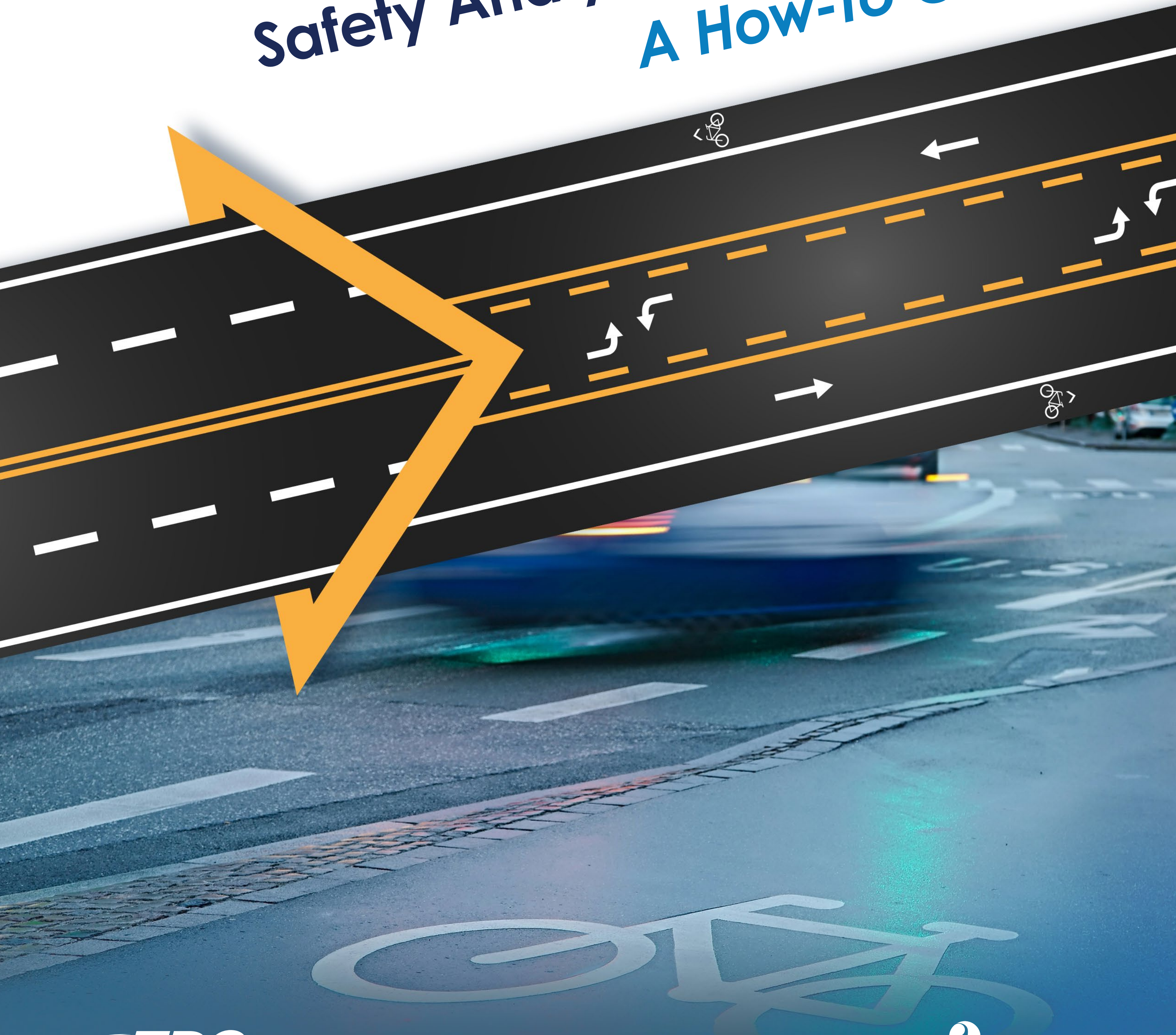
Incorporating Data-Driven Safety Analysis in Road Diets: A How-To Guide



Credit: Fotosearch.com

U.S. Department of Transportation
Federal Highway Administration

Introduction

Background

Traditional crash and roadway analysis methods rely heavily on subjective or limited quantitative measures of safety performance. This dependency makes it challenging to calculate safety impacts alongside other criteria when planning projects. Data-Driven Safety Analysis (DDSA) employs newer, evidence-based models that provide state and local agencies with the means to quantify safety impacts similar to the way they quantify other impacts such as environmental effects, traffic operations, and pavement condition. DDSA provides reliable estimates of an existing or proposed roadway's current and future safety performance and helps agencies make more informed decisions, better target investments, and reduce severe crashes occurring on their roadways.

Road diets are the conversion or reduction of an existing roadway into a safer and more accommodating roadway configuration by way of engineering and planning studies. Road diets can be an ideal solution to optimize operations, reduce vehicle speeds, and increase multi-modal use. One example of a road diet is the conversion of a four-lane roadway into a three-lane roadway with a two-way left-turn lane (TWLTL) and dedicated bike lanes, as shown in **Figure 1.**

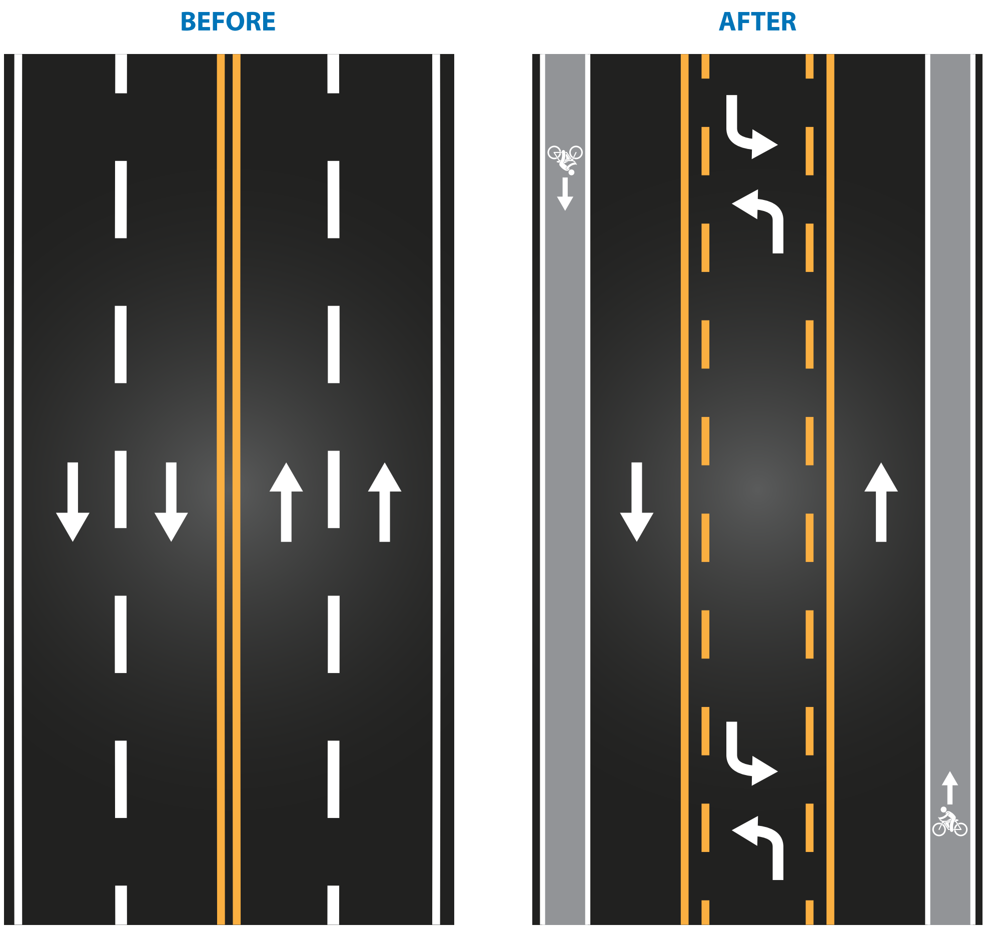


Figure 1. Example Road Diet

Credit: Fotosearch.com

Why Consider a Road Diet?

Road diets can provide both safety and operational benefits. Road diets can reduce crashes by 19 percent to 47 percent.[1] While it may seem illogical that a three-lane roadway can operate at a better level of service than a four-lane roadway, research and real-word examples have proven that road diets work.[2] Specifically, applying a road diet to a four-lane roadway helps to separate the left-turning traffic, improve the ability of side-street traffic to enter the flow of traffic, and reduce speed differential along the roadway.

Besides the potential for operational benefits, road diets can also improve roadway safety. Particularly, road diets reduce the frequency and severity of rear-end crashes, angle crashes involving left-turning vehicles, and sideswipe crashes. A four-lane undivided roadway allows drivers the opportunity to weave in and out of lanes. For example, drivers may engage in weaving activity to pass slower drivers, or a left-turning vehicle stopped in the travel lane. A three-lane roadway with a TWLTL separates the left-turning traffic and limits traffic speeds to that of the lead vehicle.

A road diet also allows transportation agencies the opportunity to accommodate other modes. For example, agencies can repurpose right-of-way from the travel lanes into bicycle lanes, wider sidewalks or shared-use paths, transit stops, or on-street parking. Bicycle lanes and on-street parking also provide separation between motorized traffic and pedestrians on the sidewalk. Further, the reduction in speed differential and fewer travel lanes also benefit pedestrians looking to cross the roadway. Together, these changes can encourage walking and biking along a corridor, while also improving the experience for those driving or commuting.

Credit: Fotosearch.com

1 *Stout, T., (2005) Before and After Study of Some Impacts of 4-Lane to 3-Lane Roadway Conversions.*

2 *Knapp, K., Chandler, B., Atkinson, J., Welch, T., Rigdon, H., Retting, R. A., … Porter, R. J. (2014). Road Diet Informational Guide (Final Report No. FHWA-SA-14-028).*

Implementing a Road Diet

Figure 2 shows the typical corridor planning process with the bold text in the figure emphasizing the safety-focused activities. When a transportation agency identifies a roadway or corridor with current or projected safety or operational issues, they typically consider several options for improvement. As part of this process, the agency defines roadway improvement objectives. To determine if the corridor would be a candidate for a road diet, the agency can assess the safety and operational impacts for various road users. The following paragraphs describe these considerations.

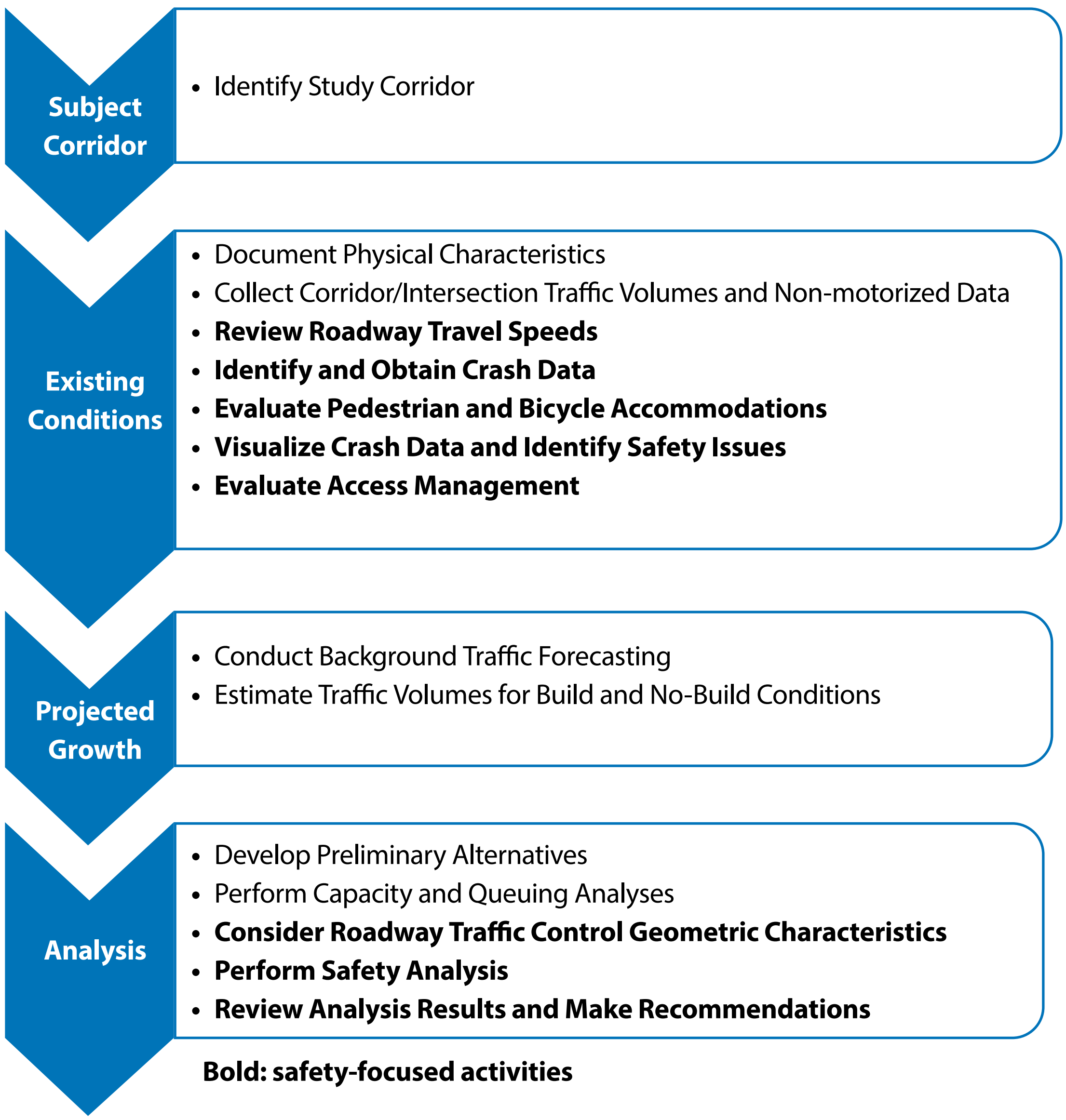


Figure 2. Typical Corridor Planning Process

To study safety issues along the roadway, the analyst conducting the study will obtain crash data to categorize and quantify crashes on the segment. The analyst will also evaluate pedestrian and bicycle accommodations on the roadway. Jurisdictions have found success in using road diets to complete multimodal networks by identifying gaps in the current network. Together, this information will allow the analyst to visualize safety issues along the segment.

Road diets are often implemented to make corridors more multimodal. In these cases, improvements to a corridor's operational characteristics may not be the main priority. Even in these cases, it is important to understand the safety and mobility issues of all users along the corridor before determining the feasibility of the proposed road diet. To study mobility issues, the analyst will review the roadway physical characteristics and collect traffic data. With this information, the analyst will evaluate roadway operations and level of service.

The analyst should also take the needs of transit and freight vehicles into consideration. This can include reviewing transit stop locations and spacing. For example, transit buses that previously stopped in the rightmost through lane before the conversion will need to stop in the only through lane after the conversion. In these cases, the relocation of the transit bus stop to the curbside could be considered. The analyst should also work with the transit provider to identify other potential issues. The area's land use, freight volumes, typical truck types (e.g., delivery truck), and delivery parking areas will help an analyst understand freight-related considerations.

Application of DDSA to Road Diets

There are several opportunities to apply DDSA approaches and concepts to a road diet. These opportunities include obtaining and visualizing safety data, evaluating pedestrian and bicyclist accommodations, and conducting safety analyses on potential alternatives. These opportunities and other information about overcoming potential challenges in applying DDSA can be found in the companion document Incorporating Data-Driven Safety Analysis in Traffic Impact Analyses: A How-To-Guide.

Example: Evaluating a Proposed Road Diet

The following sections detail an example study and provide two approaches for estimating the safety impacts of a road diet. The first approach, the application of a crash modification factor (CMF), allows analysts a quick way to understand the safety-related results of a road diet. The second approach is more robust and uses the Highway Safety Manual (HSM) models applied through the use of the HSM spreadsheet tool.[3] Finally, the operational considerations and estimated impacts are also discussed.

Credit: Fotosearch.com

3 American Association of State Highway and Transportation Officials. (2019). Tools. Retrieved November 1, 2019, from Highway Safety Manual website: **http://www.highwaysafetymanual.org/Pages/Tools.aspx**.

Project Overview

Travertine Drive is a four-lane arterial roadway that runs through a residential area and connects to a major arterial in the city of Traver. This area includes several residential communities including condominiums, townhomes, and single-family houses. A school is located nearby, as well as other entertainment and commercial establishments.

Running east and west, the study section of Travertine Drive consists of two segments separated by a signalized intersection. While the land use is suburban for both segments, the western segment (segment 1) is a mostly residential area with some commercial establishments near the intersection. The eastern segment (segment 2) contains on-street parking, a higher concentration of commercial establishments, and a greater number of access points along the road. An overview of the study is shown in **Figure 3.**

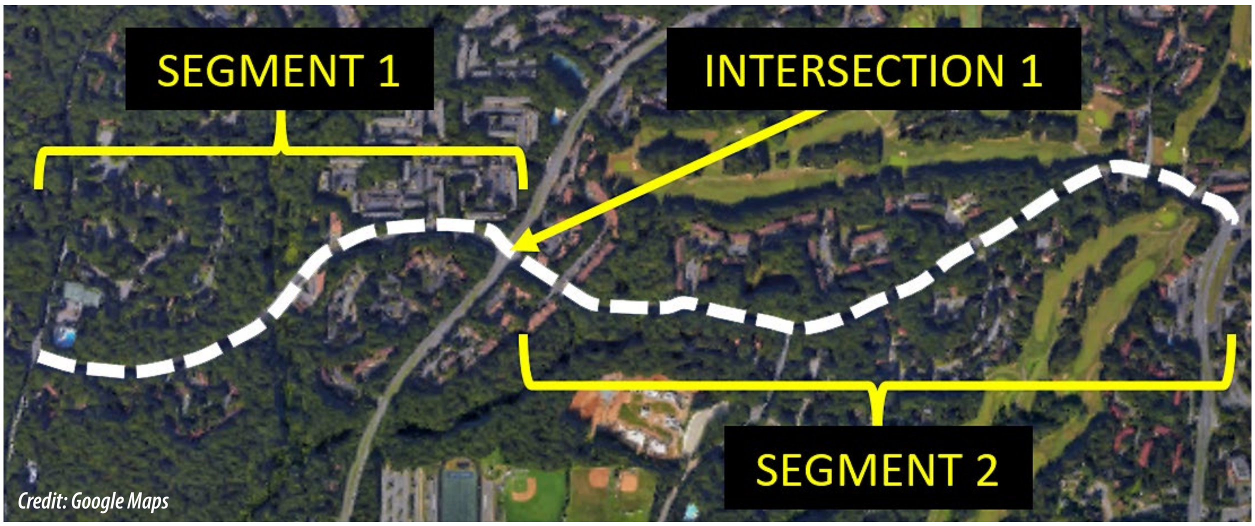


Figure 3. Study Segments

After reviewing several improvements for Travertine Drive, City staff believed that implementing a road diet and converting the existing four-lane roadway into a three-lane roadway with a TWLTL would fit well with the City's vision for the area. Implementing a road diet would be a low-cost improvement, with changes to signing and pavement markings representing the bulk of the cost.

Existing Conditions

Traffic Volumes

The analyst collected the existing condition turning movement counts for the study intersection on a typical weekday. They collected turning movement counts for both the AM (7:00 AM to 9:00 AM) and PM (4:00 PM to 6:00 PM) peak periods. The analyst collected the volumes in 15-minute intervals and determined the peak hour for the intersection with the appropriate seasonal factor applied. The existing average daily traffic (ADT) volumes along the study area were 7,000 vehicles per day for segment 1, and 6,300 vehicles per day for segment 2. FHWA guidance states that ADTs of less than 20,000 may indicate the roadway is a good candidate for a road diet.[4] PM peak hour volumes were higher than AM peak hour volumes; therefore, the analyst evaluated only PM peak hour volumes for the analysis.

Along with vehicular volumes, the analyst also collected bicycle and pedestrian volumes for the intersection on a typical weekday in 15-minute intervals. Findings from this data collection effort documented a significant amount of bicycle and pedestrian traffic present throughout the study area.

4 *Knapp, K., Chandler, B., Atkinson, J., Welch, T., Rigdon, H., Retting, R. A., … Porter, R. J. (2014). Road Diet Informational Guide (Final Report No. FHWA-SA-14-028).*

Travel Speeds

The analyst conducted a speed study to determine the speeds within the corridor. As part of this analysis, the City collected 24-hour speed counts along Travertine Drive at three locations. The speed data showed that 85th percentile speed on this roadway was 38 miles per hour, exceeding the speed limit of 35 miles per hour.

Pedestrian and Bicycle Accommodations

While documenting existing conditions, the analyst took an inventory of existing active transportation facilities during an on-site visit. The analyst documented the following observations:

- *Due to adjacent commercial and residential developments, the analyst frequently observed pedestrian and bicyclist activity along the corridor.*
- *The corridor does not include bicycle facilities.*
- *Both sides of the corridor provide sidewalks.*
- *Pedestrian signal heads, call buttons, and crosswalks are present at the signalized intersection.*

Corridor Crash Trends

The analyst reviewed existing crash data and developed a collision diagram for the corridor to determine crash patterns. The analyst identified a total of 33 crashes along the corridor in the most recent five years of crash data (2014-2018) and found angle, rear-end, and sideswipe crashes to occur most commonly. Together, angle and rear-end crashes represented nearly three-quarters of the crashes along the corridor. One benefit of a road diet is that the implementation of the TWLTL helps reduce the number of angle crashes and rear-end crashes that occur due to left-turning vehicles. **Figure 4** shows the number and distribution of crashes per year along the corridor.

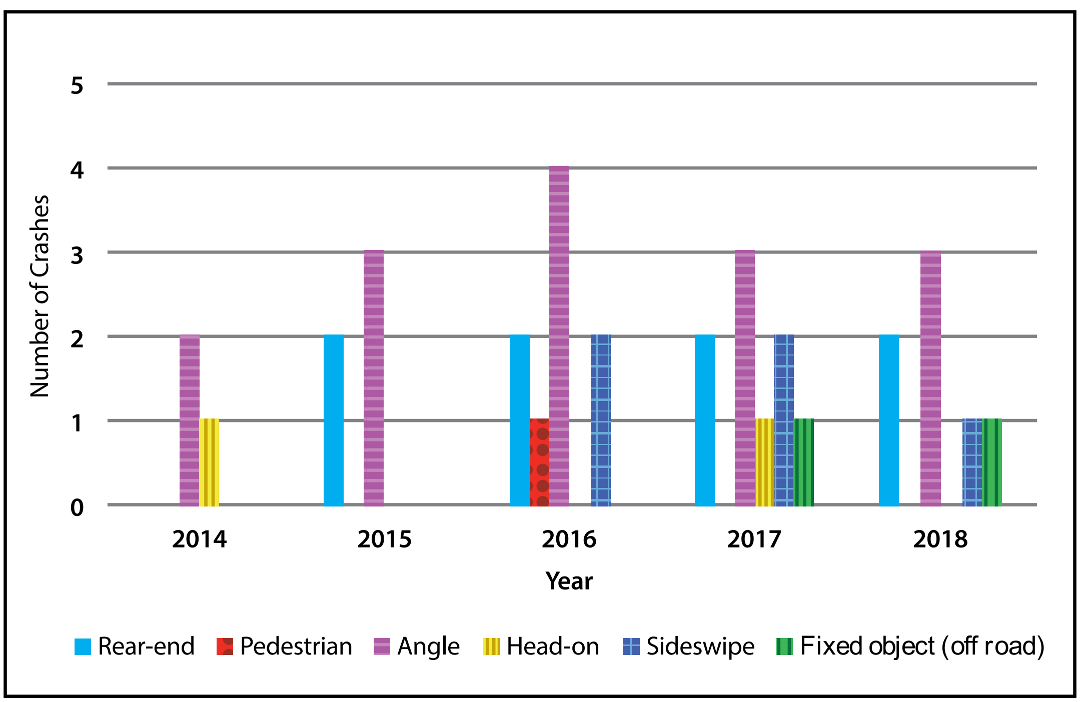


Figure 4. Number and Type of Crashes per Year along Travertine Drive

Future Conditions

In addition to reviewing existing conditions, the analyst also estimated future conditions to ensure that a road diet would continue to operate smoothly in the future. FHWA's guidance for implementing road diets recommends that directional hourly volumes are at or below 875 vehicles per hour per day (VPHPD), and preferably at or below 750 VPHPD. The analyst found that the corridor is expected to have directional hourly volumes of less than 750 VPHPD in future conditions.

Analysis

Safety Analysis

For the purpose of this example scenario, two approaches to the safety analysis are described below. The first, application of a CMF, can be done quickly and provides a general understanding of expected safety benefits from a road diet. The second, applying HSM models, provides more detail into the expected safety impacts. The second approach described below includes information on how to apply a freely available spreadsheet tool to use the HSM models.

Safety Analysis Approach #1: Application of a CMF

One method to quickly estimate the safety impacts of changes to transportation infrastructure is the use of CMFs. FHWA's CMF Clearinghouse is a useful source for identifying CMFs.[5]

Applying CMFs is straightforward. Analysts can use Equation 1 to estimate the number of crashes after a roadway modification is made.

$$C_{estimate} = C_{existing} * CMF \tag{1}$$

Where:

$C_{estimate}$= the estimated crash frequency (crashes per year) after the roadway modification

$C_{existing}$= the crash frequency before the roadway modification (crashes per year)

CMF= the crash modification factor

The analyst reviewed FHWA's evaluation of road diets research report for information on CMFs for road diets.[6] This document highlighted research into CMFs for road diets and detailed several options to select. The CMF values for a road diet vary depending on the application scenario. Because Travertine Drive was in a suburban area outside of a more urbanized area, the analyst selected the CMF value of 0.81 as it best fits this scenario.

The selected CMF value of 0.81 indicates that the road diet is expected to reduce crashes along the corridor by 19 percent. Per the guidance in FHWA's research report, the CMF factor is applicable to all crash types and crash severities. The crash data showed 33 crashes over 5 years along the corridor, equating 6.6 crashes per year. Using equation (1), the analyst estimated there would be 5.4 crashes per year after implementation of the road diet, reducing the future crash rate by approximately 1.2 crashes per year. This equates to a reduction of approximately 24 crashes over a 20-year period when compared to the existing configuration.

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5 *Federal Highway Administration. (2018). Crash Modification Factors Clearinghouse. Retrieved from* **http://www.cmfclearinghouse.org/**

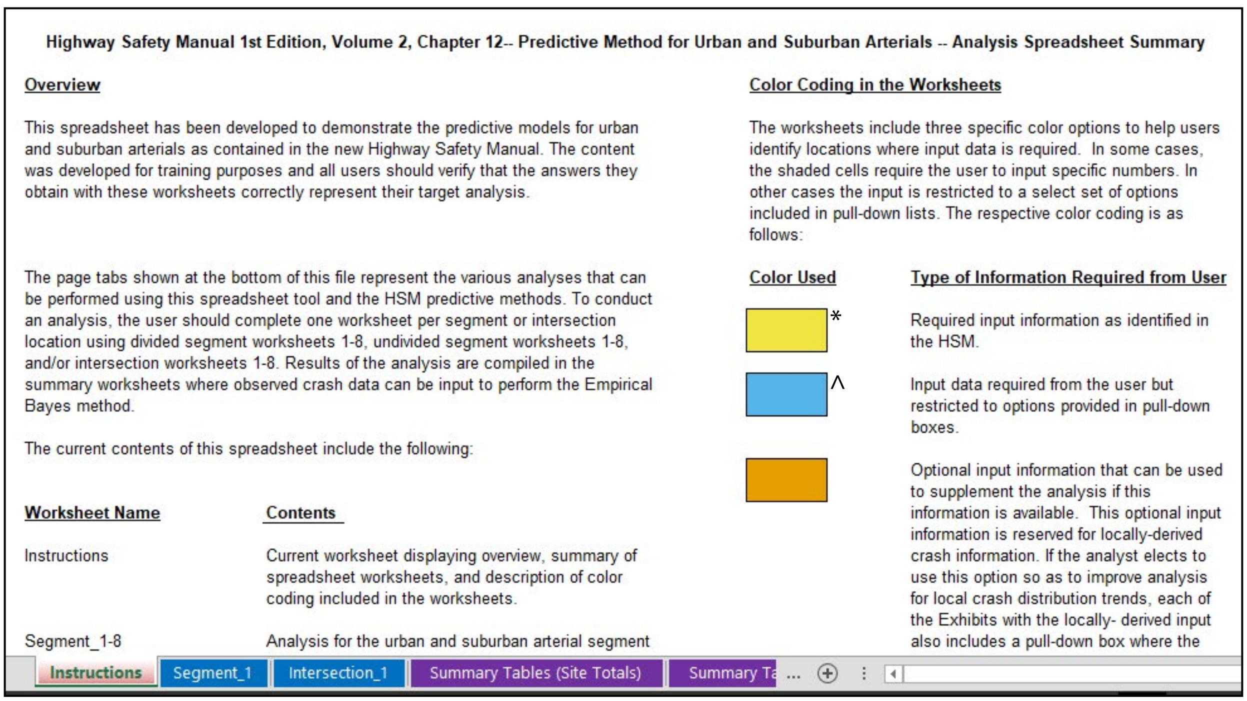
6 *Federal Highway Administration. (2010). Evaluation of Lane Reduction "Road Diet" Measures on Crashes (Summary Report No. FHWA-HRT-10-053). Retrieved from FHWA website:* **https://www.fhwa.dot.gov/publications/research/safety/10053/10053.pdf**

Safety Analysis Approach #2: HSM Spreadsheet Tool

While the selected CMF provides an idea of the crash reduction, it does not provide as much insight as an analysis that takes into account the actual traffic and roadway characteristics (e.g. AADT, lane width, etc.). An approach that does provide this level of detail is the use of the models developed as part of the Highway Safety Manual published by the American Association of State Highway and Transportation Officials (AASHTO).

AASHTO, FHWA, and the National Cooperative Highway Research Program (NCHRP) have developed a range of tools to assist with applying the complex calculations described in the HSM. For this scenario, the analyst obtained the suite of AASHTO HSM spreadsheet tools developed under NCHRP 17-38 to apply the predictive method for urban and suburban arterials.[7]

As shown in **Figure 5**, the HSM spreadsheet tool for urban and suburban arterials includes detailed instructions to walk users through its application. The tool is set up so that users can enter information for a number of roadway segments and intersections in order to understand the expected crash rate (crashes/mi/year) across the entire project.



Highway Safety Manual 1st Edition, Volume 2, Chapter 12-- Predictive Method for Urban and Suburban Arterials -- Analysis Spreadsheet Summary

Overview

This spreadsheet has been developed to demonstrate the predictive models for urban and suburban arterials as contained in the new Highway Safety Manual. The content was developed for training purposes and all users should verify that the answers they obtain with these worksheets correctly represent their target analysis.

The page tabs shown at the bottom of this file represent the various analyses that can be performed using this spreadsheet tool and the HSM predictive methods. To conduct an analysis, the user should complete one worksheet per segment or intersection location using divided segment worksheets 1-8, undivided segment worksheets 1-8, and/or intersection worksheets 1-8. Results of the analysis are compiled in the summary worksheets where observed crash data can be input to perform the Empirical Bayes method.

The current contents of this spreadsheet include the following:

Worksheet Name	Contents
Instructions	Current worksheet displaying overview, summary of spreadsheet worksheets, and description of color coding included in the worksheets.
Segment_1-8	Analysis for the urban and suburban arterial segment

Color Coding in the Worksheets

The worksheets include three specific color options to help users identify locations where input data is required. In some cases, the shaded cells require the user to input specific numbers. In other cases the input is restricted to a select set of options included in pull-down lists. The respective color coding is as follows:

Color Used	Type of Information Required from User
*	Required input information as identified in the HSM.
^	Input data required from the user but restricted to options provided in pull-down boxes.
	Optional input information that can be used to supplement the analysis if this information is available. This optional input information is reserved for locally-derived crash information. If the analyst elects to use this option so as to improve analysis for local crash distribution trends, each of the Exhibits with the locally- derived input also includes a pull-down box where the

Instructions | Segment_1 | Intersection_1 | Summary Tables (Site Totals) | Summary Ta ...

Figure 5. HSM Spreadsheet Tool for Urban and Suburban Arterials Instructions available for download at http://www.highwaysafetymanual.org/Pages/Tools.aspx

7 *American Association of State Highway and Transportation Officials. (2019). Tools. Retrieved November 1, 2019, from Highway Safety Manual website:* ***http://www.highwaysafetymanual.org/Pages/Tools.aspx***.

The HSM spreadsheet tool is a workbook containing a set of worksheets. Each worksheet contains a set of color-coded HSM worksheets (i.e., tables) to guide data entry and review. For example, when first opening the tool, the user sees the "Instructions" worksheet (**Figure 5**). This worksheet instructs users on how to operate the workbook and describes the color-coding scheme. The "Instructions" worksheet also outlines the contents of the workbook (**Table 1**). For this example, the analyst focused their attention on worksheets "Segment_1", "Segment_2", and "Intersection_1."

Table 1. HSM Spreadsheet Tool Worksheet Names and Contents

Worksheet Name	Contents
Instructions	Current worksheet displaying an overview, summary of spreadsheet worksheets, and description of color-coding included in the worksheets.
Segment_1-8	Analysis for the urban and suburban arterial segment analysis. The associated HSM worksheets are Worksheets 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1I, 1J, 1K, and 1L.
Intersection_1-8	Analysis for the urban and suburban arterial intersection analysis. The associated worksheets are Worksheets 2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I, 2J, 2K, and 2L. Worksheets specific to STOP control or traffic signals may be blank if they do not apply to the specific intersection type selected for analysis.
Summary Tables (Site Totals)	Analysis for site-specific Empirical Bayes analysis using results from the urban segment and intersection worksheets. This analysis can be performed if the analyst knows the exact location of historic crashes within the study limits. The associated HSM worksheets are Worksheets 3A, 3B, and 3C.
Summary Tables (Project Total)	Analysis for project-specific Empirical Bayes analysis using results from the segment and intersection worksheets. This analysis can be performed if the analyst has historic crash data, but does not know the exact location within the project limits at which the crashes occurred. The associated HSM worksheets are Worksheets 4A, 4B, and 4C.
Reference Tables (Segment)	Tables used for the segment analysis. Includes Tables 12-3, 12-4, 12-5, 12-6, 12-7, 12-8, 12-9, 12-19, 12-20, 12-21, and 12-23.
Reference Tables (Intersection)	Tables used for the intersection analysis. Includes Tables 12-10, 12-11, 12-12, 12-13, 12-14, 12-24, 12-26, and 12-27.
Construction - Do Not Delete	Data in this worksheet has been used to help define the pull-down options in the analysis worksheets. There is no need for a user to work within this worksheet, but the worksheet should be retained so that the other worksheets can continue to use the options included in this sheet.

The HSM spreadsheet tool contains only one data entry worksheet for segments and one for intersections ("Segment_1" and "Intersection_1"). If the study area includes more than one of each, the user must duplicate an existing worksheet and rename it (e.g., "Segment_2").

It is also important to distinguish the differences between the worksheets and the HSM worksheets. For example, "Segment_1" is a worksheet that contains a set of HSM worksheets (i.e., tables). For example, within the "Segement_1" worksheet, HSM worksheet 1A describes general information and input data for urban and suburban roadway segments.

For the purpose of this study, the analyst wanted to perform a comparison of the study corridor with and without the road diet. To complete this study, the analyst used the spreadsheet tool to enter details for the no-build scenario. Once the existing condition was entered, the analyst created a duplicate workbook and modified the data to represent the proposed road diet.

The analyst developed worksheets for two segments and an intersection for each the no-build scenario and future road diet. **Table 2** shows the data entered by the analyst for segment 1 for the no-build scenario. As shown in the table, the required data were either already collected by the analysis (e.g., traffic volume) or could be easily obtained through the use of aerial imagery (e.g., number of driveways).

Table 2. No-build Scenario Input for Segment 1 (Worksheet 1A)

Input Data		Site Conditions
Roadway type (2U, 3T, 4U, 4D, ST)		4U *
Length of segment, L (mi)		0.9^
AADT (veh/day)	$AADT_{MAX}$ = 40,100 (veh/day)	6,960^
Type of on-street parking (none/parallel/angle)		None*
The proportion of curb length with on-street parking		0^
Median width (ft) - for divided only		Not Present*
Lighting (present / not present)		Not Present*
Auto speed enforcement (present / not present)		Not Present*
Major commercial driveways (number)		2^
Minor commercial driveways (number)		0^
Major industrial / institutional driveways (number)		0^
Minor industrial / institutional driveways (number)		0^
Major residential driveways (number)		9^
Minor residential driveways (number)		1^
Other driveways (number)		1^
Speed Category		Posted Speed Greater than 30 mph*
Roadside fixed object density (fixed objects / mi)		100^
Offset to roadside fixed objects (ft) [If greater than 30 or Not Present, input 30]		10^
Calibration Factor, Cr		1.00^

* Required input information as identified in the HSM.
^ Input data required from the user but restricted to options provided in pull-down boxes.

Scrolling down through the worksheets shows a number of other HSM worksheets. For example, Worksheet 1B describes the crash modification factors applicable to urban and suburban roadway segments. These worksheets provide information to the analyst about what calculations are being made by the tool. Of particular interest to the analyst is Worksheet 1L, which summarizes the predicted number of crashes along each segment, as well as the corresponding crash severity levels. **Table 3** shows the predicted average crash frequency along segment 1 for the no-build scenario.

Table 3. HSM Spreadsheet Tool Summary Results for Segment 1 No-build Scenario (Worksheet 1L)

Crash Severity Level	Predicted average crash frequency, $N_{predicted}$ (crashes/year)	Roadway segment length, L (mi)	Crash density (crashes/mi/year)
	(Total) from Worksheet 1K		(2) / (3)
Total	2.5	0.90	2.8
Fatal and injury (FI)	0.8	0.90	0.9
Property damage only (PDO)	1.7	0.90	1.9

After entering input for the two roadway segments in each scenario, the analyst entered data for the intersection in both the no-build and road diet scenarios. **Table 4** shows Worksheet 2A, which contains the data entered for the intersection in the existing conditions. Again, like the inputs for the roadway segments, the data required for the intersection are largely data that can be easily obtained through aerial imagery and existing databases.

Table 4. Signalized Intersection Input for the No-build Scenario (Worksheet 2A)

Input Data		Site Conditions
Intersection type (3ST, 3SG, 4ST, 4SG)		4SG*
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ = 67,700 (veh/day)	22,319^
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ = 33,400 (veh/day)	14,694^
Intersection lighting (present/not present)		Present*
Calibration factor, C_i		1.00^
Data for unsignalized intersections only:		--
Number of major-road approaches with left-turn lanes (0,1,2)		0*
Number of major-road approaches with right-turn lanes (0,1,2)		0*
Data for signalized intersections only:		--
Number of approaches with left-turn lanes (0,1,2,3,4) [for 3SG, use maximum value of 3]		2*
Number of approaches with right-turn lanes (0,1,2,3,4) [for 3SG, use maximum value of 3]		2*
Number of approaches with left-turn signal phasing [for 3SG, use maximum value of 3]		2*
Type of left-turn signal phasing for Leg #1		Protected / Permissive*
Type of left-turn signal phasing for Leg #2		Protected / Permissive*
Type of left-turn signal phasing for Leg #3		Permissive*
Type of left-turn signal phasing for Leg #4 (if applicable)		Permissive*
Number of approaches with right-turn-on-red prohibited [for 3SG, use maximum value of 3]		0*
Intersection red light cameras (present/not present)		Not Present*
Sum of all pedestrian crossing volumes (PedVol) -- Signalized intersections only		15^
Maximum number of lanes crossed by a pedestrian (n_{lanesx})		3^
Number of bus stops within 300 m (1,000 ft) of the intersection		0^
Schools within 300 m (1,000 ft) of the intersection (present/not present)		Not Present*
Number of alcohol sales establishments within 300 m (1,000 ft) of the intersection		0^

* Required input information as identified in the HSM.
^ Input data required from the user but restricted to options provided in pull-down boxes.

In addition to the predicted number of crashes, the HSM spreadsheet tool allows users to estimate the expected number of crashes in the study area by taking incorporating previous crash history. The calculation for the expected number of crashes uses the Empirical Bayes method to estimate the long-term crash experience through a weighted average of the observed crashes and the predicted crashes.

The HSM spreadsheet tool offers two approaches for incorporating crash history into the prediction: at the project level and at a site-specific level. Determining the expected crashes at the project level is useful when information on the individual crash locations is not available. To determine the expected number of crashes at the project-level, only the total number of observed crashes is needed.

In this example, the crash data included the necessary detail (crash location, number of vehicles involved) to use the site-specific method. The analyst accessed the "Summary Tables (Site Totals)" worksheet in the HSM tool and entered the observed crashed frequencies into Worksheet 3A. The yellow cells in **Table 5** show the data that the analyst entered for the existing conditions.

Table 5. Predicted Crashes Input (Worksheet 3A)

Collision type / Site type	Predicted average crash frequency (crashes/year)			Observed crashes, $N_{observed}$ (crashes/ year)	Over-dispersion Parameter, k	Weighted adj., w	Expected average crash freq., $N_{expected}$
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Segment_1	1.20	0.25	0.94	2.00^	0.66	0.56	1.55
Segment_2	1.12	0.24	0.87	1.00^	0.66	0.58	1.07
Single-vehicle							
Segment_1	0.42	0.12	0.30	0.40^	1.37	0.63	0.41
Segment_2	0.36	0.11	0.26	0.60^	1.37	0.67	0.44
Multiple-vehicle driveway-related							
Segment_1	0.40	0.10	0.31	0.80^	1.10	0.69	0.53
Segment_2	0.80	0.19	0.60	0.60^	1.10	0.53	0.70
Segment Totals:	4.30	1.02	3.28	5.40			4.70
INTERSECTIONS							
Multiple-vehicle							
Intersection_1	4.60	1.51	3.08	1.20^	0.39	0.36	2.42
Single-vehicle							
Intersection_1	0.30	0.08	0.22	0.00^	0.36	0.90	0.27
Intersection Totals:	4.89	1.59	3.30	1.20			2.68
COMBINED	9.19	2.61	6.58	6.60	--	--	7.39

^ Input data required from the user but restricted to options provided in pull-down boxes.

Table 6 shows the expected crash frequencies for both the no-build scenario and the road diet scenario. As shown in this table, the road diet was expected to reduce the crash frequency by 7 percent per year. While the CMF application method provides an estimated crash reduction that affects all crash severities evenly, the HSM model provides more granularity. The HSM model estimated that this road diet would cause an 18 percent reduction in the frequency of fatal and injury crashes and a 2 percent reduction in the frequency of property-damage only crashes.

Table 6. Comparison of Expected Average Crash Frequencies Between the No-build Scenario and Road Diet Scenario

Crash Severity Level	Expected Average Crash Frequency (crashes/year)		Difference (%)
	No-build	Road Diet	
Fatal and injury	2.77	2.28	-18%
Property damage only	5.40	5.29	-2%
Total	8.17	7.57	-7%

Operational Analysis

The analyst evaluated future no-build and future road diet scenarios with operating and queuing conditions for the intersection along Travertine Drive based on the Highway Capacity Manual, 6th Edition. Each scenario analyzed the PM peak period for the year of 2040. The analyst estimated future traffic volumes based on the historic growth rate for the segments to develop each scenario.

Based on the capacity analysis results, the analyst expected the intersection to operate acceptably during the PM peak period. The road diet scenario was expected to have slightly more delay than the no-build scenario. However, the predicted level of service (LOS) was the same for the overall intersection and three of the intersection approaches. The southbound approach was expected to decrease from a LOS D in the no-build scenario to a LOS E in the road diet scenario. The capacity analysis results are shown in **Table 7**.

Table 7. Capacity Analysis Results for the 2040 PM Peak Period

Scenario	Delay (seconds) / Level of Service				
	Eastbound	Westbound	Northbound	Southbound	Intersection Total
No-build 2040 PM Peak	22.9 / C	21.2 / C	48.7 / D	54.5 / D	37.9 / D
Road Diet 2040 PM Peak	32.7 / C	30.0 / C	41.6 / D	59.8 / E	42.0 / D

Results

This analysis investigated the operational and safety impacts of implementing a road diet on a four-lane suburban roadway. The following bullets outline the key findings of this exercise:

- *Traffic volumes are expected to be within the threshold recommended by FHWA for implementing a road diet.*
- *There is a substantial number of residential dwellings along the corridor as well as commercial establishments and other attractions. Sidewalks exist, but there were no existing bicycle facilities. The road diet conversion allows for the addition of bicycle lanes. Further, the road diet increases the distance between the travel lanes and sidewalks for pedestrians.*
- *There was a total of 33 crashes along the corridor over the last 5 years of crash data. Nearly three-quarters of these crashes were angle crashes or rear-end crashes. One benefit of a road diet is that the implementation of the TWLTL helps reduce the number of angle crashes and rear-end crashes that occur due to left-turning vehicles.*
- *The analyst completed two approaches for the safety analysis: an application of a CMF and the use of the HSM spreadsheet tool. In both cases, the road diet is expected to have safety benefits over the existing configuration. The expected crash reduction ranges from 7 percent (HSM models) to 19 percent (CMF application), depending on the analysis approach selected.*
- *The analyst studied the potential operational impacts of the road diet by reviewing future traffic volumes and expected intersection delay. Future traffic volumes are expected to fall within the recommended range for implementing a road diet. The road diet scenario is expected to have slightly more delay than the future no-build scenario. Both cases are expected to perform acceptably with an intersection LOS D.*

Over the 20 year service life of the project, the proposed road diet is expected to reduce the total number of crashes in the study area by 12, with 10 of these 12 crashes resulting in either an injury or fatality. Further, the roadway reconfiguration would better accommodate bicyclists and pedestrians by increasing the offset from the travel lanes to the sidewalks and providing bicycle lanes along the corridor. Given these findings, the City moved forward with implementing the road diet design as shown in **Figure 6**.

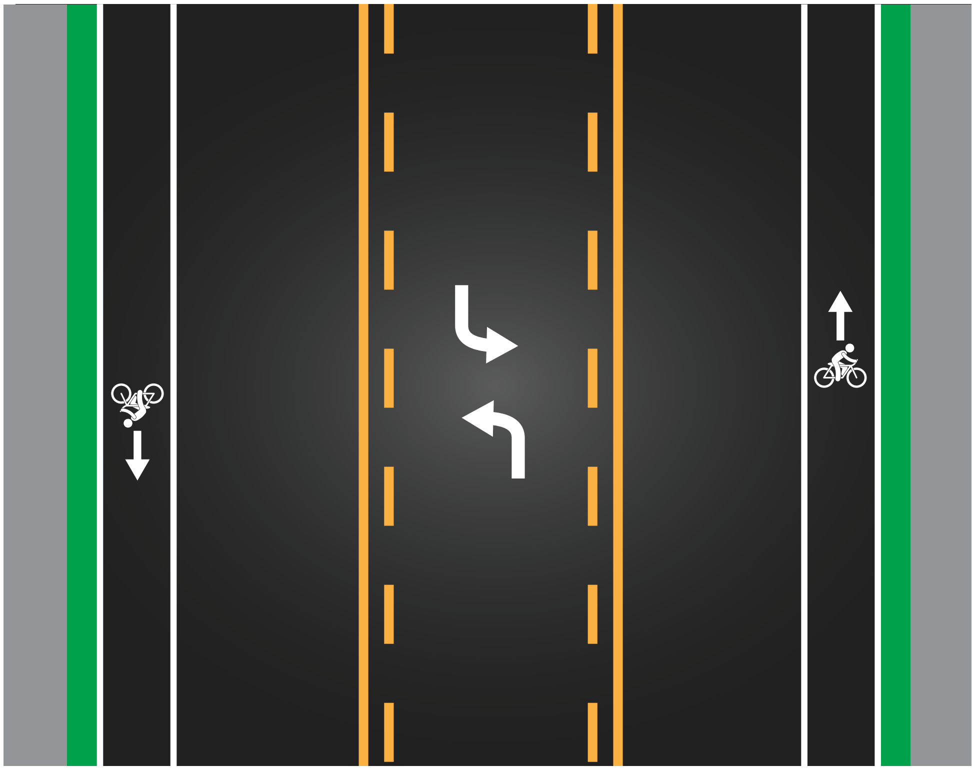
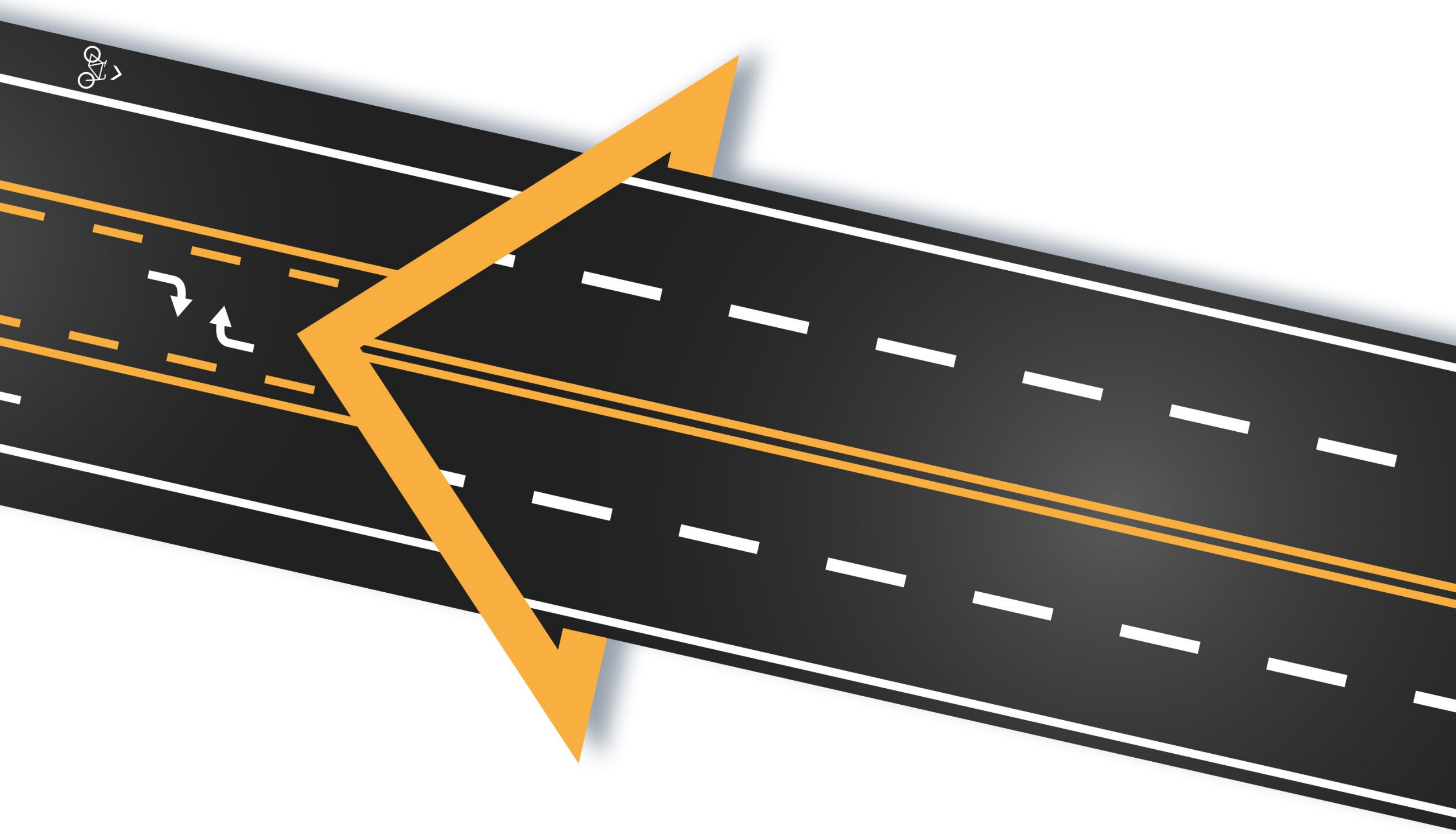


Figure 6. Selected Road Diet Design

Conclusion

This guide presented an overview of road diets, discussed considerations for implementing a road diet, and walked through an example demonstrating two approaches to estimate the safety impacts of a road diet. Road diets are proven, low-cost opportunities to not only increase the safety and mobility of a roadway, but also improve the experience of those that walk and bike in the area.



FHWA-SA-20-005

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