SAFETY COUNTERMEASURE LIBRARY

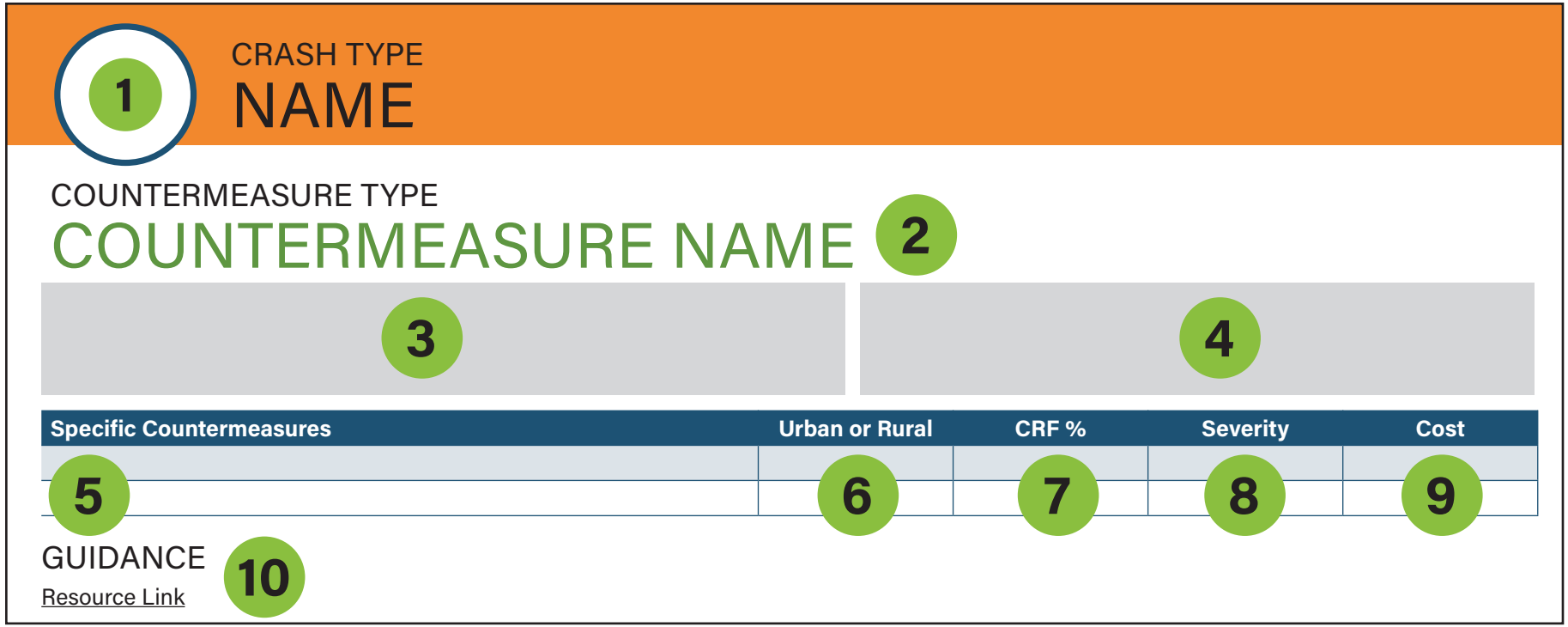
BLUEPRINT FOR SAFETY

CAMPO Regional Transportation Safety Action Plan

CONTENTS

HOW TO USE THIS DOCUMENT

This resource is a compilation of selected countermeasures, organized by countermeasure types and associated crash types, for consideration as an engineering treatment. This document does not include non-engineering countermeasures or address crash types associated with human factors, such as impairment or use of seat belts. The primary resource consulted for this document is the North Carolina Project Development Crash Reduction Factor (CRF) Information ("NCDOT CRF List").



1 Crash Type: Category of crashes, outlined as emphasis areas in the NC Strategic Highway Safety Plan (SHSP) - based on the first harmful event associated with a crash, such as a roadway element or mode of travel involved.

2 Countermeasure Type: Groups or sets of countermeasures broadly considered to address crash types.

3 Description of Countermeasure Type

4 Key Selection Factors: Highlights typical selection criteria - such as traffic volume, speed, number of lanes, and intersection configuration - used to determine the applicability of a countermeasure to a location.

5 Specific Countermeasures: An individual countermeasure and description of the applicable roadway element that has been studied for effectiveness to reduce crashes.

6 Location Type: Listed as "Urban", "Rural" or "All" depending on the context(s) in which the countermeasure is typically applied and/or studied for effectiveness to reduce crashes.

7 Crash Reduction Factor (CRF) Percentage: The percentage of expected crash reductions for a specific countermeasure based on research accepted for a treatment.

8 Severity: The severity of the injuries (as described in a crash report for the vehicles or persons involved) researched and described as crashes expected to be reduced by the specific countermeasure.

K = Fatality / A = Suspected Serious Injury
B = Suspected Minor Injury / C = Possible Injury

9 Cost: Relative cost to implement or construct a countermeasure. Costs increase (Low $) / Medium $$ / High $$$) based on factors such as project footprint, construction materials, and extent of analysis required.

10 Guidance: Resource links for additional information about conditions for safety implementation; does not include guidance for the design of specific treatments, typical sections or details.

BICYCLE

TOTAL CRASHES (2016-2023): **915**

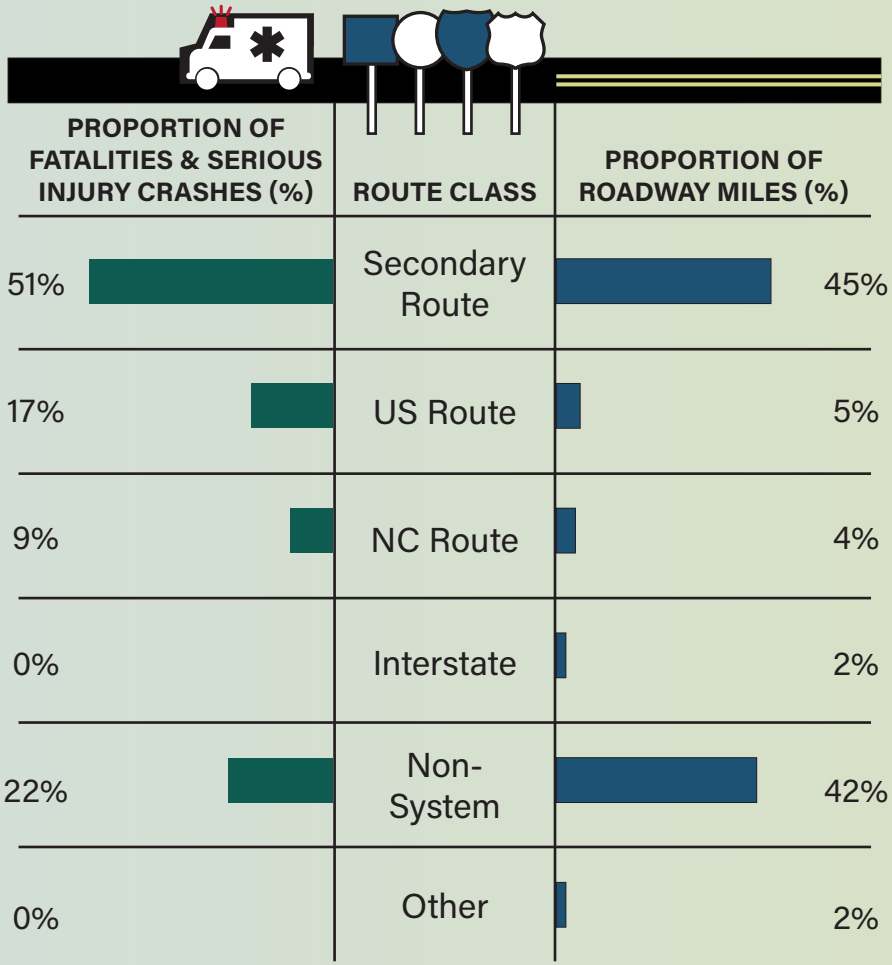
24	**74**
FATALITIES	SERIOUS INJURIES

PROPORTION OF FATAL AND SERIOUS INJURY CRASHES (%) BY DAYTIME (7AM-7PM) VS. NIGHTTIME CONDITIONS

NIGHTTIME %

42

PROPORTION OF CRASHES BY ROUTE CLASS



CRASH TYPE

BICYCLE

COUNTERMEASURE TYPE

BIKEWAYS

Bicycle-related crashes involve a bicyclist or pedalcyclist struck by a motor vehicle. Bikeways are dedicated networks along the roadway for persons traveling by bicycle or roads where bicyclists are a prioritized mode of travel.

KEY SELECTION FACTORS

Consider a designated bike lane for roads with traffic speeds above 30 miles per hour or where traffic volumes exceed 3,000 vehicles per day. Review for additional separation using buffer markings or vertical separation for roads with speeds above 35 miles per hour or volumes in excess of 6,000 vehicles per day.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Install Bicycle Boulevard	Urban	63	All	$$$
Install Buffered Bicycle Lane on 4-Lane Roadway	Urban	63	All	$$$
Removing Parking Lanes from Sides of Roadway	Urban	37	K, A, B, C	$$$
Install Buffered Bicycle Lane on 2-Lane Roadway	Urban	58	All	$$$
Install Bicycle Lane on 2-Lane Roadway	Urban	45	All	$$$
Install Bicycle Lane on 4-Lane Roadway	Urban	42	All	$$$
Convert Traditional or Flush Buffered Bicycle Lane to Separated Bicycle Lane with Flexible Delineator Posts	Urban	53	All	$$
Install Separated Bicycle Lane on 2-Lane Roadway	Urban	47	All	$$
Install Separated Bicycle Lane on 4-Lane Roadway	Urban	41	All	$$

NCDOT GUIDANCE

Multimodal Guidance: Transportation Mobility and safety Division (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Bikeway Selection Guide (2019)

FHWA, Proven Safety Countermeasures: Bicycle Lanes (2021)

FHWA, Separated Bike Lane Planning and Design Guide (2015)

FHWA, Separated Bike Lanes on Higher Speed Roadways: A Toolkit and Guide (2024)

COUNTERMEASURE TYPE

BICYCLE INTERSECTION TREATMENT

Bicycle-Intersection related crashes involve a bicyclist or pedalcyclist struck by a motor vehicle at an intersection. Additional pavement markings, signage or signal phasing may be considered to address conflicts at intersections between bicyclists and motor vehicles.

KEY SELECTION FACTORS

Bicyclist intersection treatments are considered for locations where there is a potential or an observed conflict between a bicyclist and motor vehicle traveling toward or through an intersection. Turning movement conflicts and bicyclist volumes are key criteria for selecting additional treatments for bicycle navigation and visibility at intersections.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Installation of Colored Bicycle Lanes at Signalized Intersections	Urban	39	All	$$$
Bicycle Signal Heads	Urban	N/A	N/A	$$
Active Warning Beacon for Bike Route at Unsignalized Intersection	Urban	N/A	N/A	$$
Two-Stage Turn Queue Boxes	Urban	N/A	N/A	$$
Signal Detection and Actuation	Urban	N/A	N/A	$$
Install Separated Bikeway at Intersection (Protected Intersection)	Urban	45	All	$$
Advanced Stop Line (ASL) / Bike Box	Urban	9	All	$$
Optimize Signal Timing for Bicycles	Urban	37	K, A, B, C	$$$

NCDOT GUIDANCE

Multimodal Guidance: Transportation Mobility and safety Division (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Improving Intersections for Pedestrians and Bicyclist Informational Guide (2022)

FHWA, Separated Bike Lane Planning and Design Guide (2015)

ITE, Signal Detection for Bicycles

BIKESAFE, Bike-Activated Signal Detection

FHWA, Safety Evaluations of Innovative Intersection Designs for Pedestrians and Bicyclists (2023)

NCHRP, Research Report 969: Traffic Signal Control Strategies for Pedestrians and Bicyclists (2022)

INTERSECTION

TOTAL CRASHES (2016-2023): **89, 721**

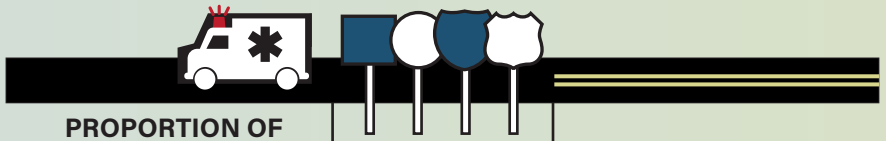
316	1,491
FATALITIES	SERIOUS INJURIES

PROPORTION OF FATAL AND SERIOUS INJURY CRASHES (%) BY DAYTIME (7AM-7PM) VS. NIGHTTIME CONDITIONS

NIGHTTIME %

32

PROPORTION OF CRASHES BY ROUTE CLASS



PROPORTION OF FATALITIES & SERIOUS INJURY CRASHES (%)	ROUTE CLASS	PROPORTION OF ROADWAY MILES (%)
49%	Secondary Route	45%
22%	US Route	5%
18%	NC Route	4%
1%	Interstate	2%
11%	Non-System	42%
0%	Other	2%

CRASH TYPE

INTERSECTION

COUNTERMEASURE TYPE

ACCESS MANAGEMENT

Locations where there is a pattern of angle or frontal impact crashes is often related to intersections with roads and driveways. Access management reduces conflicts at these intersections and can include strategies such as reduction or increasing spacing between driveways and side streets along the primary route.

KEY SELECTION FACTORS

Major street and minor street demand are both considerations for access management at intersections. Restricting left turns at intersections with low minor street volumes (i.e., less than 5,000 vehicles per day) or installing raised medians or islands to channelize heavy turning movements may also be considered.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Install Right-In-Right-Out (RIRO) Operations at Stop-Controlled Intersections	All	45	All	$$$
Median Channelization Near Signals	Urban	27	All	$$

NCDOT GUIDANCE

Policy on Street and Driveway Access to North Carolina Highways (2003)

SUPPLEMENTAL GUIDANCE

FHWA, Access Management in the Vicinity of Intersections (2013)

FHWA, Proven Safety Countermeasures: Corridor Access Management (2021)

COUNTERMEASURE TYPE

ALL WAY STOP

All Way Stop Control (AWSC) is a low-cost and highly effective countermeasure to address frontal impact or angle crash patterns at intersections. Additional treatments may be considered to enhance visibility as the driver approaches an AWSC intersection.

KEY SELECTION FACTORS

AWSC works best at intersections where approaching traffic volumes is relatively equal. An intersection where each approach has traffic volumes of 4,000 vehicles per day or less is expected to perform at an acceptable level of service. AWSC can be considered for higher volume approaches or intersections with appropriate capacity analysis.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Convert from Minor Road Stop Control to All Way Stop Control	All	80	K, A, B, C	$$$
Remove Unwarranted Signal and Replace with All Way Stop Control	All	33	All	$$$

NCDOT GUIDANCE

Selecting Optimum Intersections or Interchange Alternatives (2024)

All-Way Stops (2024)

All Way Stop – Summary Brief (2020)

COUNTERMEASURE TYPE

ALTERNATIVE INTERSECTION

Angle and left turn crashes comprise more than 60% of fatal and serious injury, intersection-related crashes. Alternative intersections are designed to maintain operational efficiency while reducing conflict points, such as left turns, at high traffic intersections.

KEY SELECTION FACTORS

Alternative intersections are most often considered for high volume intersections. Reduced Conflict Intersections are appropriate for multi-lane rural and suburban contexts. Pedestrian and bicycle crossing improvements can be incorporated into most alternative intersection types.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Signal to Signalized Reduced Conflict Intersection (RCI)	Urban	22	K, A, B, C	$
Signal at 3-Leg Intersection to Continuous Green T	All	15	K, A, B, C	$
Signal to Continuous Flow Intersection (CFI)	All	12	All	$
Unsignalized Intersection to Unsignalized Restricted Crossing U-Turn (RCUT)	All	63	K, A, B, C	$$
Two-Way Stop to Restricted Crossing U-Turn (RCUT)	All	54	K, A, B, C	$$
Signal to Unsignalized Reduced Conflict Intersection (RCI)	All	50	K, A, B, C	$$
Two-Way Stop to Signalized Reduced Conflict Intersection (RCI)	All	40	K, A, B, C	$$
Convert Four-Leg Intersection into Two T-Intersections	Urban	33	K, A, B, C	$$
Convert Four-Leg Intersection into Two T-Intersections	Rural	70	All	$$
Signal to Median U-Turn	Urban	37	All	$$
Unsignalized Reduced Conflict Intersection (RCI) to Signalized RCI	All	65	All	$$$

NCDOT GUIDANCE

Selecting Optimum Intersections or Interchange Alternatives (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Reduced Left-Turn Conflict Intersections (2021)

FHWA, Safety Evaluation of Continuous Green T Intersections (2016)

FHWA, Displaced Left Turn Intersection Informational Guide (2014)

FHWA, Restricted Crossing U-Turn Intersection Informational Guide (2014)

FHWA, Median U-Turn Intersection Informational Guide (2014)

FHWA, Informational Guide for Improving Intersections for Pedestrians and Bicyclist (2022)

COUNTERMEASURE TYPE

ROUNDABOUT

Roundabouts are an increasingly popular alternative to signalized intersections. Roundabouts eliminate left turn movements at the intersection and slow the speed of traffic approaching and travailing through the intersection. These features result in a significant reduction in serious injury and fatal crashes at intersections.

KEY SELECTION FACTORS

Single lane roundabouts are appropriate for intersections with total traffic volumes approaching 25,000 vehicles per day. A two-lane roundabout is typically expected to support up to 45,000 vehicles per day of total traffic volumes at the intersection.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Two-Way Stop to Two-Lane Roundabout	All	84	K, A, B, C	$$
Two-Way Stop to One-Lane Roundabout	Urban	78	K, A, B, C	$$
Signal to Two-Lane Roundabout	Urban	71	K, A, B, C	$$
Signal to Two-Lane Roundabout at 4-Leg Intersection	All	65	K, A, B, C	$$
Two-Way Stop to Mini-Roundabout	Urban	59	K, A, B, C	$$
Signal to One-Lane Roundabout	Urban	55	K, A, B, C	$$

NCDOT GUIDANCE

Selecting Optimum Intersections or Interchange Alternatives (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Roundabouts (2021)

NCHRP, Research Report 1043: Guide for Roundabouts (2023)

NCHRP, Research Report 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities (2017)

COUNTERMEASURE TYPE

INTERCHANGE

Interchanges are often considered as an alternative to a grade separated intersection or other locations with heavy traffic, frequently connecting to an interstate or freeway system. A variety of interchange designs can be considered depending on goals for capacity, safety and costs.

KEY SELECTION FACTORS

Alternative interchange designs that reduce conflict points, minimize potential for wrong-way driving and provide networks and protected crossings for pedestrians and bicyclists are most appropriate for urban and developed areas. These alternatives can include combinations of other intersection types, including multiple roundabouts or reduced conflict intersections.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Convert At-Grade 3-Leg Intersection to Grade-Separated Interchange	All	16	All	$
Convert At-Grade Intersections to Diverging Diamond Interchanges	All	58	All	$$
Convert At-Grade 4-Leg Intersection to Grade-Separated Interchange	All	57	K, A, B, C	$$
Convert Conventional Diamond Interchange to Diverging Diamond Interchange (DDI)	All	54	K, A, B, C	$$

NCDOT GUIDANCE

Selecting Optimum Intersections or Interchange Alternatives (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Safety Comparisons Between Interchange Types (2023)

NCHRP, Research Report 959: Diverging Diamond Interchange Informational Guide, Second Edition (2021)

COUNTERMEASURE TYPE

NEW SIGNAL

Traffic signals are a widely accepted approach for controlling traffic at intersections. Traffic signals may reduce certain angle crash types, but may also increase the frequency of rear-end or less severe crash types. Traffic signals can include design features that improve safety, such as protected phasing or timing that moderates cycle lengths and traffic speeds. NCDOT policy states that where sidewalk exists at a signalized intersection, pedestrian signal heads and crosswalks should be installed.

KEY SELECTION FACTORS

The Manual on Uniform Traffic Control Devices (MUTCD) includes nine warrants used to determine the potential for a signal to improve conditions. Crash history, traffic volumes and capacity analysis guidelines are considered when determining whether to install a traffic signal and how to design the signal that meets goals for traffic operations and safety.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Install a Traffic Signal on Major Road Speed with Speed Limit at Least 40 mph	Urban	67	All	$$
New Traffic Signal at 4-Leg Intersection	Urban	67	K, A, B, C	$$
New Traffic Signal at 3-Leg Intersection	Urban	34	K, A, B, C	$$

NCDOT GUIDANCE

Design Manual: Signal Design Section (2021)

Traffic Signal and Hybrid Beacon Recommendations for TIP

SUPPLEMENTAL GUIDANCE

FHWA, Signalized Intersections Informational Guide, Second Edition (2013)

COUNTERMEASURE TYPE

SIGNAGE / MARKINGS / FLASHERS

Warning signage and enhanced pavement marking alert drivers to changing roadway conditions, such as STOP controlled or signalized intersections. While these low-cost treatments alone do not typically control traffic, they do increase visibility of the hazard or roadway future.

KEY SELECTION FACTORS

Visibility or conspicuity enhancements on the approach to a controlled intersection alert the driver to slow down and prepare to stop. Additional features, such as blank out signs, tell the driver when conditions are changing for a permitted turning movement, such as restricting left or right turns during a pedestrian phase when actuated.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Provide "Stop Ahead" Pavement Markings at 3-Leg Intersection	Rural	67	All	$$$
Provide "Stop Ahead" Pavement Markings at 4-Leg Intersection	Rural	64	All	$$$
Actuated "Prepare to Stop" Signs in Advance of Unsignalized Intersection with Sight Distance Issues	All	32	All	$$$
Introduce Stop Ahead pavement Markings for All Way Stop Controlled Intersection	Rural	42	K, A, B, C	$$$
Introduce Stop Ahead Pavement Markings for Minor Road Stop Controlled Intersection	Rural	8	K, A, B, C	$$
Install Left Turn Yield Blank Out Sign	Urban	15	All	$$
Provide "Stop Ahead" Pavement Markings	Rural	74	All	$$$
Replace Standard Stop Sign with Flashing LED Stop Sign	All	41	All	$$$
Install Activated Advance Warning Flashers for Signal	All	30	All	$$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Systemic Application of Low-Cost Countermeasures at Stop-Controlled Intersections (2021)

COUNTERMEASURE TYPE

SIGNAL MODIFICATION

Existing traffic signals can be improved in response to several types of safety problems. Changes to signal timing and visibility enhancements with signal heads can help reduce crashes related to red-light running. Adjustments to signal phasing for left turns can reduce severe angle crashes.

KEY SELECTION FACTORS

Signalized intersections with a pattern of red-light running, angle crashes, or left-turn crashes should be reviewed for low-cost improvements to cycle length, clearance intervals, protected left-turn phases, and other visibility enchantments.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Optimize Clearance Intervals	All	12	K, A, B, C	$$
Yellow Change Intervals	All	11	All	$$
Install New Signal Back Plates	All	20	All	$$
Implement Rest in Red	All	51	All	$$$
Add Dynamic Red Extension	Rural	25	All	$$
Install Flashing Yellow Arrow - Permissive Only to FYA Protected-Permitted	All	41	K, A, B, C	$$$
Change Permissive Left-Turn Phasing to Protected Only or Protected/Permissive	All	28.2	All	$$$

NCDOT GUIDANCE

Design Manual: Signal Design Section (2021)

SUPPLEMENTAL GUIDANCE

FHWA, Signalized Intersections Informational Guide, Second Edition (2013)

NCHRP, Report 812: Signal Timing Manual, Second Edition (2015)

FHWA, Proven Safety Countermeasures: Backplates with Retroreflective Borders (2021)

FHWA, Proven Safety Countermeasures: Yellow Change Intervals (2021)

COUNTERMEASURE TYPE

TECHNOLOGY/ITS

Intelligent Transportation Systems (ITS) or technology improvements are low-cost tools to improve a variety of safety problems. Warning detection and speed management systems deployed through camera or signal technology can reduce frontal impact or angle crashes, increase compliance at signalized intersections, and help moderate speeds along the corridor. Specific vehicle or roadway users can benefit from improved detection and signal technology, such as freight carriers, transit operators and bicyclists. Data collected from warning systems, connected vehicle data platforms, or signal software can provide valuable insights about local safety problems.

KEY SELECTION FACTORS

Crash history and patterns associated with frontal impact or angle crashes, red-light running, or speeding may be factors for integrating technology into traffic control systems. Consult the Manual on Traffic Control Devices (MUTCD) for specific warrants or guidelines for implementing signal controls for heavy freight traffic, emergency vehicle preemption, transit system queue jumps or preemption, and bicycle signals.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Intersection Conflict Warning System (ICWS)	Rural	29.6	All	$$$
Adaptive Signal Control Technologies	All	17	All	$$
Closed Loop Signal System	All	15	All	$$
Add Long Vehicle Detection	All	10	All	$$
Install Actuated Advance Warning Dilemma Zone Protection System at High-Speed Signalized Intersections	All	8.2	All	$$
Add Advanced Dilemma Zone Detection	All	39	K, A, B, C	$$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Safety Evaluation of Intersection Conflict Warning Systems (2016)

FHWA, Intersection Conflict Warning System Human Factors Report (2016)

FHWA, Adaptive Signal Control, Final Report (2018)

COUNTERMEASURE TYPE

TWO WAY STOP

Two-way stop control (TWSC) is typically applied at intersections in rural or low volume areas (i.e., neighborhood or shopping center streets). The minor street approach is treated with a STOP sign, while the major road approaches remain uncontrolled.

KEY SELECTION FACTORS

Consider TWSC where traffic volumes along the major street are much higher than the minor street approach(es) to an intersection. If traffic volumes on the minor streets exceed 500 vehicles per day, consider an All Way Stop Control (AWSC).

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install a Stop Sign on Both Minor Approaches of an Unsignalized Intersection	All	22	All	$$

NCDOT GUIDANCE

Selecting Optimum Intersections or Interchange Alternatives (2024)

SUPPLEMENTAL GUIDANCE

N/A

LANE DEPARTURE

TOTAL CRASHES (2016-2023): **71,098**

853	**2,752**
FATALITIES	SERIOUS INJURIES

PROPORTION OF FATAL AND SERIOUS INJURY CRASHES (%) BY DAYTIME (7AM-7PM) VS. NIGHTTIME CONDITIONS

NIGHTTIME %

48

PROPORTION OF CRASHES BY ROUTE CLASS

PROPORTION OF FATALITIES & SERIOUS INJURY CRASHES (%)	ROUTE CLASS	PROPORTION OF ROADWAY MILES (%)
55%	Secondary Route	45%
13%	US Route	5%
16%	NC Route	4%
11%	Interstate	2%
7%	Non-System	42%
0%	Other	2%

CRASH TYPE

LANE DEPARTURE

COUNTERMEASURE TYPE

ACCESS MANAGEMENT

Access management controls the entry and exit points along a corridor. Treatments such as continuous medians restrict traffic from turning across the opposing direction of traffic, reducing the risk for severe angle or frontal impact crashes. Reduced driveway access and managed spacing between intersections limits the opportunity for traffic to make sudden maneuvers, causing angle and sideswipe crashes.

KEY SELECTION FACTORS

Reduced access should consider the frequency and severity of crashes along the corridor and all intersections. Public interests, such as access to businesses, and emergency response should be reviewed when implementing access management treatments. Where bicyclists and pedestrians are expected along a corridor, access management may increase safety along side street and driveway crossings.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Provide a Raised Median on Multilane Arterial	Urban	22	K, A, B, C	$
Provide a Raised Median on Multilane Arterial	Rural	12	K, A, B, C	$
Reducing Driveway Density on Rural 2-Lane Roads	Rural	14	All	$
Provide a Raised Median on Two-Lane Roadway	Urban	39	K, A, B, C	$$
Reducing Driveway Density on Urban Arterials	Urban	28	K, A, B, C	$$

NCDOT GUIDANCE

Policy on Street and Driveway Access to North Carolina Highways (2003)

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Corridor Access Management (2021)

FHWA, Access Management (Driveways) (2014)

COUNTERMEASURE TYPE

BARRIER

Roadside barriers include guardrails and crash barriers and they are designed to prevent vehicles from leaving the roadway or crossing a median into opposing traffic.

KEY SELECTION FACTORS

Barriers should be considered for roads with high speed and traffic volumes. Barriers are recommended for the sides of the road approaching a bridge. Median barriers are most often implemented on divided highways in rural contexts.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Bridge Approach Guardrail	All	55	K	$$$
Install Roadside Barrier	All	9.2	All	$
New or Upgraded Guardrail on 2-Lane Road	Rural	56	K, A	$$
New or Upgraded Guardrail on 4-Lane Divided or Undivided Road	Rural	45	K	$$
New or Upgraded Guardrail on 2- or 4-Lane Road	Urban	28	K	$$
Install Cable Median Barrier	Rural	50	All	$$
New Median Barrier on Multilane Divided Road	All	75	All	$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Median Barriers (2021)

NCHRP, Report 639: Guidelines for Guardrail Implementation (2009)

COUNTERMEASURE TYPE

PAVEMENT EDGE TREATMENTS

Pavement edge treatments include a shape or angle to the edge of the roadway that helps drivers recover onto the roadway in the event of lane departure.

KEY SELECTION FACTORS

Edge treatments should be considered based on crash history and distinct site conditions. Edge treatments are not appropriate where the embankment has a steeper slope than the angle of the edge or adjacent to curb and gutter road sections.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Resurfacing with Safety Edge	Rural	3	All	$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: SafetyEdgeSM (2021)

FHWA, Safety EdgeSM (2017)

COUNTERMEASURE TYPE

RUMBLE STRIPS

Rumble strips can be placed along the centerline and/or shoulders to reduce lane departure crashes. The treatment creates groves or raised markers in the pavement to alert drivers when they are drifting across the centerline or off the roadway.

KEY SELECTION FACTORS

Rumble stripes are required for all roads with full access control; and shoulder rumble stripes should be considered for all higher speed, partial access control roadways (speed limit of 55 miles per hour or greater).

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install Wider Markings and Both Edgeline and Centerline Rumble Strips with Resurfacing	Rural	38	K, A, B, C	$$$
Install Wider Markings and Edgeline Rumble Strips with Resurfacing	Rural	26	K, A, B, C	$$
Install Shoulder Rumble Stripes, Shoulder Widening, and Resurface Pavement on 2-Lane Road	Rural	27	K, A, B, C	$$
Install Shoulder Rumble Stripes, Shoulder Widening, and Resurface Pavement on 2-Lane Road	Rural	27	K, A, B, C	$$
Install Centerline Rumble Strips on Multilane Undivided Road	Rural	40	All	$$$
Install Centerline and Shoulder Rumble Strips	Rural	36	All	$$$
Install Centerline Rumble Strips on 2-Lane Road	Rural	28	All	$$$
Install Milled-In Shoulder Rumble Strips / Stripes on 2-Lane Road	Rural	23	All	$$
Install Milled-In Shoulder Rumble Strips/Stripes on Existing Shoulder of Rural 2-Lane Road	Rural	22	All	$$
Install Milled-In Shoulder Rumble Strips on Existing Shoulder of Rural Multilane Divided Road	Rural	22	K, A, B, C	$$

NCDOT GUIDANCE

Standard Practice for Milled Rumble Strips/Stripes on Facilities (2023)

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Longitudinal Rumble Strips and Stripes on Two-Lane Roads (2021)

FHWA, Rumble Strips and Rumble Stripes webpage (several resources available through menu on left) (2023)

FHWA, State of the Practice for Shoulder and Center Line Rumble Strip Implementation on Non-Freeway Facilities (2017)

COUNTERMEASURE TYPE

SIGNAGE/MARKINGS/FLASHERS

Warning signage and enhanced pavement marking alert drivers to changing roadway conditions, such as sharp curves. While these low-cost treatments alone do not typically control traffic, they do increase visibility of the hazard or location with elevated risk for speed-related or lane departure crashes.

KEY SELECTION FACTORS

Visibility enhancements, such as warning signs and wider pavement markings, can be considered for a location where a driver should slow for a curve or changes in lane configuration, to reduce the risk for lane departure crashes.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install In-Lane Curve Warning Pavement Markings	All	38	All	$$$
Enhanced Delineation for Horizontal Curves on 2-Lane Road	Rural	35	All	$$$
Install Converging Chevron Pattern Markings	Urban	32	All	$$$
Install Static Combination Horizontal Alignment / Advisory Speed Signs	All	13	K, A, B, C	$$
Install Wider Markings with Resurfacing on Undivided Multi Lane Road	Urban	8	K, A, B, C	$$
Install Wider Markings with Resurfacing on Multi Lane Divided by Median	Urban	4	K, A, B, C	$$
Install Sequential Lighted Chevron System	All	67	All	$$$
Install Chevron Signs on 2-Lane Horizontal Curves	Rural	33	All	$$$
Install Long Life Markings for Centerlines and Edgelines on 2-Lane Road	All	15	All	$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Enhanced Delineation for Horizontal Curves (2021)

FHWA, Proven Safety Countermeasures: Wider Edge Lines (2021)

FHWA, Curve Safety Solutions (2021)

FHWA, Low-Cost Treatments for Horizontal Curve Safety (2016)

COUNTERMEASURE TYPE

WIDEN SHOULDER

Widened paved shoulders provides space for drivers to recover in the event of lane departure, reducing the likelihood of lane departure crashes. Other countermeasures such as rumble strips, guardrail or other barriers should be considered in the design of the shoulder.

KEY SELECTION FACTORS

A preferred width of the shoulder is determined based on function and design speed of the road, roadside and other safety elements, and expected roadway users. Availability of right-of-way and cost can also be a factor.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Increase Shoulder Widths on Multilane Highway	Rural	18	All	$
Increase Shoulder Widths by 6' on Arterial	Urban	19	K, A, B, C	$
Increase Shoulder Widths by 4' on Arterial	Urban	13	K, A, B, C	$
Increase Shoulder Widths by 2' on Arterial	Urban	7	K, A, B, C	$
Increase Shoulder Widths by 4' on 2-Lane Road	Rural	23	All	$
Increase Shoulder Widths by 2' on 2-Lane Road	Rural	13	All	$
Increase Shoulder Widths by 6' on 2-Lane Road	Rural	33	All	$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

N/A

MOTORCYCLE

TOTAL CRASHES (2016-2023): **3,704**

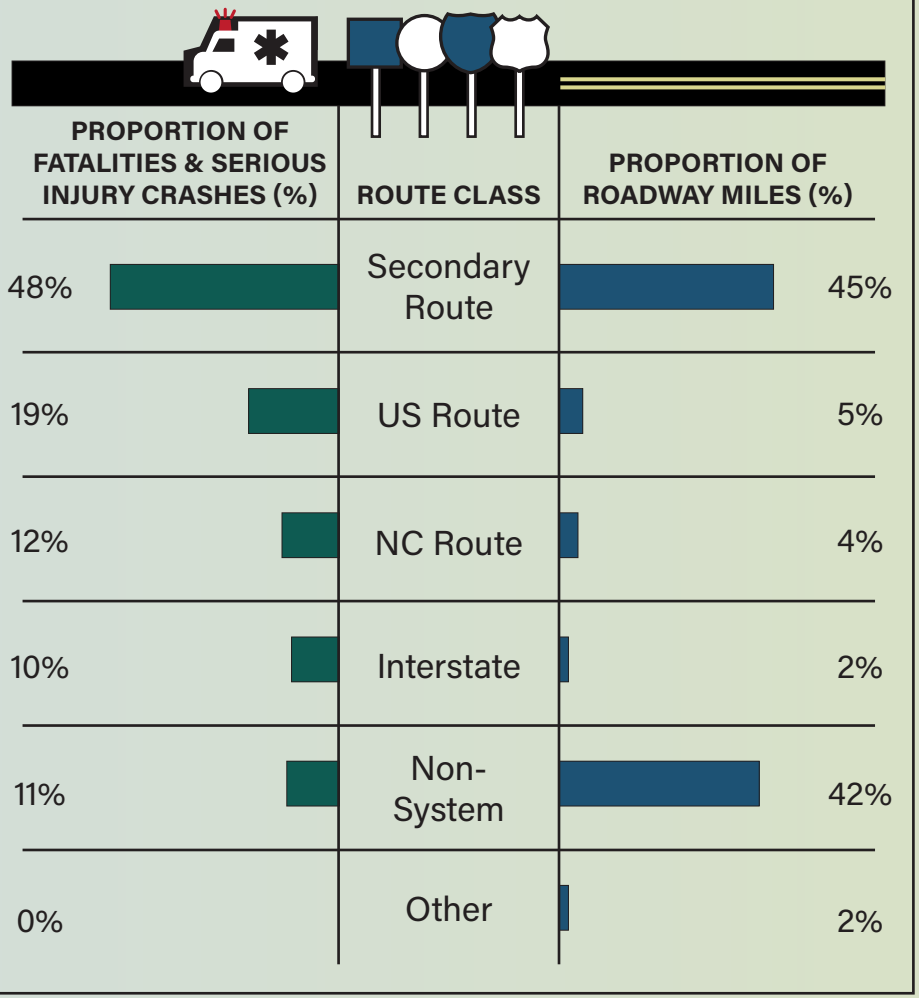
158	**627**
FATALITIES	SERIOUS INJURIES

PROPORTION OF FATAL AND SERIOUS INJURY CRASHES (%) BY DAYTIME (7AM-7PM) VS. NIGHTTIME CONDITIONS

NIGHTTIME %

34

PROPORTION OF CRASHES BY ROUTE CLASS



CRASH TYPE

MOTORCYCLE

COUNTERMEASURE TYPE

BARRIER

Motorcyclists are at greater risk of death or serious injury compared with motor vehicle drivers. Countermeasures used to address lane departure and speed-related crashes can also be considered for many types of motorcycle-related crashes.

KEY SELECTION FACTORS

Where crash history or risk for motorcycle-related crashes is identified for a location where guardrail is implemented or to be installed, an additional beam or railing can be added to prevent motorcyclists from sliding under the guardrail and increasing likelihood of death or serious injury.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Motorcycle Rub Rail Under Existing W-Beam	All	75	K	$$$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Synthesis on Barrier Design for Motorcyclists Safety (2021)

FHWA, Motorcycle Safety Noteworthy Practices: Infrastructure and Engineering (2022)

PEDESTRIAN

TOTAL CRASHES (2016-2023): **2,459**

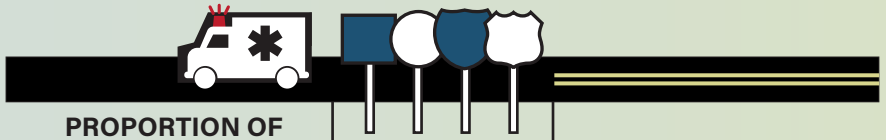
254	**396**
FATALITIES	SERIOUS INJURIES

PROPORTION OF FATAL AND SERIOUS INJURY CRASHES (%) BY DAYTIME (7AM-7PM) VS. NIGHTTIME CONDITIONS

NIGHTTIME %

64

PROPORTION OF CRASHES BY ROUTE CLASS



PROPORTION OF FATALITIES & SERIOUS INJURY CRASHES (%)	ROUTE CLASS	PROPORTION OF ROADWAY MILES (%)
33%	Secondary Route	45%
26%	US Route	5%
11%	NC Route	4%
10%	Interstate	2%
20%	Non-System	42%
0%	Other	2%

CRASH TYPE

PEDESTRIAN

COUNTERMEASURE TYPE

CROSSING IMPROVEMENTS

Pedestrian crossings account for 30-40% of fatal and serious injury crashes involving pedestrians. The distance between safe crossings, visibility and yielding compliance at the crossing, length of the roadway crossing, and speed of oncoming traffic are all factors affecting the risk of a severe pedestrian crash.

KEY SELECTION FACTORS

Traffic volume, number of lanes and speed are critical considerations for selecting crossing treatments at uncontrolled or midblock locations. Additional traffic controls or visibility improvements should be considered at crossings where traffic volume exceeds 10,000 vehicles per day or traffic speeds over 40 miles per hour. High visibility crosswalks and lighting should be present at all uncontrolled crossings.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install Pedestrian Fencing	Urban	12	All	$
School Zone Improvements	Urban	13	K, A, B, C	$$
Relocate or Improve Crossings at Bus Stops	Urban	81.9	All	$$$
Install Crosswalk with Multiple Improvements	Urban	50	All	$$$
Install Rectangular Rapid Flash Beacon (RRFB)	Urban	47	All	$$$
Curb Extensions / Bulb Outs	Urban	N/A	N/A	$$
Parking Restrictions / Daylighting	Urban	N/A	N/A	$$
Pedestrian Hybrid Beacon (HAWK)	Urban	55	All	$$
Install Raised Pedestrian Crosswalk	Urban	46	A, B, C	$$
Install Raised Median with Marked Crosswalk (Uncontrolled)	Urban	32	All	$$
Install Crosswalk	Urban	25	All	$$

NCDOT GUIDANCE

Multimodal Guidance (2024)

Pedestrian Crossing Guidance (2015)

Bus Stop Crossing Guidance (2024)

Trail Crossing Guidance (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018)

FHWA, PSC: Crosswalk Visibility Enhancements (2021)

FHWA, PSC: Rectangular Rapid Flashing Beacons (RRFB) (2021)

FHWA, PSC: Pedestrian Hybrid Beacons (2021)

FHWA, PSC: Medians and Pedestrian Refuge Islands in Urban and Suburban Areas (2021)

PEDSAFE, Access to Transit

COUNTERMEASURE TYPE

SIDEWALKS

Sidewalks are standard for urban or developed areas along roads that are not under control of access to allow pedestrians to walk outside of the roadway. In the urban core, sidewalks are wider to accommodate higher volumes of pedestrians. Shared use paths accommodate both bicyclists and pedestrians on a separated network, requiring a wider surface and different considerations at crossings.

KEY SELECTION FACTORS

Consult the local or NCDOT roadway design manual for guidance on the design of sidewalks and shared use paths. Local or state Complete Streets policy describes the expectation for sidewalk on one or both sides of the street.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install Sidewalks or Shared Use Path	Urban	74	All	$$

NCDOT GUIDANCE

Multimodal Guidance (2024)

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Walkways (2021)

COUNTERMEASURE TYPE

PEDESTRIAN INTERSECTION TREATMENT

Pedestrians should be expected at all intersections in an urban or developed area. Signals may be warranted based on pedestrian activity, crash history or traffic conditions. Left turn crashes involving pedestrians tend to lead to the most severe outcomes.

KEY SELECTION FACTORS

Signalized intersections in developed or urban areas should include pedestrian phasing, crosswalks and sidewalk access on most or all approaches. Additional consideration should be made to restrict or delay turning movements at intersections were pedestrian activity is expected to be high. Uncontrolled intersections should be reviewed for pedestrian improvements similar to midblock crossings.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Implement Barnes Dance (Pedestrian Scramble)	Urban	51	All	$$$
Prohibit Right Turns on Red	Urban	25	K, A, B, C	$$$
Install Pedestrian Countdown Heads where No Pedestrian Heads Exist	Urban	25	K, A, B, C	$$
Left-Turn Traffic Calming	Urban	20	N/A	$$
Implement Leading Pedestrian Interval (LPI)	Urban	13	All	$$
Replace Standard Pedestrian Heads with Countdown Pedestrian Heads	Urban	9	All	$$

NCDOT GUIDANCE

Multimodal Guidance (2024)

Leading Pedestrian Interval Implementation (2025)

SUPPLEMENTAL GUIDANCE

NCHRP, Research Report 969: Traffic Signal Control Strategies for Pedestrians and Bicyclists (2022)

National Institute of Transportation and Communities, Guidebook on Signal Control Strategies for Pedestrians (2017)

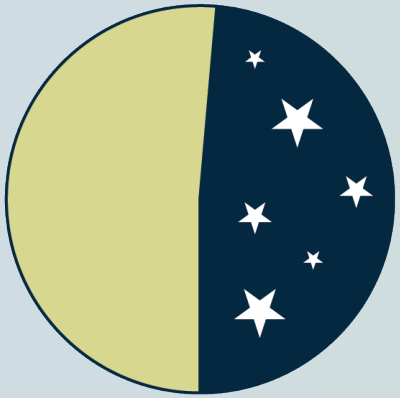
FHWA, Proven Safety Countermeasures: Leading Pedestrian Interval (2021)

SPEED

TOTAL CRASHES (2016-2023): **19,781**

393	**847**
FATALITIES	SERIOUS INJURIES

PROPORTION OF FATAL AND SERIOUS INJURY CRASHES (%) BY DAYTIME (7AM-7PM) VS. NIGHTTIME CONDITIONS



NIGHTTIME %

48

PROPORTION OF CRASHES BY ROUTE CLASS

PROPORTION OF FATALITIES & SERIOUS INJURY CRASHES (%)	ROUTE CLASS	PROPORTION OF ROADWAY MILES (%)
52%	Secondary Route	45%
15%	US Route	5%
11%	NC Route	4%
13%	Interstate	2%
9%	Non-System	42%
0%	Other	2%

CRASH TYPE

SPEED

COUNTERMEASURE TYPE

SPEED MANAGEMENT

Speed management is an overall practice using a variety of strategies to moderate traffic speeds and reduce speed-related crashes. Strategies include targeted enforcement, changes to roadway design, adjusting speed limits, and implementing low cost treatments for increased driver awareness.

KEY SELECTION FACTORS

Speed management including physical changes to the roadway are selected based on context, volume and traffic speeds.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install Dynamic Speed Feedback Signs	All	46	All	$$$
Install Transverse Rumble Strips as Traffic Calming Device	Urban	34	All	$$$
Improve Signal Timing	Urban	15	All	$$
Install Optical Speed Bars	All	21	All	$$
Install Transverse Rumble Strips at Minor Road Stop Controlled 4-Leg Intersection	Rural	25	K, A, B	$$
Install Transverse Rumble Strips at Minor Road Stop Controlled 3-Leg Intersection	Rural	10	K, A, B	$$
Advisory Speed Signs	All	13	A, B, C	$$

NCDOT GUIDANCE

Guidelines and Documentation for Establishing Speed Limits (2021)

SUPPLEMENTAL GUIDANCE

NHTSA, Countermeasures that Work: Dynamic Speed Display/Feedback Signs

ITE, Install Transverse Rumble Strips on the Intersection Approach

FHWA, Factors Influencing Operating Speeds and Safety on Rural and Suburban Roads (2015)

FHWA, Engineering Speed Management Countermeasures: A Desktop Reference of Potential Effectiveness in Reducing Crashes (2023)

COUNTERMEASURE TYPE

TRAFFIC CALMING

Traffic calming devices and programs are most often implemented by a local government on neighborhood streets. Traffic calming can include non-engineering strategies such as speed enforcement and feedback signs. Engineering approaches can include reducing the posted speed limit, changes to the lane width or configuration, and either vertical or horizontal infrastructure.

KEY SELECTION FACTORS

Traffic calming devices are typically limited to local streets or lower volume roads (i.e., less than 5,000 vehicles per day) where speeds are expected to operate at or less than 30 miles per hour.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Install Chicanes	Urban	N/A	N/A	$$
Gateways	Urban	32	K, A	$$
Install Speed Humps	Urban	40	A, B, C	$$$
Installation of Mini-Circle	Urban	59	K, A, B, C	$$

NCDOT GUIDANCE

Traffic Calming on State-Maintained Roadways (2009)

SUPPLEMENTAL GUIDANCE

FHWA, Traffic Calming ePrimer

CRASH TYPE

VARIOUS

COUNTERMEASURE TYPE

LIGHTING

Properly designed roadway lighting enhances visibility and improves safety for all users at night. This is especially true for lighting at midblock and intersection crosswalks., roundabouts and where roadway conditions change.

KEY SELECTION FACTORS

NCDOT guidance typically calls for lighting at roundabouts, midblock pedestrian crossings, and at locations with high-risk for lane departure or intersection crashes.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Provide Intersection Lighting (Non-Roundabout)	All	77	K	$$
Provide Intersection Lighting (Roundabout)	All	77	K	$$
Lighting of Roadway Segments	All	69	K	$$

NCDOT GUIDANCE

Roadway Lighting Policy (2020)

SUPPLEMENTAL GUIDANCE

FHWA, Lighting Handbook (2023)

COUNTERMEASURE TYPE

ROAD DIET

A roadway reconfiguration ("Road Diet") is typically implemented to reduce the total number of travel lanes and to add a two-way center left turn lane along an undivided, multi-lane road. Road Diets reduce the number of severe turning movement or angle crashes.

KEY SELECTION FACTORS

A typical four-to-three lane reconfiguration should be considered for roads with annual average daily traffic (AADT) volumes of 12,000 vehicles per day or less. Other criteria such as side street volumes and delay at intersections are considerations for the design and feasibility of a road diet.

Specific Countermeasures	Urban or Rural	CRF %	Impact	Cost
Road Diet (4-Lane Undivided Roadway to 2-Lanes Plus Turning Lane)	Urban	29	All	$$$

NCDOT GUIDANCE

TBD

SUPPLEMENTAL GUIDANCE

FHWA, Proven Safety Countermeasures: Road Diets (2021)

COUNTERMEASURE TYPE

ANIMAL CROSSING

Animal crashes involve animals struck by a motor vehicle while crossing a roadway. There are few countermeasures designed specifically for animal crossing locations. Research is ongoing to identify additional treatments to reduce crashes or risk of animal-vehicle crashes.

KEY SELECTION FACTORS

Animal crash history is a key criteria. Conditions such as presence of wildlife habitat may also be considered.

Specific Countermeasures	Urban or Rural	CRF %	Severity	Cost
Add Wildlife Crossing Structure with Fencing	All	45.1	All	$

NCDOT GUIDANCE

N/A

SUPPLEMENTAL GUIDANCE

FHWA, Wildlife Crossing Structure Handbook Design and Evaluation in North America (2011)

FHWA, Wildlife Vehicle Collision Reduction Study: Best Practices Manual (2008)

Transportation Pooled Fund, Wildlife Vehicle Collision Reduction and Habitat Connectivity study (2022) - multiple relevant reports included in the "Documents" section)