Chapter 15

Analysis Techniques

Revised: November 27, 2012

Analysis Techniques

There are a number of analysis techniques, but the ones most commonly used by the NCDOT Traffic Safety Unit are the following:

- Severity
- Frequency
- Cluster/Concentration
- Crash Rates
- Critical Crash Rates
- Sliding Scale
- Collision Diagram

Keep in mind statistical significance!

Analysis Techniques (Cont.)

The analysis of crash data is used to identify where, when, and why crashes are occurring, which can then lead to mitigation of the crash issues through a determination of potential countermeasures such as the following:

- Installation/adjustment of auxiliary lanes (left turn, right turn, etc.)
- Installation or removal of a traffic signal
- Adjustment of signal phasing, timing, and/or system
- Install or widen shoulders
- Installation of median islands, leftovers, etc.

Severity Analysis

Remember that the equivalent property damage only (EPDO) value for moderate (B) and minor (C) injury types was equal to 8.4 property damage only (PDO) crashes.

Therefore,

…locations with a severity index (SI) greater than 8.4 tend to have more severe injuries sustained in crashes.

…locations with a severity index (SI) less than 8.4 tend to have less severe and/or infrequent injuries sustained in crashes.

Severity Analysis (Cont.)

Exception 1

Approximately 99% of all pedestrians involved in crashes sustain some type of injury. Therefore, the normal severity index (SI) for pedestrian crashes is approximately 13.4

Exception 2

Approximately 92% of all bicyclists involved in crashes sustain some type of injury. Therefore, the normal severity index (SI) for bicycle crashes is approximately 11.3

Severity Analysis Example

This example is based on an analysis of TIP Project R-2237C (saved under the study name of “TROY200412077X”). The location was on US 321 in Watauga County, in the Town of Blowing Rock. This analysis identified 104 crashes within the municipal limits between 6/1/2001 and 5/31/2004.

Crash Severity Summary

Crash Type	Number of Crashes	Percent of Total
Total Crashes	104	100.00
Fatal Crashes	0	0.00
Class A Crashes	1	0.96
Class B Crashes	7	6.73
Class C Crashes	19	18.27
Property Damage Only Crashes	77	74.04

Severity Analysis Example (Cont.)

(0 K crashes + 1 A crash) * 76.8	=	1 * 76.8	=	76.8
(7 B crashes + 19 C crashes) * 8.4	=	26 * 8.4	=	218.4
(77 O crashes + 0 U crashes) * 1	=	77 * 1.0	=	77.0
		Total EPDO	=	372.2

$$\text{Severity Index} = \frac{\text{Total EPDO}}{\text{Total Crashes}} = \frac{372.2}{104} = 3.58$$

Miscellaneous Statistics

Severity Index =	3.58
EPDO Crash Index =	372.20
Estimated Property Damage Total = $	796246.00

Therefore, this location tends to have less severe crashes.

Frequency Analysis

Frequency analyses are exactly what they appear to be - how often does something occur? These type of analyses can be useful in identifying recurring issues which may be trends and patterns.

- Crash Type
- Time (month, day, hour)
- Vehicle Type
- Others

Frequency Analysis Example

Accident Type Summary

Accident Type	Number of Crashes	Percent of Total
ANGLE	3	2.88
ANIMAL	1	0.96
BACKING UP	1	0.96
FIXED OBJECT	6	5.77
HEAD ON	2	1.92
LEFT TURN, DIFFERENT ROADWAYS	2	1.92
LEFT TURN, SAME ROADWAY	3	2.88
MOVABLE OBJECT	1	0.96
OTHER COLLISION WITH VEHICLE	3	2.88
OTHER NON-COLLISION	1	0.96
OVERTURN/ROLLOVER	1	0.96
PARKED MOTOR VEHICLE	1	0.96
RAN OFF ROAD - LEFT	3	2.88
RAN OFF ROAD - RIGHT	14	13.46
REAR END, SLOW OR STOP	50	48.08
REAR END, TURN	1	0.96
RIGHT TURN, DIFFERENT ROADWAYS	4	3.85
SIDESWIPE, OPPOSITE DIRECTION	5	4.81
SIDESWIPE, SAME DIRECTION	2	1.92

Frequency Analysis Example (Cont.)

Monthly Summary

Month	Number of Crashes	Percent of Total
Jan	5	4.81
Feb	6	5.77
Mar	5	4.81
Apr	6	5.77
May	10	9.62
Jun	9	8.65
Jul	11	10.58
Aug	9	8.65
Sep	10	9.62
Oct	13	12.50
Nov	9	8.65
Dec	11	10.58

Daily Summary

Day	Number of Crashes	Percent of Total
Mon	9	8.65
Tue	18	17.31
Wed	9	8.65
Thu	11	10.58
Fri	16	15.38
Sat	18	17.31
Sun	23	22.12

Frequency Analysis Example (Cont.)

Hourly Summary

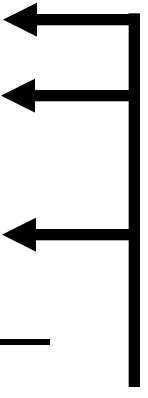
Hour	Number of Crashes	Percent of Total
0000-0059	0	0.00
0100-0159	2	1.92
0200-0259	2	1.92
0300-0359	0	0.00
0400-0459	0	0.00
0500-0559	0	0.00
0600-0659	1	0.96
0700-0759	1	0.96
0800-0859	5	4.81
0900-0959	8	7.69
1000-1059	8	7.69
1100-1159	4	3.85
1200-1259	10	9.62
1300-1359	6	5.77
1400-1459	7	6.73
1500-1559	8	7.69
1600-1659	12	11.54
1700-1759	6	5.77
1800-1859	6	5.77
1900-1959	4	3.85
2000-2059	7	6.73
2100-2159	1	0.96
2200-2259	2	1.92
2300-2359	4	3.85

Frequency Analysis Example (Cont.)

Note: heavy trucks (truck/trailer, truck/tractor, tractor/semi-trailer, tractor/doubles, and unknown heavy truck) are involved in crashes approximately 1.7% of the time.

Vehicle Type Summary

Vehicle Type	Number Involved	Percent of Total
LIGHT TRUCK (MINI-VAN, PANEL)	4	2.06
MOTORCYCLE	3	1.55
PASSENGER CAR	108	55.67
PICKUP	31	15.98
SPORT UTILITY	34	17.53
TRACTOR/SEMI-TRAILER	2	1.03
TRUCK/TRAILER	1	0.52
UNKNOWN	2	1.03
UNKNOWN HEAVY TRUCK	1	0.52
VAN	8	4.12



2.07% (However, is this statistically significant with 194 total vehicles?)

Cluster/Concentration Analysis

A cluster (or concentration) analysis identifies locations where crashes are grouped together in close proximity to each other. Examples of these locations are:

- Intersections of roadways
- Access points (shopping center entrances, etc.)
- Access strips (commercially built up roads, etc.)
- Roadway features (curves, bridges, etc.)

Cluster/Concentration Analysis Example

ML-BLOWING ROCK

0.000	
0.010	
0.020	
0.030	
0.040	100729305 | 100817099
0.050	
0.060	100534507 | 100788832
0.070	
0.080	
0.090	
0.100	
0.110	
0.120	
0.130	
0.140	100795002 | 100973143
0.150	
0.160	
0.170	
0.180	
0.190	100626640
0.200	
0.210	
0.220	
0.230	
0.240	100787756
0.250	
0.260	
0.270	
0.280	

Cluster/Concentration Analysis Example

	1.840	
	1.850	101015284
	1.860	
	1.870	
	1.880	
	1.890	
	1.900	
	1.910	
	1.920	
	1.930	
	1.940	
SUNSET	1.950	100473187 | 100596040 | 100551585 | 100586495 | 100639334 | 100706580 | 100715572 | 100728216 | 100754818 | 100823002 | 100898986 | 100966574 | 100989799 | 100996573 | 101075938
	1.960	100607331
	1.970	
	1.980	
	1.990	
CORNISH	2.000	100406471 | 100646008 | 100965071
	2.010	
	2.020	
	2.030	
	2.040	
	2.050	
	2.060	
	2.070	
	2.080	

Crash Rates

- Crash rates involve combining crash frequency with vehicle exposure (traffic volumes) and are expressed as crashes per 100 million vehicle miles traveled (MVMT).

- In North Carolina, we typically only look at rates for total crashes, fatal crashes, non-fatal injury crashes, night crashes, and wet crashes.

- Crash rates are currently calculated for strip locations over a three year period with no Y-line (0 feet) and separated by locality (urban vs. rural) and road classification (i.e. two lane undivided, four lane divided, etc.).

Crash Rates (Cont.)

The formula for calculating crash rates is:

$$\text{Crash Rate} = \frac{\text{Crashes}}{\text{Exposure}}$$

Where exposure is determined as:

$$\left(\frac{\text{Vehicles}}{\text{Day}}\right) \times \left(\frac{\text{365 Days}}{\text{Year}}\right) \times \left(\frac{\text{3 Years}}{1}\right) \times \left(\frac{\text{Miles}}{1}\right)$$

AADT

Length of road where rate is being calculated

Crash Rates (Cont.)

Crash rate information is located at the following URL:

https://connect.ncdot.gov/resources/safety/Pages/Crash-Data.aspx

Example:

URBAN UNITED STATES ROUTES

ROAD TYPE	SYSTEM MILES	TOTAL	FATAL	NON-FATAL INJURY	NIGHT	WET
2 LANES UNDIVIDED	494	321.84	0.98	117.08	62.62	53.87
2 LANES CONT. LEFT TURN LANE*	9	219.28	0.86	68.79	36.12	36.98
3 LANES UNDIVIDED*	5	336.28	1.71	124.61	69.99	47.80
4 OR MORE LANES UNDIVIDED	119	631.41	1.49	235.78	120.71	109.43
4+ LANES CONT. LEFT TURN LANE	249	374.08	1.19	138.79	75.20	69.30
4 OR MORE LANES DIVIDED WITH						
NO CONTROL ACCESS	192	432.42	1.23	145.91	91.93	72.71
PARTIAL CONTROL ACCESS	112	245.66	0.76	85.97	51.56	44.10
FULL CONTROL ACCESS	98	155.81	0.89	51.24	36.08	30.96
TOTAL	1,278	346.74	1.08	123.47	70.88	61.07

Crash Rate Analysis Example

- Crashes on US 321 in Blowing Rock (Watauga County)
- Urban section (2 lanes undivided)
- June 1, 2001 - May 31, 2004

Rate	Crashes	Crashes per 100 MVM	Statewide Rate [1]
Total	104	407.70	321.84
Fatal	0	0.00	0.98
Non-Fatal Injury	27	105.84	117.08
Night	25	98.00	62.62
Wet	28	109.76	53.87

[1] 2000-2002 statewide crash rate for urban 2-lane undivided US routes in North Carolina

Note - crashes at locations exceeding statewide rates may or may not be random occurrences.

Critical Crash Rates

- Critical crash rates are crash rates that have been statistically adjusted, based on other roads with similar characteristics (i.e. all urban sections of 2-lane undivided US roads in the state), to remove the elements of chance and randomness.

- This is a check to determine if the "rate at a particular location is significantly higher than a predetermined average rate for locations of similar characteristics, based on Poisson's distribution"[1].

- Also called the "Rate Quality Control Method".

[1] Khisty, C. Jostin and B. Kent Lall. Transportation Engineering, An Introduction. 2nd ed. 1998.

Critical Crash Rates (Cont.)

The formula for calculating critical crash rates is:

$$\text{Critical Rate} = \text{Crash Rate} + K\left(\sqrt{\frac{\text{Crash Rate}}{\text{Exposure}}}\right) + \left(\frac{1}{(2)(\text{Exposure})}\right)$$

Where the probability factor (K) is equal to 1.645 (which is considered to be a 95% level of confidence), and exposure is determined as follows:

$$\left(\frac{\text{Vehicles}}{\text{Day}}\right) \text{X} \left(\frac{\text{365 Days}}{\text{Year}}\right) \text{X} \left(\frac{\text{3 Years}}{1}\right) \text{X} \left(\frac{\text{Miles}}{1}\right)$$

AADT

Length of road where rate is being calculated

Critical Crash Rate Analysis Example

- Crashes on US 321 in Blowing Rock (Watauga County)
- Urban section
- June 1, 2001 - May 31, 2004

Rate	Crashes	Crashes per 100 MVM	Statewide Rate [1]	Critical Rate [2]
Total	104	407.70	321.84	382.23
Fatal	0	0.00	0.98	6.16
Non-Fatal Injury	27	105.84	117.08	154.28
Night	25	98.00	62.62	90.35
Wet	28	109.76	53.87	79.74

[1] 2000-2002 statewide crash rate for urban 2-lane undivided US routes in North Carolina

[2] Based on the statewide crash rate (95% level of confidence).

Note - crashes at locations exceeding critical rates are generally not random occurrences.

Critical Crash Rate Analysis Example

Category	Item	Count	Analysis	State	+ / -
ROAD SURFACE CONDITION	DRY	66	63.5%	81.7%	-25.1%
ROAD SURFACE CONDITION	WET	28	26.9%	15.2%	55.4%
ROAD SURFACE CONDITION	ICE	5	4.8%	0.9%	138.1%
ROAD SURFACE CONDITION	SNOW	4	3.8%	0.6%	145.1%
ROAD SURFACE CONDITION	SAND, MUD, DIRT, GRAVEL	1	1.0%	0.2%	144.1%
WEATHER CONDITION	CLEAR	65	50.4%	67.8%	-29.4%
WEATHER CONDITION	CLOUDY	18	14.0%	19.1%	-31.3%
WEATHER CONDITION	RAIN	22	17.1%	10.6%	46.3%
WEATHER CONDITION	SNOW	5	3.9%	0.9%	123.6%
WEATHER CONDITION	FOG, SMOG, SMOKE	14	10.9%	0.6%	180.2%
WEATHER CONDITION	SLEET, HAIL, FREEZING RAIN/DRIZZLE	1	0.8%	0.5%	46.3%
WEATHER CONDITION	SEVERE CROSSWINDS	4	3.1%	0.1%	190.8%
WEATHER CONTRIBUTED TO THE CRASH	YES	24	24.0%	5.7%	123.8%
WEATHER CONTRIBUTED TO THE CRASH	UNKNOWN	76	76.0%	94.3%	-21.5%
AMBIENT LIGHT	DAYLIGHT	75	72.1%	74.9%	-3.8%
AMBIENT LIGHT	DUSK	3	2.9%	2.9%	-0.5%
AMBIENT LIGHT	DARK - LIGHTED ROADWAY	4	3.8%	15.0%	-118.4%
AMBIENT LIGHT	DARK - ROADWAY NOT LIGHTED	19	18.3%	4.8%	116.7%
AMBIENT LIGHT	DARK - UNKNOWN LIGHTING	2	1.9%	0.3%	142.6%
AMBIENT LIGHT	OTHER	1	1.0%	0.1%	151.4%
VEHICLE MANEUVER/ACTION	STOPPED IN TRAVEL LANE	32	16.5%	12.3%	28.8%
VEHICLE MANEUVER/ACTION	PARKED OUT OF TRAVEL LANES	5	2.6%	5.1%	-65.8%
VEHICLE MANEUVER/ACTION	GOING STRAIGHT AHEAD	90	46.4%	46.6%	-0.5%
VEHICLE MANEUVER/ACTION	MAKING RIGHT TURN	8	4.1%	3.9%	6.1%
VEHICLE MANEUVER/ACTION	MAKING LEFT TURN	21	10.8%	11.2%	-3.1%
VEHICLE MANEUVER/ACTION	MAKING U TURN	1	0.5%	0.3%	40.6%
VEHICLE MANEUVER/ACTION	BACKING	1	0.5%	4.2%	-156.7%
VEHICLE MANEUVER/ACTION	SLOWING OR STOPPING	28	14.4%	6.3%	78.4%
VEHICLE MANEUVER/ACTION	STARTING IN ROADWAY	5	2.6%	2.6%	-1.4%
VEHICLE MANEUVER/ACTION	OTHER	3	1.5%	2.3%	-40.9%

Crash Rate Resources

Connect NCDOT
BUSINESS PARTNER RESOURCES

Doing Business | Bidding & Letting | Projects | Resources | Local Governments

CADD | Environmental | Geotechnical | Hydraulics | Materials & Tests | Products | Specifications | State R

Crash Data and Maps

Crash data, organized by type, ranking, overall cost, and maps and other resources for analysis.

Resources ▶ Traffic Safety ▶ Crash Data and Maps

Crash Data, Facts and Statistics

City Rankings are based on the following criteria: Total Crashes, Total Non-Fatal Injury Crashes, Total Fatal Crashes, Annual Crashes Per 1000 Persons, Annual Non-Fatal Injury Crashes Per 1000 Persons, Annual Fatal Crashes Per 1000 People, EPDO (equivalent property damage), Severity Index, Average Annual Crash Cost and Average Annual Crash Cost Per Person

County Rankings are based the following criteria: Total Crash Rate, Fatal Crash Rate, Non-Fatal Injury Crash Rate, Crash Injuries Per 1000 People, Fatal Crash Injuries Per 1000 People, Non-Fatal Injuries Per 1000 People, Total Crashes Per 1000 Registered Vehicles, Fatal Crashes Per 1000 Registered Vehicles, Non-Fatal Injury Crashes Per 1000 Registered Vehicles, Percent Alcohol-Related Crashes, Severity Index, Annual Cost Per 100 Miles Traveled, Annual Cost Per Person and Annual Cost Per Vehicle.

Crash Data List

Type	Name
Crash Type : **Crash By Ranking** (27)	
Crash Type : **Crash Costs** (14)	
Crash Type : **Crash Facts by Year** (50)	
Crash Type : **Crash Profile** (10)	
Crash Type : **Crash Rates** (24)	

- 1980 Crash Rates
- 1983 Crash Rates
- 1984 Crash Rates
- 1985 Crash Rates
- 1986 Crash Rates
- 1986-1988 Crash Rates
- 1987 Crash Rates
- 1987-1989 Crash Rates
- 1988-1990 Crash Rates
- 1990-1992 Crash Rates
- 1991-1993 Crash Rates
- 1992-1994 Crash Rates
- 1994-1996 Crash Rates
- 1995-1997 Crash Rates
- 1996-1998 Crash Rates
- 2001 Crash Rates
- 2002 Crash Rates
- 2003 Crash Rates
- 2005 Crash Rates
- 2006 Crash Rates
- 2007 Crash Rates
- 2008 Crash Rates
- 2009 Crash Rates
- 2010 Crash Rates

https://connect.ncdot.gov/resources/safety/Pages/Crash-Data.aspx

Sliding Scale Analysis

• A sliding scale analysis is a way of identifying crash concentrations based on a predetermined minimum number of crashes along a given length of road. The scale “slides” along a road and identifies all locations along that road that meet the predetermined criteria. The final location(s) identified will be on segments that are at least as long as the initial length of road criteria.

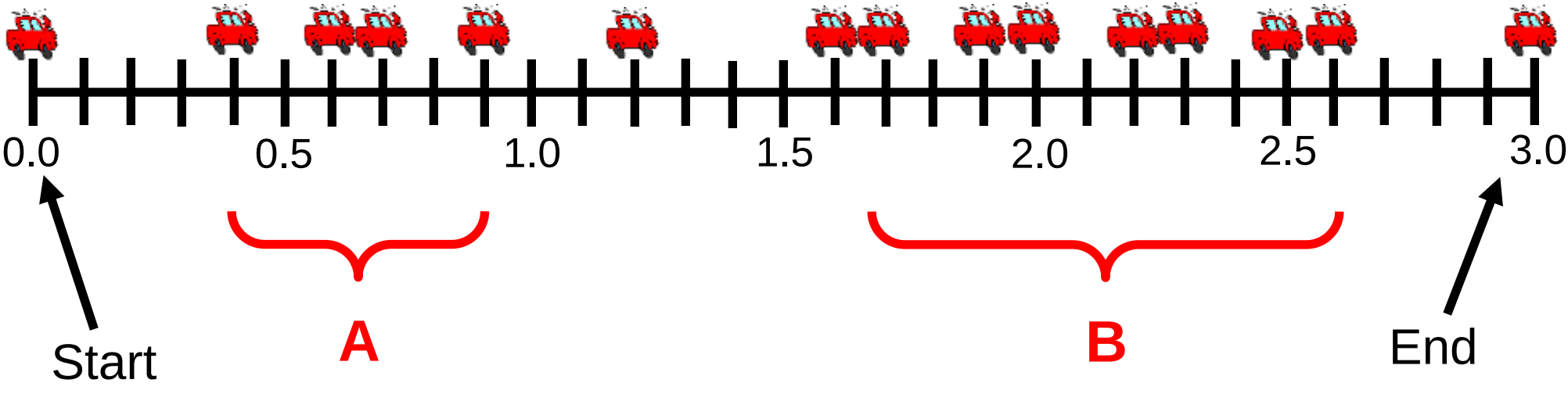
• For example, if the minimum number of crashes was set at 5, and the maximum length of road was set at 0.5 miles, then the scale would start at the beginning of the road (thereby covering the first half-mile of the road from 0.0 to 0.5 miles) and “slide” along the road identifying any locations that had at least 5 crashes. The length of these locations may increase if the criteria is continuously met.

Sliding Scale Analysis Example

Minimum Criteria:

Crashes = 4

Scale = 0.5 miles



Two locations were identified. Location ‘A’ had 4 crashes within 0.5 miles (mileposts 0.4 to 0.9) and location ‘B’ had 8 crashes within 1 mile (mileposts 1.6 to 2.6).

HSIP Safety Warrants

- HSIP = Highway Safety Improvement Program

- Statistically identified minimum crash data thresholds for potentially hazardous (PH) locations

- Safety warrants address intersection, strip, and bridge locations for all motor vehicle crashes

- Safety warrants also address intersection and strip locations for pedestrian and bicycle crashes

- Example: Warrant I-1 (frontal impact crashes) addresses locations with a minimum of 25 crashes in the most recent 5-year period, a minimum of 50% of all crashes were frontal impact, and a minimum of 25% of the total crashes occurred in the last 2 years.

HSIP Safety Warrants Example

North Carolina Highway Safety Improvement Program

Potentially Hazardous Intersection Locations in North Carolina - Statewide Rank of 400 or Higher

2010 Cycle

PH Number / State Rank	Total Weight	Divison / SHP Troop	Region	Location	Overall Crashes Severity Index	WARRANT INFORMATION				
64I00433		3	CAPE FEAR	NEW HANOVER (WILMINGTON)	81	Warrant	Crashes	Percent	Severity	Weight
1	12.28	B		US 117 (MP 5.10) AT HOGGARD	7.94	I-1	55	67.9%	8.63	3.52
Excluded: ☐ *Comments:*						I-4	31	38.3%	11.44	3.49
30I00028		3	CAPE FEAR	DUPLIN (RURAL)	100	Warrant	Crashes	Percent	Severity	Weight
2	10.63	B		I 40 (MP 12.97) AT NC 24 (MP 9.61) * POSSIBLE LOOP *	7.97	I-1	62	62.0%	9.08	4.17
Excluded: ☐ *Comments:*						I-3	45	45.0%	7.97	2.55
40I00897		7	TRIAD	GUILFORD (RURAL)	79	Warrant	Crashes	Percent	Severity	Weight
3	10.3	D		US 70 (MP 21.10) AT ENGLISH (MP 12.33)	6.67	I-1	41	51.9%	7	2.13
Excluded: ☐ *Comments:*						I-3	32	40.5%	6.67	1.52
						I-4	32	40.5%	10.13	3.18
66I00168		3	CAPE FEAR	ONSLOW (JACKSONVILLE)	80	Warrant	Crashes	Percent	Severity	Weight
4	7.39	B		SR 1336 (MP 0.00) AT SR 1470 (MP 1.69)	6.8	I-2	30	37.5%	6.73	3.39
Excluded: ☐ *Comments:*						I-3	45	56.3%	6.8	2.18
30I00052		3	CAPE FEAR	DUPLIN (WARSAW)	33	Warrant	Crashes	Percent	Severity	Weight
5	6.01	B		I 40 (MP 4.50) AT NC 24B (MP 0.00) * POSSIBLE LOOP *	10.1	I-2	12	36.4%	21.8	4.39
Excluded: ☐ *Comments:*						I-3	19	57.6%	10.13	1.37
64I00495		3	CAPE FEAR	NEW HANOVER (RURAL)	87	Warrant	Crashes	Percent	Severity	Weight
6	5.99	B		US 76 (MP 1.97) AT SR 1218 (MP 0.09)	6.49	I-1	57	65.5%	7.68	3.24
Excluded: ☐ *Comments:*						I-3	40	46.0%	6.49	1.85

HSIP Resources

https://connect.ncdot.gov/resources/safety/Pages/NC-Highway-Safety-Program-and-Projects.aspx

Collision Diagram

A collision diagram is a visual representation of crash information identified by the study.