APPENDIX A

SAFETY ANALYSIS TECHNICAL MEMORANDUM

Memorandum

Date: March 2025

To: Boulder County VZAP Team

From: Consor Engineers

Subject: Boulder County VZAP – Safety Analysis & HIN Methodology

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Introduction

Recognizing the importance of implementing a regional approach to roadway safety, Boulder County, Lafayette, and Superior joined forces and successfully applied for Safe Streets and Roads for All (SS4A) grant funding to create a Vision Zero Action Plan for each agency. Specific to Boulder County, this project has analyzed historic crash activity on unincorporated Boulder County roads, Colorado Department of Transportation (CDOT) roads, and roads in the mountain towns of Jamestown, Nederland, and Ward. Identified safety trends and community input gathered in summer 2024 were combined to characterize roadway safety challenges and develop a vision and plan for improving safety in Boulder County. The Federal Highway Administration recommends that local agencies take a holistic view of Vision Zero plans to create a safe system that anticipates human mistakes and minimizes impact energy on human bodies so that a crash doesn't result in serious injury or death. The Boulder County Vision Zero Action Plan relies on a thorough understanding of motor vehicle, bicycle, and pedestrian crash trends to inform strategic investments in safety improvements aimed at decreasing fatal and severe injuries on roadways throughout the county. This memorandum documents the overview of historical crash trends and safety assessment within Boulder County and development of the High-Injury Network (HIN).

Definitions

The list below provides definitions for terms that are used throughout the memorandum.

First Harmful Event: The first harmful event is the first point of injury or damage in the sequence of events in a crash.

Approach Turn Crash: A crash that occurs when someone turns left in front of oncoming traffic without yielding the right-of-way.

Pedestrian and Bicycle Involved Crash: This crash type involves a motor vehicle and at least one person who is walking, rolling, or biking.

Broadside Crash: Also known as a T-bone crash, a broadside crash happens when the front end of one car crashes into the side of another car.

Fixed-Object Crash: This crash type involves a motor vehicle and a stationary object such as utility poles, guardrails, trees, or buildings

Rear-end Crash: This crash type occurs when the front of one vehicle collides with the back of another vehicle

High-Injury Network: A roadway network that identifies locations where the most injury crashes occur based on historical crash data.

High-Risk Network: Identifies contextual factors related to historical crashes to identify locations where there is a high risk for potential crashes in the future based on roadway characteristics.

Killed or Seriously Injured (KSI): Killed and serious Injury (KSI) crashes are crashes that resulted in one or more fatalities or serious injuries. Serious injuries are defined as broken extremities, severe lacerations, paralysis, etc. Fatal crashes are defined when one or more people die within 30 days of the crash as a result of the injuries sustained in the collision.

Centerline Mile: A measurement of roadway length along the centerline of the road, regardless of the number of lanes. It represents the total length of a roadway segment from start to end, measured along its central axis.

Injury Crash: A traffic crash that results in one or more individuals sustaining injuries, ranging from minor to severe.

Vulnerable Road User: A traffic crash that involves a pedestrian, bicyclist, or motorcyclist.

Crash Severity: Refers to the extent of injury and/or property damage resulting from a traffic crash. Crash severity is categorized as property damage only, possible injury, minor injury, serious injury, or fatality.

Methodology: Data Collection and Study Area

Crash data within Boulder County was obtained from January 1, 2013 to December 31, 2022 from crash data provided by Colorado Department of Transportation (CDOT). Crashes that occurred on private property or in parking lots were excluded from the data source. At the time of analysis, 2023 crash data was not available. The study area included an analysis of all unincorporated Boulder County roads and intersections, CDOT highways and intersections within unincorporated Boulder County, and roadways within the mountain towns of Jamestown, Nederland, and Ward. The data presented in this memorandum is the latest available, however, it is subject to change as new information is obtained in the years to come and traffic safety trends should be monitored in future years beyond the scope of this project. All crash data that was used as part of the analysis went through a cleaning process to provide quality assurance/quality control for the locations of the crash data points. Boulder County's crash cleaning process was followed and the cleaning process was documented in a separate memorandum.

Safety Analysis Summary

This section provides a summary of reported crashes within the ten-year period from January 2013 to December 2022 for all crashes in the study area using CDOT data. The primary goal of this analysis is to identify trends and high-risk factors that are associated with serious injury and fatal crashes. During the ten-year period, a total of 10,642 crashes occurred on all roadways in the study area, including CDOT (7,007 crashes) and Boulder County roadways (3,635 crashes). Of those crashes, 496 (4.6%) resulted in a serious injury or fatality. Table 1 summarizes the number of all crashes, serious injury, and fatal crashes by unincorporated Boulder County and each of the mountain towns within the study area by county roads, CDOT highways, and all roads. Most of the crashes occurred in unincorporated Boulder County.

Table 1. Summary of Crashes by Area and CDOT Highways versus Boulder County Roads

	County Road			CDOT Highways			All Roads		
	# of All Crashes	# of Serious Crashes	# of Fatal Crashes	# of All Crashes	# of Serious Crashes	# of Fatal Crashes	# of All Crashes	# of Serious Crashes	# of Fatal Crashes
Unincorporated	3,532	121	30	6,901	256	82	10,433	377	112
Nederland	91	1	0	100	3	1	191	4	1
Jamestown	10	0	0	0	0	0	10	0	0
Ward	2	0	0	6	2	0	8	2	0
Total (Sum)	**3,635**	**122**	**30**	**7,007**	**261**	**83**	**10,642**	**383**	**113**

Over the ten-year period, 123 people died in 113 traffic crashes in the project area. Figure 1 displays the number of crashes by severity for each year in the analysis period from 2013 to 2022. Overall, the total number of crashes has decreased since 2019. The traffic crashes in 2020 were likely lower than previous years due to the Covid-19 pandemic and decreased traffic on roadways. Figure 2 displays a summary by year of only the fatal and serious injury crashes. Although the number of total crashes has decreased since 2019, the number of serious and fatal crashes each year is increasing, meaning the serious injury and fatal crashes represent a greater percentage of the total crashes than previous years.

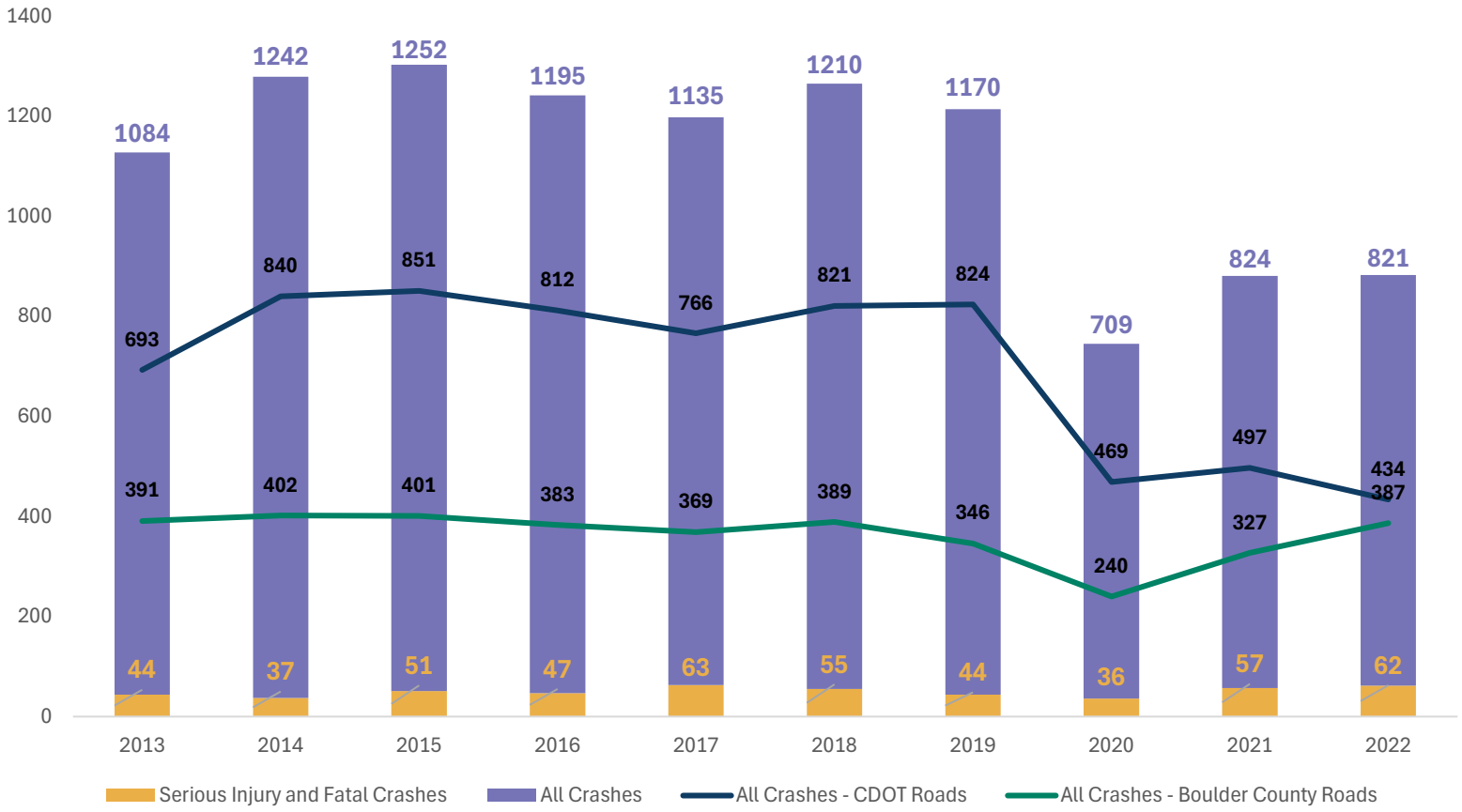

Figure 1. All Crashes Over Time in Study Area

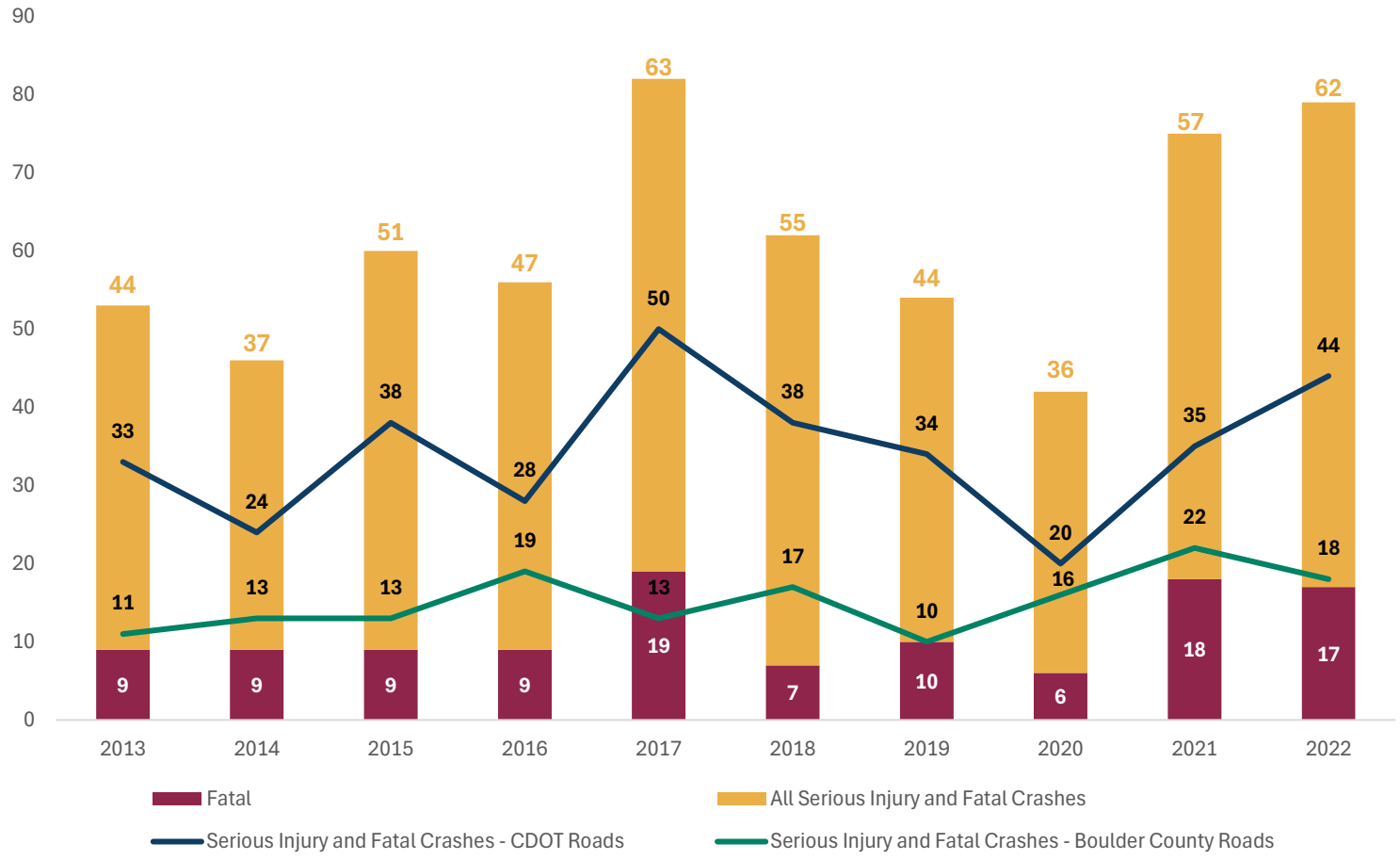

Figure 2. Severe and Fatal Crashes Over Time in Study Area

County Roads versus CDOT Highways

There are a mix of both Boulder County roads and CDOT highways within Boulder County. Figure 3 displays a map of roadways that are owned by Boulder County versus CDOT within the project area. Given the roadway context is different between roadway types and implementation of recommendations would be implemented by different agencies, analysis was completed for the full data set that included all roads (both Boulder County roads and CDOT highways), only Boulder County roads, and only CDOT highways to understand the different trends within the county versus on state highways.

Table 2 summarizes the number of crashes and percentages of all crashes and serious injury and fatal crashes distributed between Boulder County and CDOT highways within the study area. In the study area, 14% of the roadway centerline miles are CDOT highways, but these roadways account for 70% of the serious injury and fatal crashes in the study area. Boulder County roads make up 86% of the centerline miles, but only 30% of the serious injury and fatal crashes in the study area.

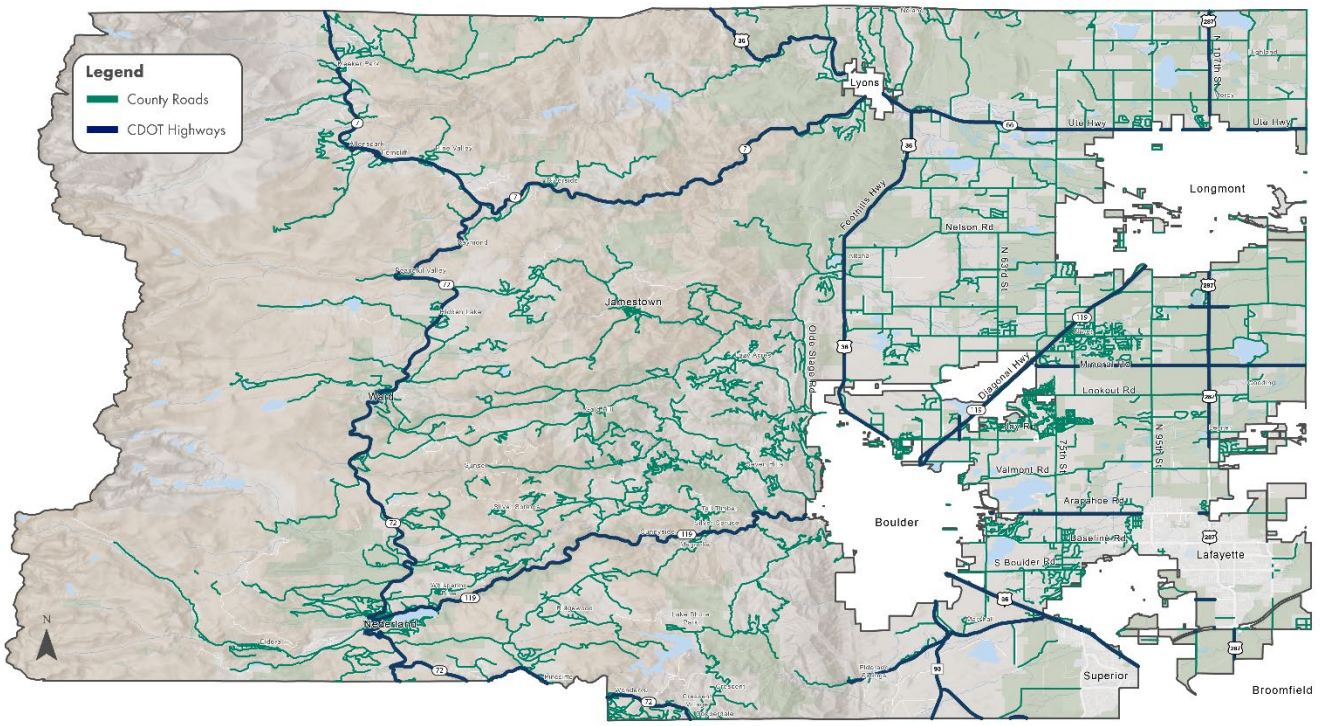

Figure 3. Boulder County roads versus CDOT Highways

Table 2. Summary of Crashes – CDOT Highways versus Boulder County Roads

	Boulder County Roads	CDOT Highways
All Crashes	3,635 crashes (34%)	7,007 crashes (66%)
KSI Crashes	152 KSI crashes (30%)	344 crashes (70%)
Centerline Miles	1,066 miles (86%)	174 (14%)

Crash Type

The top crash types were analyzed for all roads, Boulder County roads, and CDOT highways for all crashes and serious injury and fatal crashes. **Figure 4, Figure 5,** and **Figure 6** display the crash types for all roads, Boulder County roads, and CDOT highways, respectively. Key takeaways of the crash type analysis include the following:

- The most common crash type that results in serious injury and fatality on all roads in the study area are fixed-object and overturning crashes.
- The most common crash type that results in serious injury and fatality on county roads are bicycle-involved crashes.
- The most common crash type that results in serious injury and fatality on CDOT highways are overturning crashes.
- Bicycle and pedestrian crashes account for 4% of all crashes on Boulder County roads, but account for 24% of serious injury and fatal crashes. Thus, bicycle and pedestrian crashes are over-represented in the serious injury and fatal crashes.
- Although rear-end crashes typically result in a higher percentage of all crashes, they are typically less severe and will not be a focus of the Action Plan.

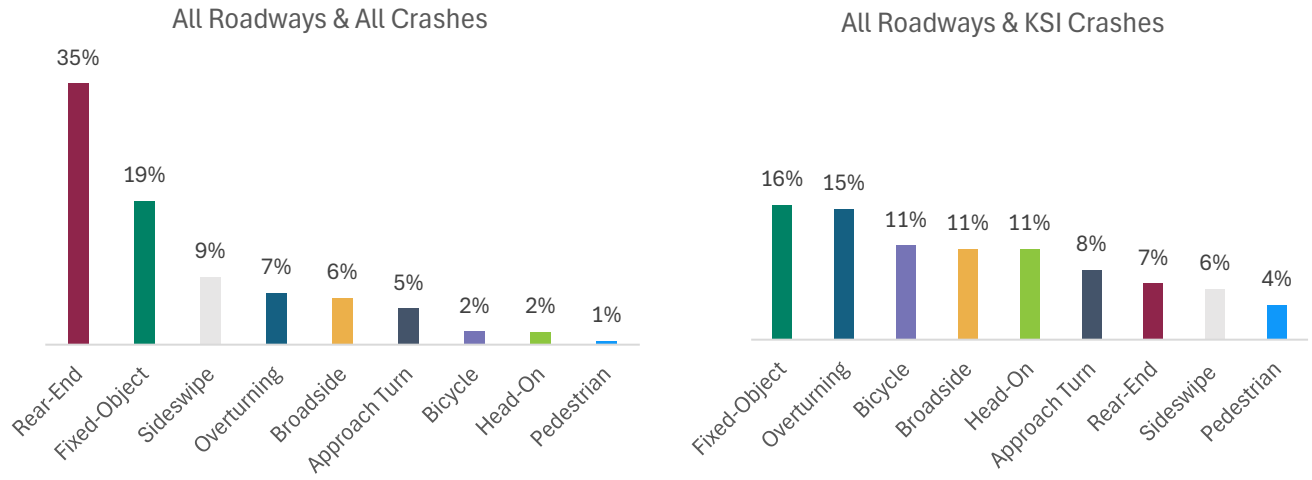

Figure 4. Summary of Top All Crash Types and Serious Injury & Fatal Crash Types – All Roads

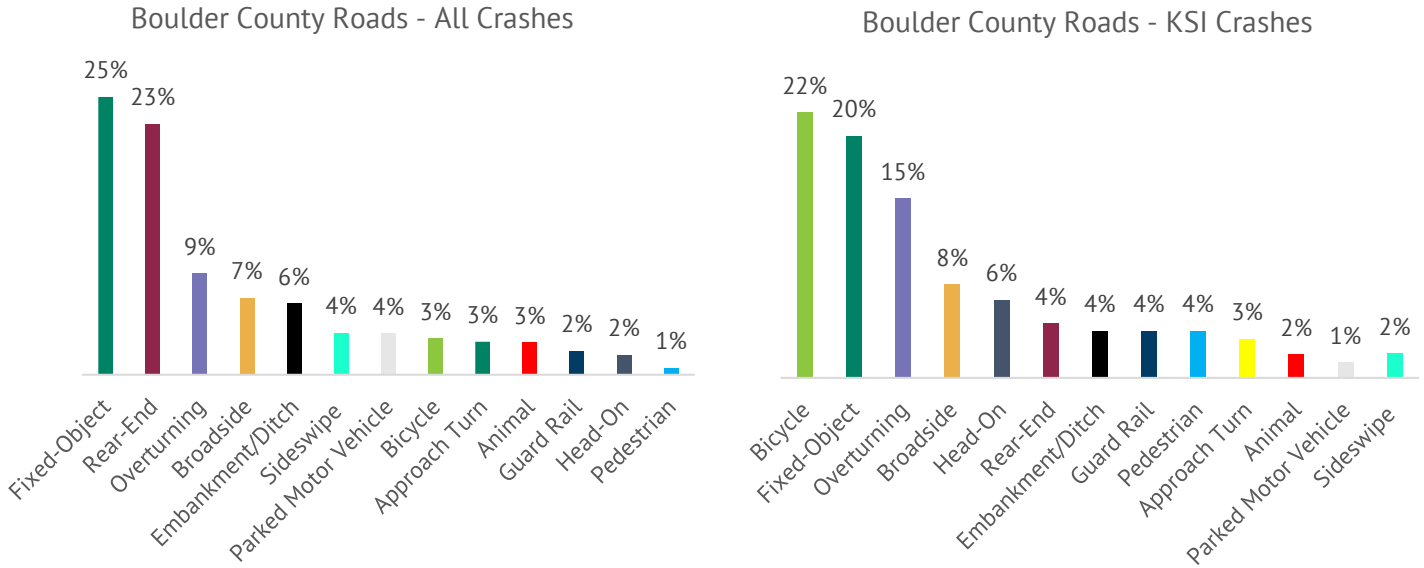

Figure 5. Summary of Top All Crash Types and Serious Injury & Fatal Crash Types – Boulder County Roads

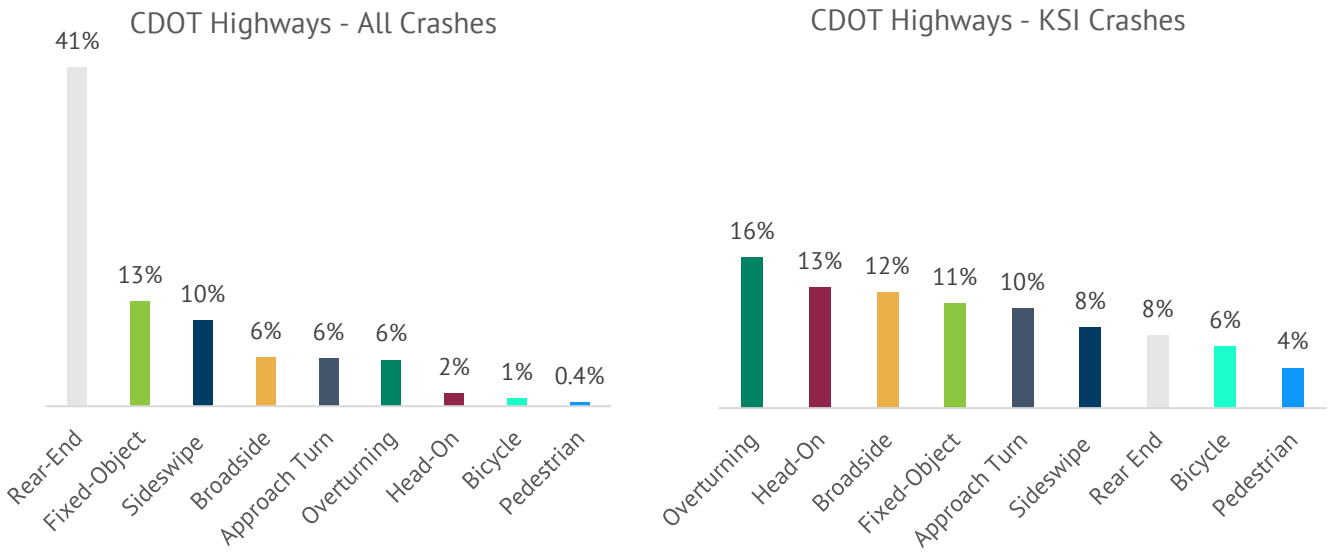

Figure 6. Summary of Top All Crash Types and Serious Injury & Fatal Crash Types – CDOT Highways

In more detail summarized by year, **Table 3** shows the distribution of all crashes in Boulder County by crash type from 2013 to 2022 and **Table 4** shows the distribution of serious injury and fatal crashes in Boulder County.

Table 3. Number of All Crashes by Year and Crash Type in Boulder County

	County Roads												CDOT Highways												Grand	Grand
Crash Type	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**	**%**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**	**%**	**Total**	**Total (%)**
Animal	9	9	11	20	8	12	14	2	10	12	107	2.9%	26	41	42	57	40	60	31	36	25	20	378	5.4%	485	4.6%
Approach Turn	14	9	17	13	14	8	13	2	5	14	109	3.0%	29	28	35	54	55	47	57	33	33	28	399	5.7%	508	4.8%
Barricade/Traffic Barrier	0	0	0	0	0	0	1	5	1	3	10	0.3%	0	0	0	0	0	0	0	2	0	1	3	0.0%	13	0.1%
Bicycle	18	15	11	13	16	8	5	9	7	15	117	3.2%	4	11	6	12	7	6	10	5	4	1	66	0.9%	183	1.7%
Broadside	20	30	21	27	21	34	27	19	24	29	252	6.9%	38	43	49	36	34	53	58	31	30	35	407	5.8%	659	6.2%
Cable Rail	0	0	1	0	0	0	0	1	0	0	2	0.1%	0	0	0	0	0	0	0	0	0	0	0	0.0%	2	0.0%
Crash Cushion	0	0	0	0	0	0	0	0	0	0	0	0.0%	4	1	8	1	0	1	1	0	0	0	16	0.2%	16	0.2%
Curb/Median	2		2	1	4	2	1	1	4	2	19	0.5%	1	2	1	0	5	3	4	2	1	5	24	0.3%	43	0.4%
Embankment/Ditch	41	19	35	33	24	15	16	16	12	22	233	6.4%	34	39	30	18	26	29	28	7	16	14	241	3.4%	474	4.5%
Fixed Object	94	115	108	95	89	106	91	67	66	84	915	25.2%	122	114	113	96	114	90	96	54	45	39	883	12.6%	1,798	16.9%
Ground	0	0	0	0	0	0	0	0	0	1	1	0.0%	0	0	0	0	0	0	0	0	0	2	2	0.0%	3	0.0%
Guard Rail	7	5	8	6	11	8	5	7	15	7	79	2.2%	15	8	16	14	13	15	13	9	11	11	125	1.8%	204	1.9%
Head On	3	14	7	5	7	4	9	6	5	5	65	1.8%	13	15	10	5	14	13	11	3	7	17	108	1.5%	173	1.6%
Large Boulder	9	10	10	12	4	11	8	8	8	7	87	2.4%	13	17	17	16	11	9	14	15	7	11	130	1.9%	217	2.0%
Other/Unknown	0	2	1	0	1	0	0	3	2	3	12	0.3%	5	1	5	1	1	2	2	0	2	0	19	0.3%	31	0.3%
Overtaking Turn	3	4	4	2	8	5	3	4	9	5	47	1.3%	6	7	7	9	7	15	13	4	15	6	89	1.3%	136	1.3%
Overturning	34	35	33	27	36	47	42	33	25	22	334	9.2%	35	48	42	44	36	35	31	50	36	32	389	5.6%	723	6.8%
Parked Motor Vehicle	13	7	13	21	16	17	17	9	9	13	135	3.7%	8	5	2	8	10	7	5	7	6	3	61	0.9%	196	1.8%
Pedestrian	2	2	1	1	4	3	4	1	3	2	23	0.6%	2	2	6	3	5	4	4	1	2	1	30	0.4%	53	0.5%
Railroad Crossing Equipment	0	0	0	0	0	0	0	0	0	1	1	0.0%	0	0	0	0	0	0	0	0	0	0	0	0.0%	1	0.0%
Railway Vehicle	0	0	0	0	0	0	0	0	0	0	0	0.0%	1	0	0	0	0	0	0	0	0	0	1	0.0%	1	0.0%
Rear End	87	95	85	87	80	83	70	38	89	111	825	22.7%	255	344	361	349	311	359	356	161	198	164	2,858	40.8%	3,683	34.6%
Road Maintenance Equipment	2	1	0	2	2	1	0	0	0	0	8	0.2%	3	1	2	2	1	0	2	0	0	0	11	0.2%	19	0.2%
Sideswipe (Opposite Direction)	19	12	16	7	12	15	7	3	9	6	106	2.9%	13	29	18	15	22	9	12	8	16	12	154	2.2%	260	2.4%
Sideswipe (Same Direction)	12	17	17	11	11	9	11	4	23	22	137	3.8%	62	76	73	68	51	60	70	38	39	31	568	8.1%	705	6.6%
Vehicle Cargo/Debris	2	1	0	0	1	1	2	2	1	1	11	0.3%	4	8	8	4	3	4	6	3	4	1	45	1%	56	0.5%
Grand Total	**391**	**402**	**401**	**383**	**369**	**389**	**346**	**240**	**327**	**387**	**3,635**	**100%**	**693**	**840**	**851**	**812**	**766**	**821**	**824**	**469**	**497**	**434**	**7,007**	**100%**	**10,642**	**100%**

Table 4. Number of Serious Injury and Fatal by Year and Crash Type in Boulder County

	County Roads												CDOT Highways												Grand	Total
Crash Type	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**	**%**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**	**%**	**Total**	**(%)**
Animal	0	0	0	0	0	0	0	0	1	2	3	2.0%	1	1	0	0	1	0	0	1	0	1	5	1.5%	8	1.6%
Approach Turn	0	1	1	2	0	0	0	0	0	1	5	3.3%	3	2	2	5	4	6	3	0	6	4	35	#####	40	8.1%
Barricade/Traffic Barrier	0	0	0	0	0	0	0	1	0	0	1	0.7%	0	0	0	0	0	0	0	0	0	0	0	0.0%	1	0.2%
Bicycle	5	4	3	2	6	3	2	1	2	3	31	20.4%	1	2	1	4	5	2	4	0	2	1	22	6.4%	53	10.7%
Broadside	1	0	1	1	1	1	0	1	2	4	12	7.9%	4	1	4	3	5	5	6	3	1	9	41	#####	53	10.7%
Cable Rail	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
Crash Cushion	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
Curb/Median	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
Embankment/Ditch	0	1	1	1	1	1	0	0	0	0	5	3.3%	1	1	3	1	1	2	0	1	1	0	11	3.2%	16	3.2%
Fixed Object	1	3	1	7	1	3	3	5	6	1	31	20.4%	2	5	7	0	6	4	5	4	4	2	39	#####	70	14.1%
Ground	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	1	1	0.3%	1	0.2%
Guard Rail	0	0	0	0	1	0	0	1	4	0	6	3.9%	1	0	2	1	2	0	0	1	0	0	7	2.0%	13	2.6%
Head On	0	1	1	1	0	1	1	2	1	2	10	6.6%	5	3	3	1	8	5	4	1	6	8	44	#####	54	10.9%
Large Boulder	1	0	1	0	0	1	0	0	1	0	4	2.6%	1	0	2	2	0	1	0	1	0	0	7	2.0%	11	2.2%
Other/Unknown	0	0	0	0	0	0	0	0	0	0	0	0.0%	1	0	2	0	1	0	0	0	0	0	4	1.2%	4	0.8%
Overtaking Turn	0	0	0	0	0	0	0	1	0	0	1	0.7%	0	0	0	0	1	0	0	0	1	0	2	0.6%	3	0.6%
Overturning	2	0	4	2	2	4	3	2	1	3	23	15.1%	8	5	2	7	6	3	5	5	5	8	54	#####	77	15.5%
Parked Motor Vehicle	0	0	0	0	0	2	0	0	0	0	2	1.3%	0	0	0	0	0	0	0	0	1	1	2	0.6%	4	0.8%
Pedestrian	0	1	0	0	0	1	1	0	2	1	6	3.9%	0	1	3	0	2	3	2	0	2	1	14	4.1%	20	4.0%
Railroad Crossing Equipment	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
Railway Vehicle	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
Rear End	1	0	0	3	0	0	0	1	1	1	7	4.6%	1	1	4	2	3	6	2	1	3	4	27	7.8%	34	6.9%
Road Maintenance Equipment	0	0	0	0	1	0	0	0	0	0	1	0.7%	0	0	0	0	0	0	0	0	0	0	0	0.0%	1	0.2%
Sideswipe (Opposite Direction)	0	1	0	0	0	0	0	1	0	0	2	1.3%	2	2	1	0	4	1	3	1	2	3	19	5.5%	21	4.2%
Sideswipe (Same Direction)	0	1	0	0	0	0	0	0	1	0	2	1.3%	2	0	2	2	1	0	0	1	1	1	10	2.9%	12	2.4%
Vehicle Cargo/Debris	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0%	0	0.0%
Grand Total	**11**	**13**	**13**	**19**	**13**	**17**	**10**	**16**	**22**	**18**	**152**	**100%**	**33**	**24**	**38**	**28**	**50**	**38**	**34**	**20**	**35**	**44**	**344**	**100%**	**496**	**100%**

Where Crashes Are Occurring

A heatmap of all crashes in Boulder County from 2013 to 2022 is shown in Figure 7. Most crashes are concentrated on the following roads:

- US 36 – Boulder/Denver Turnpike
- CO 119 – Diagonal Highway
- US 287

Figure 8 displays the concentration of where injury crashes (minor injury, serious injury, fatal) are occurring. Figure 9 displays the locations of the serious injury and fatal crashes in Boulder County and differentiates if they are occurring at an intersection or non-intersection location. Most of the crashes in the study area occur at non-intersection locations. Figure 10 displays the breakdown of serious injury and fatal crashes occurring on CDOT and Boulder County roads. Over 60% of crashes on CDOT highways and over 60% of crashes on Boulder County roads occur at non-intersection locations. 33% of crashes on CDOT highways occur at intersections or are intersection-related whereas 29% of crashes on Boulder County roads occur at intersections or are intersection-related. The remainder of the crashes occur at driveways or are driveway access related or at ramps or are ramp related.

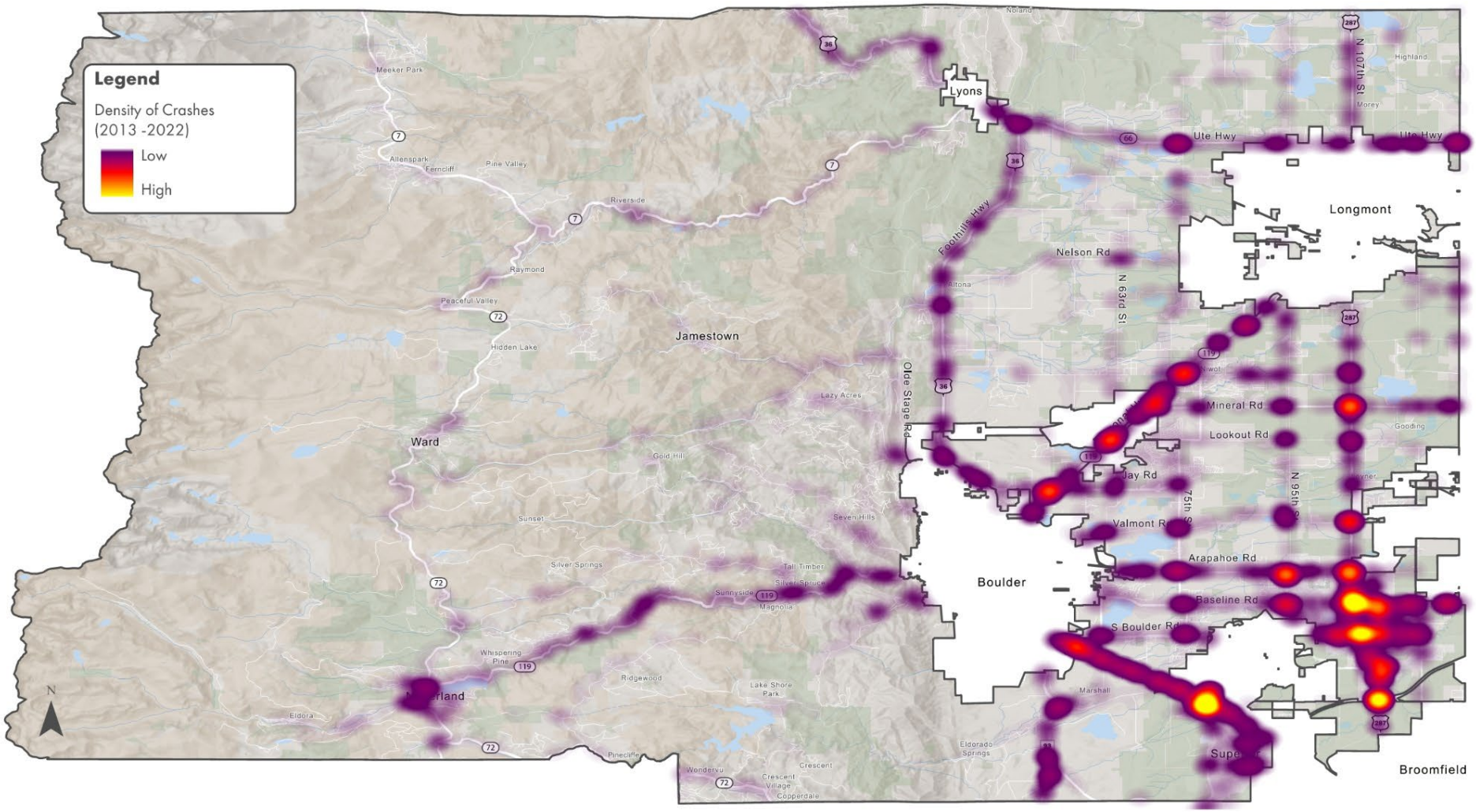

Figure 7. Map of All Crashes in Study Area

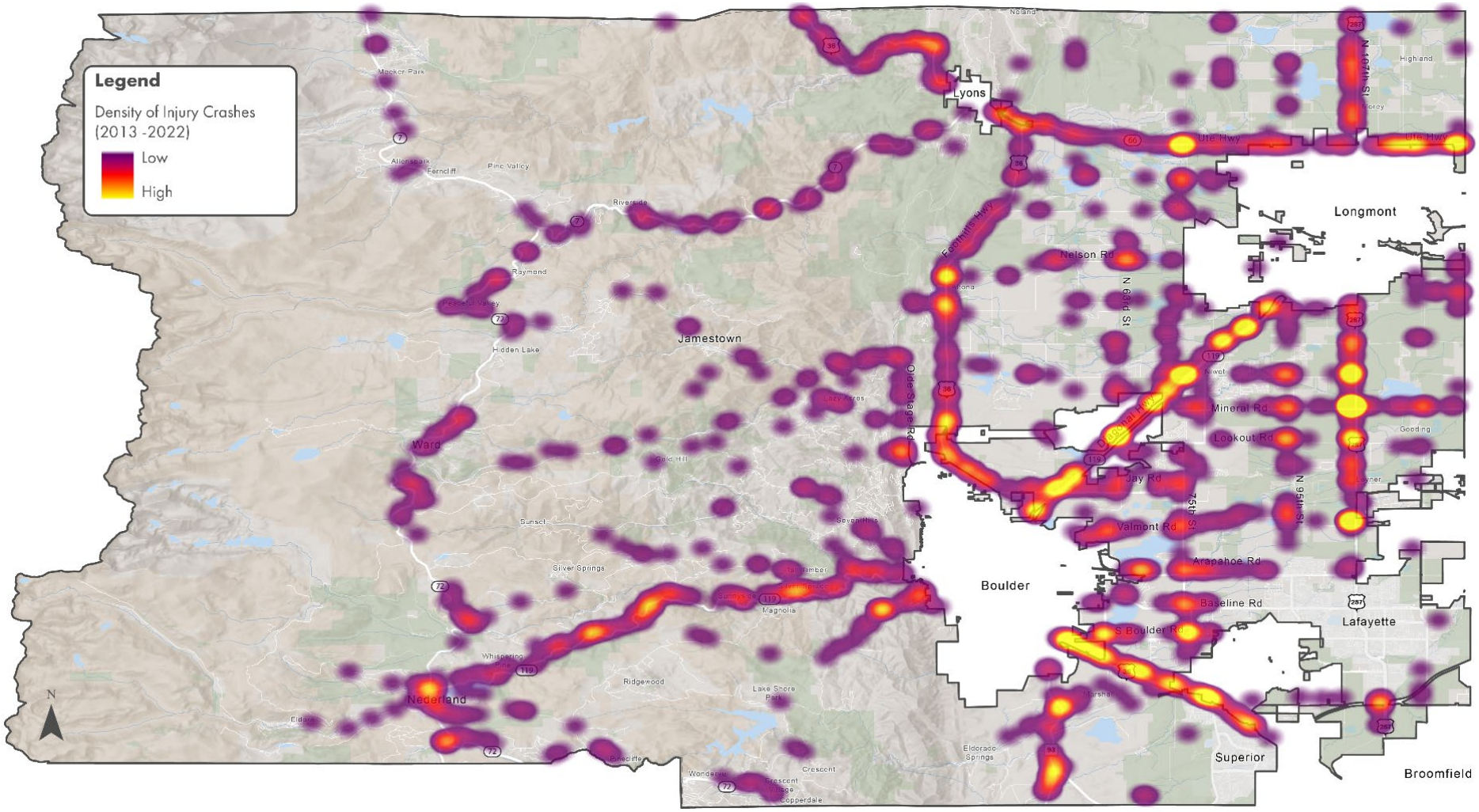

Figure 8. Map of All Injury Crashes (Minor, Severe, Fatal) in Study Area

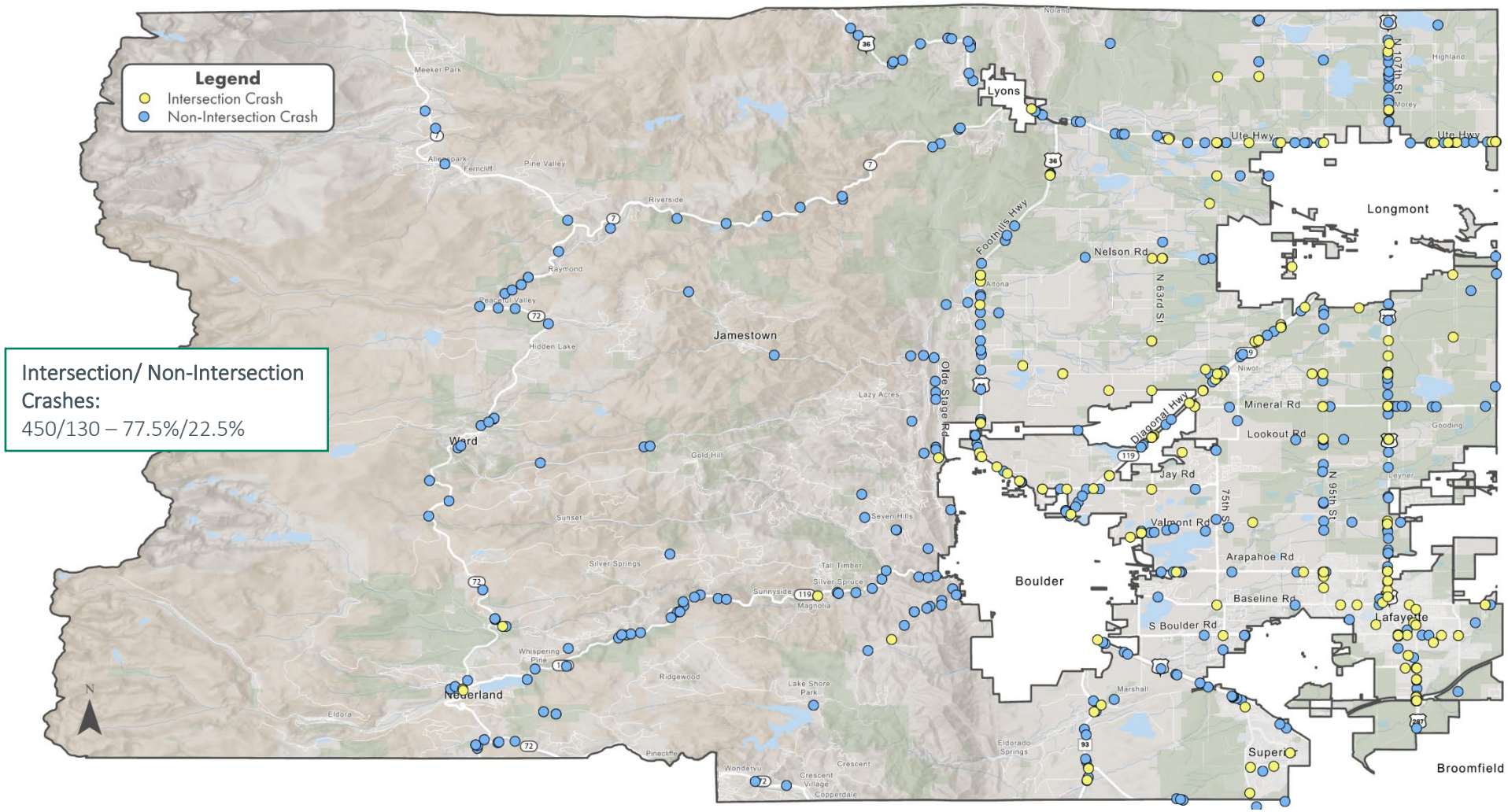

Figure 9. Map of All Serious Injury and Fatal Crashes in Study Area

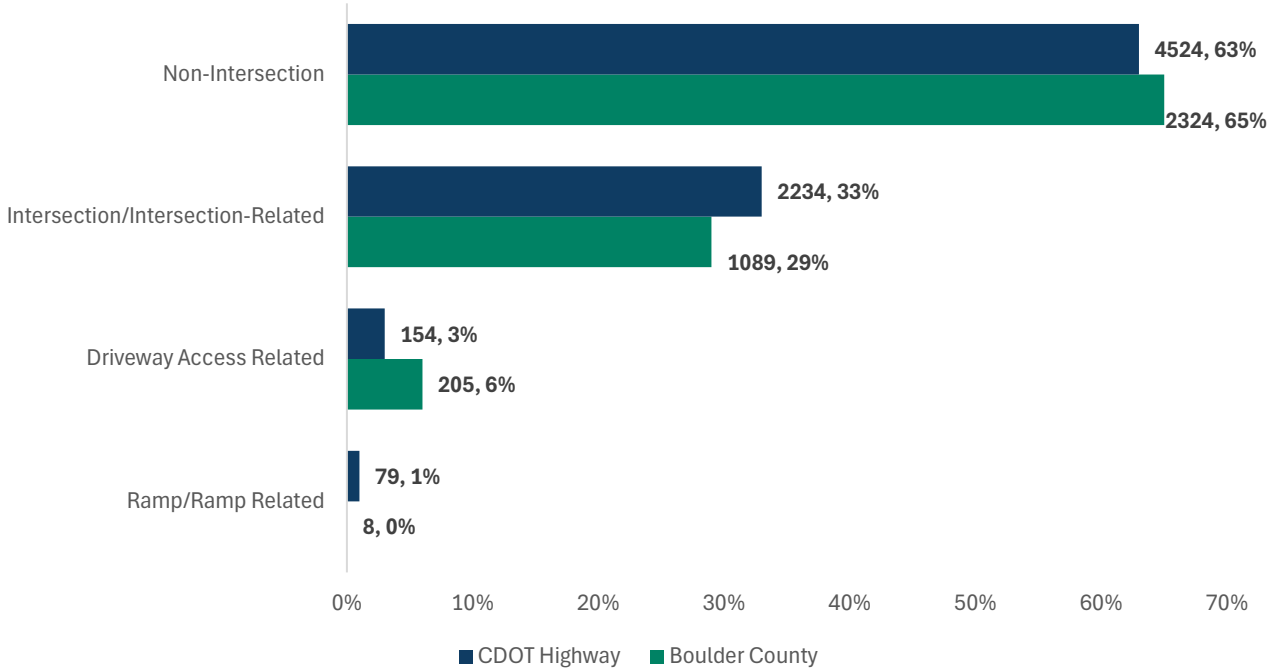

Figure 10. Summary of Crash Location Description, All Crashes– Boulder County and CDOT Highways

When Crashes Are Occurring

Figure 11 displays the percentage of all crashes by time of day. Overall, crashes are distributed between 6AM and 12AM; however, most of the crashes occur between 3PM and 6PM. Figure 12 displays the frequency of crashes in Boulder County by month. Generally, crashes are fairly distributed throughout the year, but March through May have the lowest percentage of crashes and the months with over 9% of crashes include July, October, and November. Figure 13 and Figure 14 display the road conditions and lighting conditions for all crashes, respectively. Most crashes were occurring in dry roadway conditions where 14% of all crashes and 6% of serious injury and fatal were occurring in icy, slushy, or snowy conditions and 7% of all crashes and 5% of serious injury and fatal crashes are occurring in wet conditions. Approximately 70% of crashes occur in the daylight and approximately one-quarter of crashes are occurring in the dark unlighted or dark lighted conditions.

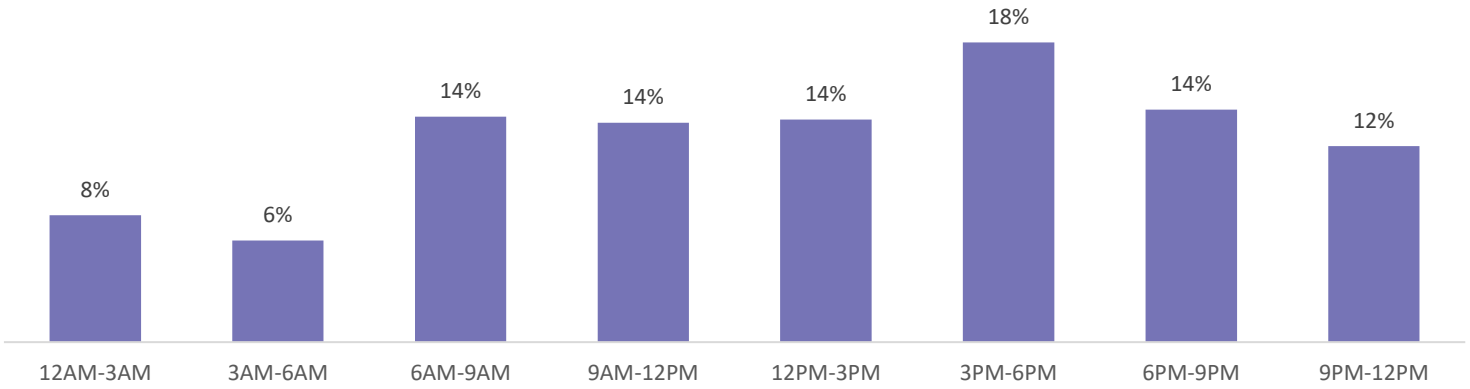

Figure 11. All Crashes by Time of Day in Boulder County – All Roads

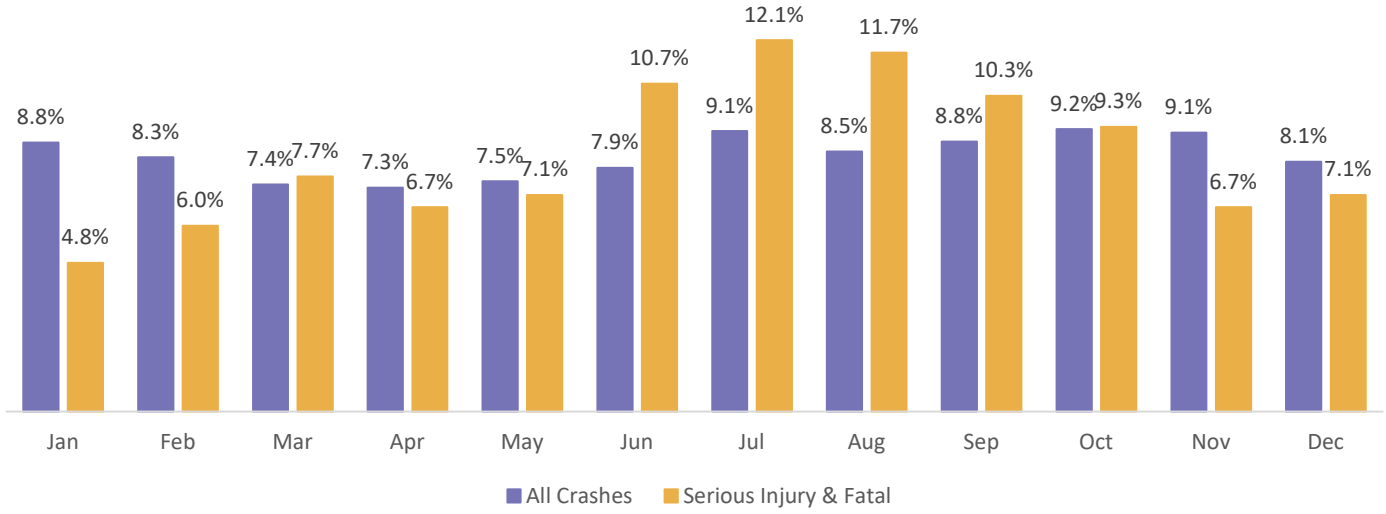

Figure 12. All Crashes and KSI Crashes by Month in Boulder County – All Roads

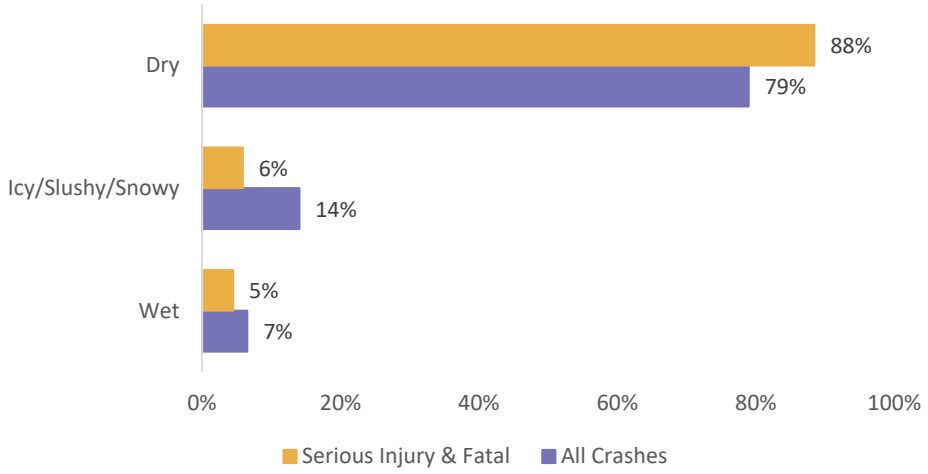

Figure 13. All Crashes Summary of Road Conditions – All Roads

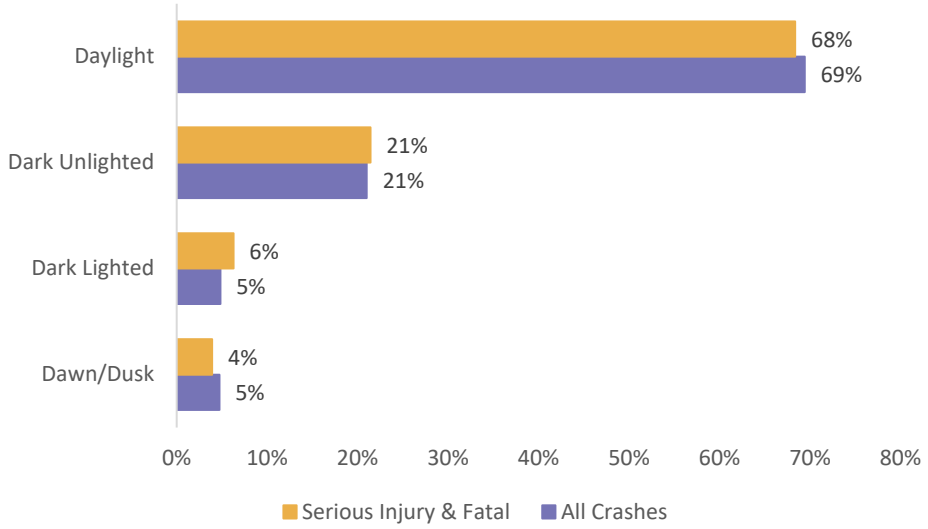

Figure 14. All Crashes Summary of Lighting Conditions – All Roads

Who is Involved in Crashes

Figure 15 displays the vehicle type for the vehicle at fault broken down for all crashes and serious injury and fatal crashes. Most of the vehicles at fault include a passenger car/van or an SUV. For serious injury or fatal crashes, a motorcycle or bicycle at fault is overrepresented compared to other crash types.

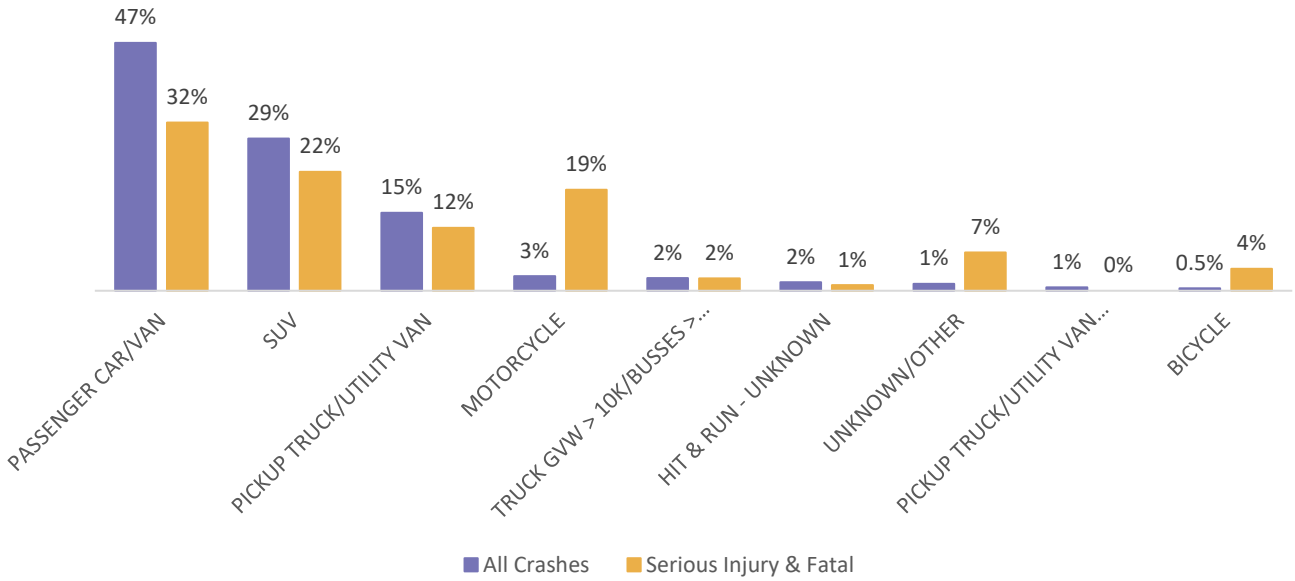

Figure 15. Summary of Vehicle Type at Fault - All Roads

CRASHES INVOLVING PEDESTRIANS, BICYCLISTS, AND MOTORCYCLISTS

A vulnerable road user crash is a crash that involves a pedestrian, bicyclist, or motorcyclist and were analyzed in detail. Bicycle crashes were the most common crash type on Boulder County roads. Bicyclists and pedestrians have notably higher risk of being involved in serious or fatal crashes compared to motorists which is evidenced by their overrepresentation in crashes that result in injury or death. 31% of all Boulder County pedestrian and bicycle crashes resulted in a fatality or serious injury. Figure 16 displays the number of pedestrian and

bicycle crashes per year by severity level. 2017 had the greatest number of all pedestrian and bicycle crashes and KSI pedestrian and bicycle crashes. Most years within the study period had 6-9 serious injuries or fatal bicycle and pedestrian crashes. **Figure 17** displays the number of bicycle and pedestrian crashes by month. The months with the highest number of bicycle/pedestrian crashes are July through October with the highest month being August. **Figure 18** displays a map with the location of pedestrian, bicycle, and motorcycle crashes by severity. The roads that experience the majority of the bicycle crashes include the US-36 corridor (north of Boulder) and the CO-110 corridor. Roads with the most motorcycle crashes include SH 72, CO 119 – Boulder Canyon, and US 36 – N US 36.

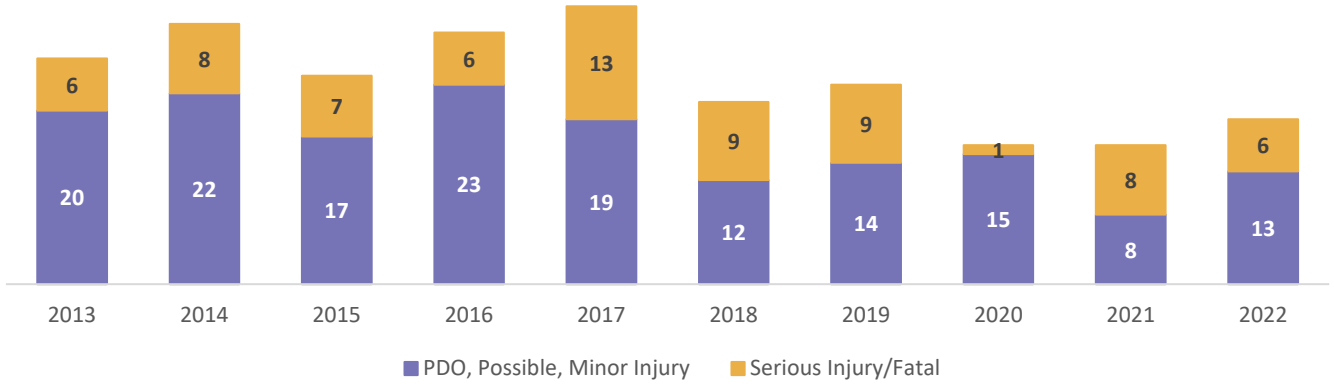

Figure 16. Number of Bicycle and Pedestrian Crashes by Severity and Year

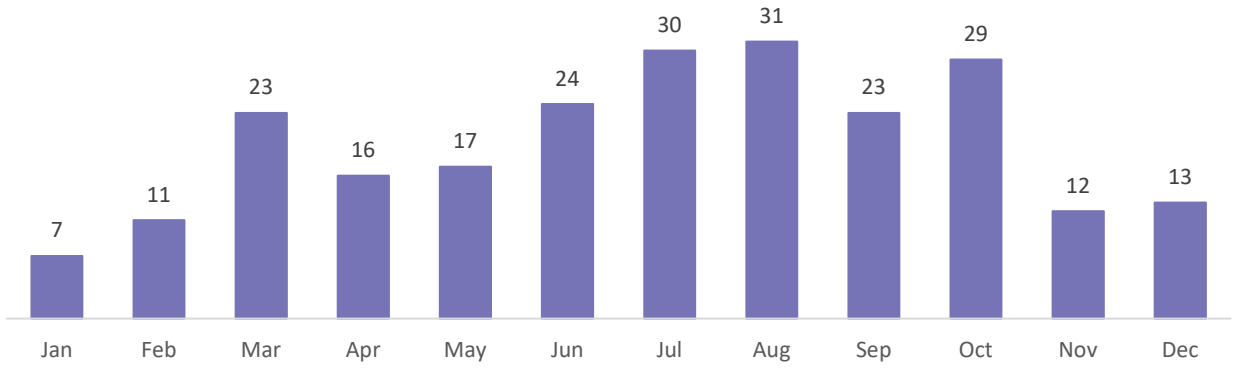

Figure 17. Number of Pedestrian and Bicycle Crashes by Month

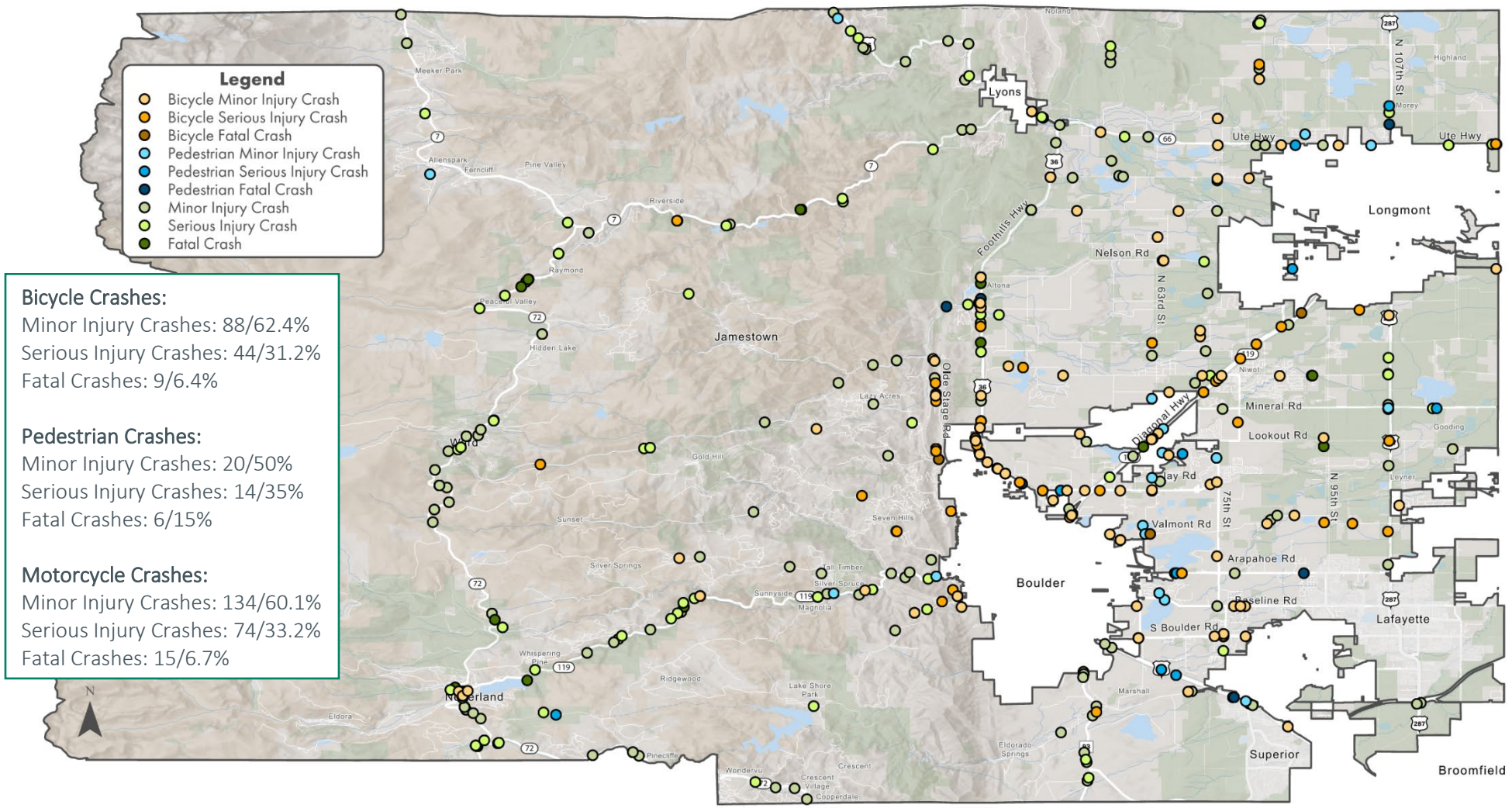

Figure 18. Pedestrian, Bicycle, and Motorcycle Crashes Locations by Severity

Crash Characteristics and Contributing Factors

Table 5 and Table 6 display the top driver actions for vehicles at fault and the top human contributing factors, respectively.

Table 5. All Crashes Driver Action – All Roads

Driver Action	% of All Crashes
CARELESS DRIVING	41%
FOLLOWING TOO CLOSE	9%
CARELESS DRIVING CAUSE INJURY	5%
DRIVE UNDER INFLUENCE ALCOHOL	4%
TOO FAST FOR CONDITIONS	2%
TURN LEFT/ONCOMING TRAFFIC	2%
UNSAFE LANE CHANGE	2%

Table 6. All Crashes Human Contributing Factors – All Roads

Human Contributing Factor	% of All Crashes
NO APPARENT CONTRIBUTING FACTOR WHEN HUMAN FACTOR IS KNOWN	42%
UNKNOWN	20%
DRIVER PREOCCUPIED (“DISTRACTED”)	15%
DRIVER INEXPERIENCE	12%
DRIVER UNFAMILIAR WITH AREA	4%
ASLEEP AT WHEEL	3%
ILLNESS	2%

In the 2013-2020 CDOT data, alcohol/drug use was stated in driver action. Starting in 2021, the data set was updated, and alcohol and drugs were tracked in separate fields with more detail. A summary of alcohol and marijuana use related crashes was completed for the crashes that occurred in the 2021 and 2022 data set that had this information. Table 7 displays the summary of 2021 and 2022 alcohol use and marijuana use crashes on all roads in the study area. There was no information provided (i.e., field was left blank) or alcohol use was unknown for 27% of the crashes in the 2021 and 2022 data set. Where there was data available and known, there was no alcohol suspected in 88% of the crashes. There was no information provided (i.e., field was left blank) or marijuana use was unknown for 19% of the crashes in the 2021 and 2022 data set. Where there was data available and known, there was no marijuana suspected in 97% of the crashes.

Table 7. All Crashes 2021 and 2022 Alcohol Use Crashes – All Roads

Alcohol Use (2021-2022)	
No Alcohol Suspected	88%
Yes, Alcohol Suspected/Confirmed	12%
Marijuana Use (2021-2022)	
Marijuana Not Suspected	97%
Marijuana Suspected	3%

High Injury Network (HIN) Development

Boulder County crash data was utilized to develop a High Injury Network (HIN), which is a network of roadway segments and intersections that historically show a higher concentration of crashes resulting in injury. **The HIN that has been identified includes 7% of the centerline miles and 32 intersections but account for 66% of the serious injury and fatal crashes.** This network provides a framework for identifying high priority locations to focus improvements designed to address traffic fatalities and serious injuries. **Figure 19** displays the overall process for the development of the HIN. Details of the analysis are described in more detail in the subsequent sections below. To address areas of high-injury for all modes and areas of high-injury for vulnerable users, **Figure 20** displays the overall and pedestrian/bicycle HIN.

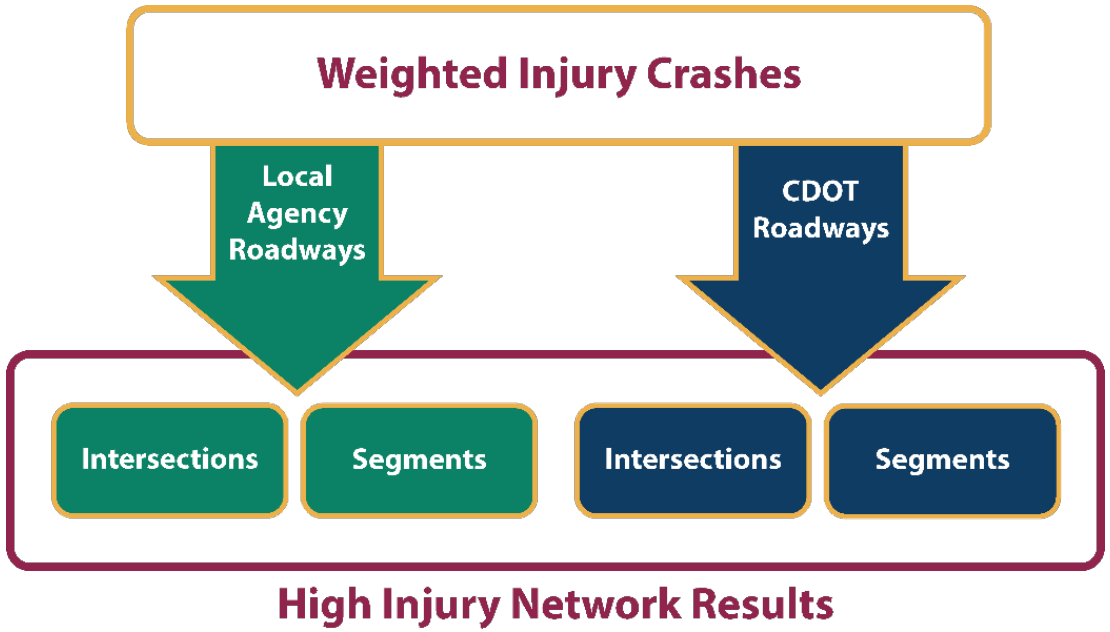

Figure 19. High Injury Network Development Process

Step 1: Prepare Network with Segmentation of Roads

ArcGIS was used to provide visual analysis of the existing available centerline data provided by Boulder County showed roadway segments broken into varying lengths, primarily split at intersections. To connect roads across intersections and provide a more standard segment length, centerlines were dissolved using the roadway name and clipped to the study area. Segments with a length over 1 mile were then divided at mile marker points where available. Segments without mile marker points that were under 2 miles in length were split directly in half, while those that were over 2 miles were divided into one-mile-long segments with any remaining line length divided equally amongst the divisions. All segments were assigned a unique segment ID.

Step 2: Define Weighting of Injury Crashes

Due to the relatively small dataset of fatalities and serious injuries in Boulder County, minor injury crashes were also included in the analysis to improve the ability to reach meaningful conclusions. To maintain a focus on areas with high rates of fatalities and serious injuries, crashes were weighted according to their severity with minor injury crashes having a weight of 1, serious injury crashes having a weight of 2, and fatal crashes having a weight of 4.

Step 3: Intersection versus Road Segment Crashes

To avoid identifying segments where injury crashes were occurring at intersections appearing on the high injury network, it was decided to analyze intersection crashes separately from segments. This separation of intersection versus non-intersection crashes allowed the project team to more clearly assign crashes to location segments and intersections to pinpoint the specific locations where injury crashes are occurring and improve the accuracy of the high injury network. Non-intersection crashes were then assigned to the road segment they occurred on. Each segment was given a score for the weighted number of crashes and the weighted number of crashes per mile.

Intersection points were created at the intersections of each roadway segment. Each intersection was assigned a unique intersection ID. Intersection points that included only local roadway segments were buffered by 50ft, while intersection points with non-local roadway segments were buffered by 75ft to encompass the typically larger intersection size. These two buffer layers were combined into one full dataset comprising the buffers for all intersections.

Intersection crashes that were located within the buffer distance of intersections were assigned to each intersections. Each intersection was given a score for the weighted number of crashes.

Step 4: Boulder County versus CDOT Segments and Intersections

A review of the intersections and segments with the highest number of weighted crashes revealed that the majority of the top intersections and segments were occurring on CDOT highways. The project team determined that CDOT intersections and segments would be analyzed separately from Boulder County intersections and segments. Separating the analysis of the HIN into Boulder County and CDOT was completed for the following reasons:

1. Highlight Boulder County intersections and roads that had a higher proportion of injury crashes compared to other locations owned by Boulder County, even though these locations may not have had as high a proportion when compared to CDOT highways. This gave the project team the flexibility to determine different thresholds for CDOT and County roads.
2. Crash trends and characteristics of CDOT highways versus County roadways are different.
3. Ownership and implementation of roadways is different so ultimately recommended actions identified in the Final Action Plan should be designated based on CDOT or Boulder County roads.

Step 5: Developing a Threshold to Select HIN Segments and Intersections

For intersections, Boulder County and CDOT intersections were sorted by total number of weighted crashes. A threshold for which intersections for each jurisdiction would be included on the high-injury network was determined by calculating the average number of weighted crashes plus one standard deviation. This threshold differed for Boulder County intersections and CDOT intersections, which allowed the project team to identify Boulder County intersections that may not have risen above a combined dataset threshold.

For segments, the number of weighted injury crashes per mile was used to calculate the weighted injury crash rate per mile to determine the highest concentrations of injury crashes. The segments were then sorted by this rate to determine the segments with the highest concentrations of injury crashes. Similarly to the intersection process, segments were split into CDOT highways and Boulder County roads to maintain the focus on Boulder County roads with high concentrations of injury crashes compared to other Boulder County roads, rather than comparing to the proportionally higher state highway rates. The threshold for which county roadway segments and intersections would be included on the high-injury network was determined by calculating the average weighted injury crash per mile plus one standard deviation. For CDOT highways, this threshold was lowered to around 1.5x the county threshold, due to the over-representation of injury crashes on CDOT highways.

Step 6: Refining the HIN

As a result of the dissolve step of the segmentation process, some segments had a very short length and thus were found to have a disproportionately high weighted injury crash rate per mile. To rectify this, very short segments containing injury crashes were manually cleaned by merging with the adjacent, longer segments to be closer to 1 mile long. Segment length and weighted injury crash rates per mile were recalculated, and following this cleaning process segment thresholds for both CDOT highways and Boulder County roads were recalculated.

After reviewing the network of segments falling above the threshold, the project team decided to analyze Boulder County segments at a half mile length to take a closer look at more specific locations with concentrated injury crashes. To accomplish this analysis, the previous Boulder County 1-mile segments were split directly in half. Then, the same steps to determine the weighted crash rate per mile were completed as for the 1-mile segments. CDOT highways were analyzed only under the 1-mile scenario.

When comparing the two scenarios for Boulder County (1-mile segments and ½-mile segments), the project team determined that, though there were many segments that overlapped, there were some segments that were more appropriately analyzed at a 1-mile segment, and

some that were more appropriate at a ½ mile segment. This was largely determined based on the relative distribution of crashes along the two segment lengths. For example, if the majority of crashes occurred on half of the 1-mile segment, it was determined to be most appropriate as a ½-mile segment displayed on the high-injury network. If the majority of crashes were evenly dispersed along the entire 1-mile segment, it was determined to be most appropriate to remain at that length for display on the high-injury network. The project team manually reviewed each Boulder County segment falling above the identified thresholds and used engineering judgement to select the ultimate Boulder County segments to be displayed on the final high-injury network. Appendix A displays the comprehensive list of HIN segments and intersections with their weighted crash scores/thresholds.

Bicycle & Pedestrian High Injury Network Development

Given that bicycle and pedestrian crashes made up a relatively large proportion of injury crashes in Boulder County, the project team created a high-injury network focused specifically on these crash types. To identify this network, the same process was followed as for the general high-injury network, with the injury crash dataset limited to those with a crash type of "BICYCLE" or "PEDESTRIAN." Similarly to the general high-injury network, segments and intersections were analyzed separately, and thresholds were determined separately for CDOT highways and Boulder County roads. For Boulder County and CDOT segments, 1-mile segments were used for the Bicycle & Pedestrian HIN. Due to the relatively small dataset and the short length of some neighborhood roads, some segments and intersections with only 1 injury crash fell above their respective "average + 1 standard deviation" thresholds. These segments were removed from the bicycle & pedestrian high-injury network if the single crash resulted in a minor injury, but were retained if the crash resulted in a serious injury or fatality.

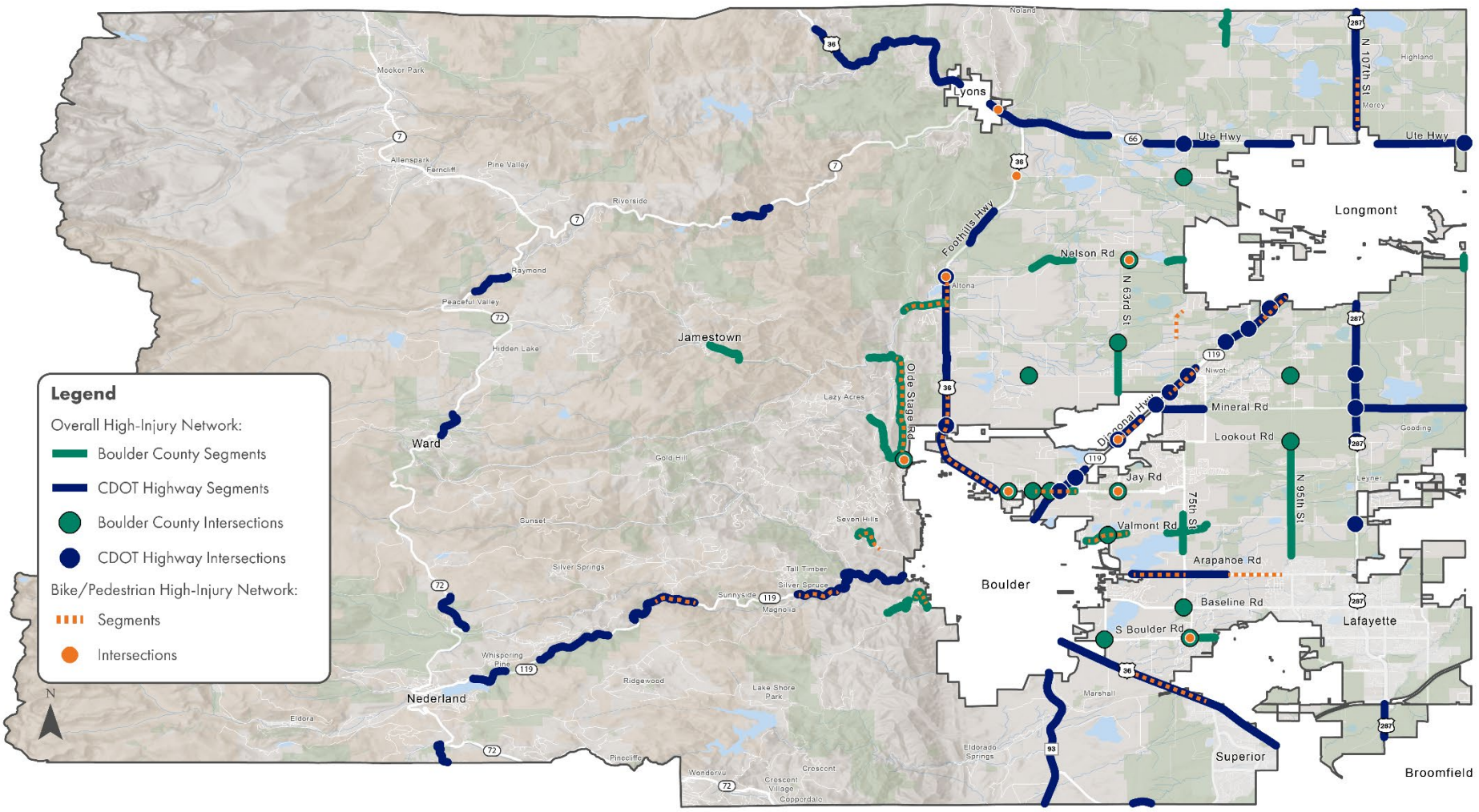

Figure 20. Boulder County High Injury Network

Final Considerations

Ten years of crash data was obtained from CDOT from January 1, 2013 to December 31, 2022 for completion of the safety analysis and development of the HIN. The following key findings are based on a review of crash data from 2013 to 2022.

- Overall, the number of crashes has decreased since 2019, but the number of serious injuries and fatal crashes has remained constant or has increased.
- Since 2020, the number of serious and fatal crashes each year is increasing.
- CDOT highways account for 14% of the centerline miles within the study area, but account for 70% of the serious injury and fatal crashes.
- Boulder County roads account for 86% of the centerline miles within the study area, but only 30% of the serious injury and fatal crashes.
- Top crash types were analyzed separately for CDOT highways and Boulder County roads to understand how crash types differed on each roadway type.
    - Top crash types on Boulder County roads that result in serious injury and fatality include bicycle (20%), fixed-object (20%), overturning (15%), broadside (8%), and head on (6%).
    - Top crash types on CDOT highways that resulted in serious injury and fatality include overturning (16%), head on (13%), broadside (13%), fixed-object (11%), and approach turn (10%).
    - Rear-ends typically result in a high percentage of all crashes, but a lower percentage of serious injury and fatal crashes; thus, rear-ends typically result in less serious injury.
- The following crash profiles represent 77% of the serious injury and fatal crashes in Boulder County:
    - Single-vehicle (including vehicles departing from the road, colliding with fixed-objects, and overturning vehicles) – 36%
    - Bicycle – 12%
    - Head-on – 11%
    - Broadside – 9%
    - Left-turn -9%
- Most crashes on both county roads and CDOT highways occur at non-intersection locations.
- Most crashes occur between 3PM and 6PM in daylight and dry conditions.
- Passenger car/van is the most common vehicle type at fault. However, motorcycle and bicycle crashes are overrepresented in serious injury and fatal crashes for vehicles at fault.
- Roads with the most motorcycle crashes include SH 72, CO 119 – Boulder Canyon, and US 36 – N US 36.
- Roads with the most bicycle crashes include US 36 – US 36 and CO 119 – Diagonal Highway.

A high-injury network (HIN) based on historical crash data has been identified that includes 7% of the centerline miles but accounts for 66% of the serious injury and fatal crashes.

Appendix A: HIN Segments and Intersections – Ranked by Total Number of Weighted Crashes

Table 8: Boulder County HIN Intersections

Intersecting Roadways	Total Weighted Injury Crashes
76th Street & South Boulder Road	13
Cherryvale Road & South Boulder Road	10
65th Street & Nelson Road	9
95th Street & Lookout Road	9
63rd Street & Oxford Road	7
95th Street & Niwot Road	7
75th Street & Baseline Road	6
30th Street & Jay Road	6
63rd Street & Jay Road	6
75th Street & Hygiene Road	5
51st Street & Jay Road	5
Lee Hill Drive & Wagonwheel Gap Road	5
Golf Club Drive & Niwot Road	5
61st Street & Valmont Road	5
47th Street & Jay Road	5

Table 9: Colorado Department of Transportation HIN Intersections

Intersecting Roadways	Total Weighted Injury Crashes
US 287 & Mineral Road	63
Isabelle Road & US 287	50
CO 119 & Niwot Road	22
75th Street & Ute Highway	20
US 287 & Lookout Road	20
66th Street, East County Line Road, & Ute Highway	18
US 287 & Niwot Road	17
63rd Street & CO 119	16
Airport Road, CO 119, & Ogallala Road	16
55th Street & CO 119	14
IBM Drive, Mineral Road, & CO 119	14
US 36 & Nelson Road	13
Monarch Road & CO 119	11
83rd Street & CO 119	9
Fordham Street & CO 119	7
CO 119 & Jay Road	7
Longhorn Road & US 36	7
US 36 & Hygiene Road	5
McConnell Drive, Stone Canyon Drive, & Ute Highway	4

Table 10: Boulder County HIN Roadway Segments

Roadway	Segment Starting Roadway	Segment Ending Roadway	Total Weighted Injury Crashes per Mile
South Boulder Road	McCaslin Boulevard	Ponderosa Drive	15
Lefthand Canyon Drive	Olde Stage Road	Crossing over Left Hand Creek	12
Flagstaff Road	Gregory Lane	MM 1	12
Nelson Road	Clover Basin Reservoir	75th Street	11
Sunshine Canyon Drive	Timber Trail	Eagles Drive	10
Lefthand Canyon Drive	US 36	West of Geer Canyon Drive	9
Flagstaff Road	MM 2	Flagstaff Drive	9
Valmont Road	57th Street	6300 Block	8
Nelson Road	Centennial Ranch	55th Street	8
Olde Stage Road	Lefthand Canyon	Lee Hill Drive	7
75th Street	UP Railroad	Red Deer Drive	6
Valmont Road	Approx 0.4mi W of 75th Street	Approx 0.6mi East of 7th Street (end of curves)	6
Jay Road	47th Street	55th Street	6
63rd Street	Oxford Road	Monarch Road	6
James Canyon Drive	Main Street	MM 2	6
East County Line Road	North of Quicksilver Road	Pike Road	6
95th Street	Lookout Road	Boulder County Boundary	6
73rd Street	East of Plateau Road	North of Nimbus Road	5
83rd Street	County Line Road	Yellowstone Road	5

Lee Hill Drive	57th Street	East of Reed Ranch Road	5

Table 11: Colorado Department of Transportation HIN Roadway Segments

Roadway	Segment Starting Roadway	Segment Ending Roadway	Total Weighted Injury Crashes per Mile
US 36	Boulder County Boundary	MM 41	38
US 36	MM 41	MM 42	28
US 36	MM 42	MM 43	27
Ute Highway	C & S Railroad	Pace Street	26
Ute Highway	Pace Street	County Line Road	26
Boulder Canyon Drive	MM 30	MM 31	24
US 36	County Boundary	Highway 128	23
US 36	Longhorn Road	Highway 7/Broadway	22
Boulder Canyon Drive	MM 32	MM 33	21
Peak to Peak Highway	MM 44	MM 45	21
Saint Vrain Road	MM 17	MM 18	21
US 36	MM 40	MM 41	21
CO 119	MM 50	MM 51	20
US 287	Yellowstone Road	County Road 4	20
Peak to Peak Highway	Boulder County Boundary	Coal Creek Canyon Road	19
CO 119	MM 48	MM 49	18
CO 128	Boulder County Boundary (East of MP 2)	Boulder County Boundary (W of MP3)	18
US 287	Plateau Road	Oxford Road	17
Boulder Canyon Drive	MP 37	MP 38	17
US 287	County Road 4	South of MM 319	17
Ute Highway	North 87th Street	North 95th Street	16
Boulder Canyon Drive	MM 33	MM 34	16
Ute Highway	Boulder County Boundary	US 36	16
US 36	Nelson Road	Middle Fork Road	16
Peak to Peak Highway	MM 51	MM 52	16
Saint Vrain Road	MM 15	MM 16	15
US 36	MM 44	County Boundary	15

CO 119	MM 52	MM 53	15
Arapahoe Road	Arapahoe Ridge High School	75th Street	14
Ute Highway	McCall Drive	75th Street	14
US 287	Niwot Road	Mineral Road	14
US 36	MM 43	MM 44	14
US 36	Highway 128	Eldorado Springs Drive	13
Ute Highway	US 36	53rd Street	13
112th Street	Boulder County Boundary/144th Avenue	Boulder County Boundary	13
US 36	South Vrain Road	North of MM 26	13
US 36	South of MM 30	Longhorn Road	13
US 36	MM 28	MM 29	13
Boulder Canyon Drive	MM 40	Boulder County Boundary	13
CO 119	MM 45	South of MM 46	12
Mineral Road	North 115th Street	County Line Road	12
US 287	Oxford Road	Niwot Road	12
Mineral Road	US 287	115th Street	11
US 287	Boulder County Boundary	Yellowstone Road	11
Arapahoe Road	75th Street	East of MM 58	11
Peak to Peak Highway	MM 37	Sugarloaf Road	11
Boulder Canyon Drive	MM 27	MM 28	11
US 287	Mineral Road	Lookout Road	11
Ute Highway	53rd Street	61st Street	11
Ute Highway	75th Street	Table Mountain Road	11
US 36	MM 29	South of MM 30	11
US 36	Highway 7/Broadway	Jay Road	11
Saint Vrain Road	MM 14	MM 15	10
Saint Vrain Road	MM 18	MM 19	10
Saint Vrain Road	MM 19	Boulder County Boundary	10
CO 119	South of MM 46	MM 47	9
Saint Vrain Road	MM 16	MM 17	9

Boulder Canyon Drive	MM 38	MM 39	9
US 36	MM 15	Eldorado Springs Drive	9
CO 119	MM 53	MM 54	8
Mineral Road	71st Street	79th Street	8
Boulder Canyon Drive	MM 29	MM 30	8
Saint Vrain Road	MM 25	MM 26	8
Boulder Canyon Drive	MM 39	MM 40	8
Arapahoe Road	West of MM 58	Boulder County Boundary	7