Note: A cell with a "-" indicates that the value for that item in the proposed redesign was the same as the value in the existing condition.

In addition to these data inputs for W South Boulevard, the analysis required certain data for I-65, Davenport Drive, and the interchange and intersection between W South Boulevard and those two roads. The analysts used peak-hour volumes and a k-factor[1] equal to 10 and computed the AADTs for the I-65 ramps and Davenport Drive.

The analysts categorized the I-65 entrance and exit ramps as two-lane suburban ramps, with AADTs of 8,190 vpd and 5,060 vpd, respectively. The analysts classified the ramp terminal at W South Boulevard and I-65 as a four-leg ramp terminal (D4) with protected/permissive signal phasing for left turns and channelized right turns delineated with pavement markings. The only changes in the proposed ramp terminal configuration were a change in the number of lanes on the crossroad (W South Boulevard) and a change in the median width.

Table 2 summarizes the model inputs for the W South Boulevard and Davenport Drive intersection in both the existing and proposed scenarios. Davenport Drive was a two-lane suburban arterial, with an AADT of 2,630 vpd. The road's speed was categorized as "Low" (given the posted speed limit of 25 mph). The intersection between W South Boulevard and Davenport Drive was a four-leg signalized intersection with three bus stops and one to eight alcohol sales establishments. The daily pedestrian volume across each approach was equal to 50 pedestrians per day. The existing intersection had a maximum pedestrian crossing distance of seven lanes, included a protected left-turn signal phasing on W South Boulevard, and allowed right-turn-on-red with no channelization. The proposed intersection condition reduced the maximum lanes crossed by pedestrians from seven to four due to the addition of a median (i.e., pedestrian refuge). Proposed improvements also included the addition of lighting at the intersection.

[1] K-factor is the proportion of AADT occurring in the peak hour, otherwise known as the design hour volume (FHWA, 2018).

**Table 2. W South Boulevard and Davenport Drive intersection inputs for the existing scenario and proposed redesign.**

| Item | Existing | Redesign |
|---|---|---|
| Number of legs | 4 | - |
| Traffic control | Signalized | - |
| AADT | W South: 34,150 vpd<br>Davenport: 2,630 vpd | |
| Number of lanes | W South: 6/7<br>Davenport: 2/3 | - |
| Daily pedestrian volumes (sum crossing all legs) | Very low (under 100/day) | - |
| Maximum number of lanes crossed by a pedestrian considering the presence of refuge islands | 7 | 4 |
| Major road left-turn signal phasing | Protected | - |
| Number of major road approaches with channelized right turn lane | 0 | - |
| Number of approaches with right turn on red prohibited | 0 | - |
| Number of approaches with U-turn prohibited | 0 | - |
| Proportion of total crashes occurring at night | Use default | - |
| Number of bus stops within 300 m | 3 | - |
| School presence within 300 m | 0 | - |
| Number of alcohol sales establishments within 300 m | 1-8 | - |
| Presence of red-light camera | None | - |
| Presence of lighting | None | Yes |
| Presence of left turn lane | On both W South approaches | - |
| Presence of right turn lane | On both W South approaches | - |

Note: A cell with a "-" indicates that the value for that item in the proposed redesign was the same as the value in the existing condition.

## Crash Prediction Analysis & Results

The CPM analysis produced crash estimates for the year 2017. Table 3, table 4, and table 5 display these results for the existing condition, as well as the proposed redesign. The results in the tables correspond to the predicted number of crashes over the course of a year. Table 3 and table 4 show the predicted overall crash performance of the existing condition and proposed redesign, including fatal and injury (FI) crashes, property damage only (PDO) crashes, and total crashes. These two tables show that the proposed redesign for W South Boulevard would be expected to reduce total crashes 21-percent annually, with a prediction of 39 crashes per year compared to the predicted 49 crashes per year in the existing condition. Within this total crash reduction, the proposed redesign predicted an 18-percent reduction in FI crashes (around 4 FI crashes per year) and a 24-percent reduction in PDO crashes (around 6 PDO crashes per year).

**Table 3. Predicted crashes per year for existing condition (2017 conditions).**

| Analysis Component | Facility Type | FI Crashes | PDO Crashes | Total Crashes |
|---|---|---|---|---|
| W South Boulevard | Suburban arterial segment | 3.90 | 6.22 | 10.13 |
| W South Boulevard/Davenport Drive | Signalized 4-leg intersection | 2.40 | 2.91 | 5.31 |
| I-65 ramps/W South Boulevard | Ramp terminal | 15.82 | 17.88 | 33.70 |
| **Total** | **N/A** | **22.12** | **27.01** | **49.13** |

**Table 4. Predicted crashes per year for proposed redesign (2017 conditions).**

| Analysis Component | Facility Type | FI Crashes | PDO Crashes | Total Crashes |
|---|---|---|---|---|
| W South Boulevard | Suburban arterial segment | 2.17 | 3.96 | 6.14 |
| W South Boulevard/Davenport Drive | Signalized 4-leg intersection | 2.03 | 3.41 | 5.44 |
| I-65 ramps/W South Boulevard | Ramp terminal | 14.01 | 13.25 | 27.26 |
| **Total** | **N/A** | **18.21** | **20.63** | **38.84** |

Based on the purpose and need of the project to improve pedestrian safety along the W South Boulevard corridor, table 5 focuses on predicted pedestrian crashes (which are all assumed to be FI crashes in the CPM due to pedestrian vulnerability). Note that the results in table 5 are included in the overall crash numbers seen in table 3 and table 4. While pedestrian crashes make up a smaller portion of the overall predicted crash numbers, these results still show an improvement of around 12 percent in pedestrian safety for the proposed design over the existing condition. Given the pedestrian crash history on W South Boulevard, this data-driven analysis demonstrated that the proposed design should help ALDOT meet the overall purpose and need of the project.

**Table 5. Predicted pedestrian FI crashes per year (2017 conditions).**

| Analysis Component | Facility Type | Pedestrian FI Crashes (Existing) | Pedestrian FI Crashes (Proposed) |
|---|---|---|---|
| W South Boulevard | Suburban arterial segment | 0.13 | 0.105 |
| W South Boulevard/Davenport Drive | Signalized 4-leg intersection | 0.15 | 0.14 |
| I-65 ramps/W South Boulevard | Ramp terminal | 0.28 | 0.25 |
| **Total** | **N/A** | **0.56** | **0.495** |

## Documentation and Use of Analysis Results

The FHWA GDL produced a brief report detailing the analysis inputs and results, including the data received from ALDOT describing the segment (FHWA, 2019). ALDOT used this report to finalize design decisions on the proposed improvements to W South Boulevard.

The predicted decrease in total and pedestrian crashes per year increased ALDOT's confidence in the proposed redesign, and ALDOT completed the project in 2020 (figure 5). The Alabama Transportation Assistance Program (ATAP) produced a set of before and after videos showcasing the project motivation and outcome (ATAP, 2019; ATAP, 2020).


Figure 5. Photo. Aerial photo of completed W South Boulevard improvements.

## Challenges

The HSM crash prediction models demonstrated that several design elements in the proposed redesign should reduce crashes compared to the existing condition, including decreasing the number of through lanes, adding a median, adding an inside shoulder, and adding lighting. However, it is important to note that several of the proposed improvements to W South Boulevard are not included in the HSM crash prediction models used in the IHSDM software. Excluded significant design features include the addition of sidewalks, pedestrian traffic signals, crosswalks and mid-block crossings, signage, and U-turn loons. In addition, the HSM models did not account for the safety impact of restricted median crossings, restricting left turns to/from driveways, and frontage roads.

One challenge for performing the analysis is that the proposed five-lane divided cross-section cannot be directly evaluated in IHSDM. However, the project team used a work around to mitigate this challenge. The project team conducted two evaluations, once as a four-lane divided road and once as a six-lane divided road. The final result for the proposed scenario was the average of the four-lane and six-lane results. It should be noted that the HSM (2010) does not include models for urban/suburban arterials with six or more lanes. However, National Cooperative Highway Research Program (NCHRP) Project 17-58 developed models for these facility types, and they are included in IHSDM (NCHRP, n.d.). Although the FHWA GDL did not take this approach, the project team noted that another possible approach would have been to model a four-lane divided road and apply a crash modification factor associated with adding a lane (especially for adding a fifth lane to a four-lane facility).

One specific challenge with interpreting the results of this analysis is that the models used in the CPM are not calibrated for use in Alabama. However, the project team tried to mitigate this challenge and designed the analysis to compare the existing condition with a proposed design. For facilities that use the same predictive model in both scenarios, such as the I-65/W South Boulevard ramp terminal and the W South Boulevard/Davenport Drive intersection, the relative difference between the two scenarios would still be valid even if calibration factors might have shifted the individual crash prediction results. Due to the more substantial changes to the W South Boulevard segment, the two scenarios depend on different predictive models. The potential calibration factors for these two models could vary, leading to possible differences in the estimated crash results.

ALDOT provided site-specific crash data for the segment, but they were not used in this analysis. While the HSM Part C methods include an Empirical-Bayes process to account for actual (observed) crashes, it is not applicable for projects in which the number of through lanes differs between scenarios. This project involved decreasing the number of through lanes from six in the existing condition to five in the proposed redesign. In addition, the facility type changed from undivided (with TWLTL) to divided. As a result, even though historic crash data were available, they were not used to predict future crashes for the existing and proposed designs.

## Conclusions

This example showcases a unique, but repeatable application of IHSDM to support pedestrian safety analysis and improve a high-volume, high-speed suburban arterials. ALDOT identified a specific need to improve pedestrian safety, and the FHWA GDL employed IHSDM to assess safety performance on the corridor and support ALDOT's decision making and investments. Tables 4 and 5 show that the proposed improvements are expected to reduce total crashes, as well as FI pedestrian crashes on the corridor.

ALDOT specifically identified this portion of W South Boulevard for its pedestrian safety concerns. W South Boulevard represents a facility type that is common throughout the United States, especially where suburban and rural areas interface and mixed land uses are adjacent to major freeway corridors. ALDOT hopes this project can serve as a model for corridor redesigns in similar locations throughout the State. The safety analysis performed in support of this project provided confidence that these improvements can provide a repeatable framework to improve the pedestrian environment.

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