Hypothetical Safety Analysis

Brian Almdale, MUPP

Brian Almdale, MUPP

Brian Almdale, MUPP

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# Preface

Lorem Ipsum is simply dummy text of the printing and typesetting industry. Lorem Ipsum has been the industry’s standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s with the release of Letraset sheets containing Lorem Ipsum passages, and more recently with desktop publishing software like Aldus PageMaker including versions of Lorem Ipsum.

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| Strategies summarized |
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## Lorem Ipsum 2

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# 1. Mapping + Counts

## 1.1 Introduction

Note: counts filtered to only include counts conducted between 2018-2022. We have all historical counts for permanent counters and 2017-2023 SDC stored in our database.

## 1.2 Count Locations

[Figure 1.1](#fig-count_locs) displays where we have permanent (magenta) and short duration counts (yellow) available for this effort.

|  |
| --- |
| Figure 1.1: Permanant and Short Duration Count Locations |

### Permanent Counters

Table 1.1: Perm Summary/Overview (only includes 2018-2022 counts).

| name | install\_date | uninstall\_date | obs\_duration | modes |
| --- | --- | --- | --- | --- |
| 2nd Ave PBL | 4/23/16 |  | 4 years 11 mons 30 days 23:00:00 | Bike |
| 39th Ave NE Greenway | 1/1/14 | 5/31/18 | 0 years 4 mons 29 days 23:00:00 | Bike |
| BGT | 1/1/14 |  | 4 years 11 mons 30 days 23:00:00 | Bike and Ped |
| Broadway PBL | 1/1/14 | 10/30/21 | 3 years 9 mons 29 days 23:00:00 | Bike |
| Chief Sealth | 1/1/14 | 10/30/21 | 1 year 4 mons 29 days 23:00:00 | Bike |
| Elliot Bay | 5/11/13 | 12/11/22 | 4 years 11 mons 10 days 23:00:00 | Bike and Ped |
| Fremont Bridge | 10/8/12 |  | 4 years 11 mons 30 days 23:00:00 | Bike |
| MTS or I-90 Trail | 12/18/13 | 12/31/21 | 3 years 11 mons 30 days 23:00:00 | Bike and Ped |
| NW 58th St | 1/1/14 | 7/31/22 | 4 years 6 mons 30 days 23:00:00 | Bike |
| Spokane Bridge | 11/24/13 |  | 4 years 11 mons 30 days 23:00:00 | Bike |

### Consectuive Zeros

Table 1.2: QC: Consectuive Zeros (only includes 2018-2022 counts).

| station\_id | year | n\_zero\_flags | n\_records | pct\_flagged |
| --- | --- | --- | --- | --- |
| 2nd\_nb | 2018 | 0 | 8,760 | 0.00% |
| 2nd\_nb | 2019 | 0 | 8,760 | 0.00% |
| 2nd\_nb | 2020 | 0 | 8,784 | 0.00% |
| 2nd\_nb | 2021 | 0 | 8,736 | 0.00% |
| 2nd\_nb | 2022 | 12 | 8,760 | 0.14% |
| 2nd\_sb | 2018 | 0 | 8,760 | 0.00% |
| 2nd\_sb | 2019 | 0 | 8,760 | 0.00% |
| 2nd\_sb | 2020 | 0 | 8,784 | 0.00% |
| 2nd\_sb | 2021 | 0 | 8,736 | 0.00% |
| 2nd\_sb | 2022 | 12 | 8,760 | 0.14% |
| 39\_nb | 2018 | 18 | 3,600 | 0.50% |
| 39\_sb | 2018 | 18 | 3,600 | 0.50% |
| 58\_eb | 2018 | 0 | 8,760 | 0.00% |
| 58\_eb | 2019 | 293 | 8,088 | 3.62% |
| 58\_eb | 2020 | 327 | 8,040 | 4.07% |
| 58\_eb | 2021 | 0 | 8,726 | 0.00% |
| 58\_eb | 2022 | 0 | 5,088 | 0.00% |
| 58\_wb | 2018 | 0 | 8,760 | 0.00% |
| 58\_wb | 2019 | 271 | 8,088 | 3.35% |
| 58\_wb | 2020 | 364 | 8,040 | 4.53% |
| 58\_wb | 2021 | 0 | 8,726 | 0.00% |
| 58\_wb | 2022 | 0 | 5,088 | 0.00% |
| 90\_b\_eb | 2018 | 231 | 8,760 | 2.64% |
| 90\_b\_eb | 2019 | 308 | 8,760 | 3.52% |
| 90\_b\_eb | 2020 | 170 | 8,784 | 1.94% |
| 90\_b\_eb | 2021 | 862 | 8,760 | 9.84% |
| 90\_b\_wb | 2018 | 231 | 8,760 | 2.64% |
| 90\_b\_wb | 2019 | 338 | 8,760 | 3.86% |
| 90\_b\_wb | 2020 | 170 | 8,784 | 1.94% |
| 90\_b\_wb | 2021 | 1,794 | 8,760 | 20.48% |
| 90\_p\_eb | 2018 | 231 | 8,760 | 2.64% |
| 90\_p\_eb | 2019 | 3,370 | 8,760 | 38.47% |
| 90\_p\_eb | 2020 | 7,404 | 8,784 | 84.29% |
| 90\_p\_eb | 2021 | 8,760 | 8,760 | 100.00% |
| 90\_p\_wb | 2018 | 231 | 8,760 | 2.64% |
| 90\_p\_wb | 2019 | 3,370 | 8,760 | 38.47% |
| 90\_p\_wb | 2020 | 7,404 | 8,784 | 84.29% |
| 90\_p\_wb | 2021 | 8,760 | 8,760 | 100.00% |
| bgt\_b\_nb | 2018 | 2,390 | 8,760 | 27.28% |
| bgt\_b\_nb | 2019 | 0 | 8,760 | 0.00% |
| bgt\_b\_nb | 2020 | 0 | 7,008 | 0.00% |
| bgt\_b\_nb | 2021 | 0 | 1,464 | 0.00% |
| bgt\_b\_nb | 2022 | 0 | 8,760 | 0.00% |
| bgt\_b\_sb | 2018 | 2,378 | 8,760 | 27.15% |
| bgt\_b\_sb | 2019 | 0 | 8,760 | 0.00% |
| bgt\_b\_sb | 2020 | 0 | 7,008 | 0.00% |
| bgt\_b\_sb | 2021 | 0 | 1,464 | 0.00% |
| bgt\_b\_sb | 2022 | 0 | 8,760 | 0.00% |
| bgt\_p\_nb | 2018 | 2,488 | 8,760 | 28.40% |
| bgt\_p\_nb | 2019 | 0 | 8,760 | 0.00% |
| bgt\_p\_nb | 2020 | 363 | 7,008 | 5.18% |
| bgt\_p\_nb | 2021 | 1,464 | 1,464 | 100.00% |
| bgt\_p\_nb | 2022 | 8,760 | 8,760 | 100.00% |
| bgt\_p\_sb | 2018 | 2,486 | 8,760 | 28.38% |
| bgt\_p\_sb | 2019 | 0 | 8,760 | 0.00% |
| bgt\_p\_sb | 2020 | 0 | 7,008 | 0.00% |
| bgt\_p\_sb | 2021 | 1,464 | 1,464 | 100.00% |
| bgt\_p\_sb | 2022 | 8,760 | 8,760 | 100.00% |
| brd\_nb | 2018 | 112 | 8,760 | 1.28% |
| brd\_nb | 2019 | 0 | 7,344 | 0.00% |
| brd\_nb | 2020 | 629 | 5,112 | 12.30% |
| brd\_nb | 2021 | 1,093 | 7,272 | 15.03% |
| brd\_sb | 2018 | 216 | 8,760 | 2.47% |
| brd\_sb | 2019 | 0 | 7,344 | 0.00% |
| brd\_sb | 2020 | 727 | 5,112 | 14.22% |
| brd\_sb | 2021 | 1,155 | 7,272 | 15.88% |
| cs\_b\_nb | 2020 | 257 | 5,136 | 5.00% |
| cs\_b\_nb | 2021 | 2,444 | 7,262 | 33.65% |
| cs\_b\_sb | 2020 | 250 | 5,136 | 4.87% |
| cs\_b\_sb | 2021 | 2,225 | 7,262 | 30.64% |
| cs\_p\_nb | 2020 | 5,136 | 5,136 | 100.00% |
| cs\_p\_nb | 2021 | 7,262 | 7,262 | 100.00% |
| cs\_p\_sb | 2020 | 5,136 | 5,136 | 100.00% |
| cs\_p\_sb | 2021 | 7,262 | 7,262 | 100.00% |
| eb\_b\_nb | 2018 | 0 | 8,760 | 0.00% |
| eb\_b\_nb | 2019 | 0 | 8,760 | 0.00% |
| eb\_b\_nb | 2020 | 0 | 8,784 | 0.00% |
| eb\_b\_nb | 2021 | 1,166 | 8,760 | 13.31% |
| eb\_b\_nb | 2022 | 315 | 8,280 | 3.80% |
| eb\_b\_sb | 2018 | 0 | 8,760 | 0.00% |
| eb\_b\_sb | 2019 | 0 | 8,760 | 0.00% |
| eb\_b\_sb | 2020 | 0 | 8,784 | 0.00% |
| eb\_b\_sb | 2021 | 1,166 | 8,760 | 13.31% |
| eb\_b\_sb | 2022 | 315 | 8,280 | 3.80% |
| eb\_p\_nb | 2018 | 0 | 8,760 | 0.00% |
| eb\_p\_nb | 2019 | 0 | 8,760 | 0.00% |
| eb\_p\_nb | 2020 | 0 | 8,784 | 0.00% |
| eb\_p\_nb | 2021 | 1,166 | 8,760 | 13.31% |
| eb\_p\_nb | 2022 | 315 | 8,280 | 3.80% |
| eb\_p\_sb | 2018 | 0 | 8,760 | 0.00% |
| eb\_p\_sb | 2019 | 0 | 8,760 | 0.00% |
| eb\_p\_sb | 2020 | 0 | 8,784 | 0.00% |
| eb\_p\_sb | 2021 | 1,166 | 8,760 | 13.31% |
| eb\_p\_sb | 2022 | 315 | 8,280 | 3.80% |
| fmt\_e | 2018 | 0 | 8,760 | 0.00% |
| fmt\_e | 2019 | 0 | 8,760 | 0.00% |
| fmt\_e | 2020 | 0 | 8,784 | 0.00% |
| fmt\_e | 2021 | 0 | 8,760 | 0.00% |
| fmt\_e | 2022 | 0 | 8,760 | 0.00% |
| fmt\_w | 2018 | 0 | 8,760 | 0.00% |
| fmt\_w | 2019 | 0 | 8,760 | 0.00% |
| fmt\_w | 2020 | 0 | 8,784 | 0.00% |
| fmt\_w | 2021 | 0 | 8,760 | 0.00% |
| fmt\_w | 2022 | 0 | 8,760 | 0.00% |
| sb\_eb | 2018 | 0 | 8,760 | 0.00% |
| sb\_eb | 2019 | 0 | 8,760 | 0.00% |
| sb\_eb | 2020 | 0 | 8,784 | 0.00% |
| sb\_eb | 2021 | 706 | 8,736 | 8.08% |
| sb\_eb | 2022 | 656 | 10,248 | 6.40% |
| sp\_wb | 2018 | 0 | 8,760 | 0.00% |
| sp\_wb | 2019 | 0 | 8,760 | 0.00% |
| sp\_wb | 2020 | 0 | 8,784 | 0.00% |
| sp\_wb | 2021 | 792 | 8,736 | 9.07% |
| sp\_wb | 2022 | 634 | 10,248 | 6.19% |

### Short Duration Counts

Table 1.3: SDC Summary/Overview.

| dow | study\_time\_cat | n\_sites | n\_hours | n\_bike | n\_ped | bike\_per\_hr | ped\_per\_hr |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Weekday | 10:00 AM-12:00 PM | 50 | 1786 | 17,949.0 | 338,965.0 | 10.0 | 189.8 |
| Weekday | 12:00 PM-2:00 PM | 5 | 24 | 466.0 | 11,662.0 | 19.4 | 485.9 |
| Weekday | 5:00 PM-7:00 PM | 49 | 1756 | 62,270.0 | 608,536.0 | 35.5 | 346.5 |
| Weekend | 10:00 AM-12:00 PM | 4 | 8 | 84.0 | 1,392.0 | 10.5 | 174.0 |
| Weekend | 12:00 PM-2:00 PM | 50 | 1770 | 34,339.0 | 559,484.0 | 19.4 | 316.1 |

Table 1.4: SDC Locations.

| site\_descr | n\_hours | n\_bike | n\_ped | bike\_per\_hr | ped\_per\_hr | start\_year | end\_year |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 12TH AVE AND E MADISON ST | 108 | 3,698.0 | 60,076.0 | 34.2 | 556.3 | 2018 | 2022 |
| 12TH AVE NE AND NE 65TH ST | 108 | 1,793.0 | 31,122.0 | 16.6 | 288.2 | 2018 | 2022 |
| 12TH AVE S AND S JACKSON ST | 108 | 3,505.0 | 49,372.0 | 32.5 | 457.1 | 2018 | 2022 |
| 15TH AVE NW AND NW MARKET ST | 108 | 253.0 | 44,306.0 | 2.3 | 410.2 | 2018 | 2022 |
| 15TH AVE W AND BALLARD BR | 108 | 249.0 | 4,046.0 | 2.3 | 37.5 | 2018 | 2022 |
| 1ST AVE S AND S JACKSON ST | 108 | 2,347.0 | 39,967.0 | 21.7 | 370.1 | 2018 | 2022 |
| 1ST AVE S AND S LANDER ST | 108 | 617.0 | 10,721.0 | 5.7 | 99.3 | 2018 | 2022 |
| 23RD AVE AND E UNION ST | 108 | 1,661.0 | 22,367.0 | 15.4 | 207.1 | 2018 | 2022 |
| 24TH AVE NW AND NW MARKET ST | 108 | 2,478.0 | 37,370.0 | 22.9 | 346.0 | 2018 | 2022 |
| 26TH AVE SW AND SW BARTON ST | 108 | 226.0 | 8,234.0 | 2.1 | 76.2 | 2018 | 2022 |
| 32ND AVE NW AND NW 54TH ST | 108 | 920.0 | 15,112.0 | 8.5 | 139.9 | 2018 | 2022 |
| 32ND AVE W AND W MCGRAW ST | 106 | 487.0 | 22,148.0 | 4.6 | 208.9 | 2018 | 2022 |
| 35TH AVE SW AND SW AVALON WAY | 108 | 2,029.0 | 12,141.0 | 18.8 | 112.4 | 2018 | 2022 |
| 5TH AVE AND STEWART ST | 108 | 1,552.0 | 82,176.0 | 14.4 | 760.9 | 2018 | 2022 |
| 5TH AVE NE AND NE NORTHGATE WAY | 108 | 228.0 | 27,124.0 | 2.1 | 251.1 | 2018 | 2022 |
| 6TH AVE AND MADISON ST | 108 | 488.0 | 23,366.0 | 4.5 | 216.4 | 2018 | 2022 |
| 7TH AVE S AND S JACKSON ST | 108 | 2,502.0 | 25,280.0 | 23.2 | 234.1 | 2018 | 2022 |
| 8TH AVE S AND S CLOVERDALE ST | 108 | 617.0 | 3,700.0 | 5.7 | 34.3 | 2018 | 2022 |
| 8TH AVE S AND S DEARBORN ST | 108 | 1,477.0 | 5,318.0 | 13.7 | 49.2 | 2018 | 2022 |
| 9TH AVE N AND MERCER SR ST | 104 | 5,431.0 | 20,670.0 | 52.2 | 198.8 | 2018 | 2022 |
| AIRPORT WAY S AND S VALE ST | 108 | 527.0 | 7,555.0 | 4.9 | 70.0 | 2018 | 2022 |
| ALASKAN WAY AND BROAD ST | 108 | 5,776.0 | 32,154.0 | 53.5 | 297.7 | 2018 | 2022 |
| ALASKAN WAY AND COLUMBIA ST | 102 | 3,061.0 | 25,817.0 | 30.0 | 253.1 | 2018 | 2022 |
| BEACON AVE S AND S LANDER ST | 108 | 1,150.0 | 22,634.0 | 10.6 | 209.6 | 2018 | 2022 |
| BOREN AVE AND PINE ST | 108 | 3,914.0 | 43,796.0 | 36.2 | 405.5 | 2018 | 2022 |
| BOSTON ST AND QUEEN ANNE AVE N | 104 | 686.0 | 47,237.0 | 6.6 | 454.2 | 2018 | 2022 |
| BROAD ST AND VALLEY ST | 106 | 2,332.0 | 31,691.0 | 22.0 | 299.0 | 2018 | 2022 |
| BROADWAY AND E PINE ST | 108 | 5,108.0 | 102,787.0 | 47.3 | 951.7 | 2018 | 2022 |
| BROADWAY E AND E OLIVE WAY | 106 | 2,408.0 | 134,418.0 | 22.7 | 1,268.1 | 2018 | 2022 |
| BROOKLYN AVE NE AND NE 45TH ST | 108 | 1,133.0 | 53,149.0 | 10.5 | 492.1 | 2018 | 2022 |
| CALIFORNIA AVE SW AND FAUNTLEROY WAY SW | 108 | 950.0 | 14,614.0 | 8.8 | 135.3 | 2018 | 2022 |
| CALIFORNIA AVE SW AND SW ALASKA ST | 108 | 802.0 | 54,691.0 | 7.4 | 506.4 | 2018 | 2022 |
| DENNY WAY AND DEXTER AVE | 108 | 5,286.0 | 50,152.0 | 48.9 | 464.4 | 2018 | 2022 |
| EAST GREEN LAKE DR N AND NE RAVENNA EB BV | 108 | 4,609.0 | 46,378.0 | 42.7 | 429.4 | 2018 | 2022 |
| EAST MARGINAL WAY S AND S HANFORD ST | 108 | 5,813.0 | 958.0 | 53.8 | 8.9 | 2018 | 2022 |
| EASTLAKE AVE E AND FUHRMAN AVE E | 108 | 9,226.0 | 13,178.0 | 85.4 | 122.0 | 2018 | 2022 |
| FAIRVIEW AVE N AND MERCER ST | 72 | 344.0 | 9,102.0 | 4.8 | 126.4 | 2018 | 2022 |
| FAIRVIEW AVE N AND VALLEY ST | 108 | 2,086.0 | 12,224.0 | 19.3 | 113.2 | 2018 | 2022 |
| FAUNTLEROY WAY SW AND SW CLOVERDALE ST | 106 | 984.0 | 5,070.0 | 9.3 | 47.8 | 2018 | 2022 |
| FREMONT AVE N AND N 34TH ST | 108 | 15,517.0 | 47,402.0 | 143.7 | 438.9 | 2018 | 2022 |
| GREENWOOD AVE N AND N 85TH ST | 108 | 1,026.0 | 25,046.0 | 9.5 | 231.9 | 2018 | 2022 |
| LAKE CITY WAY NE AND NE 125TH ST | 108 | 379.0 | 21,253.0 | 3.5 | 196.8 | 2018 | 2022 |
| LINDEN AVE N AND N 130TH ST | 110 | 2,881.0 | 6,885.0 | 26.2 | 62.6 | 2018 | 2022 |
| M L KING JR WAY S AND RAINIER AVE S | 108 | 197.0 | 8,066.0 | 1.8 | 74.7 | 2018 | 2022 |
| M L KING JR WR WAY S AND S ALASKA ST | 108 | 399.0 | 13,837.0 | 3.7 | 128.1 | 2018 | 2022 |
| M L KING JR WR WAY S AND S OTHELLO ST | 108 | 289.0 | 29,229.0 | 2.7 | 270.6 | 2018 | 2022 |
| MONTLAKE BLVD NE AND NE PACIFIC ST | 108 | 467.0 | 74,707.0 | 4.3 | 691.7 | 2018 | 2022 |
| RAINIER AVE S AND S HENDERSON ST | 108 | 352.0 | 11,694.0 | 3.3 | 108.3 | 2018 | 2022 |
| SAND POINT WAY NE AND NE 65TH ST | 108 | 903.0 | 6,909.0 | 8.4 | 64.0 | 2018 | 2022 |
| STONE WAY N AND N 45TH ST | 108 | 3,945.0 | 22,790.0 | 36.5 | 211.0 | 2018 | 2022 |

# 2. HIN Intro

There are many established ways to examine crashes to better understand traffic safety patterns. Hotspot analyses have long been used to address high crash locations by retrospectively identifying the greatest concentrations of reported crashes over a determined period of time. Hotspot analysis is a valuable method to visualize locations with historic crash issues, but it is less effective at identifying locations with latent crash risk factors. In this way, it can be described as reactive. Additionally, hotspots may be less effective for analyzing bicyclist safety if crash frequencies are low due to geographic sparsity, which can exacerbate issues related to regression to the mean. Conversely, a systemic analysis is effective for identifying roadways with risk factors for crashes, independent from their crash history. For example, a wide arterial with a 45-mph posted speed limit, high traffic volumes, no bike facility, and few trip-attracting land uses may not have any reported bike crashes. However, the roadway and operational characteristics of that arterial are associated with higher bicycle crash risk. The absence of crashes is therefore not a reflection of low crash risk, but a reflection of lack of exposure that hotspot analyses cannot adequately convey. Systemic analysis is largely proactive; it allows planners and engineers to find locations that may warrant safety improvements before crashes have occurred there.

High injury networks strike a balance between entirely retrospective and entirely proactive methods. Using spatial patterns of crash history, a High Injury Network identifies areas on the road network where crashes have been concentrated in sequence. A stretch of arterial roadway with crashes occurring at every other intersection might not show up on a traditional hotspot analysis because no one location has multiple crashes happening in the same place. However, the pattern of crashes all along the corridor suggests a larger safety issue. Further, the entire corridor likely shares similar characteristics that could be addressed systemically – even the intersections along the corridor that have not yet had crashes.

This section describes the development of a statewide High Injury Network and the results of the related High Injury Network analysis. The High Injury Network was built from a standard sliding windows analysis, which measures severity-weighted crash density by mode along segments on the network.

# 3. Intro and Purpose

The Bipartisan Infrastructure Law (BIL), passed in 2021, created a new requirement for state departments of transportation to conduct a Vulnerable Road User Safety Assessment (VRUSA) every five years. Anchored in the Safe System Approach (SSA), this assessment must use a data-driven process to identify high-risk areas and incorporate equity and demographics into the analysis. Official guidance around the VRUSA recommends the use of a High Injury Network, predictive analysis, and/or systemic analysis to identify high-risk areas[[1]](#footnote-34).

To improve the safety of vulnerable road users in the state of Minnesota and partially satisfy the new VRUSA requirements, the Minnesota Department of Transportation’s (MnDOT) Office of Traffic Engineering (OTE) commissioned a Vulnerable Road User Safety Assessment in 2022, including the development of a High Injury Network for the state and a study of bicycling crashes from 2016-2019 in urban and rural areas within the state. The initial VRUSA built upon a recently-completed study of pedestrian safety in the state. The resulting VRUSA report captured trends and risk factors related to crashes involving bicyclists, pedestrians, and other vulnerable road users using personal conveyances across the state to direct infrastructure improvements and safety countermeasures, especially those that reduce crashes that result in cyclists’ serious injury or death. This report builds on the prior VRUSA and safety work and updates the vulnerable road user safety analysis through:

1. a descriptive safety analysis of more recent crash data
2. a Statewide High Injury Network, which was built on xxxxxx bicyclist, pedestrian, and other vulnerable road user crashes from 2018-2022
3. integration of this updated VRUSA into the 2025-2029 SHSP

This report focuses on vulnerable road user crashes, paralleling the 2021 Minnesota Statewide Pedestrian Safety Analysis[[2]](#footnote-36) and the 2022 Minnesota Vulnerable Road User Safety Assessment[[3]](#footnote-38). While bicyclists and pedestrians are different roadway users, use different infrastructure in many places, and have both overlapping and distinct safety concerns, both are vulnerable roadway users who are disproportionately killed and seriously injured in the transportation system. Often, bicycle and pedestrian countermeasures are planned and implemented in tandem, and an understanding of bicycle and pedestrian crash trends needs to inform these processes. Collectively, the 2021 Minnesota Statewide Pedestrian Safety Analysis, the 2022 VRUSA, and the current VRUSA update (including the development of a High Injury Network for vulnerable road users) constitute a robust, data-driven process for identifying higher-risk areas in the transportation system.

This report follows the methodology of the initial Minnesota Vulnerable Road User Safety Assessment. For the descriptive and systemic analyses, VRU crashes from 2018-2022 are conflated with roadway and environmental characteristics to create a dataset for analysis,including variables about injury severity, lighting, roadway functional classification, development intensity, Suitability of Pedestrian and Cyclist Environment (SPACE) scores and related factors, and bicycle infrastructure. Given data limitations, some of the detailed analysis focuses only on MnDOT’s trunk highway network.

This report also presents a statewide High Injury Network, which uses a standard sliding window analysis to measure severity-weighted crash density by mode. The HIN section of the analysis includes all vulnerable road users: bicyclists, pedestrians, and other personal conveyances.

The rest of the report is structured as follows: First, an overview of the crash data is presented, followed by descriptive and systemic analyses. The descriptive analyses present trends among crash and temporal variables. The systemic analysis presents the High Injury Network.

## 3.1 Data Overview

### Crash Data

Crash, party, and vehicle data that were provided to the consultant team include reported crashes from 2018 through 2022 for crashes for all modes (pedestrians, bicyclists, other - personal conveyances, and motorists).

All crash data were processed by Safe Streets Research & Consulting (“Safe Streets”) and loaded into a Postgres database for additional analysis using Python, SQL, and R programming languages. The crash, party, and vehicle tables have a relational structure, which is common for storing crash data. For every reported crash, there is one crash record. The party and vehicle tables contain information for all the primary “actors” and their respective “vehicles” involved in the crash and have a many-to-one relationship – i.e., all relevant party records are matched via a case identification number to the one crash record. The party and vehicle tables contain information for each primary person and their “vehicle” such as age, sex, pre-crash action, injury severity, and vehicle characteristics. This structure is shown in xxxxx.

Safe Streets processed and restructured the crash data used in this analysis. New variables were calculated and assigned, and the quality of the data was assessed through a robust quality control process. All reported crashes were processed (not just VRU crashes), but only crashes that involved at least one VRU and at least one motorist are included in this analysis.

Crashes involving a person using a scooter (e.g., shared e-scooter or ADA assistive device) are defined in the State of Minnesota as pedestrian crashes. However, they are coded in MnDOT’s crash database as the unit type “Other – Personal Conveyance” rather than as “Pedestrian”. The “Other – Personal Conveyance” category also includes many modes that are not pedestrians, such as farm equipment (tractor, combine), all-terrain vehicles, snowmobiles, horse and buggy, and the like. There is no single coded field in the crash database that differentiates between pedestrians using personal conveyance devices and these other modes. A targeted effort was conducted to classify these crashes based on a keyword scan of officer narratives. While we could reliably differentiate these crashes from farm equipment based on this procedure, we could not consistently differentiate between mobility scooters and other devices used by people with mobility impairments and other types of scooters or pedestrian devices. As stated in the 2019 Pedestrian Safety Analysis, a long-term solution to facilitate routine analysis of these modes in Minnesota would be to update the crash form with a field to indicate the type of scooter or device involvement (e.g., e-scooter, kick-scooter, ADA assistive device, moped scooter) and retrain officers to utilize the new field to record accurate and detailed information for more streamlined analysis.

Crashes that met one or more of the following criteria were removed from the study dataset during the data consolidation process (see cccccc for the number of crashes that met each criterion; crashes can meet more than one criterion):

* Motorist-only (non-VRU) – The research team received a complete crash database for the years of interest (2018-2022). Because the scope of this project is only to analyze vulnerable road users, crashes that do not include a bicyclist, pedestrian, or someone potentially using a personal conveyance device are excluded from the analysis.
* Missing coordinates - Crash location GPS coordinates were not available.
* Farm Equipment – The “unit type” is coded as “Other – Personal Conveyance” and the officer narrative includes the words “tractor”, “horse”, or “trailer.”
* Too far away from the street or along a private street - The geospatial location of the crash is greater than 300 feet from any street or the street was a private roadway.
* The crash occurred in a parking lot – The location type recorded in the crash data is a parking lot.
* Crashes that involved only a bicyclist and no other road users are not included in the crash data.

## 3.2 Injury Severity Assignment

The officer-reported injury severity levels used in this analysis are specific to the most severely injured (MSI) road user involved in the crash. This injury severity is different than the reported MSI assigned to each crash record. In most cases, VRUs are the most severely injured victim involved in the crash. Using the victim-level severity helps improve accuracy of summarizing injury severities. It should be noted that research from the San Francisco Department of Public Health has documented reporting errors related to mis-coded injury severities, particularly for suspected serious injuries[[4]](#footnote-42), suggesting a need for some fluidity when discussing minor and serious injuries. This analysis does not have access to hospital records to verify injury severities stored in the crash data, so the results in this document reflect the best available data at the time. For reference, the injury severities recorded in the crash data and summarized in this analysis are defined as followed:

* K - Fatal: A fatal injury is any injury that results in death within 30 days after the motor vehicle crash in which the injury occurred. If the person did not die at the scene but died within 30 days of the motor vehicle crash in which the injury occurred, the injury classification should be changed from the injury previously assigned to “Fatal Injury.”
* A – Suspected Serious Injury: An incapacitating injury is any injury, other than a fatal injury, which prevents the injured person from walking, driving, or normally continuing the activities the person was capable of performing before the injury occurred. Also called “Serious Injury” or “Injury A”. This category includes:
  + severe lacerations
  + broken or distorted limbs
  + skull or chest injuries
  + abdominal injuries
  + unconsciousness at or when taken from the scene of the crash, or unable to leave the crash scene without assistance
* B – Suspected Minor Injury: A minor injury is any injury that is evident at the scene of the crash, other than fatal or serious injuries. Also called “Minor Injury” or “Injury B”. Examples include:
  + lump on the head
  + abrasions
  + bruises
  + minor lacerations (cuts on the skin surface with minimal bleeding and no exposure of deeper tissue/muscle)
* C – Possible Injury: A possible injury is any injury reported or claimed which is not a fatal, suspected serious, or suspected minor injury. Possible injuries are those that are reported by the person or are indicated by their behavior, but no wounds or injuries are readily evident. Examples include:
  + momentary loss of consciousness
  + claim of injury
  + limping
  + complaint of pain or nausea
* O – Property Damage Only: Crash where only property is damaged. No injuries resulted from the crash.

## 3.3 Roadway and Contextual Data

The crash dataset includes many useful variables for analyzing VRU safety; however, detailed information about roadway conditions and nearby land uses is also necessary to provide a more complete understanding of the context in which crashes occurred and support future countermeasure selection. A robust data collection and consolidation process was conducted as part of the 2021 MnDOT Statewide Pedestrian Safety Analysis. Data from that effort was provided to the study team for use in this VRU assessment. Data collected during the Statewide Pedestrian Safety Analysis was re-processed using the same methods documented in the data collection section of the Pedestrian Safety Analysis. Please refer to the Statewide Pedestrian Crash Analysis[[5]](#footnote-45) for a detailed summary regarding data usage and limitations.

# Appendix A — Acronyms

Table A.1: Acronyms

| Acronym | Definition |
| --- | --- |
| AADT | Annual Average Daily Traffic |
| ADA | Americans with Disabilities Act |
| FHWA | Federal Highway Administration |
| GIS | Geographic Information System |
| HIN | High Injury Network |
| KA | Killed of severely injured |
| MSI | Most severely injured |
| MC | Motorcycle |
| MV | Motor Vehicle |
| PED | Pedestrian |
| PHB | Pedestrian Hybrid Beacon |
| RRFB | Rectangular Rapid Flashing Beacon |
| SSA | Safe System Approach |
| VPD | Vehicles per day |
| VRU | Vulnerable road user |
| VRUSA | Vulnerable Road User Safety Assessment |
| K [\*\*K\*\*ABCO] | Fatal Injury Severity |
| A [K\*\*A\*\*BCO] | Suspected Serious Injury |
| C [KA\*\*B\*\*CO] | Minor Injury |
| C [KAB\*\*C\*\*O] | Possible Injury |
| O [KABC\*\*O\*\*] or PDO | Property Damage Only |
| KA or KSI | Killed or Seriously Injured |

# Appendix B — List of Figures

| Figure | Short Caption | Download |
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| [Figure 1.1](#fig-count_locs) | Permanant and Short Duration Count Locations | PDF |

# Appendix C — List of Tables

| Table | Short Caption |
| --- | --- |
| [Table A.1](#tbl-acronyms) | Acronyms |
| [Table 1.1](#tbl-perm_summary) | Perm Summary/Overview (only includes 2018-2022 counts). |
| [Table 1.2](#tbl-perm_summary_zero) | QC: Consectuive Zeros (only includes 2018-2022 counts). |
| [Table 1.3](#tbl-sdc_summary) | SDC Summary/Overview. |
| [Table 1.4](#tbl-sdc_summary_year) | SDC Locations. |

1. [https://highways.dot.gov/sites/fhwa.dot.gov/files/2022- 10/VRU%20Safety%20Assessment%20Guidance%20FINAL\_508.pdf](https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-%2010/VRU%20Safety%20Assessment%20Guidance%20FINAL_508.pdf) [↑](#footnote-ref-34)
2. <https://edocs-public.dot.state.mn.us/edocs_public/DMResultSet/download?docId=26158751> [↑](#footnote-ref-36)
3. <https://www.dot.state.mn.us/trafficeng/safety/vrusa.html> [↑](#footnote-ref-38)
4. [https://www.visionzerosf.org/wp-content/uploads/2021/11/Severe-Injury-Trends 2011-2020 final report.pdf](https://www.visionzerosf.org/wp-content/uploads/2021/11/Severe-Injury-Trends%202011-2020%20final%20report.pdf) [↑](#footnote-ref-42)
5. <https://edocs-public.dot.state.mn.us/edocs_public/DMResultSet/download?docId=26158751> [↑](#footnote-ref-45)