Northeast Ohio Areawide Coordinating Agency

2024–2025

Community Safety Report

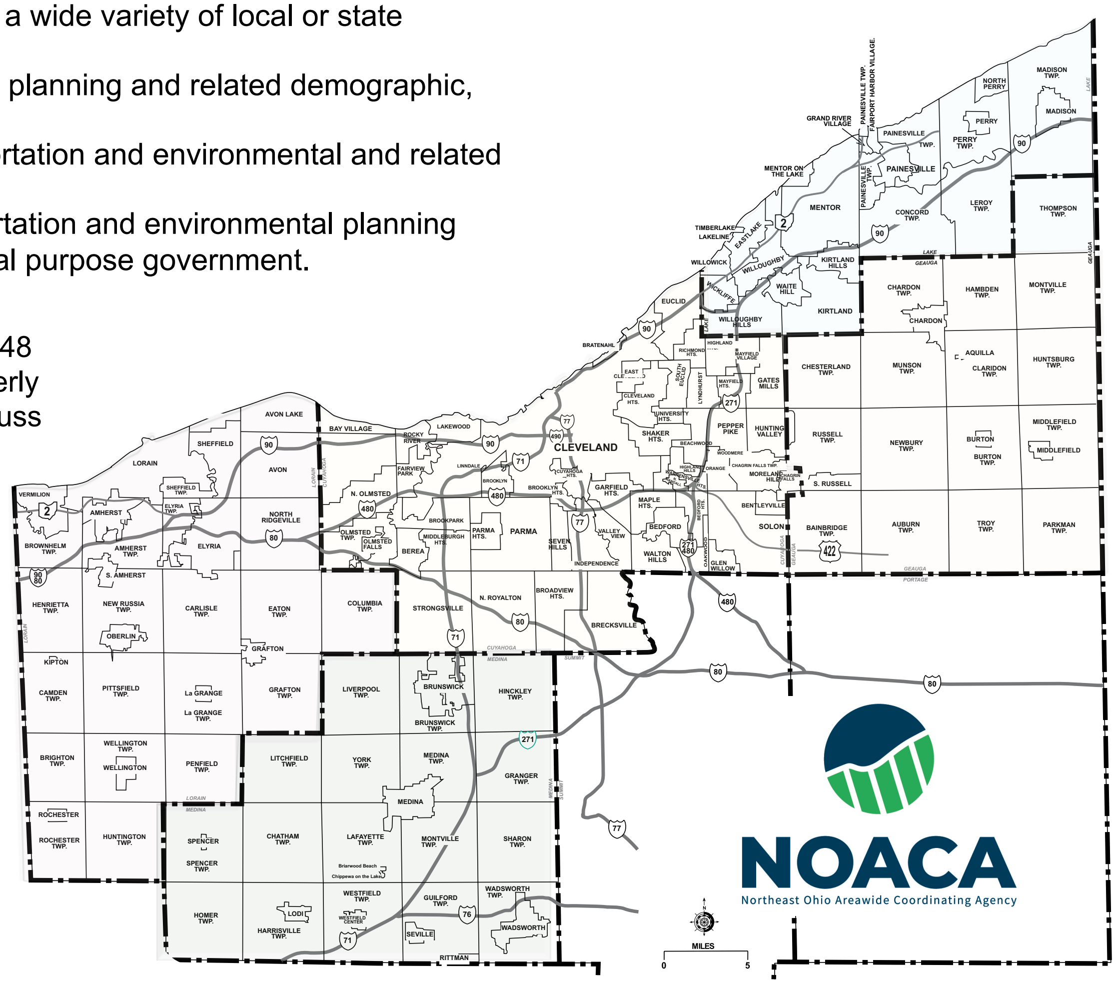
City of Sheffield Lake

The **Northeast Ohio Areawide Coordinating Agency** (NOACA) is a public organization serving the counties of and municipalities and townships within Cuyahoga, Geauga, Lake, Lorain and Medina (covering an area with 2.1 million people). NOACA is the agency designated or recognized to perform the following functions:

- Serve as the Metropolitan Planning Organization (MPO), with responsibility for comprehensive, cooperative and continuous planning for highways, public transit, and bikeways, as defined in the current transportation law.
- Perform continuous water quality, transportation-related air quality and other environmental planning functions.
- Administer the area clearinghouse function, which includes providing local government with the opportunity to review a wide variety of local or state applications for federal funds.
- Conduct transportation and environmental planning and related demographic, economic and land use research.
- Serve as an information center for transportation and environmental and related planning.
- As directed by the Board, provide transportation and environmental planning assistance to the 172 units of local, general purpose government.

The NOACA Board of Directors is composed of 48 local public officials. The Board convenes quarterly to provide a forum for members to present, discuss and develop solutions to local and areawide issues and make recommendations regarding implementation strategies. As the area clearinghouse for the region, the Board makes comments and recommendations on applications for state and federal grants, with the purpose of enhancing the region's social, physical, environmental and land use/ transportation fabric. NOACA invites you to take part in its planning process. Feel free to participate, to ask questions and to learn more about areawide planning.

For more information, call (216) 241-2414 or visit http:\\www.noaca.org



NOACA
Northeast Ohio Areawide Coordinating Agency

2025 NOACA Board of Directors

Board Officers

President: Chris Ronayne
Cuyahoga County Executive

First Vice President: Justin Bibb
Mayor, City of Cleveland

Second Vice President: James W. Dvorak
Geauga County

Secretary: Jeff Riddell
Lorain County Commissioner

Treasurer: Morris W. Beverage, III
Lake County Commissioner

Immediate Past President: Jeff Brandon
Trustee Chair, Montville Township

Assistant Secretary: Annette M. Blackwell
Mayor, City of Maple Heights

Assistant Secretary: Blaine Griffin
Cleveland City Council, Ward 6

Assistant Secretary: Aaron Harrison
Medina County Commissioner

Assistant Secretary: John Plecnik
Lake County Commissioner

Assistant Treasurer: Jack Bradley
Mayor, City of Lorain

Assistant Treasurer: Michael Dylan Brennan
Mayor, City of University Heights

Assistant Treasurer: Andy Conrad P.E., P.S.
County Engineer, Medina

Assistant Treasurer: Mark Cunningham
Columbia Township Trustee

Board Members

Cuyahoga County

Samuel J. Alai
Mayor, City of Broadview Heights

Larry Antoskiewicz
Mayor, City of North Royalton

Annette M. Blackwell
Mayor, City of Maple Heights

Pamela Bobst
Mayor, City of Rocky River

Michael Dylan Brennan
Mayor, City of University Heights

Matthew Castelli
Mayor, City of Middleburg Heights

Mary Cierebiej
Executive Director, Cuyahoga County Planning Commission

Timothy J. DeGeeter
Mayor, City of Parma

Michael Dever
Director of Public Works Cuyahoga County

Kirsten Holzheimer Gail
Mayor, City of Euclid

Michael Houser, Sr.
County Council Member

Meghan George
Mayor, City of Lakewood

Chris Ronayne
County Executive

Kahlil Seren
Mayor, City of Cleveland Heights

Kim Thomas
Mayor, City of Richmond Heights

City of Cleveland

Justin Bibb
Mayor, City of Cleveland

James DeRosa
Director, Office of Capital Projects

Marka Fields
Interim Director, City Planning Commission

Blaine A. Griffin
Ward 6, Council President

Stephanie Howse-Jones
Ward 7, Council Member

Brian Kazy
Ward 16, Council Member

Kerry McCormack
Ward 3, Council Member

Calley Mersmann
Sr. Strategist for Transportation & Mobility

Geauga County

Carolyn Brakey
County Commissioner

James W. Dvorak
County Commissioner

Ralph Spidalieri
County Commissioner

Lake County

Morris W. Beverage, III
County Commissioner

Ben Capelle
CEO, Laketran

Alan Exley P.E., P.S.
County Engineer

John Plecnik
County Commissioner

Richard Regovich
County Commissioner

Lorain County

Jack Bradley
Mayor, City of Lorain

Kevin Brubaker
Mayor City of Elyria

Kenneth Carney, Sr., P.E., P.S.
County Engineer

Kevin Corcoran
Mayor of North Ridgeville

Mark Cunningham
Trustee, Columbia Township

David Moore
County Commissioner

Jeff Riddell
County Commissioner

Medina County

Jeff Brandon
Trustee Chair, Montville Township

Andy Conrad, P.E., P.S.
County Engineer

Aaron M. Harrison
County Commissioner

Paul Magovac
City Engineer

Regional and State

David Gutheil
Interim President and CEO, Cleveland-Cuyahoga County, Port Authority

Paul Koomar
Board President, Greater, Cleveland Regional Transit Authority

John Picuri, P.E.
Deputy Director, District 12, Ohio Department of Transportation

Kyle Dreyfuss-Wells
Chief Executive Officer, Northeast Ohio Regional Sewer District

Ex Officio Members

Ferzan M. Ahmed, P.E.
Executive Director, Ohio Turnpike and Infrastructure Commission

David Emerman
District Chief, Ohio EPA, Northeast District Office

NOACA Directors

Grace Gallucci
Executive Director & CEO

Ronnie Blackshear
Deputy Director of Policy and Compliance

Lindy Burt
Director of Administrative Services

Joseph MacDonald, Ph.D
Director of Strategic & Environmental Planning

Ali Makarachi, Ph.D
Director of Transportation Planning & Engineering

Ed May
Director of Programming

Danielle Render
Director of Public Affairs

Deborah Wordell
Director of Finance

TABLE OF CONTENTS

FIGURES

MAPS

TABLES

Executive Summary

NOACA employs Systemic Safety Management and Safe System Approaches in its ongoing safety program to create a system that safeguards road users, even when they inevitably make mistakes; after all, to err is human. This program uses crash prediction models based on roadway and traffic characteristics to estimate the expected average crash frequency along selected arterials and their intersections. This process is taken from the Highway Safety Manual (HSM), produced by the American Association of State Highway and Transportation Officials (AASHTO). It provides predictive methods for estimating crash frequencies by road network, facility, or individual site. Combining these expected future crash locations with observed crash history sites will result in safety improvement projects with higher efficacy.

The NOACA systemic safety management approach considers 1,047 centerline miles and 3,240 lane miles of arterial roadways within the five-county region. This safety analysis separated the arterials by jurisdictional boundaries into 925 distinct segments and evaluated 512 major intersections based on their roadway and traffic characteristics.

This analysis considered five centerline miles and ten lane miles of arterial roadway within the City of Sheffield Lake, encompassing two arterial intersections. The analyzed arterial roadways in Sheffield Lake constitute 0.5% of the total considered arterial roadway lengths, which is proportional to Sheffield Lake having about 0.5% of the population of the NOACA region.

The recorded crash data for 2022 and 2023 were utilized for this analysis. During this period, the annual average of recorded crashes along the analyzed arterials and their intersections was 17. The predictive method resulted in 15 average annual expected crashes in the same area. The lower expected crash value may be explained by roadway conditions not yet captured in the predictive method or road user error. Countermeasures are an effective way of making roads safer while being proactive about safety. Part V includes examples of countermeasures with cost-benefit ratios for the selected arterial segments with the highest expected values of crashes. Countermeasures evaluated include High Visibility Crosswalk Markings, Rectangular Rapid Flashing Beacons, Pedestrian Refuge Islands, Pedestrian Hybrid Beacons, Leading Pedestrian Intervals, Bicycle Lanes and Delineators, Backplates with Retroreflective Borders, Wider Edge Lines, Center Line Rumble Strips, and Shoulder Rumble Strips.

Most crashes are wrongly attributed to user error, but it's only the last failure in the causal chain of events leading to a collision. That doesn't mean it's the driver's *fault,* but it means that the roads, vehicles, speeds, people, and post-crash care have *all* failed to protect vulnerable human bodies. Driver mistakes, infrastructure deficiencies, or environmental conditions shouldn't cost any roadway user their life. Instead, factors like lane widths, lighting, corner radii, signal timing, pedestrian detection, emergency braking, and storm clearance must be designed, calibrated, and invested in to provide multiple redundant levels of protection so that someone is seriously hurt or killed only when *everything* fails. If just one layer fails, the roadway users will still have their lives.

The following tables list a prioritization ranking of the selected arterials and intersections within the City of Sheffield Lake based on the estimated average annual crash frequency from highest to lowest.

RANK	ARTERIAL ROAD NAME	FROM	TO
1	US 6 (LAKE RD)	E OF ROOT RD	E OF ERIEVIEW BLVD
2	SR 301 (ABBE RD N)	SHEFFIELD LAKE SCL	LAKE RD (US-6)
3	LAKEBREEZE RD	SHEFFIELD NCL	US 6 (LAKE RD)

RANK	MAJOR LEG OF INTERSECTION	MINOR LEG OF INTERSECTION
1	US 6 (LAKE RD)	LAKE BREEZE RD
2	US 6 (LAKE RD)	SR 301 (ABBE RD N)

The prioritized sites should be examined together with the observed history of crash locations to invest in more effective safety improvements.

All parts of society must work together to fix system design errors, slow down our streets, design safer vehicles for both the people within and outside, and separate users of different modes by space and time. Engineers' focus must be on safety first and vehicle throughput second.

This safety report includes five parts:

- PART I: Background, Definitions, and Methodology
- PART II: Selected Arterials and Intersections
- PART III: Crash Frequency Prediction
- PART IV: Prioritization of Expected Crash Sites
- PART V: FHWA Proven Safety Countermeasures Cost-Benefit Analysis

Part I includes jurisdiction background information, definitions of roadway and intersection types, and descriptions of predictive methods.

Part II presents the roadway and traffic characteristics of the analyzed arterials and major intersections.

Part III discusses the estimated crash results.

Part IV prioritizes arterials and intersections based on the estimated annual predicted crash frequency.

Part V provides a Cost-Benefit Ratio for one or more Proven Safety Countermeasures recommended in a particular community and an overview of ratios and costs across all selected countermeasures for the region.

Four appendices are also provided:

- APPENDIX A: Outputs of Safety Performance Functions and Recorded Crashes
- APPENDIX B: Highway Safety Manual Coefficient Tables and Functions
- APPENDIX C: FHWA Proven Safety Countermeasures
- APPENDIX D: Educational Supplements

PART I: Background, Definitions, and Methodology

Background

The national Vision Zero initiative envisions a transportation network with zero deaths or serious injuries. One of NOACA's transportation planning goals is to achieve this vision in its five-county region by 2050. The conventional concept of road safety encompasses education of road users, engineering solutions that are highly effective yet low-cost, and enforcement of laws. NOACA has expanded these fundamentals to complementary policies: engagement with underrepresented populations towards achieving equity for all, emergency response time reduction, and systematic evaluation of data. NOACA administers several safety initiatives as part of the agency's Regional Safety Program (RSP) to improve the safety and efficiency of the transportation system.

The primary focus of the RSP is to improve safety by reducing crashes, particularly fatal and serious injury crashes, on all modes of transportation in the NOACA region. This is accomplished in various ways, including:

- Safety Performance Measures: monitor and report on crash trends and progress in meeting regional crash reduction goals
- SAVE Plan Implementation: address the goals and actions in the plan to improve regional transportation safety

The SAVE plan intends to save lives by identifying high-crash locations and implementing safety treatments at those sites. This plan was developed with the vision that traffic deaths and injuries can be prevented with appropriate planning, policies, and programs.

The SAVE Plan is a localized companion document that supports the Ohio Department of Transportation's (ODOT's) Strategic Highway Safety Plan (SHSP), which is the cornerstone of the federal Highway Safety Improvement Program (HSIP) in Ohio. The 10 emphasis areas identified for specific action in the SAVE Plan are Intersections, Roadway Departures, Young Drivers, Speeding, Impaired Driving, Older Drivers, Distracted Driving, Pedestrians, Motorcycles, and Bicycles.

A Systemic Safety Management approach has been incorporated into ongoing NOACA safety programs to complement the current safety plans. This approach addresses crash types that occur with high frequency across the roadway network but are not concentrated at individual locations. These crashes tend to be overlooked when ranking sites using a crash-history-based safety management approach. As a proactive approach, Systemic Safety Management enhances analysis for implementation by detecting crash potential at locations that may not have a history of crashes. In particular, even sites with zero crash history can be identified for potential safety improvements. By applying this approach, NOACA will consider the potential for future crashes and crash history when determining where to make safety improvements.

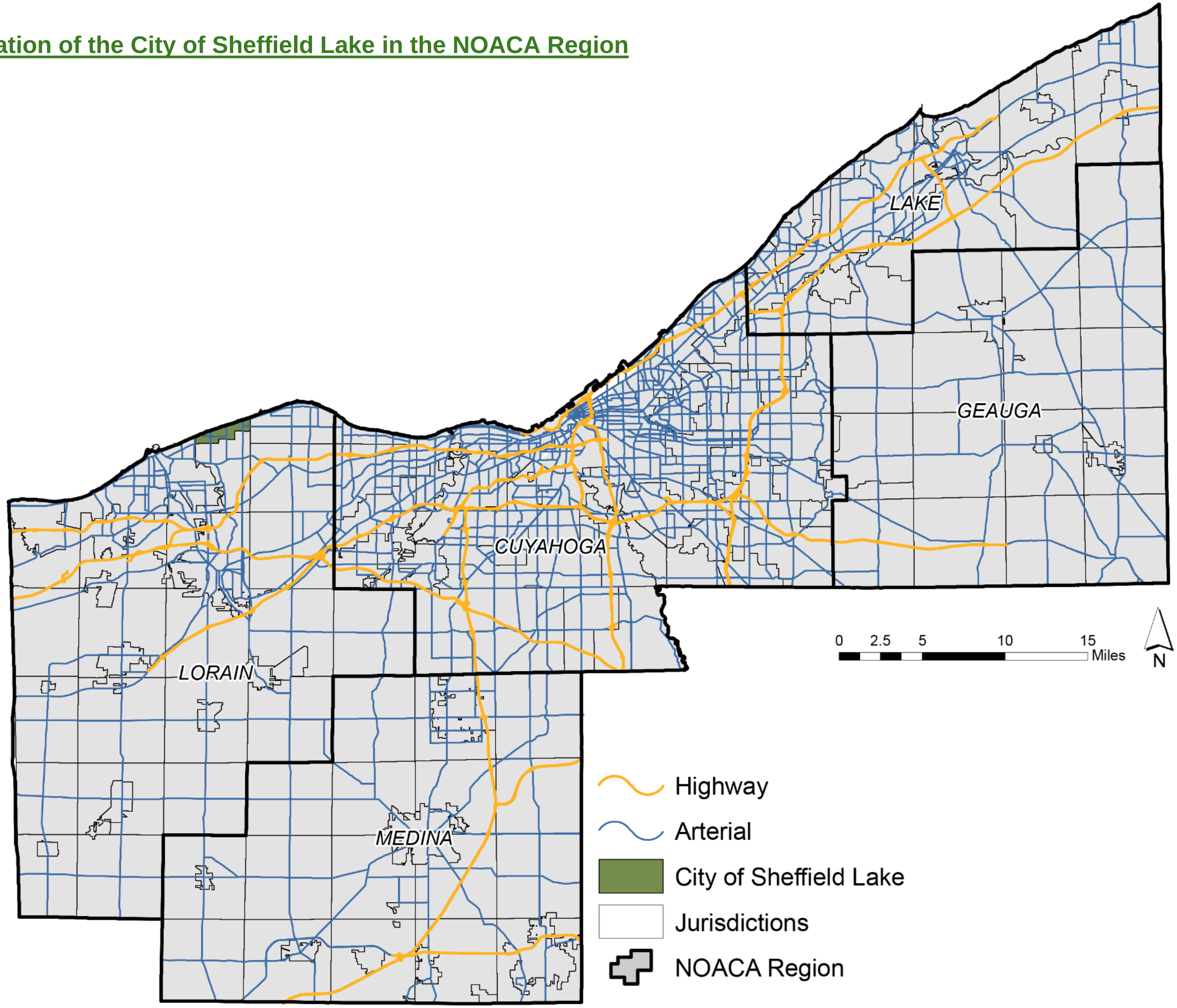
History

Sheffield Lake, founded in 1815, is located at the northern edge of Lorain County, overlooking Lake Erie. It was incorporated in 1920, and the southern part split off as Sheffield Village in the 1930s. (Adapted from Wikipedia)

Based on the 2020 census, the current Sheffield Lake population is 8,360, and these residents form 3,627 households. It should be noted that 1,093 individuals are employed within the city limits.

Map 1 illustrates the location of the City of Sheffield Lake in the NOACA region.

Map 1: Location of the City of Sheffield Lake in the NOACA Region



Definitions

This section defines the fundamental terms used in the Highway Safety Manual (HSM) and throughout the report.

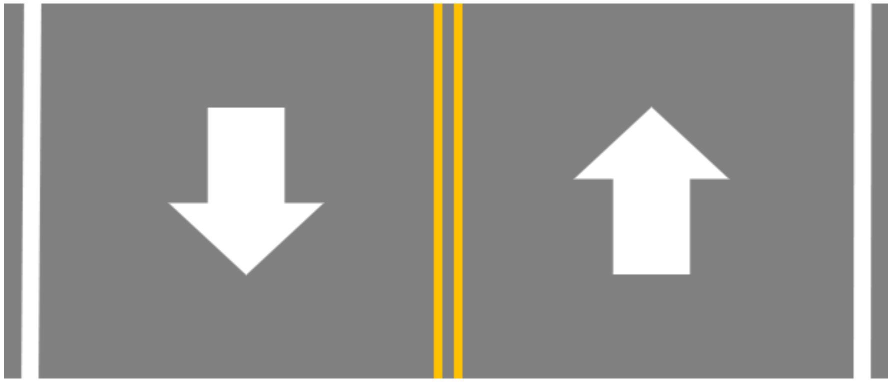
- Crash frequency is defined as the number of crashes that occur at a particular site, facility, or network annually
- Crash estimation refers to any methodology used to forecast or predict the crash frequency
- The predictive method is the methodology used to estimate the "expected average crash frequency" of a roadway segment or intersection under a given geometric design and traffic volume during a year
- Safety Performance Functions (SPFs) are regression equations that estimate the average crash frequency for a specific site type (with specified base conditions)
- Crash Modification Factors (CMFs) represent the relative changes in crash frequency due to a change in one specific condition. A CMF may serve as an estimate of the effect of a particular geometric design or traffic control feature

The following segment and intersection types are used for arterial roadways and intersections to select the correct SPF.

Roadway Segment Types

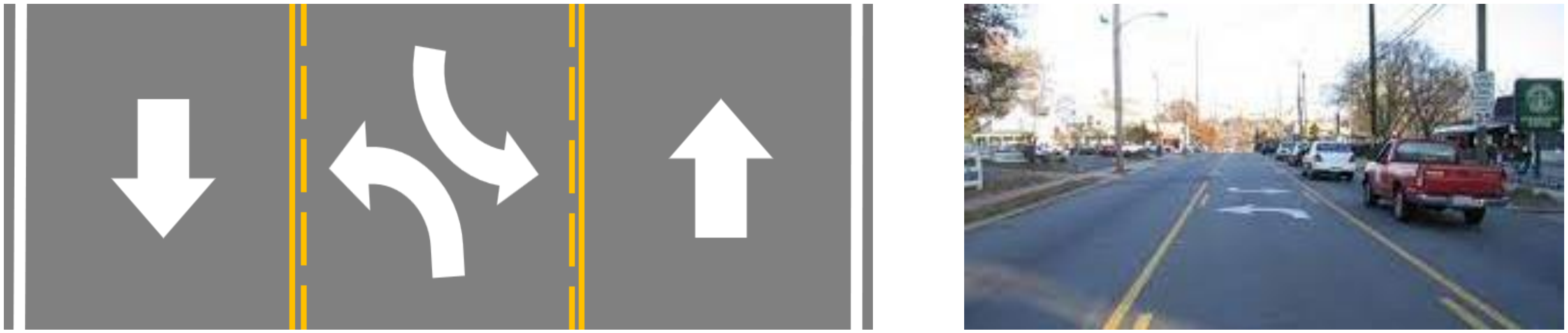
- **Two-lane undivided arterial (2U)** – a roadway consisting of two lanes with a continuous cross-section providing two directions of travel in which the lanes are not physically separated by either distance or a barrier

Figure 1: Two-lane Undivided Arterial (2U) Schematic and Example



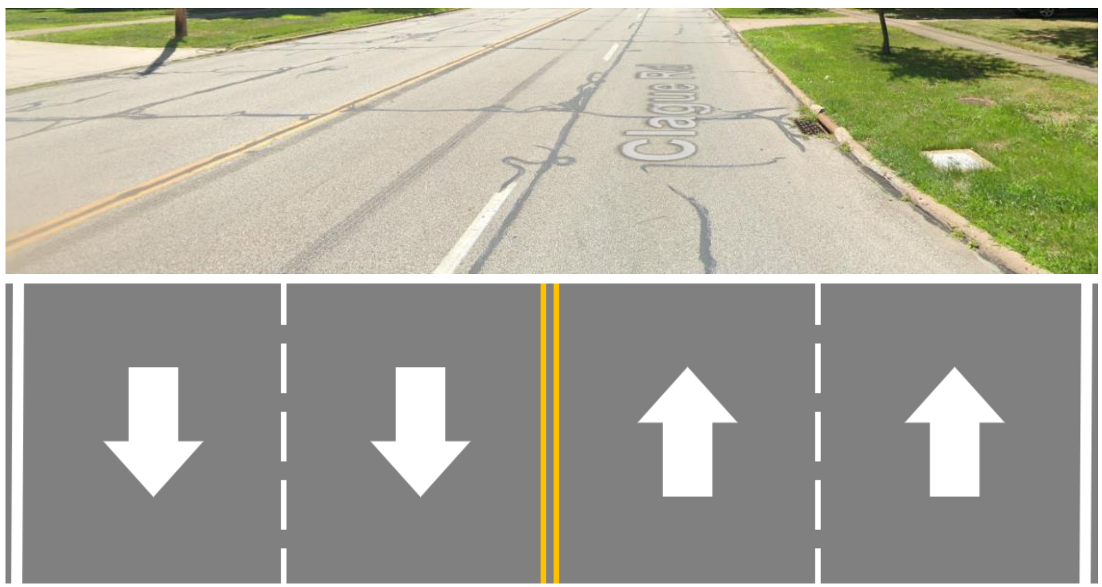
- **Three-lane arterials (3T)** – a roadway consisting of three lanes with a continuous cross-section providing two directions of travel in which the center lane is a two-way left-turn lane (TWLTL)

Figure 2: Three-lane (3T) Schematic and Example



- **Four-lane undivided arterials (4U)** – a roadway consisting of four lanes with a continuous cross-section providing two directions of travel in which the lanes are not physically separated by either distance or a barrier.

Figure 3: Four-lane Undivided Arterial (4U) Schematic and Example

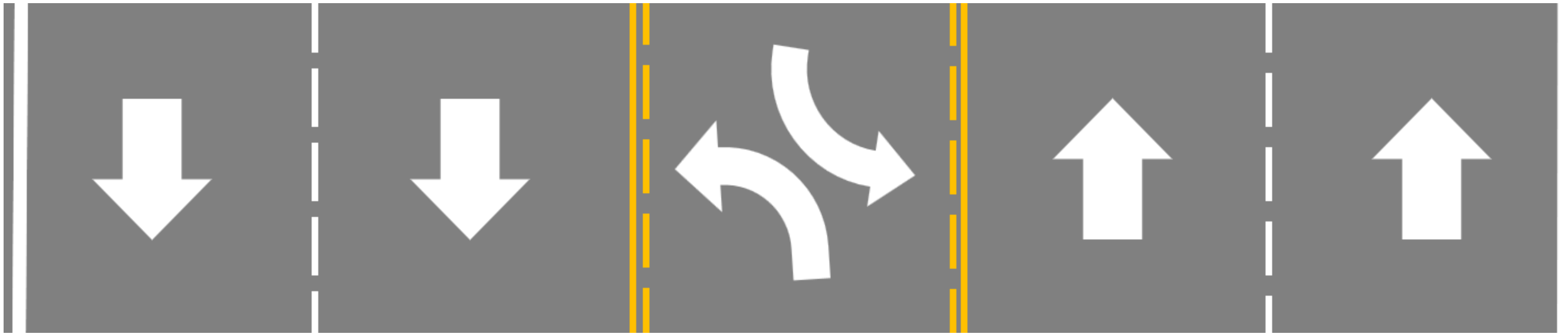


- **Four-lane divided arterials (i.e., including a raised or depressed median) (4D)** – a roadway consisting of two directional lanes with a continuous cross-section providing two directions of travel in which either distance or a barrier physically separates the lanes.

Figure 4: Four-lane Divided Arterial (4D) Schematic and Example

- **Five-lane arterials including a center TWLTL (5T)** – a roadway consisting of five lanes with a continuous cross-section providing two directions of travel in which the center lane is a two-way left-turn lane (TWLTL)

Figure 5: Five-lane Arterial (5T) Schematic and Example



Intersection Types

- **Three-leg intersection with stop control (3ST)** – an intersection of an urban or suburban arterial and a minor road. A stop sign is provided on the minor road approach to the intersection only
- **Three-leg signalized intersection (3SG)** – an intersection of an urban or suburban arterial and a minor road. Signalized control is provided at the intersection by traffic lights
- **Four-leg intersection with stop control (4ST)** – an intersection of an urban or suburban arterial and two minor roads. A stop sign is provided on both the minor road approaches to the intersection
- **Four-leg signalized intersection (4SG)** – an intersection of an urban or suburban arterial and two minor roads. Signalized control is provided at the intersection by traffic lights

Predictive Models for Urban and Suburban Arterials and Intersections

The input data needed for the predictive crash modeling includes:

- Traffic volume
- Basic roadway characteristics: number of lanes, presence of median dividers, and number of driveways
- Safety Performance Function coefficients (SPFs), provided by the Highway Safety Manual

The essential equation used to determine the number of predicted annual crashes for a given arterial segment or intersection is as follows:

$$N_{predictedrs} = C_r \times (N_{br} + N_{pedr} + N_{biker})$$

Where:

$N_{predictedrs} = Predicted\ annual\ average\ crash\ frequency\ of\ an\ individual\ roadway\ segment\ or\ intersection$

$C_r = Calibration\ factor\ for\ roadway\ segments\ of\ a\ specific\ type\ developed\ for\ use\ for\ a\ particular\ geographical\ area$

$N_{br} = Predicted\ average\ crash\ frequency\ of\ an\ individual\ roadway\ segment\ or\ intersection\ (excluding\ vehicle\ /pedestrian\ and\ vehiclebicycle\ collisions)$

$N_{biker} = Predicted\ average\ frequency\ of vehicle/bicycle\ collisions\ for\ an\ individual\ roadway\ segment\ or\ intersection$

$N_{pedr} = Predicted\ average\ frequency\ of vehicle/pedestrian\ collisions\ for\ an\ individual\ roadway\ segment\ or\ intersection$

N_{br}, N_{pedr}, and N_{biker} are determined using several different SPFs for crash types shown in Tables 1 and 2.

Calculating predicted average crash frequency involves multiple steps and equations for different crash types, such as mode and severity. Individual SPFs with unique coefficients are used to calculate crash subtotals, as shown in Table 1. These predicted crash subtotals are then added together to determine an individual roadway segment's total predicted average crash frequency.

Table 1: Crash Types for Roadway Segments

NON-DRIVEWAY				DRIVEWAY		VEHICLE-PEDESTRIAN COLLISIONS	VEHICLE-BICYCLE COLLISIONS
MULTIPLE-VEHICLE COLLISIONS		SINGLE-VEHICLE COLLISIONS		MULTIPLE-VEHICLE COLLISIONS			
FATAL & INJURY	PROPERTY DAMAGE ONLY	FATAL & INJURY	PROPERTY DAMAGE ONLY	FATAL & INJURY	PROPERTY DAMAGE ONLY		

The intersection crash types, shown in Table 2, are similar but without a calculation for driveways.

Table 2: Crash Types for Intersections

MULTIPLE-VEHICLE COLLISIONS		SINGLE-VEHICLE COLLISIONS		VEHICLE-PEDESTRIAN COLLISIONS	VEHICLE-BICYCLE COLLISIONS
FATAL & INJURY	PROPERTY DAMAGE ONLY	FATAL & INJURY	PROPERTY DAMAGE ONLY		

Appendix B at the end of this report contains the SPFs and coefficients from the Highway Safety Manual for each crash type.

A Predictive Method for Estimating Average Crash Frequency and Severity

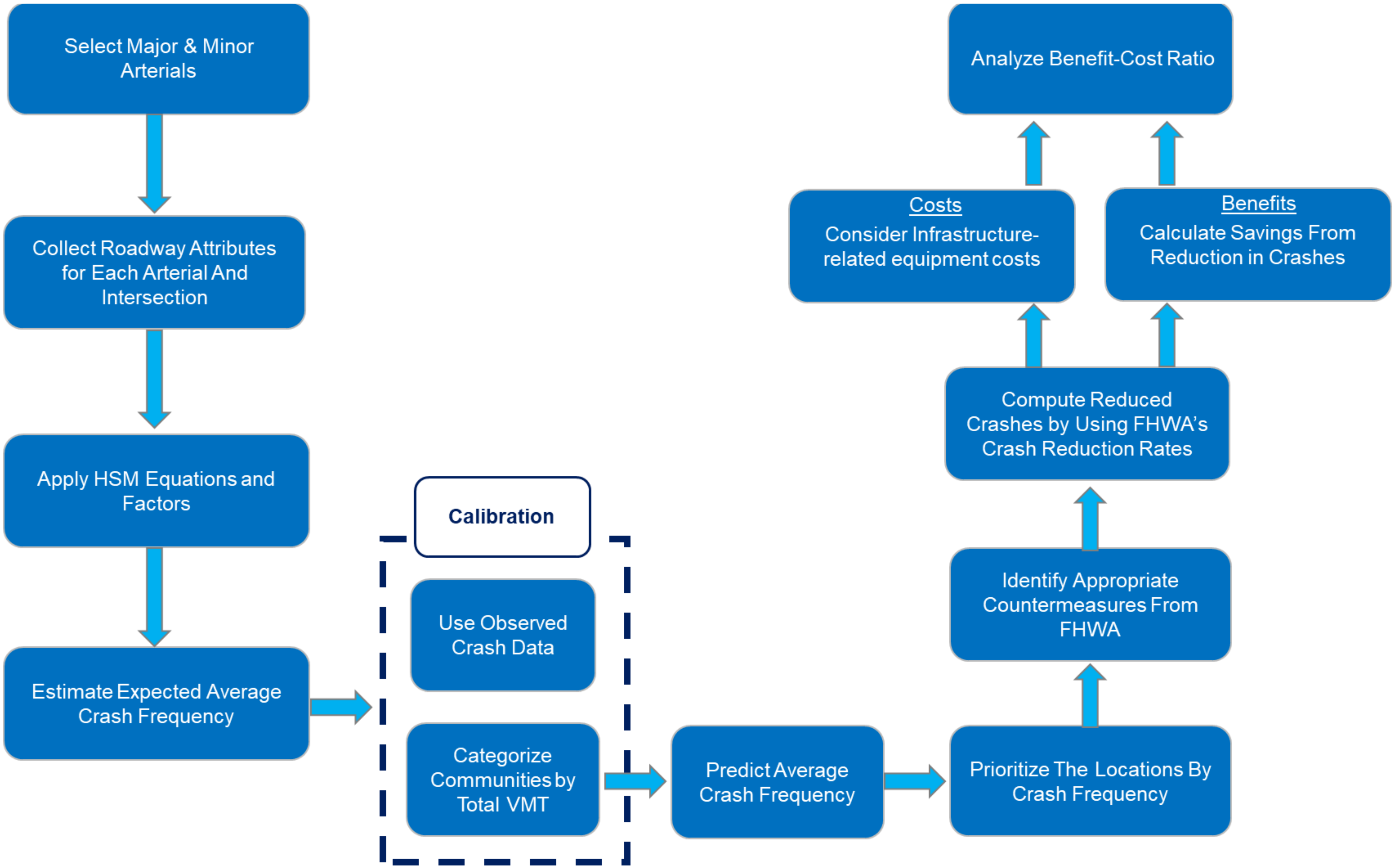
The predictive method described below provides estimated annual crash frequency and severity along arterials and at intersections using various approaches from the Highway Safety Manual. These estimates are not solely based on observed historical crash data but incorporate roadway and traffic characteristics to estimate expected average crash frequency. This can assist decision makers in determining where to invest in prioritized safety improvements with higher efficacy.

The roadway and traffic input data include:

- Road segment type
- Average Two-Way Daily Traffic volume (ADT)
- Number of lanes
- Number of driveways (access points serving land uses)
- Vehicle Miles Traveled (VMT)

Figure 6 illustrates the overall crash frequency prediction process and the Cost-Benefit Analysis Process.

Figure 6: Crash Frequency Prediction and Cost-Benefit Analysis Process



PART II: Selected Arterials and Intersections

The road network within the City of Sheffield Lake's boundaries was reviewed, and two arterial segments and two intersections were identified for analysis. Each record in Tables 3 and 4 represents an arterial segment or intersection, respectively. The tables display the SPF input data of roadway name and termini, segment type, length (miles), number of driveways, and ADT volume.

Table 3: Length and Segment Configuration for Selected Arterial Segments

ROAD NAME	FROM	TO	LENGTH (MILES)	SEGMENT TYPE
SR 301 (ABBE RD N)	SHEFFIELD LAKE SCL	LAKE RD (US-6)	0.59	2U
US 6 (LAKE RD)	E OF ROOT RD	E OF ERIEVIEW BLVD	3.50	2U

Table 3a: Average Daily Traffic, Average Recorded Crashes (2022-2023), and Estimated Number of Driveways for Selected Arterial Segments

ROAD NAME	FROM	TO	DRIVEWAYS	ADT	CRASHES
SR 301 (ABBE RD N)	SHEFFIELD LAKE SCL	LAKE RD (US-6)	35	2,860	1.0
US 6 (LAKE RD)	E OF ROOT RD	E OF ERIEVIEW BLVD	270	3,780	15.5

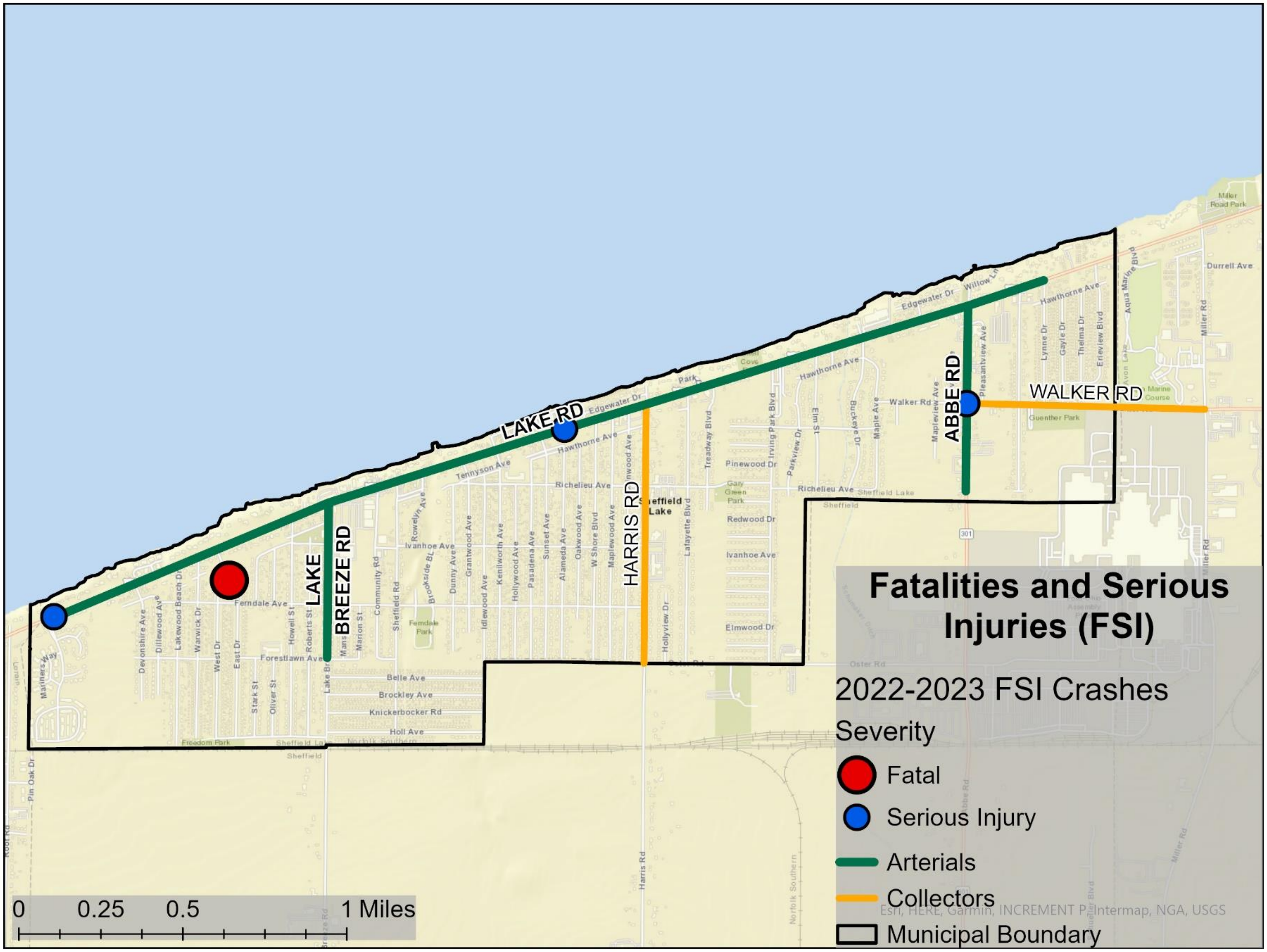
Table 4: Selected Intersections

MAJOR RD	MINOR RD	INTERSECTION TYPE	ADT OF MAJOR ROAD	ADT OF MINOR ROAD
US 6 (LAKE RD)	LAKE BREEZE RD	4SG	4,981	2,215
US 6 (LAKE RD)	SR 301 (ABBE RD N)	4SG	4,273	2,714

- Note 1: Arterial road segments were selected to be consistent with other NOACA community reports
- Note 2: ADT volumes were derived from the NOACA travel forecasting model 2024 scenario
- Note 3: Google satellite imagery was used for estimating the number of driveways since a detailed driveway inventory with land uses does not currently exist for the region
- Note 4: Major and minor roads at intersections were selected using the highest directional approach ADT volumes
- Note 5: Only the intersections where two arterials meet were considered for this analysis
- Note 6: Pedestrian activity is assumed to be “low” for all intersections

Map 2 illustrates the arterials and intersections in the City of Sheffield Lake included in this analysis. It also shows the 2022-2023 crash locations where fatalities or serious injuries occurred.

Map 2: Arterials and Intersections in the City of Sheffield Lake



PART III: Crash Frequency Prediction

The developed SPFs were used to estimate the annual average crash frequency for each of the selected arterials and intersections. Due to a lack of comprehensive data for the crash modification factors (CMFs), the calibration factor, C_r, was derived from two sources:

- The recorded crash data for 2022 and 2023
- The total daily auto and truck VMT of arterials

The process of calculating the calibration factors is as follows:

- Cities and villages within each of the five counties are grouped based on a set of VMT ranges. The VMT ranges are determined based on generating a normal distribution of communities.
- The ratio of the total observed to total predicted crashes is calculated for all the selected arterials and intersections within each city and village.
- Within each VMT range, the median value of the above ratios is selected as the calibration factor for those jurisdictions in the associated VMT range.
- The calibration factor is then applied to each arterial segment and intersection within a community to estimate the final annual average crash frequency.

Table 5 displays the daily arterial VMT ranges for communities of Lorain County and their associated calibration factors.

Table 5: Daily Arterial VMT Ranges and Calibration Factors for Jurisdictions of Lorain County

DAILY ARTERIAL VMT RANGE	JURISDICTIONS INCLUDED	CALIBRATION FACTOR
< 30,000	Grafton, Sheffield Lake	2.33
30,000 - 125,000	Amherst, Avon Lake	3.21
> 150,000	Avon, Elyria, Lorain, North Ridgeville, Sheffield	2.47

Tables 6 and 7 provide the predicted crashes by arterial and intersection, respectively. **These estimated average annual crash frequencies are the calibrated and aggregated values of motorized and nonmotorized collisions.**

Table 6: Estimated Average Annual Crash Frequency for Selected Arterial Segments

ROAD NAME	FROM	TO	ESTIMATED AVERAGE ANNUAL CRASH FREQUENCY
SR 301 (ABBE RD N)	SHEFFIELD LAKE SCL	LAKE RD (US-6)	1.12
US 6 (LAKE RD)	E OF ROOT RD	E OF ERIEVIEW BLVD	9.57

Table 7: Estimated Average Annual Crash Frequency for Selected Intersections

MAJOR RD	MINOR RD	ESTIMATED AVERAGE ANNUAL CRASH FREQUENCY
US 6 (LAKE RD)	LAKE BREEZE RD	2.51
US 6 (LAKE RD)	SR 301 (ABBE RD N)	2.26

Tables 8 and 9 display breakouts of the predicted nonmotorized crashes by arterial and intersection, respectively. **The nonmotorized crashes include the calibrated total value of vehicle-bicycle and vehicle-pedestrian collisions.**

Table 8: Estimated Average Annual Nonmotorized Crash Frequency for Selected Arterials

ROAD NAME	LENGTH (MILES)	ESTIMATED AVERAGE ANNUAL NONMOTORIZED CRASH FREQUENCY
SR 301 (ABBE RD N)	0.59	0.01
US 6 (LAKE RD)	3.50	0.09

Table 9: Estimated Average Annual Nonmotorized Crash Frequency for Selected Intersections

MAJOR RD	MINOR RD	ESTIMATED AVERAGE ANNUAL NONMOTORIZED CRASH FREQUENCY
US 6 (LAKE RD)	LAKE BREEZE RD	0.26
US 6 (LAKE RD)	SR 301 (ABBE RD N)	0.25

PART IV: Prioritization of Expected Crash Sites

Part IV includes Tables 10 and 11, which tabulate a prioritized ranking of the selected arterials and intersections based on the estimated average annual crash frequency from highest to lowest.

Table 10: Selected Arterials Ranked by Expected Average Annual Crash Frequency

RANK	ROAD NAME	FROM	TO
1	US 6 (LAKE RD)	E OF ROOT RD	E OF ERIEVIEW BLVD
2	SR 301 (ABBE RD N)	SHEFFIELD LAKE SCL	LAKE RD (US-6)
3	LAKEBREEZE RD	SHEFFIELD NCL	US 6 (LAKE RD)

Table 11: Selected Intersections Ranked by Expected Average Annual Crash Frequency

RANK	MAJOR RD	MINOR RD
1	US 6 (LAKE RD)	LAKE BREEZE RD
2	US 6 (LAKE RD)	SR 301 (ABBE RD N)

Map 3 highlights the aforementioned prioritized sites in the City of Sheffield Lake. The arterial segments highlighted in various colors, from red to green, represent the highest estimated average annual arterial segment crash frequency. The purple circles represent the estimated average annual intersection crash frequency, with larger circles indicating higher rankings.

Map 3: Arterial and Intersection Prioritization Sites

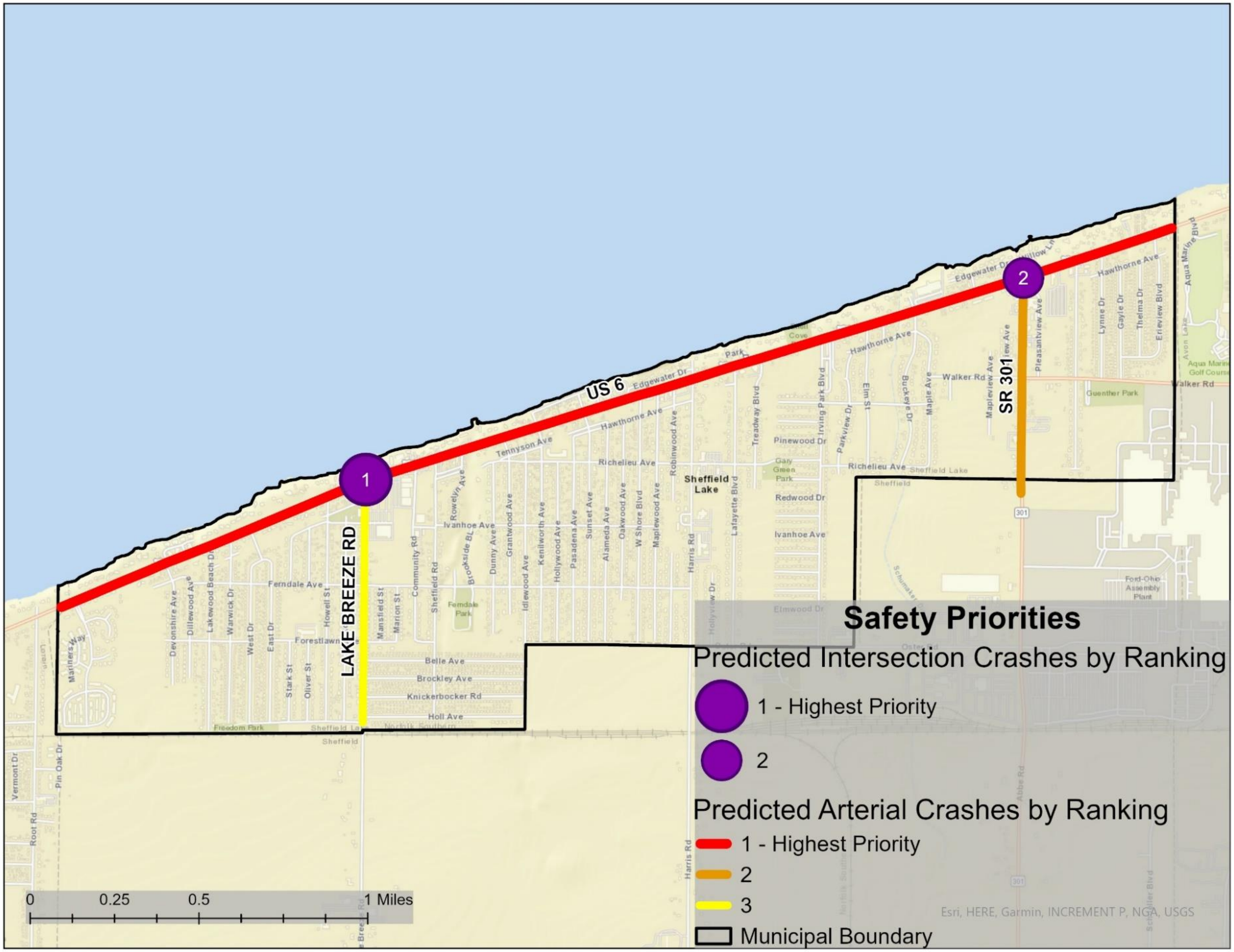


Table 12 summarizes the total annual average of 2022 and 2023 recorded crash data and the total expected annual average crash frequency for the selected arterials and intersections in the City of Sheffield Lake.

Table 12: Comparison of History and Predicted Annual Average Crash Frequency

SELECTED ARTERIALS AND INTERSECTIONS IN THE CITY OF SHEFFIELD LAKE	
TOTAL RECORDED AVERAGE ANNUAL CRASH DATA	TOTAL ESTIMATED AVERAGE ANNUAL CRASH FREQUENCY
16.50	15.45

The prioritized sites should be examined in tandem with the observed history of crash locations to invest in safety improvements with higher efficacy. Additionally, certain safety features or traffic calming measures can be incorporated into the SPFs to forecast how improvements can affect expected crashes (e.g., adding medians, turning lanes, or automated speed enforcement). It should be noted that US 6 (Lake Road) from East of Root Road to East of Erieview Boulevard has both the highest expected and observed crashes and is therefore the top candidate for safety countermeasures. Part V contains proven countermeasures compiled by the Federal Highway Administration (FHWA) to assist in selecting safety improvements.

If recorded crashes are HIGHER than estimated crashes…	…then this may be due to roadway hazards and conditions not yet captured in the SPFs or human error during vehicle operation.
If recorded crashes are LOWER than estimated crashes…	…then those segments may have incorporated safety countermeasures not captured in the SPFs.

PART V: Cost-Benefit Analysis and Regional Statistics

Cost-Benefit Analysis

Using data from the Federal Highway Administration's (FHWA) Proven Safety Countermeasures and PedBikeSafe, this analysis examines crash reduction strategies based on a cost-benefit ratio. By analyzing crash data from the Ohio Department of Transportation's (ODOT) Geographic Crash Analysis Tool (GCAT) and the American Association of State Highway and Transportation Officials' (AASHTO) AASHTOWare Crash Query tool, the study takes into account that human error contributes to 48% of crashes. 48% of crashes analyzed were attributed to factors such as poor decision-making (e.g., speeding, impaired or distracted driving), user errors identified by responding officers, and contributing circumstances like running red lights or improper lane changes. Infrastructure deficits account for the remaining 52%. Common infrastructure issues include inadequate or poorly visible road signage, lack of pedestrian and bicycle infrastructure, and insufficient lighting, particularly at night, which increases pedestrian-related crashes. Based on the 2024 crash severity proportions and crash costs from ODOT, the average crash cost was about $75,010. However, taking 52% of the total average crash cost, a proportional estimate attributed to the infrastructure deficit is $38,632. Then, the expected crash reductions were calculated by multiplying the crash reduction factor from FHWA by the predicted pedestrian, bicycle, or motorized crashes that were calculated according to AASHTO Highway Safety Manual formulas, multiplied by our 52% infrastructure cost of $38,632, which came up with an annual savings figure for fewer crashes occurring in that segment. For segments where pedestrian or bicycle countermeasures were recommended, the projected yearly savings were calculated over ten years to emphasize long-term impacts and crash reduction. In contrast, the predicted crash rates were ten times higher for segments where vehicle-related countermeasures were suggested due to the significantly larger number of vehicle users. As a result, only a single year's savings was considered when calculating their ratios. In this manner, the data are more directly comparable since the values are of the same magnitude for both groups.

A benefit-cost ratio consists of a numerator and a denominator. The annual savings from crash reductions at each location serve as the numerators, while the denominators reflect the present value of the equipment costs needed for the intervention. This methodology empowers stakeholders to determine safety enhancements that meet local needs by weighing the benefits of fewer crashes against the expenses of employing these safety measures. Although they do not account for ongoing maintenance or replacement costs, these preliminary figures are sufficient to argue that low-cost countermeasures should be deployed in as many locations as possible. The findings of this research present a strong financial case for investing in road safety improvements with the potential for lasting benefits, especially for nonmotorized users, as crashes are reduced and prevented.

Furthermore, the quality of the cost-benefit ratio was assessed using the SAFE RETURNS qualitative range, which was separated into four different levels based on degrees of effectiveness or impact. Four levels are applied:

Satisfactory, indicating that the outcome is acceptable and satisfies the bare minimum requirements (0* - 2)
Approved, indicating that the outcome is appropriate and expected to meet or is slightly above expectations (2 - 6)
Favorable, indicating a solid result that is better than predicted (6 - 10) and
Excellent, indicating a remarkable outcome above expectations (greater than 10).

*Although a ratio above 1.0 is generally considered a good return, a few segments below 1.0 do not result in benefits. However, safety is about saving lives, not just financial outcomes.

Example - Safety Measure Recommendation

Bicycle Lanes and Delineators

For the City of Sheffield Lake, as shown in the table below, the chosen safety measure includes the installation of:

Bicycle Lanes with Delineators provide separation and a vertical barrier (optionally with a marked buffer area for even better protection) to separate bicyclists from vehicles.

Appendix C includes more information about all the FHWA Proven Safety Countermeasures.

This improvement is expected to reduce the number of crashes by 53%. The total cost of the countermeasures is $394,160. As a result, the benefit-cost ratio (BCR) is calculated to be 0.01, indicating that the investment is considered a satisfactory return.

Table 13: Cost-Benefit and Safety Measures Analysis

TOTAL COSTS	REDUCES CRASHES BY %	DECADE OF SAVINGS	B/C RATIO	SAFE RETURNS
$394,160	53%	$4,160	0.01	SATISFACTORY

CITY	ROAD NAME	FROM	TO	COUNTERMEASURE
SHEFFIELD LAKE	US 6 (LAKE RD)	E OF ROOT RD	E OF ERIEVIEW BLVD	BUFFER AND DELINEATORS TO BIKE LANES

Lists of Countermeasures & Costs

The tables below list motorized and nonmotorized countermeasures recommended for communities in these reports. Cost estimates for each countermeasure were obtained from the FHWA, with the highest cost used when a range was provided. These estimates were adjusted for inflation at a rate of 2% per year from the original publication of the information to ensure costs align with present values. It should be noted that these estimates were approximated and not directly compared to actual costs, which may vary depending on regional markets and specific implementation requirements. Nevertheless, these estimates serve as a resource for community planning, decision-making, and education about the costs and benefits of crash reduction strategies.

Table 14: Nonmotorized Countermeasure Cost and Impact Assessment

NONMOTORIZED COUNTERMEASURES	COSTS	RATIO RANGES	10 YEARS SAVINGS
High Visibility Crosswalk Marking (HVCM)	$6,400	0 – 12	$1,600 – $76,700
Rectangular Rapid Flashing Beacon (RRFB)	$58,600	0 – 1	$5,200 – $90,600
Pedestrian Refuge Island (PRI)	$46,400	0 – 3	$21,700 – $123,400
Pedestrian Hybrid Beacons (PHB)	$144,100	0.02	$2,300
Leading Pedestrian Interval (LPI)	$1,400	2 – 10	$2,400 – $13,700
Bicycle Lanes and Delineators	$56,300 (per mile)	No Financial Benefit	$4,200 – $10,700
Concrete Sidewalks - Patterned	$200 (Linear Foot)	0 – 1	$103,800 – $343,200
HVCM+ RRFB	$65,000	0 – 6	$13,300 – $37,100
HVCM+ PRI	$52,800	1 – 2	$55,000 – $128,300
HVCM+ LPI	$7,800	3 – 7	$23,900 – $58,400

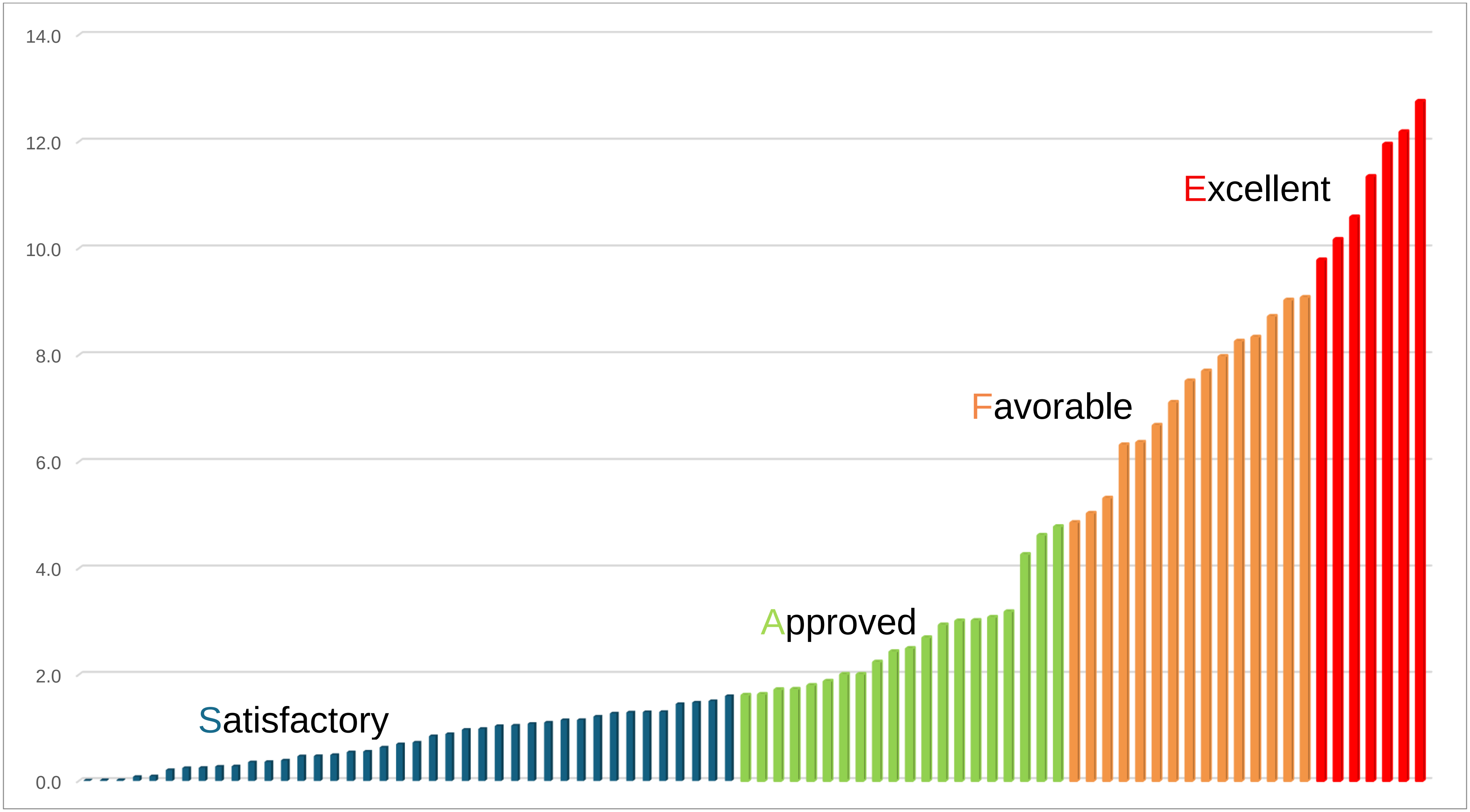
Table 15: Motorized Countermeasure Cost and Impact Assessment

MOTORIZED COUNTERMEASURES	COSTS	RATIO RANGES	ANNUAL SAVINGS
Backplates with Retroreflective Borders	$100 (per new plate)	12 – 78	$13,600 – $87,400
Wider Edge Lines	$700 (per mile)	27.5	$91,000
Center Line Rumble Strips	$7,200 (per mile)	5 – 13	$65,200 – $278,000
Shoulder Rumble Strips	$7,200 (per mile)	1 – 8	$23,800 – $112,000

Regional Overview

Based on the reported SAFE Returns qualitative range, the chart displays the benefit-cost ratios (BCR) for all segments where countermeasures were recommended. While a few ratios are at the lower and higher ends of the ideal range, most countermeasures fall within a reasonable and acceptable range.

Figure 7: Overview of Cost-Benefit Ratios in Qualitative Range



Appendix A: Outputs of Safety Performance Functions and Recorded Crashes

The following tables contain the outputs of the HSM Safety Performance Functions before calibration for the selected arterial segments and intersections in the City of Sheffield Lake.

Table A-1: Predicted Average Vehicle Crashes of Arterials (Excluding Pedestrians and Bicycles)

ROAD NAME	NON-DRIVEWAY				DRIVEWAY	
	MULTIPLE-VEHICLE PREDICTED CRASHES PER YEAR		SINGLE-VEHICLE PREDICTED CRASHES PER YEAR		MULTIPLE-VEHICLE PREDICTED CRASHES PER YEAR	
	FATAL AND INJURY	PROPERTY DAMAGE ONLY	FATAL AND INJURY	PROPERTY DAMAGE ONLY	FATAL AND INJURY	PROPERTY DAMAGE ONLY
SR 301 (ABBE RD N)	0.028	0.065	0.211	0.005	0.054	0.113
US 6 (LAKE RD)	0.264	0.616	1.396	0.089	0.549	1.152

Table A-2: Predicted Average Vehicle Crashes at Intersections (Excluding Pedestrians and Bicycles)

MAJOR RD	MINOR RD	MULTIPLE-VEHICLE PREDICTED CRASHES PER YEAR		SINGLE-VEHICLE PREDICTED CRASHES PER YEAR	
		FATAL AND INJURY	PROPERTY DAMAGE ONLY	FATAL AND INJURY	PROPERTY DAMAGE ONLY
US 6 (LAKE RD)	LAKE BREEZE RD	0.257	0.640	0.036	0.030
US 6 (LAKE RD)	SR 301 (ABBE RD N)	0.224	0.574	0.036	0.026

Table A-3: Predicted Average Pedestrian and Bicycle Crashes of Arterials

ROAD NAME	LENGTH (MILES)	PEDESTRIAN PREDICTED CRASHES PER YEAR	BICYCLE PREDICTED CRASHES PER YEAR
SR 301 (ABBE RD N)	0.59	0.002	0.002
US 6 (LAKE RD)	3.50	0.020	0.016

Table A-4: Predicted Average Pedestrian and Bicycle Crashes at Intersections

MAJOR RD	MINOR RD	PEDESTRIAN PREDICTED CRASHES PER YEAR	BICYCLE PREDICTED CRASHES PER YEAR
US 6 (LAKE RD)	LAKE BREEZE RD	0.098	0.014
US 6 (LAKE RD)	SR 301 (ABBE RD N)	0.096	0.013

Appendix B: Highway Safety Manual Coefficient Tables and Functions

The following equations and tables are extracted from Chapter 12 of the Highway Safety Manual (2010).

Arterials

<u>Multiple-Vehicle Non-Driveway Crashes</u>

$$N_{brmv} = exp(a + b \times ln(ADT) + ln(\mathrm{L}))$$

Where:

$N_{brmv} =$ *Predicted average crash frequency of an individual roadway segment for multiple vehicle nondriveway crashes*

$\mathrm{ADT} = Average\ Daily\ Two\ Way\ Traffic\ Volume$

$\mathrm{L} = Number\ of\ Lanes$

Table B-1: SPF Coefficients for Multiple-Vehicle Non-Driveway Crashes on Roadway Segments

ROAD TYPE	TOTAL CRASHES		FATAL AND INJURY CRASHES		PROPERTY DAMAGE ONLY CRASHES	
	INTERCEPT (a)	ADT (b)	INTERCEPT (a)	ADT (b)	INTERCEPT (a)	ADT (b)
2U	-15.22	1.68	-16.22	1.66	-15.62	1.69
3T	-12.40	1.41	-16.45	1.69	-11.95	1.33
4U	-11.63	1.33	-12.08	1.25	-12.53	1.38
4D	-12.34	1.36	-12.76	1.28	-12.81	1.38
5T	-9.70	1.17	-10.47	1.12	-9.97	1.17

$$N_{brmv(FI)} = N_{brmv}\left(\frac{N'_{brmv(FI)}}{N'_{brmv(FI)} + N'_{brmv(PDO)}}\right)$$

Where:

$N'_{bmrv(FI)} = preliminary\ fatal\ and\ injury\ predicted\ crash\ frequency\ for$ $multiple\ vehicle\ nondriveway\ crashes$

$N'_{brmv(PDO)} = preliminary\ property\ damage\ only\ predicted\ crash\ frequency\ for$ $multiple\ vehicle\ nondriveway\ crashes$

The *N'* values use the same formula as N_{brmv} but replace the *a* and *b* coefficients with the respective values for fatal and injury crashes and property damage only crashes from Table B-1.

Finally, to ensure $N_{brmv} = N_{brmv(FI)} + N_{brmv(PDO)}$, the following equation is used to calculate $N_{brmv(PDO)}$.

$$N_{brmv(PDO)} = N_{brmv} - N_{brmv(FI)}$$

Single-Vehicle Crashes

$$N_{brsv} = exp(a + b \times ln(ADT) + ln(\mathrm{L}))$$

Where:

$N_{brsv} =$ $Predicted\ average\ crash\ frequency\ of\ an\ individual\ roadway\ segment\ for\ single\ vehicle\ crashes$

$\mathrm{ADT} = Average\ Daily\ Two\ Way\ Traffic\ Volume$

$\mathrm{L} = Number\ of\ Lanes$

Table B-2: SPF Coefficients for Single-Vehicle Crashes on Roadway Segments

ROAD TYPE	TOTAL CRASHES		FATAL AND INJURY CRASHES		PROPERTY DAMAGE ONLY CRASHES	
	INTERCEPT (a)	ADT (b)	INTERCEPT (a)	ADT (b)	INTERCEPT (a)	ADT (b)
2U	-5.47	0.56	-3.96	0.23	-6.51	0.64
3T	-5.74	0.54	-6.37	0.47	-6.29	0.56
4U	-7.99	0.81	-7.37	0.61	-8.50	0.84
4D	-5.05	0.47	-8.71	0.66	-5.04	0.45
5T	-4.82	0.54	-4.43	0.35	-5.83	0.61

$$N_{brsv(FI)} = N_{brsv}\left(\frac{N'_{brsv(FI)}}{N'_{brsv(FI)} + N'_{brsv(PDO)}}\right)$$

Where:

$N'_{bmsv(FI)} = preliminary\ fatal\ and\ injury\ predicted\ crash\ frequency\ for\ \text{single vehicle crashes}$

$N'_{brsv(PDO)} = preliminary\ property\ damage\ only\ predicted\ crash\ frequency\ for\ \text{single vehicle crashes}$

The *N'* values use the same formula as N_{brsv} but replace the *a* and *b* coefficients with the respective values for fatal and injury crashes and property damage only crashes from Table B-2.

Finally, to ensure N_{brsv} = $N_{brsv(FI)} + N_{brsv(PDO)}$, the following equation is used to calculate $N_{brsv(PDO)}$.

$$N_{brsv(PDO)} = N_{brsv} - N_{brsv(FI)}$$

Multiple-Vehicle Driveway Crashes

The function below calculates the number of predicted multiple-vehicle driveway crashes. The values for N_j and *t* are taken from Table B-3 below.

$$N_{brdwy} = \sum_{\substack{\text{all} \\ \text{driveway} \\ \text{types}}} n_j \times N_j \times \left(\frac{ADT}{15{,}000}\right)^{(t)}$$

Where:

$N_{brdwy} =$ $Predicted\ average\ crash\ frequency\ of\ an\ individual\ roadway\ segment\ for\ multipe-vehicle\ driveway\ crashes$

$n_j = Number\ of\ driveways\ along\ a\ roadway\ segment$

$N_j = Number\ of\ driveway-related\ collision\ per\ driveway\ per\ year\ coefficient$

$ADT = Average\ Daily\ Two\ Way\ Traffic\ Volume$

$t = Regression\ coefficient\ for\ traffic\ volume\ adjustment$

Table B-3: SPF Coefficients for Multiple-Vehicle Driveway Crashes on Roadway Segments

DRIVEWAY TYPE (j)	2U	3T	4U	4D	5T
NUMBER OF DRIVEWAY-RELATED COLLISIONS PER DRIVEWAY PER YEAR (N_j)					
MAJOR COMMERCIAL	0.158	0.102	0.182	0.033	0.165
MINOR COMMERCIAL	0.050	0.032	0.058	0.011	0.053
MAJOR INDUSTRIAL/INSTITUTIONAL	0.172	0.110	0.198	0.036	0.181
MINOR INDUSTRIAL/INSTITUTIONAL	0.023	0.015	0.026	0.005	0.024
MAJOR RESIDENTIAL	0.083	0.053	0.096	0.018	0.087
MINOR RESIDENTIAL	0.016	0.010	0.018	0.003	0.016
OTHER	0.025	0.016	0.029	0.005	0.027
REGRESSION COEFFICIENT FOR ADT (t)					
ALL DRIVEWAYS	1.000	1.000	1.172	1.106	1.172
PROPORTION OF FATAL AND INJURY CRASHES (f_{dwy})					
ALL DRIVEWAYS	0.323	0.243	0.342	0.284	0.269
PROPORTION OF PROPERTY DAMAGE ONLY CRASHES					
ALL DRIVEWAYS	0.677	0.757	0.658	0.716	0.731

$$N_{brdwy(FI)} = N_{brdwy} \times f_{dwy}$$

Where:

$f_{dwy} = proportion\ of\ fatal\ and\ injury\ crashes\ coefficient$ from Table B-3.

To ensure N_{brdwy} = $N_{brdwy(FI)} + N_{brdwy(PDO)}$, the following equation is used to calculate $N_{brdwy(PDO)}$.

$$N_{brdwy(PDO)} = N_{brdwy} - N_{brdwy(FI)}$$

The final calculation for total (motorized) vehicle crashes along arterials is a sum of the three types of crashes detailed above:

$$N_{br} = N_{brmv} + N_{brsv} + N_{brdwy}$$

Bicycle and Pedestrian Crashes

To calculate predicted pedestrian crashes, the vehcile crashes are multiplied by the appropriate Pedestrian Crash Adjustment factor in Table B-4 (f_{pedr}).

$$N_{pedr} = N_{br} \times f_{pedr}$$

Table B-4: Pedestrian Crash Adjustment Factor for Roadway Segments

ROAD TYPE	POSTED SPEED 30 MPH OR LOWER	POSTED SPEED GREATER THAN 30 MPH
2U	0.036	0.005
3T	0.041	0.013
4U	0.022	0.009
4D	0.067	0.019
5T	0.030	0.023

Similarly, the Bicycle Crash Adjustment factors in Table B-5 are used to calculate predicted bicycle crashes.

$$N_{biker} = N_{br} \times f_{biker}$$

Table B-5: Bicycle Crash Adjustment Factor for Roadway Segments

ROAD TYPE	POSTED SPEED 30 MPH OR LOWER	POSTED SPEED GREATER THAN 30 MPH
2U	0.018	0.004
3T	0.027	0.007
4U	0.011	0.002
4D	0.013	0.005
5T	0.050	0.012

Intersections

Multiple-Vehicle Intersection Crashes

$$N_{bimv} = exp(a + b \times ln(ADT_{maj}) + c \times ln(ADT_{min}))$$

Where:

$N_{bimv} =$ *Predicted average crash frequency of multiple vehicle crashes for an intersection*

$ADT_{maj} =$ *Average Daily Two Way Traffic Volume for the major road at an intersection*

$ADT_{min} =$ *Average Daily Two Way Traffic Volume for the minor road at an intersection*

Table B-6: SPF Coefficients for Multiple-Vehicle Crashes at Intersections

INTERSECTION TYPE	TOTAL CRASHES			FATAL AND INJURY CRASHES			PROPERTY DAMAGE ONLY CRASHES		
	INTERCEPT (a)	ADT_{maj} (b)	ADT_{min} (c)	INTERCEPT (a)	ADT_{maj} (b)	ADT_{min} (c)	INTERCEPT (a)	ADT_{maj} (b)	ADT_{min} (c)
3ST	-13.36	1.11	0.41	-14.01	1.16	0.30	-15.38	1.20	0.51
3SG	-12.13	1.11	0.26	-11.58	1.02	0.17	-13.24	1.14	0.30
4ST	-8.90	0.82	0.25	-11.13	0.93	0.28	-8.74	0.77	0.23
4SG	-10.99	1.07	0.23	-13.14	1.18	0.22	-11.02	1.02	0.24

$$N_{bimv(FI)} = N_{bimv}\left(\frac{N'_{bimv(FI)}}{N'_{bimv(FI)} + N'_{bimv(PDO)}}\right)$$

Where:

$N'_{bimv(FI)} = preliminary\ fatal\ and\ injury\ predicted\ crash\ frequency\ for$ multiple vehicle crashes $at\ intersections$

$N'_{bimv(PDO)} = preliminary\ property\ damage\ only\ predicted\ crash\ frequency\ for$ multiple vehicle crashes $at\ intersections$

The *N'* values use the same formula as N_{bimv} but replace the *a*, *b*, and *c* coefficients with the respective values for fatal and injury crashes and property damage only crashes from Table B-6.

Finally, to ensure $N_{bimv} = N_{bimv(FI)} + N_{bimv(PDO)}$, the following equation is used to calculate $N_{bimv(PDO)}$.

$$N_{bimv(PDO)} = N_{bimv} - N_{bimv(FI)}$$

Single-Vehicle Intersection Crashes

$$N_{bisv} = exp(a + b \times ln(ADT_{maj}) + c \times ln(ADT_{min}))$$

Where:

$N_{bisv} =$ *Predicted average crash frequency of single vehicle crashes at an intersection*

$ADT_{maj} =$ *Average Daily Two Way Traffic Volume for the major road at an intersection*

$ADT_{min} =$ *Average Daily Two Way Traffic Volume for the minor road at an intersection*

Table B-7: SPF Coefficients for Single-Vehicle Crashes at Intersections

INTERSECTION TYPE	TOTAL CRASHES			FATAL AND INJURY CRASHES			PROPERTY DAMAGE ONLY CRASHES		
	INTERCEPT (a)	ADT_{maj} (b)	ADT_{min} (c)	INTERCEPT (a)	ADT_{maj} (b)	ADT_{min} (c)	INTERCEPT (a)	ADT_{maj} (b)	ADT_{min} (c)
3ST	-6.81	0.16	0.51				-8.36	0.25	0.55
3SG	-9.02	0.42	0.40	-9.75	0.27	0.51	-9.08	0.45	0.33
4ST	-5.33	0.33	0.12				-7.04	0.36	0.25
4SG	-10.21	0.68	0.27	-9.25	0.43	0.29	-11.34	0.78	0.25

To calculate fatal and injury crashes at 3SG and 4SG intersections, the following function is used:

$$N_{bisv(FI)} = N_{bisv}\left(\frac{N'_{bisv(FI)}}{N'_{bisv(FI)} + N'_{bisv(PDO)}}\right)$$

Where:

$N'_{bisv(FI)} = preliminary\ fatal\ and\ injury\ predicted\ crash\ frequency\ for\ \text{multiple vehicle crashes}\ at\ intersections$

$N'_{bisv(PDO)} = preliminary\ property\ damage\ only\ predicted\ crash\ frequency\ for\ \text{multiple vehicle crashes}\ at\ intersections$

The *N'* values use the same formula as N_{bisv} but replace the *a*, *b*, and *c* coefficients with the respective values for fatal-and-injury crashes and property damage only crashes from Table B-7.

Table B-8 is used for Single-Vehicle fatal and injury crashes at stop-sign-controlled intersections since no regression coefficients exist for these types of intersections.

$$N_{bisv(FI)} = N_{bisv} \times f_{bisv}$$

Where:

$f_{bisv} = proportion\ of\ fatal\ and\ injury\ crashes$

Table B-8: Factors for Single-Vehicle Fatal and Injury Crashes at Stop-Controlled Intersections

INTERSECTION TYPE	ADJUSTMENT FACTOR
3ST	0.31
4ST	0.28

Finally, to ensure $N_{bisv} = N_{bisv(FI)} + N_{bisv(PDO)}$, the following equation is used to calculate $N_{bisv(PDO)}$.

$$N_{bisv(PDO)} = N_{bisv} - N_{bisv(FI)}$$

The final calculation for total (motorized) vehicle crashes at intersections is a sum of the multiple-vehicle and single-vehicle crashes detailed above:

$$N_{bi} = N_{bimv} + N_{bisv}$$

Bicycle and Pedestrian Intersection Crashes

$$N_{bikei} = N_{bi} \times f_{bikei}$$

Table B-9: Bicycle Crash Adjustment Factor for Intersections

INTERSECTION TYPE	BICYCLE CRASH ADJUSTMENT FACTOR
3ST	0.016
3SG	0.011
4ST	0.018
4SG	0.015

$$N_{pedi} = N_{bi} \times f_{pedi}$$

Table B-10: Pedestrian Crash Adjustment Factor for Stop-Controlled Intersections

INTERSECTION TYPE	PEDESTRIAN CRASH ADJUSTMENT FACTOR
3ST	0.021
4ST	0.022

$$N_{pedbase} = exp(a + b \times ln(ADT_{total}) + c \times \ln\left(\frac{ADT_{min}}{ADT_{maj}}\right) + d \times \ln(PedVol) + e \times n_{lanesx})$$

Where:

$ADT_{total}(= ADT_{maj} + ADT_{min})$ $Average\ Daily\ Traffic\ volume\ for\ the\ major\ and\ minor\ roads$

$PedVol = sum\ of\ daily\ pedestrian\ volumes\ crossing\ all\ intersection\ legs$

$n_{lanesx} = maximum\ number\ of\ traffic\ lanes\ crossed\ by\ a\ pedestrian\ at\ the\ intersection$

Table B-11: Pedestrian Crash Adjustment Factor for Signal-Controlled Intersections

INTERSECTION TYPE	INTERCEPT (a)	ADT_{total} (b)	ADT_{min}/ADT_{maj} (c)	PedVol (d)	n_{lanesx} (e)
3SG	-6.60	0.05	0.24	0.41	0.09
4SG	-9.53	0.40	0.26	0.45	0.04

Table B-12: Pedestrian Crash Adjustment Factor for Signal-Controlled Intersections

GENERAL LEVEL OF PEDESTRIAN ACTIVITY	3SG	4SG
High	1,700	3,200
Medium-High	750	1,500
Medium	400	700
Medium-Low	120	240
Low	20	50

Crash Modification Factors

The HSM includes the following roadway and arterial features as Crash Modification Factors (CMFs), which can impact expected crashes beyond the aforementioned roadway characteristics. These characteristics include:

Segment CMFs:

- On-Street Parking
- Roadside Fixed Objects
- Width of Median (if present)
- Lighting
- Automated Speed Enforcement

Intersection CMFs:

- Left Turn Lanes
- Left Turn Signal Phasing
- Right Turn Lanes
- Right Turn on Red
- Lighting
- Red Light Cameras

The scope of this report does not include a detailed roadway inventory of the specific characteristics associated with the Crash Modification Factors. Therefore, all CMF values were assumed to be equal to 1 for the purposes of this report, having no impact on the predicted crash frequency calculations.

These CMF characteristics, however, could be identified and taken into account for a more detailed future analysis of specific roadway segments or intersections, should a jurisdiction desire to do so.

Appendix C: FHWA Proven Safety Countermeasures

The Federal Highway Administration (FHWA) details 28 safety strategies that have been proven to reduce fatal and serious injury crashes. A summary of each countermeasure is listed below. Detailed information can be found at https://safety.fhwa.dot.gov/provencountermeasures/. FHWA resources can provide guidance when determining how to improve safety at the priority locations listed in Part IV of this report, as well as roadways and intersections with a history of high recorded crashes, and NOACA can also help.

FHWA has determined the categories for the tables of countermeasures.

Table C-1: Speed Management

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Speed Safety Cameras	Cameras that measure vehicle speeds and capture photographs or video of traffic over a specified speed threshold	47-54%
	Variable Speed Limits	Installing electronic signs to change the speed limits when road conditions change (e.g., congestion, crashes, weather/visibility)	34%
	Appropriate Speed Limits for All Road Users	Studying and updating speed limits for roads that are not limited access highways to protect vulnerable road users	26%

Table C-2: Roadway Departure

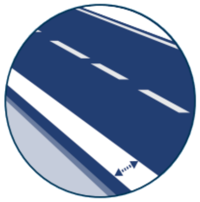
SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Wider Edge Lines	Increasing the width of edge lines for greater visibility of travel lanes and upcoming road alignment	22-37%
	Enhanced Delineation for Horizontal Curves	These markings indicate upcoming curves for drivers. Strategies include: • Pavement markings • In-lane curve warning pavement markings • Retroreflective strips on signposts • Delineators • Chevron signs • Larger, fluorescent, and/or retroreflective signs • Dynamic curve warning signs • Sequential dynamic chevrons	15-38%
	Longitudinal Rumble Strips and Stripes	Rumble Strips are milled or raised features outside travel lanes that indicate, with sound or vibrations, that a driver has drifted out of the lane. Rumble Stripes are rumble strips combined with painted markings to increase the visibility of the strips	13-51% (Shoulder) 44-64% (Center Line)
	SafetyEdge[SM]	These devices create a 30-degree slope at the roadway edge during paving to eliminate a vertical edge as the shoulder soil wears away	11-21%

Table C-2: Roadway Departure (continued)

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE

	Roadside Design Improvements at Curves	FHWA lists six design improvements to reduce crashes at curves, which can be implemented together or individually
		
		• Safe Recovery Areas
		  o Clear zone
		  o Slope flattening
		  o Adding or widening shoulders
		
		• Severity Reduction
		  o Cable barrier
		  o Metal-beam guardrail
		  o Concrete barrier
			22-44%

	Median Barriers	Median barriers separate opposing traffic and create divided highways to reduce head-on and cross-directional crashes Types of Medians: • Cable barriers • Metal-beam guardrails • Concrete barriers	97%

Table C-3: Intersections

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Backplates with Reflective Borders	Yellow reflective borders around traffic signals increase visibility at all times of the day and in various conditions	15%

Table C-3: Intersections (continued)

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Corridor Access Management	Access management is the design and control of roadway entry and exit points. FHWA provides the following strategies to improve interactions for all road users at a variety of access points: • Reduce density through driveway closure, consolidation, or relocation • Manage spacing of intersection and access points • Limit allowable movements at driveways (such as right-in/right-out only) • Place driveways on an intersection approach corner rather than a corner, which is expected to have fewer total crashes • Implement raised medians that preclude across-roadway movements • Use designs such as roundabouts or reduced left-turn conflicts (such as restricted crossing U-turns, median U-turns, etc.) • Provide turn lanes (i.e., left-only, right-only, or interior two-way left) • Use lower-speed, one-way, or two-way off-arterial circulation roads	5-23% (Rural) 25-31% (Urban)
	Left- and Right-Turn Lanes at Two-Way Stop-Controlled Intersections	Turning lane installations along a major road at an intersection with stop-controlled access for the minor road where there are large turning volumes or a history of turn-related crashes	28-48% (Left Turn) 14-26% (Right Turn)
	Reduced Left-Turn Conflict Intersections	Updating intersection geometric design to reduce left-turn conflicts. The recommended proven designs are Restricted Crossing U-Turn (RCUT) and Median U-Turn (MUT).	54-63% (RCUT) 30% (MUT)

Table C-3: Intersections (continued)

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Roundabouts	Roundabouts are intersections with circular design and yield-based entry, which reduce speeds and road-user conflict while also keeping traffic flowing	78-82%
	Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections	Suggested low-cost countermeasures include: • On the Through Approach ○ Doubled-up (left and right), oversized advance intersection warning signs, with supplemental street name plaques (can also include flashing beacon) ○ Retroreflective sheeting on signposts ○ Enhanced pavement markings that delineate through lane edge lines • On the Stop Approach ○ Doubled-up (left and right), oversized advance "Stop Ahead" intersection warning signs (can also include flashing beacon) ○ Doubled-up (left and right), oversized stop signs ○ Retroreflective sheeting on signposts ○ Properly placed stop bar ○ Removal of vegetation, parking, or obstructions that limit sight distance ○ Double arrow warning sign at the stem of T-intersections	10-27%
	Yellow Change Intervals	This countermeasure involves reviewing traffic signal timing to adjust the length of yellow signals so that the yellow is neither too long nor too short	8-14%

Table C-4: Pedestrian/Bicyclist

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Crosswalk Visibility Enhancement	Enhancements include high-visibility crosswalks, improved crosswalk lighting, and enhanced signage and pavement markings	25-42%
	Bicycle Lanes	These facilities provide separation between motorized traffic and bicycles and can involve road paint or a vertical barrier	30-49%
	Rectangular Rapid Flashing Beacons (RRFB)	RRFBs are flashing signals usually activated by a push button to alert motorists to the presence of a crosswalk	47%
	Leading Pedestrian Interval	Traffic signals are reprogrammed to provide several seconds of pedestrian crossing before motorists receive a green light	13%
	Medians and Pedestrian Refuge Island in Urban and Suburban Areas	Medians create separation between traffic flowing in opposite directions. A pedestrian refuge provides space within a median for pedestrians to wait safely after partially crossing a road.	46% (Median) 56% (Refuge Island)

Table C-4: Pedestrian/Bicyclist (continued)

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Pedestrian Hybrid Beacons	Pedestrian hybrid beacons remain ”dark“ until a pedestrian pushes the call button to activate the beacon. This initiates a yellow-to-red flashing light sequence, directing motorists to slow down and stop. These are often used at higher speed roadways, longer road segments without intersections, or where insufficient gaps in traffic exist	55% (Pedestrian) 15-29% (Total)
	Road Diets (Roadway Reconfiguration)	This countermeasure adjusts the number of lanes and lane widths to reduce speeds and increase safety perceptions for all road users. A typical example involves changing a four-lane undivided roadway into three lanes: one traffic lane in each direction, a center turning lane, and possible bicycle lanes	19-47%
	Walkways	Spaces for people walking or using wheelchairs: • Sidewalks • Shared-use paths • Pedestrian Walkways separated from roadways	65-89%

Table C-5: Crosscutting

SAFETY COUNTERMEASURE		DESCRIPTION	CRASH REDUCTION RATE
	Pavement Friction Management	This strategy involves understanding pavement friction conditions using Continuous Pavement Friction Measurement (CPFM) equipment and subsequently selecting appropriate locations to install High Friction Surface Treatment (HFST)	20-63%
	Lighting	Providing vertical and horizontal lighting both to reduce fatal crashes and improve the sense of safety for pedestrians	28-42%
	Local Road Safety Plans (LSRP)	LSRPs can help local jurisdictions identify and prioritize locally owned roadways for safety enhancements sensitive to local conditions and funding abilities.	17-35%
	Road Safety Audits (RSAs)	An RSA is conducted by a cross-discipline or cross-departmental team independent of a roadway project. It examines all factors across all road users and compiles them into a report. A response is required from the roadway owner before project work can proceed.	10-60%

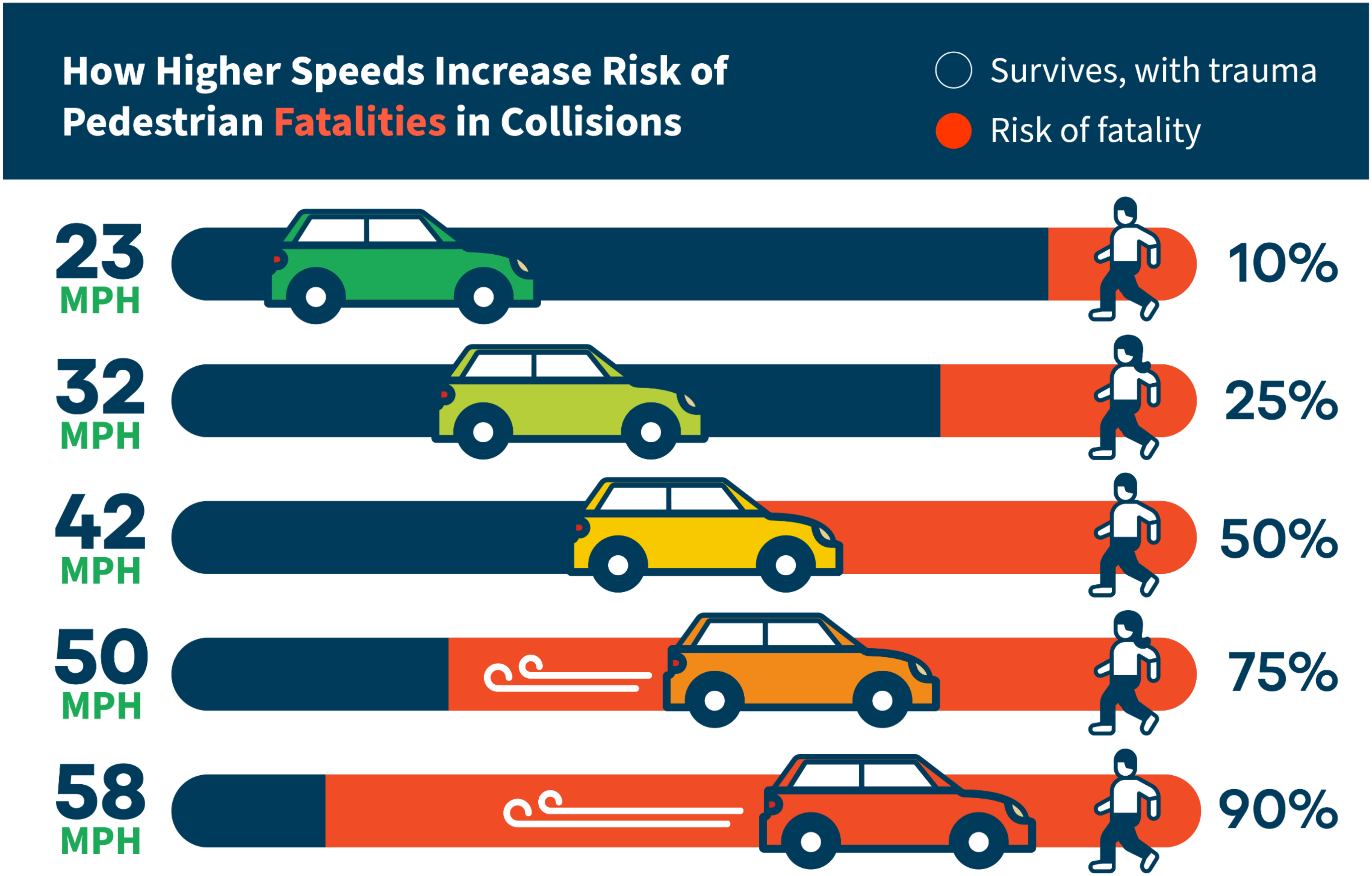
Appendix D: Educational Supplements

Speed Management

NOACA advises that communities systematically review and consider reducing speed limits within their boundaries. Reducing speeds citywide is essential for creating a safer and more livable urban environment. This comprehensive approach offers consistent safety standards across all roads, addressing traffic safety as a holistic issue. Lower speeds reduce the severity of collisions, allow for additional response time to hazards, provide enhanced protection for pedestrians and cyclists, and support the principles of Vision Zero initiatives aimed at eliminating traffic fatalities.

A citywide focus on speed reduction ensures that every road contributes to overall safety, regardless of classification. This approach simplifies enforcement efforts, promotes community equity by avoiding disparities in safety measures, and allows for more effective public awareness and education campaigns. Additionally, lower speeds contribute to improved traffic flow, making transportation more efficient and enhancing residents' overall quality of life. In summary, citywide, adopting speed reductions aligns with contemporary urban planning principles, prioritizes the well-being of all road users, and supports creating a safer, more sustainable, and vibrant urban environment. While the costs for this countermeasure come in time and overcoming resistance rather than money, they shouldn’t be underestimated. Seattle has seen a 26% reduction in traffic fatalities since implementing comprehensive, city-wide speed management strategies, including setting speed limits of non-arterial streets to 20mph and arterial streets to 25mph, so the savings are substantial.

Figure 8: Speed and Pedestrian Risk of Fatality

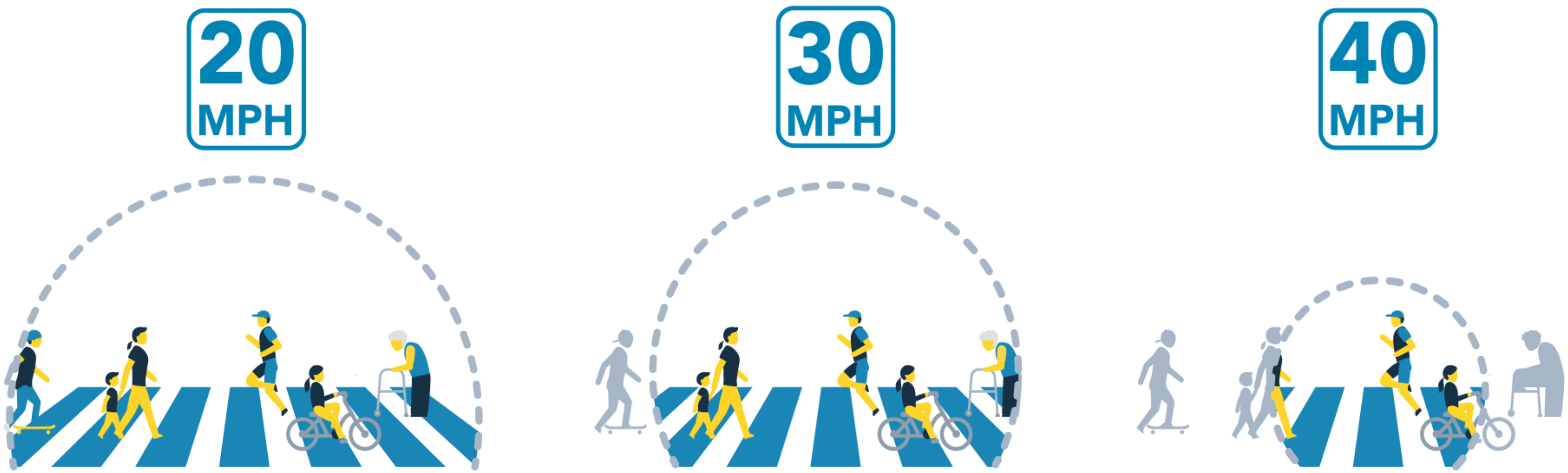


Source: NOACA graphic based on data from Tefft (2011)

Figure 9: Speed and Pedestrian Risk of Severe Injury

Source: NOACA graphic based on data from Tefft (2011)

Figure 10: How Our Cone of Vision Decreases with Greater Speed



Source: NACTO Urban Street Design Guide (2013)

Figure 11: Stopping Distance Increases with Greater Speeds

Source: FHWA

Figure 12: Co-Pilot Rights #PassengersSpeakUp

NOACA

Northeast Ohio Areawide Coordinating Agency

1299 Superior Avenue E.
Cleveland, Ohio 44114
www.noaca.org