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Safe Truck Mobility for North Dakota Winter Roads

Prepared for:

North Dakota Highway Patrol

Prepared by:

Yun Zhou, Statistician
Kimberly Vachal, Program Director
Kelly Bengtson, Bridge & Pavement Engineer
Del Peterson, Associate Research Fellow
Kshitij Sharma, Associate Research Fellow
Andrew Kubas, Consulting Scientist

Upper Great Plains Transportation Institute
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ABSTRACT

Winter storms significantly increase crash risk and disrupt travel, especially under extreme conditions. Gusty winds, heavy moisture, and low temperatures can quickly make travel dangerous in the Northern Plains. This study was aimed at understanding winter truck crashes, given the prominence of commercial vehicle travel in the region's economy. Truck mobility was studied in the Safe System context with an investigation into North Dakota's primary east-west traffic corridor along Interstate 94. Analysis of 594 truck-involved crashes among 2,105 crashes during winter months over a five-year period revealed key crash features and contributing factors. Case study analysis highlighted the sequence and nature of truck-involved crashes during a severe winter storm that involved interstate closure. In addition, a peer state interview exercise gathered insight into winter road management processes, enforcement practices, road closure decisions, education programs, and communication practices. The literature review provided context for winter storm safe mobility challenges and strategies to mitigate crash risk and travel disruptions. Proactive planning, policy, and resource deployment were crucial to minimizing impacts to the traveling public. Strategies aimed at safe truck winter mobility were key to managing road closures and travel recovery. A study limitation focused on one state's corridor in the winter crash record analysis. The study framework and recommendations may be informative to other states that prioritize commercial vehicle safe mobility during severe winter seasons and dangerous winter storm events.

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1. INTRODUCTION

Emergency preparedness and response are essential public services. While not a nationwide phenomenon, winter storms can create disaster-type conditions for the traveling public and vulnerable residents (Shao et al., 2021). Working within the dynamic storm event environment, engineering/maintenance, education, and enforcement are combined to achieve a safe mobility goal. Winter storms present unique challenges relative to other natural disasters, with extremely low temperatures, low visibility, and longer-lasting hazardous conditions (Sullivan & Dowds, 2018). The duration and severity of storms are affected by climate factors such as wind and precipitation. Seasonal factors and road design, including total snowfall, ground temperature, and lane elevation, mean fluctuating driving conditions. While storm prediction methods have advanced, some ambiguity remains.

Winter weather conditions in North Dakota often lead to hazardous road conditions, significantly impacting the safety of trucking operations. Truck crashes during winter storms have prompted the need for a proactive and targeted investigation into the root causes and potential preventive measures. This study adopts a retrospective approach, analyzing crash events to identify patterns, contributing factors, and areas where intervention strategies can be implemented to minimize travel disruptions effectively.

An enhanced understanding of truck traffic winter storm safe mobility can translate to safety and economic benefits. Descriptive statistics, case study analyses, and interviews are combined to understand factors and strategies essential to safe truck mobility during varying winter weather conditions. The research delves into existing literature and policies on truck safety during winter storms, aiming to provide a holistic understanding of principal issues and evidence-based strategies for enhanced mobility and safety.

The analysis focuses on current preparations and policies governing truck safety during winter weather, discussing strengths and limitations. The work may entail reviewing government regulations, industry standards, and best practices to prevent weather-related truck crashes. The primary goal is to provide evidence-based recommendations for enhancing strategies to prevent truck crashes in North Dakota during winter storm events. Truck crashes can become particularly disruptive with events such as jackknifed or overturned trailers that block travel lanes and disrupt winter weather maintenance and travel recovery activities. By consolidating the findings from historical crash records, peer state interviews, case study analyses, and existing literature, valuable insights will be gained for developing and improving resource allocation to effectively prevent winter weather-related truck crashes.

The aim is to summarize practical insights that government and industry stakeholders can use to enhance truck safety during winter storms. Our collective efforts will use the Safe System lens to promote road safety, particularly in regions with challenging winter weather conditions. The following sections discuss truck-involved winter storm crash factors, decision processes, policies, and countermeasures. It is a holistic effort to facilitate a multifaceted intervention plan prioritizing the safe mobility of truck drivers and the public during winter storm events.

1.1 Background

Commercial vehicles are essential for freight movement and economic stability. According to the Bureau of Transportation Statistics, trucks carried 12,206 million tons of freight valued at $12,036 billion in 2019 (Bureau of Transportation Statistics). Unlike passenger vehicles with significant flexibility in changing travel plans, trucks must often be operated in adverse weather conditions. In 2020, 4,965 fatalities occurred in crashes involving large trucks (National Highway Traffic Safety Administration). These statistics highlight the importance of safety in crashes involving commercial trucks. In addition, truck crashes result in more severe injuries and fatalities due to associated risks such as heavier weight, larger vehicle size, and possible hazardous material release. Thus, investigations are needed to prioritize efforts to reduce the occurrence and severity of commercial truck crashes.

Weather conditions are influential in Northern Plains truck-involved crashes (Uddin & Huynh, 2020). Understanding safe mobility decisions for trucks during winter storms is vital for sustained safety improvements. Winter storms are associated with decreased safety (Knapp et al., 2000). Winter weather contributed to over 50% of Wyoming's truck-related crashes (Haq et al., 2019). Mitigating these truck-involved crashes improves safety with reduced injury risk and improves mobility with fewer delays in clearing oversized vehicles after severe storm events.

This investigation aligns with the state's Vision Zero initiative by analyzing truck safety through statistical analysis, case study documentation, and stakeholder expertise focused on winter storm events. Results will support decision-makers by unveiling data-driven decision-making criteria for large truck safety. Elements may be included in the North Dakota Highway Patrol (NDHP) Commercial Vehicle Safety Plan (CVSP), statewide road safety plans, and other planning activities such as emergency response. Findings will enable a safe system approach that recognizes human vulnerability and requires proactive and shared responsibility to prevent traffic injuries (USDOT, 2022).

1.2 Research Objectives

Goal: Safe System Analysis for ND Truck Mobility during Winter Storms

Objectives:

- Highlight winter storm truck crash risk and traffic management in North Dakota
- Investigate contributing factors, policies, decision processes, and strategies for safe truck mobility during winter storm crash prevention
- Explore peer state procedures, decisions, and communications related to proactive winter storm truck traffic management and incident response
- Query local truck experts about winter storm policies and driver guidance
- Highlight safe mobility strategies for trucks and surrounding traffic to minimize travel disruption and crash risk during winter storm events

2. LITERATURE REVIEW

Traffic safety is a critical concern, especially during the winter when adverse weather conditions pose significant challenges for road users (Federal Highway Administration, 2024a). Traffic safety culture refers to a community's shared values, beliefs, and behaviors that prioritize safe road use. In the context of truck drivers, a positive safety culture is crucial for promoting responsible driving practices and fostering a collective commitment to safety. Research indicates that a strong safety culture among truck drivers is associated with reduced crash rates and improved overall safety outcomes (Transportation Research Board, 2003; Ward et al., 2019).

Vision Zero is a traffic safety initiative that aims to eliminate fatalities and severe injuries on the road. In the context of winter storm months for truck drivers in North Dakota, Vision Zero would focus on implementing strategies to minimize crash risk and promote safe travel. This might involve improvements to road infrastructure, modifications with maintenance strategies, education on winter driving techniques, enhancements in traffic enforcement policies, and enhancements in communication about road/weather conditions (Veneziano, 2010). The Safe System lens was used in the study.

2.1 Factors in Truck-Involved Winter Storm Crashes on Rural Interstates

2.1.1 Interstate Corridors

Winter storms present significant challenges for traffic safety, especially on Upper Midwest rural interstate highways. This region regularly experiences adverse weather conditions that can increase truck crash risk. Figure 1 through Figure 4 visually highlight related climate indices.

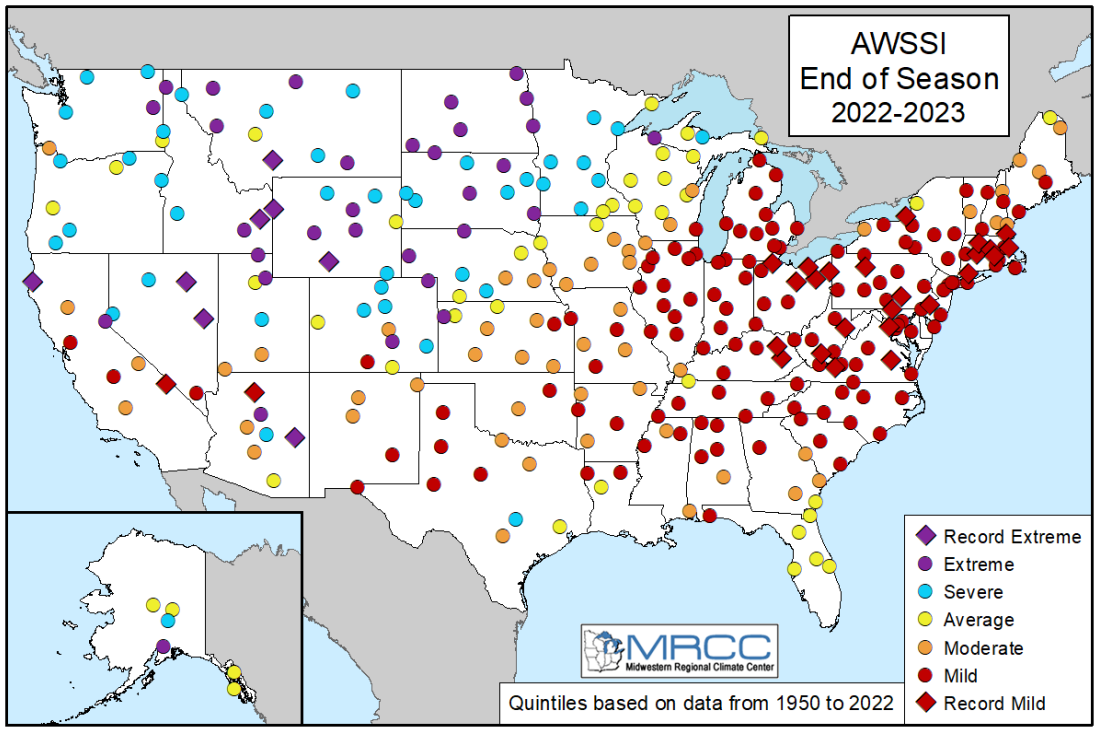


Figure 1. Accumulated Winter Storm Severity Index, 2022-2023

According to the North Dakota Department of Transportation (NDDOT), crashes among heavy vehicles (more than 10,000 pounds) most often occur during cold weather months, from October through March, than during the warmer weather months. Furthermore, 69% of winter month crashes occur on rural roadways, where storm response is often impeded by limited visibility and reduced road surface friction. During 2022, one heavy vehicle-related crash occurred almost every 12 hours (NDDOT, 2024). This literature review synthesizes leading research on the various elements influencing truck-involved winter storm crashes on rural interstates and potential strategies to reduce crash risk and traffic disruptions.

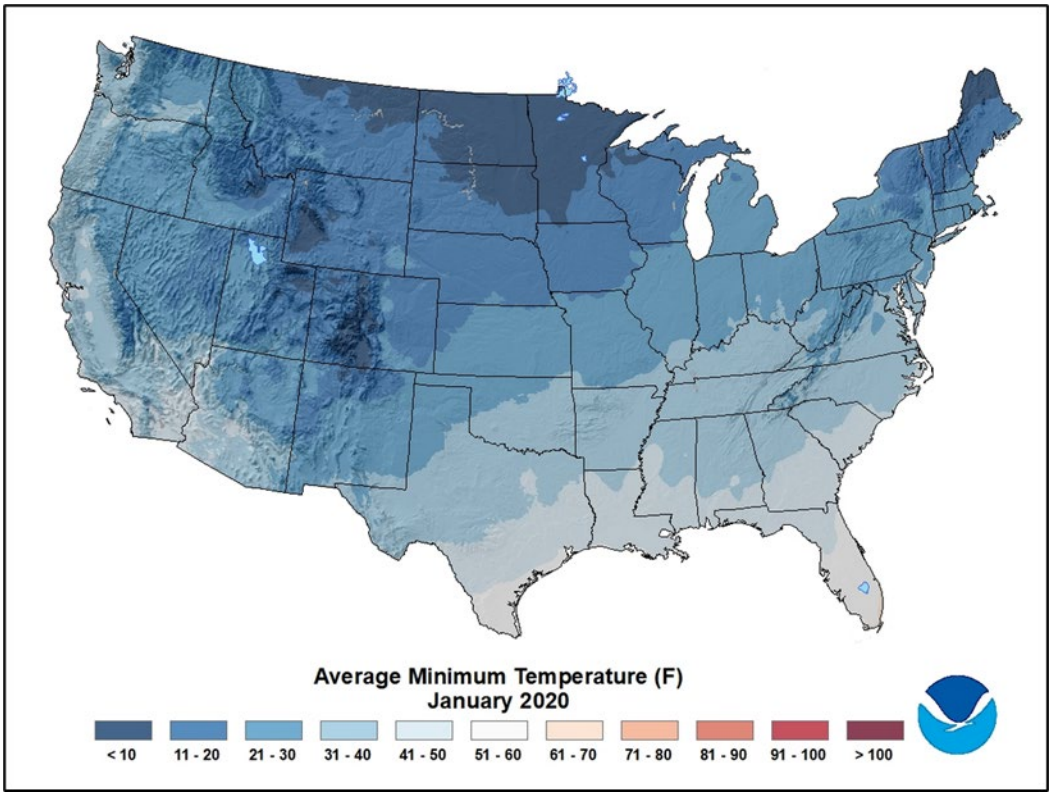


Figure 2. U.S. Average Minimum Temperature, January 2020

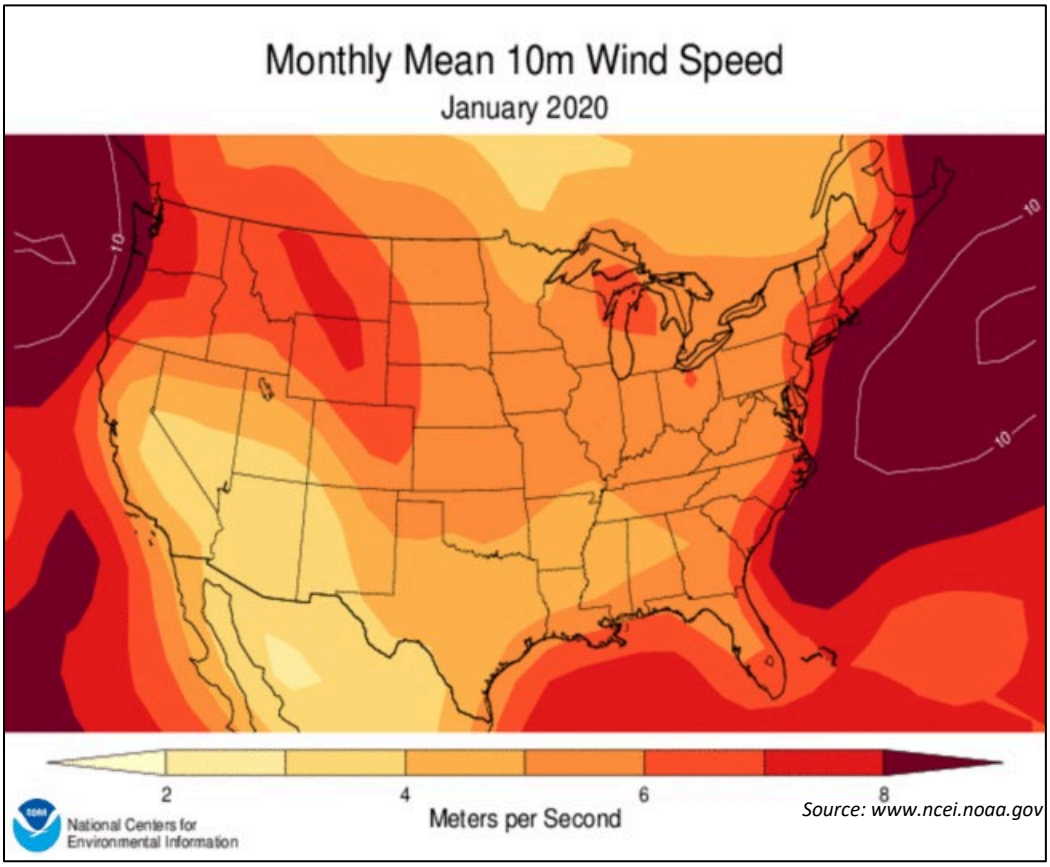


Figure 3. U.S. Average Monthly Wind Speed, January 2020

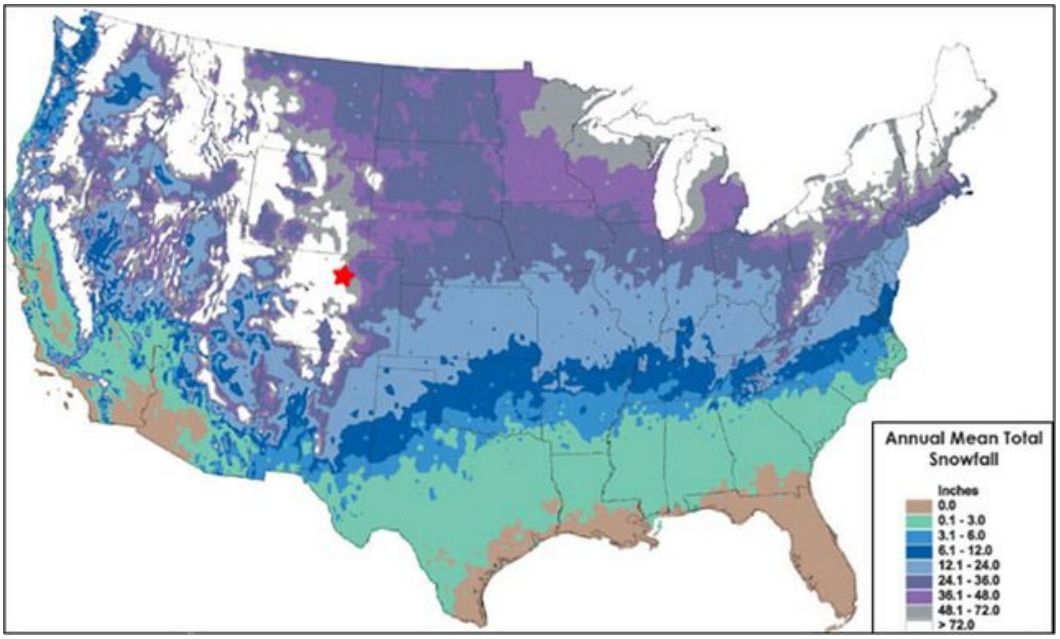


Figure 4. Annual Snow Precipitation Proxy, NOAA

2.1.2 Snow and Ice Accumulation

Numerous studies emphasize the correlation between adverse weather conditions, such as heavy snowfall and ice accumulation, and an elevated risk of truck-involved crashes during winter storms. Reduced visibility and slippery road surfaces contribute to the challenges faced by truck drivers. The relationship between temperature fluctuations and road surface conditions plays a significant role in winter storm crashes. Sudden temperature changes can create black ice, making roadways treacherous for truck drivers (Knapp et al., 2000; Eisenberg & Warner, 2005; Tobin et al., 2021).

According to data gathered by the Federal Highway Administration (FHWA, 2022), almost 20% of all vehicle crashes occur during bad weather, with most of those incidents due to snow and ice. When a truck's wheels do not have a sufficient grasp on the road, the entire vehicle may begin to drift. While this is startling for any driver, it can be disastrous for large trucks due to their size and weight. If the truck begins to drift, it risks sliding into the median or, worse, oncoming traffic. Likewise, if the truck trailer drifts independently of the cab, it will cause the vehicle to fishtail. These events are hazardous because they can cause a major crash. If the truck driver does not regain control, the trailer could veer across lanes or result in a jackknife.

During periods of heavy snowfall, trucks and other vehicles can get stranded in snow drifts. Communities along interstates often have limited capacity to respond to stranded occupants. These impacts can compound storm effects in dangerous rescues and extended travel recovery time.

2.1.3 Reduced Visibility

Winter months often bring heavy snowfall and blizzards, reducing visibility on roads. Studies have shown that driving in such conditions increases the likelihood of crashes, with trucks being particularly vulnerable due to their size and weight. Fog and mist are additional atmospheric conditions that can limit visibility during the winter (Ashley et al., 2015). Truck drivers navigating these conditions face difficulties perceiving obstacles, road signs, and other vehicles, leading to a higher risk of collisions. Drivers with diminished visibility can crash into other vehicles, structures, objects, and even pedestrians.

Winter is a difficult time for truck drivers not just because of the weather but also because of diminishing daylight during the winter solstice in December. Less daylight often means visibility is limited to the headlights. About 50% of all car crashes occur in the dark, which naturally increases toward the end of the year. Not only are crashes in the dark more probable but they are also nearly four times more fatal than crashes that occur during the day (National Safety Council, 2023).

2.1.4 Strong Winds

Trucks, though massive vehicles, are not immune to the effects of powerful winds. This poses challenges to stability, making them susceptible to jackknife during windy conditions. If the trailer is empty or has unsuitable weight distribution, a powerful gust of wind can cause the trailer to fishtail regardless of whether the road is wet. Understanding the aerodynamics of trucks is essential in assessing their vulnerability to strong winds. Researchers have investigated the impact of crosswinds and gusts on these vehicles, considering factors such as the truck's size, shape, and load distribution. Studies have highlighted the aerodynamic forces that can lead to lateral instability, making trucks susceptible to tipping over during certain wind conditions (Neupane et al., 2015).

Several case studies and real-world incidents have been analyzed to identify patterns and contributing factors to wind-induced crashes involving trucks. Researchers have examined crashes caused by sudden gusts of wind, especially in areas prone to high wind speeds. By studying these incidents, insights into the specific conditions and scenarios that increase the risk of trucks overturning have been gained (Cai et al., 2015). Winds can also blow trucks on their sides depending on their dimensions, and drivers can sustain shoulder injuries and head trauma as trucks flip violently on roads (Alrejjal & Ksaibati, 2023; Garcia et al., 2022).

2.1.5 Unforeseen Debris

Unforeseen debris during winter months impacts truck driver safety. The potential hazards faced by truck drivers navigating winter conditions can depend on whether unforeseen debris is present and, if so, the type and cause of the debris. Research indicates that winter debris can encompass a wide range of materials, including but not limited to ice patches, snow accumulation, fallen branches, and remnants of winter storms. These elements contribute to road hazards, creating an environment where truck drivers must navigate obstacles that may not be immediately visible (e.g., Kordani et al., 2018).

Several factors contribute to the presence of unforeseen debris during winter months. One primary cause is the occurrence of winter storms, which can result in fallen trees, branches, and other materials on roadways. Additionally, freezing and thawing cycles can lead to the formation of ice patches, posing a significant threat to truck drivers. Research also highlights the impact of poor road maintenance and inadequate snow and ice removal, exacerbating the accumulation of debris (Soil, 1993).

The hazards associated with unforeseen debris during winter months are substantial for truck drivers. One of the major concerns is the potential for crashes and collisions due to reduced visibility and slippery road conditions. Truck drivers may also face challenges maneuvering their vehicles around debris, increasing the risk of jackknifing or losing control. Moreover, the impact of debris on road surfaces can result in damage to trucks, affecting both the safety and efficiency of transportation operations.

With visibility being very low throughout the winter, contacting debris like rocks and other objects can cause trucks to crash into other vehicles. Truck drivers can also skid hazardously due to debris on the roadway. At their worst, debris-related crashes may cause trucks to flip over. In these situations, truck drivers can sustain multiple injuries to their shoulders, head, and soft tissue (Eigen, 2005).

2.1.6 The Holiday Rush

Truck drivers are continually under pressure to deliver shipments on time, which often increases with the holiday rush. The holiday season is often marked by an increased demand for the transportation of goods, with a surge in online shopping and consumer spending. While this period brings joy and festivities for many, it also poses significant challenges for truck drivers who play a crucial role in meeting the heightened delivery demands. Tight delivery schedules and time constraints may force drivers to extend their working hours, resulting in fatigue and elevated stress levels. Studies have shown that extended work hours can compromise cognitive functions and decision-making abilities, posing safety risks to truck drivers and other road users (Batterman et al., 2015).

Not only do more hours behind the wheel statistically increase the danger of a crash, but truck drivers progressively find themselves pushed to the point of exhaustion to get their shipments to their destination on time. With the current truck driver shortage, some drivers feel pressured to either put in more hours than they are comfortable with or even work more than their allotted hours-of-service limits to guarantee that shipments arrive on schedule (Belzer, 2018). The average truck driver logs more hours than usual during the November and December holiday season. That, in turn, means more truck drivers experiencing sleeping disorders or even falling asleep at the wheel (Mahajan et al., 2019; Garbarino et al., 2018).

The surge in holiday-related traffic exacerbates the challenges faced by truck drivers. Congested roadways and increased vehicle volumes contribute to delays in deliveries, adding to the stress experienced by drivers. Delays impact the timely completion of routes and intensify the pressure to catch up, potentially compromising safety protocols. The holiday rush can take a toll on the mental health of truck drivers. The combination of increased workload, tight schedules, and the pressure to meet delivery deadlines may contribute to heightened stress, anxiety, and even depression. Mental health issues can negatively impact job performance, safety, and overall well-being. Elevated stress levels can impair a truck driver's physical and mental alertness, increasing the risk of crashes. The pressure to deliver goods promptly during the holiday rush may lead to risky behaviors such as speeding and reduced attention to road conditions. Studies have linked stress-induced fatigue to a higher likelihood of crashes, emphasizing the need to address stressors in the trucking industry (Apostolopoulos et al., 2014).

2.1.7 Insufficient Parking

The trucking industry plays a crucial role in maintaining the economic flow of goods, especially in regions with harsh winter conditions like North Dakota. Adequate truck parking is essential for the well-being of truck drivers and the safety of the overall transportation system (Kawamura et al., 2014). The USDOT maintains a national inventory of public truck parking facilities. In addition, some states have supplemental static and dynamic truck parking inventory systems. Figure 5 depicts the national truck stop parking locations (Bureau of Transportation Statistics, 2024). A lack of parking location and capacity information for truck drivers traversing North Dakota and the region during winter is a safety issue. Trucks may end up parking on the exit ramps or shoulders with no essential services. These parked trucks can also slow recovery during storms due to limited towing capacity in rural areas.

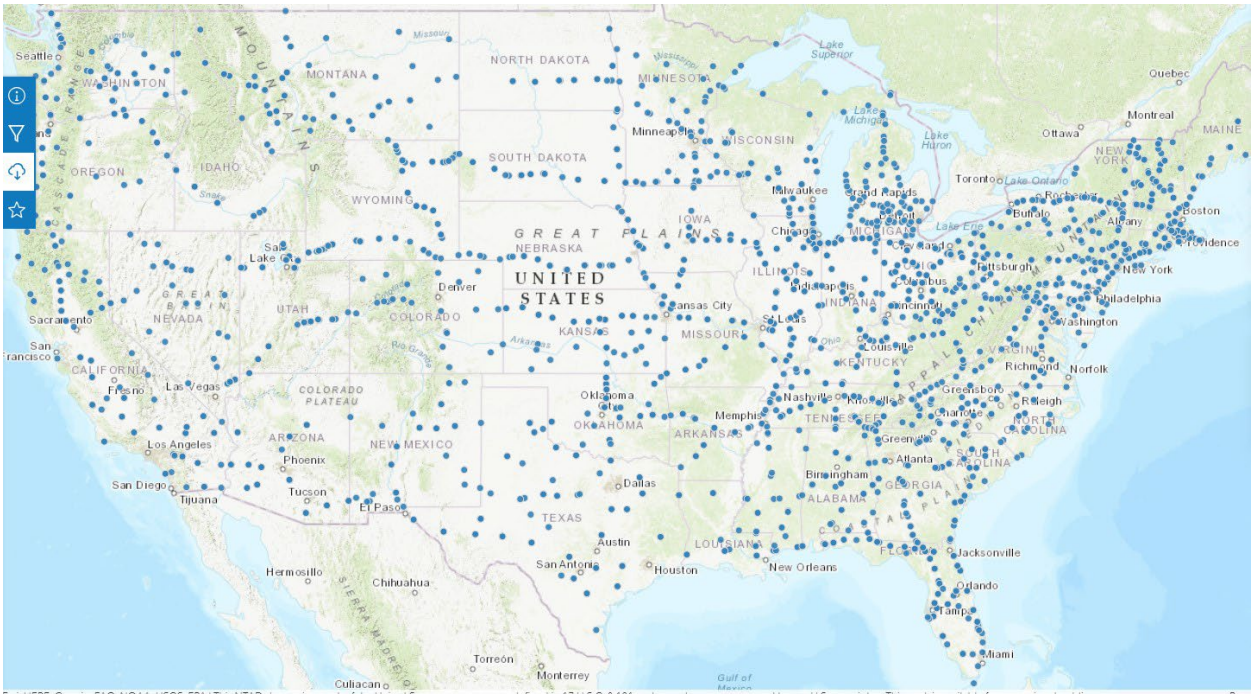


Figure 5. BTS National Truck Stop Parking Map

One significant consequence of insufficient truck parking is the increased risk of driver fatigue. North Dakota's winter weather can create challenging driving conditions, making it imperative for truck drivers to take regular breaks for rest. However, a lack of available parking spaces forces drivers to continue driving beyond their recommended hours, leading to fatigue and a subsequent decline in alertness. Several studies have linked driver fatigue to an elevated risk of crashes, emphasizing the importance of adequate rest breaks (e.g., Mahajan et al., 2019).

North Dakota winters bring extreme weather conditions, including snowstorms, icy roads, and low visibility. When truck drivers cannot find suitable parking, they may be compelled to continue their journeys in adverse weather, heightening the probability of crashes. Literature has documented the correlation between weather-related challenges and road safety, underscoring the necessity of providing safe and accessible parking facilities (Nevland et al., 2020).

Insufficient parking not only affects individual truck drivers but also contributes to increased traffic congestion. The lack of designated truck parking areas can lead to trucks parking on shoulders, ramps, or other unauthorized locations, further exacerbating safety concerns. Studies have highlighted the correlation between traffic congestion and elevated crash rates, emphasizing the need for adequate parking infrastructure to mitigate these issues (Hernandez et al., 2018).

Extended periods of searching for parking spaces during adverse winter conditions can contribute to heightened stress levels among truck drivers. Chronic stress has been associated with impaired decision-making and increased crash risk. Exploring the psychological impact of parking challenges on truck drivers during winter months is crucial in understanding the broader implications for road safety.

2.1.8 Impacts of Road Closures and Delays

Maze et al. (2005) interviewed motor carriers regarding winter road closures to determine what occurred on closed roadways before and during closures. They found that expected routine delays were valued as generalized costs, including the value of the driver's time, fuel, insurance, wear and tear on the vehicle, etc. However, unexpected delays were valued much higher because they disrupted multiple activities at the trip's destination. To reduce the costs of delays resulting from road closures, they recommended that public agencies communicate the likelihood of a potential road closure as early as possible.

Maze et al. (2005) interviewed trucking companies to learn the various costs associated with winter road closures. Costs due to delay ranged from $25 to $100 per hour (roughly $40 to $160 per hour in 2024 dollars). The estimate included the cost of fuel consumption while idling, capital costs for the equipment, and lost opportunity costs such as missed future revenue opportunities. Additionally, many companies stated they may be subject to customer penalties for late-arriving shipments. For example, one company reported a cost of $1,000 per hour when shipments of specific parts arrived late.

Studies have differentiated winter storm impacts considering passenger and truck traffic cohorts. Datla et al. (2013) studied the impact of cold and snow on traffic volumes during winter travel months in Canada. Their results indicated that the association of highway traffic patterns with snow and cold varies by day, hour, and the severity of weather conditions. For example, when the mean temperature was above 32°F, a reduction of 1% to 2% in total traffic volume was found for each centimeter of snowfall. When different vehicle classes were analyzed, Datla et al. (2013) found that passenger cars were more susceptible to winter weather than trucks. Their modeling results revealed that higher truck volumes could occur during heavy snowfall in winter months due to changing travel patterns from secondary highways with poor winter maintenance to primary highways with advanced winter maintenance practices.

Roh et al. (2015) based their research on a detailed five-year case study of WIM data in Alberta, Canada. Dummy variables were used to relate daily and hourly truck traffic volumes with snowfall, while temperature was categorized as the independent variable. Study results showed that truck traffic volume was not significantly affected by average snowfall (less than 6 inches per day) or typical cold temperatures higher than -15°F. They concluded that these findings can help effectively monitor traffic regardless of the severity of winter weather conditions because truck traffic volumes are largely independent of seasonal weather patterns.

Hallenbeck et al. (2014) discussed travel costs resulting from road closures in Washington state due to local flooding. Costs were calculated for interstate highways, U.S. highways, and state roads. Travel costs included the additional cost of time and vehicle mileage associated with available detour routes, as well as costs associated with potential trips that were abandoned. Costs per trip for abandoned and delayed trips were calculated for both passenger vehicles and commercial trucks. The cost per abandoned trip by commercial truck was calculated as $8 for a local trip, $26 for an external trip that begins locally, and $42 for a through trip beginning and ending outside the road closure location. Delayed truck trips cost $5 for local trips, $16 for an internal/external trip, and $26 for a through trip. The cost estimates are associated largely with local rerouting and short local trip cancellations. Hence, these estimates are not directly comparable to widespread or longer duration road closures associated with severe winter storms.

3. WINTER STORM TRUCK CRASH PREVENTION AND SAFETY PROMOTION STRATEGIES

Winter storm conditions pose significant challenges to truck safety on roads, necessitating the development and implementation of effective prevention and safety promotion strategies. This literature review synthesizes existing research on various approaches and initiatives to prevent winter storm truck crashes and promote safety in adverse weather conditions.

3.1 Safer People

3.1.1 Driver Training and Education

Winter Driving Training: Research indicates that truck driver experience and training are crucial factors affecting their ability to navigate adverse winter weather conditions. Knowledge and experience about adjusting speeds and following distances appropriate for weather and road conditions is a basic winter driving survival skill. Well-trained and experienced drivers are better equipped to make informed decisions during challenging situations. Rigorous training programs focused on winter driving skills, including techniques for handling snow and ice, are crucial for truck drivers. Specialized winter driving courses have shown a positive impact on reducing crash rates during adverse weather conditions (Galal et al., 2023).

Educational Campaigns: Public awareness campaigns targeting truck drivers and the public can contribute to safer winter road travel (Delhomme et al., 2009; Garcia et al., 2022). Over-the-road (OTR) training plays a crucial role in enhancing truck safety, particularly in regions like North Dakota, where long-haul transportation is prevalent (Talvitie, 1999). By focusing on skill development, adaptation to regional challenges, regulatory compliance, fatigue management, emergency response, technological proficiency, and community awareness, OTR training contributes significantly to reducing crashes and improving overall safety standards in long-haul trucking operations (NDDOT, 2024; Swift Transportation, 2024).

3.1.2 Regulatory Measures and Enforcement

Chain-Use Regulations: Clear regulations regarding tire chain use during winter storms are essential for ensuring truck safety. Effective enforcement mechanisms can encourage compliance with these regulations (Alnes et al., 2021).

Hours-of-Service Regulations: Hours-of-service regulations for truck drivers are integral to ensuring road safety and preventing fatigue-related crashes. One critical aspect of hours-of-service regulations is the level of compliance and the effectiveness of enforcement mechanisms. Research indicates that strict enforcement leads to better compliance, while lax enforcement may compromise the intended safety benefits of these regulations. Advancements in technology, such as electronic logging devices (ELDs), have revolutionized the monitoring and enforcement of hours-of-service regulations. Literature suggests that ELDs contribute to more accurate tracking of driving hours and provide real-time data for regulatory compliance. Understanding the regional nuances of hours-of-service regulations is essential. Different jurisdictions may have varying regulations; thus, it is important to consider the implications of such variances on truck driver safety within the context of North Dakota.

While hours-of-service regulations aim to enhance safety, criticisms exist. Some argue that rigid regulations may lead to economic burdens for trucking companies and drivers. However, adapting hours-of-service regulations to account for the challenges posed by winter storms is crucial. Flexible regulations may allow drivers to adjust their schedules to avoid adverse weather conditions and reduce the risk of fatigue-related crashes (Jensen & Dahl, 2009)

3.1.3 Truck Driver's Emergency Kit

Winter Driving Preparedness: Numerous trucking firms have established winter driving preparation websites for their drivers and clients. Cloud Trucks (2021) recommends the items illustrated in Figure 6, the Truck Driver's Emergency Kit.

They also recommend an extensive list of detailed driving tips, including:

1. Be prepared for your trip.
2. Inspect your truck before driving.
3. Practice chaining ahead of time.
4. When in doubt, pull over.
5. Keep lights cleaned off.
6. Don't follow the brake lights.
7. Pack layers.
8. Pack a bag of kitty litter or salt.
9. Carry anti-gel.
10. Bring an extra gallon of washer fluid.

Figure 6. Truck Driver's Emergency Kit

3.1.4 Weather Forecasting and Communication

Advanced Weather Prediction Models: Accurate and timely weather forecasting is crucial for truck drivers and transportation authorities to prepare for impending winter storms. Integrating advanced meteorological models and real-time data can enhance prediction accuracy (Chung, 2021).

Communication Technologies: The use of communication technologies facilitates the timely dissemination of crucial information to truck drivers about changing weather conditions, road closures, and alternative routes (Nagarajan et al., 2018; Thakuriah et al., 2013).

Driving Applications: Driving applications such as Drivewyze and Google Maps are common among truck and other vehicle drivers. These applications are fundamentally designed to re-route rather than postpone or delay travel. In the literature and during peer interviews (p. 57), some mention was given to efforts that would integrate emergency road closures, such as winter storms, into the driving applications.

Truck Parking: Applications and dynamic truck parking inventory programs are under development and in the early phases of deployment. One nationwide example is Truck Parking Across America (2024). Application-based tools to find safe truck parking is under development at Trucksparkhere.com and the University of Connecticut (2024). A specific state example is Minnesota, where some truck parking information has been integrated into its 511 platform (2024).

Industry Communications: South Dakota was novel in its progress with Google Map negotiations. South Dakota also mentioned sharing information with the SD Truck Association for industry dissemination as part of its standard winter storm road closure procedure.

3.1.5 State Winter Driving Policies

N.D. Cent. Code § 39-10-21.1 – "Closing road because of hazardous conditions – Road closure notice – Entering closed road prohibited"

- The policy does not mention any fines.
- Perhaps fines should be commensurate with the class of driver, increasing with additional repeat offenses.
- Penalties could be added, commensurate with the class of driver, increasing with additional repeat offenses.

2023-2025 Commercial Driver License Manual Class A, B and C, section 2.13, deals with driving in winter.

- Perhaps there should be another section, "Deciding to Delay Driving in Winter."
- Must add section on road closures
    - There is no mention of what to do in case of road closures.
    - If the fine of $250 mentioned in the Commercial Driver License Manual Class D under the Winter Driving section applies to commercial drivers, too, then similar language must be included in the Commercial Driver License Manual Class A, B, and C.

2023-2025 Commercial Driver License Manual Class D under the Winter Driving section does mention, "It is not legal to enter a road that is officially closed due to hazardous conditions. The penalty for doing this is a $250 fine."

3.2 Safer Roads

3.2.1 Road Design to Reduce Winter Maintenance

Road maintenance practices play a pivotal role in ensuring truck safety during winter conditions. The literature highlights various strategies, including snow and ice removal techniques, pre-treatment strategies, technology integration, anti-spray measures, public awareness, and infrastructure investment. A holistic approach that combines these practices can significantly enhance road safety for heavy-duty trucks in winter, ultimately reducing the risks associated with adverse weather conditions (Blomquist, 2001).

The design and layout of rural interstates, including considerations for slope, curves, and exit ramps, can affect the safety of truck travel during winter storms (Torbic et al., 2004). Designing roads with a separation above natural ground of 5 to 6 ft will allow the winds to blow snow off the road into the ditches in open areas. This design will also have deeper road ditches, which have more snow-holding capacity. The excavated dirt from the road ditches can be used to build the subgrade elevation of the roadbed. This concept can be implemented during a major reconstruction project, which will result in widened right of way and eliminate the congestion of narrow right of ways, which create opportunities for land use practices that are not conducive to snow removal, such as shown in the picture below. Figure 7 illustrates a road with low to negative separation from natural ground and narrow right of way, which limits snow plowing efforts.

Figure 7. Winter Scene with Low to Negative Road Elevation

Winter road design considerations should also be made on curve cross slopes or superelevation (Figure 8). It should not exceed 5% as ice or slippery road conditions could cause vehicles to lose control and slide out of their lane either off the roadway or into oncoming traffic (Federal Highway Administration, 2024b). In some cases, cross-slope changes can be addressed during a resurfacing project. New bituminous surfaces with their dark black color tend to melt off snow and ice during clear days from the sun's solar energy faster than white concrete or faded asphalt surfaces.

Figure 8. Curve Cross Slope Road Example

Finally, road surface width designs should include a width that is more than the minimum AASHTO requirements to allow for a higher chance of recovery if vehicles lose control during winter driving conditions. Wider shoulders also allow for more flexibility in road maintenance project designs in future years.

3.2.2 Snow Fences

Living Snow Fence

A living snow fence (LSF) is a designed planting of trees, shrubs and native grasses along highways, roads, and ditches that create a vegetative barrier to control blowing and drifting snow (Shaw, 1988; Tabler, 1991). When strategically placed, these fences provide a cost-effective method in reducing highway maintenance work during winter snow events.

In 2015, the Colorado Department of Transportation (CDOT) performed a study regarding the tools and knowledge needed to expand the use of LSFs. The Colorado State Forest Service identified approximately 177 existing LSFs along state highways. Training sessions were held in each of the five CDOT regional offices. The NRCS of the USDA, Colorado Forest Service, and Colorado Soil Conservation Board, along with Pheasants Forever, have participated with funding or installation labor with these projects. Other benefits for adjacent landowners are livestock shelters, soil and crop protection, and improved wildlife habitat.

CDOT has also installed slatted or mechanical snow fences. In some locations, landowners require that these be removed during the summer months. The Wyoming DOT is replacing many of its wood snow fences with LSFs. The DOT has been working with the Wyoming State Forest Service and local

conservation districts, which greatly assists in gaining landowner acceptance. Weed control materials are important to maintain good relations with landowners.

LSFs are not a new concept. As early as 1905, railroad companies planted trees as barriers to control blowing snow along their right of ways. By 1915, the Great Northern Railway Company had planted over a million trees. In North Dakota, over 96,000 trees and shrubs were established. CDOT provides $10,000 in funding each year to the State Conservation Board to coordinate, locate, and install LSFs. The Colorado Division of Wildlife contributed materials valued at approximately $10,000 per year toward this same effort. Over 300 LSFs were installed along state and local highways. CDOT has since dropped its agreements with the other state agencies and has relied more on local government coordination in recent years.

LSFs have a service life of 50 to 75 years, compared with a slat fence service life, which is only 20 to 25 years. Living mature trees can capture up to 12 times more snow than slat fences. LSFs can be installed to mitigate tree loss from highway construction projects. Trees and shrubs also reduce CDOTs carbon footprint by sequestering carbon from the atmosphere. Reductions in snow plowing efforts reduce fuel consumption, costs, and greenhouse gas emissions.

Less permanent approaches to an LSF have been successfully deployed in several states. Row crops, tall grass, and crop storage options have been considered in conjunction with wood fences and deciduous fixtures (Nixon, Davidson, and Kochumman, 2006).

In large open areas, LSFs need to be 150 to 200 feet away from the road surface. This may require planting outside of the road right of way. Coordination with the landowners, county commissioners, resource conservation districts, state and federal forest services, and land management agencies make the planning process more rewarding. Site planning may include easements, tree planting, site preparation, seedlings, and supplies. Irrigation or watering systems may be needed along with fencing to prevent livestock or wildlife browsing damage. LSFs may take five to seven years to become effective and up to 20 years to be fully functional.

The average LSF size in the study was 1,040 feet long and with three rows. A common rule of thumb is the 10H rule for windbreak design. This rule states that wind velocity is reduced by 50% for a distance of up to 10 times the height of the barrier. A 20-foot-tall tree gives 200 feet of protection. Snow storage capacity increases four times when tree height is doubled. Keeping LSFs back far enough from the road surface to prevent capture of snow on the roadway is critical. This distance may need to be at least 200 ft in areas commonly impacted by snow cuts that block a highway completely. To offset costs over a 50-

Figure 9. Snow Fence Photo

year expected life, a reduction of only one traffic crash would need to happen every 23 years. Snow plowing time was reduced by about six hours per year. The CDOT has estimated that the department realizes a benefit of $600 per LSF per storm event along the I-70 corridor.

In regions that experience heavy snowfall of nearly 50 inches or more per season, winds blow the snow around, limit visibility, and block roadways. Where hills, overpasses, and other geographic features create the right conditions, snow forms deep drifts on highways. Keeping these roads safe and open to traffic creates a challenge that requires time, money, and equipment. Preventing drifts from forming on the road is an effective way to manage this problem.

New fences made of plastic mesh and mounted in a wood frame are effective when placed properly. Costs are approximately $8.68 per linear foot per season. Wherever snow fences are placed, visibility is improved, and the road stays clearer. This improves safety for the traveling public (FHWA, 1996).

Structural Snow Fences

Structural snow fences have been increasingly used in northern regions of the United States. They are a cost-effective and efficient technology that prevents snow accumulation on highways and improves road safety (Yuan et al., 2022). Structural snow fences, however, are used only during winter. To add more value to the structure, an idea to install solar photovoltaic (PV) panels on structural snow fences was first proposed by the Minnesota Department of Transportation (MnDOT), which looked at the feasibility of integrating structural snow fences with PV panels, or PV snow fences (PVSFs). PVSFs would be constructed by replacing the rails between the structural fence poles with customized PV panels with the exact dimensions of the rail. This arrangement ensured that the original function of the snow fences, eliminating blowing and drifting snow on highways, would not be affected.

Considering different factors or parameters, such as project size, panel size, installation angle or orientation of the panels, discount rate, energy selling price to a utility company, availability of incentives, and ownership of the PV system, a comprehensive cost-benefit model has been established to analyze the pros and cons of different implementation plans. The analysis results show that the longer the length of the PVSF, the more cost-effective the project is due to a lower capital cost and increased power generation. A power purchase agreement (PPA) would significantly shorten the payback period in consideration of its key benefits, including minimal up-front capital costs, lower energy costs, no risk, no upkeep, leveraging available tax credits, and property value enhancement, which is, therefore, more realistic and would be a higher priority for an agency like MnDOT or other state DOTs.

Figure 10. Photovoltaic Snow Fence

Three HeatTrak® snow-melting pads are purchased and adopted to melt the snow around the control room and the west end of the solar snow fence. The HeatTrak® could be remotely controlled through a smart home application. The HeatTrak® pad consumes 450 watts per hour every hour. Each pad works five hours daily and is arranged for 5.0 hours. Based on the snow-melting capacity of the HeatTrak® pad, it can melt 2 inches per hour and 10 inches in five hours. Maximum snow precipitation is 10 inches on average in Fargo, ND, from October to April, which can be effectively handled by the HeatTrak® snow melting pads.

Table 1. Benefits of Implementing Solar Photovoltaic Structural Snow Fence

Table 4.2 The quantitative benefit generated in this project

Benefit type	Estimated benefit in dollars	Comments/notes
Drifting snow removal savings ($/mile/year)	$34,486.03	Agency cost savings for drifting snow removal
Reduced salt usage (Ice removal) savings ($/mile/year)	$10,207.09	Agency cost savings due to reduced salt usage and sprays.
Reduced crash incident savings ($/mile/year)	$29,638.00	Cost savings from fatal, injury, and property damages due to car crashes
Reduced traffic delay savings ($/mile/year)	$12,826.93	Saving caused by travel time reductions due to improved road conditions
Reduced carbon emission savings ($/mile/year)	$241.40	Cost savings caused by less fuel used in snow removal and salt spray
Salvage values ($/foot)	$0.09	Savings received from steel pole recycling (Scrapmonster)

3.2.3 Intelligent Transportation Systems (ITS)

Roadside Weather Stations: The deployment of roadside weather stations equipped with sensors enables real-time data collection for monitoring temperature, humidity, and road conditions. This information can be integrated into an ITS to provide accurate, localized weather updates for truckers (Boselly et al., 1993; NDDOT, 2019)

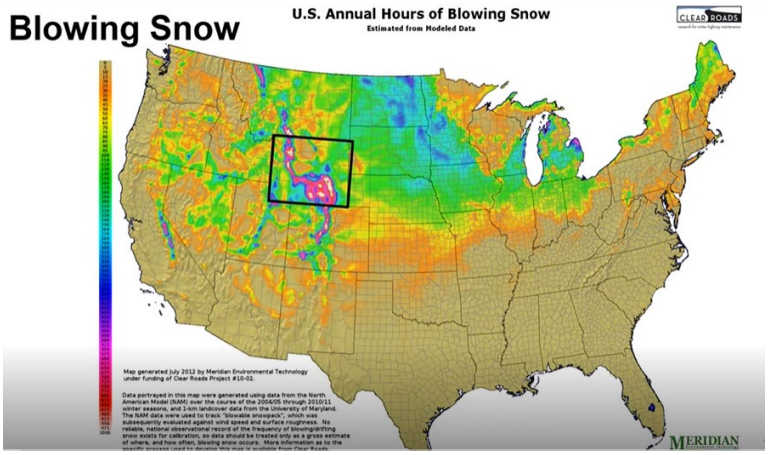
Smart Road Infrastructure: Integrating intelligent technologies into road infrastructure enhances safety during winter storms by minimizing ice accumulation and providing real-time safety information (NDDOT, 2019.)

Variable Speed Limit (VSL) is a kind of ITS that has shown potential for improving safety on roadways that experience adverse weather conditions. A rural VSL system was installed by the Wyoming Department of Transportation along I-80 in the southeastern part of Wyoming. Results indicated that

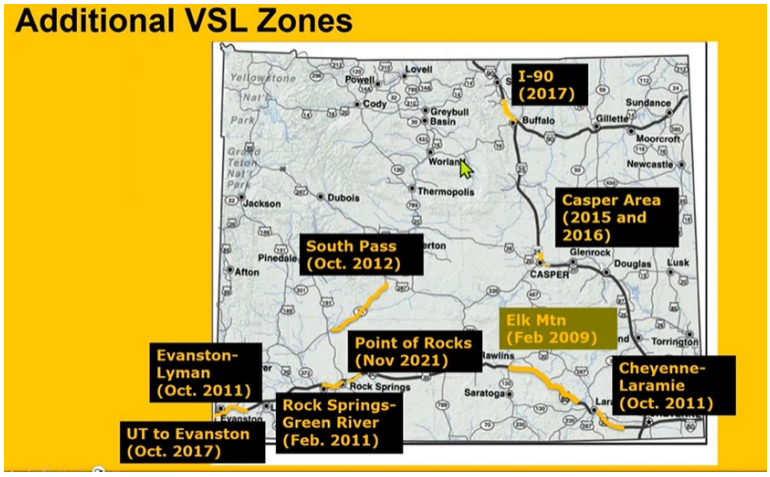
drivers decreased their speeds by 0.47 to 0.75 mph for every mile per hour in posted speed reduction (Buddemeyer et al., 2010; Rillagoda et al., 2022).

Another VSL system was deployed on a segment of I-80 in Parlay's Canyon, Utah, due to elevation changes and snowstorms in the winter. The new signs resulted in significantly lower crash rates throughout the corridor. Crash severity decreased substantially during inclement weather conditions when the roadway was icy and visibility reduced. Also, the safety model indicated that road crashes were reduced using unique amber lighting for the VSL signs (Azin & Yang, 2022).

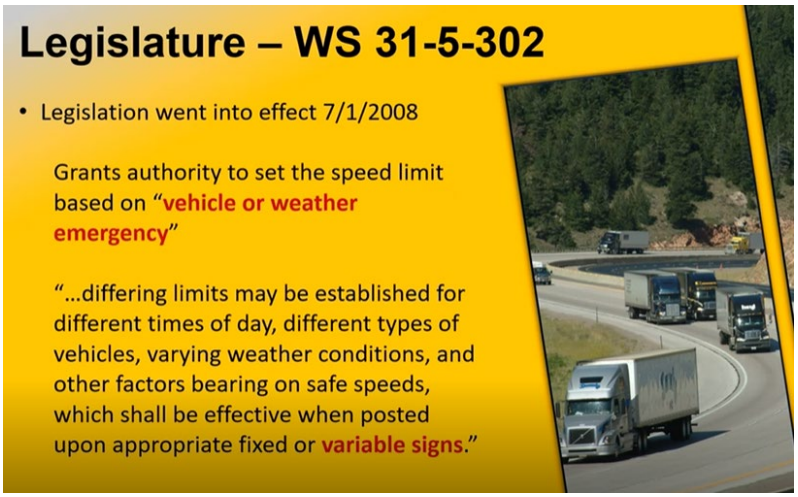
Per the peer state interviews, VSL applications are active in Wyoming and South Dakota. Supplemental presentations were arranged and attended to learn more about Wyoming's implementation and the South Dakota planning phase. The Wyoming program was initiated after two severe and fatal multiple-vehicle winter weather-related crashes occurred in March 2006 and December 2007. The Wyoming legislature passed a law that went into effect on July 1, 2008, allowing for variable speed limits in the state. The focus was on I-80, located in an area with a history of blowing snow issues. Meridian mapping has a record of areas in the United States with frequent blowing snow incidents, and Wyoming has the largest area compared with any other U.S. state.

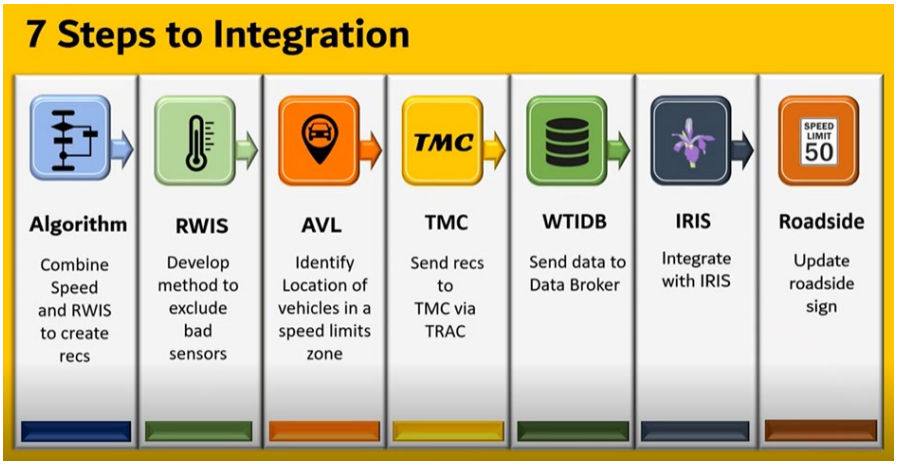


The Wyoming DOT worked diligently to implement a VSL on a segment in the fall of 2008. However, delays in sensing and warning device deliveries resulted in the first segment being functional in the Elk Mountain area by February 2009. Since then, eight other segments have been added.



Implementing a speed limit change has seven steps, starting with an algorithm developed by the U of Wyoming and the Wyoming DOT. The algorithm considers several factors, including road surface temperature, humidity, visibility, and stopping sight distance. The integration process uses IRIS (intelligent roadway information system) to push the speed change to the signs in the field. Highway patrol or highway department personnel can also advise on the speeds.





VSL segments tighten up speed distribution ranges so more vehicles travel at the same speed, resulting in a higher safety level. For each 10-mph reduction, the actual reduction in traffic speed is 6 to 8 mph (Figure 11). The most common complaint of a VSL change is not increasing back to normal speed limits after a storm. Today, crash severity and frequency are much lower in these segments due to VSL.

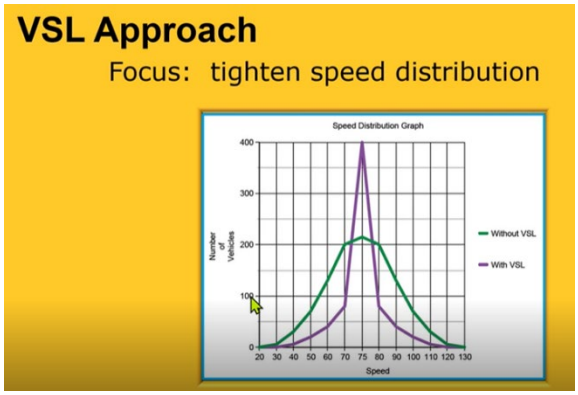


Figure 11. VSL Speed Distribution

The VSL is used as a system of technologies to collect and generate information (Figure 12). Speed sign boards using amber lighting have the best visibility results. Research shows that amber is 40% better than white LED signs and more than 100% better than black-on-white fixed signs.

Figure 12. VSL System Example

SDDOT, in a collaborative effort with state legislators and ITS experts, has outlined its pilot phase and investment plans for a problematic corridor near Brookings. They are working together to design a VSL system and establish legislative authority to enforce the variable sign speeds as statutory speed limits in the corridor. Planning is underway for a second (western) corridor. The state is committed to sharing more information about the program as it progresses, making everyone feel valued and integral to the process.

3.3 Safer Vehicles

3.3.1 Vehicle Equipment and Maintenance

Tire and Brake Systems: Properly maintained and equipped trucks are essential for safe winter travel. Research highlights the importance of tire traction and effective brake systems in preventing crashes on snow-covered and icy roads (Kirkbride, 1985; NHTSA, 2024).

Technological Advancements: The integration of advanced safety technologies, such as anti-lock braking systems (ABS), electronic stability control (ESC), and traction control systems, has shown promise in reducing the risk of truck-involved crashes during winter storms (NHTSA, 2024).

3.3.2 Technological Innovations in Truck Design

Enhanced Traction Control Systems: Enhanced traction control systems represent a promising avenue for improving truck safety in winter storms. Integrating advanced sensors, algorithms, and collaborative technologies such as ABS and VSC contributes to optimized traction and stability. Ongoing research, including field testing and consideration of human factors, will further refine these systems, ensuring their efficacy in enhancing truck safety during adverse winter weather conditions (Freund et al., 2006).

Autonomous and assisted driving systems hold significant potential in improving truck safety during winter storms. Research explores their ability to assist drivers in making better decisions and reacting to

changing road conditions (Bathla et al., 2022). By leveraging advanced sensor technologies, V2X communication, AI, and ML algorithms, these systems can adapt to the challenges of icy roads and reduced visibility. As research and development in this field progress, it is crucial to establish comprehensive regulatory frameworks and standards to ensure the widespread adoption and safe deployment of these technologies in the trucking industry, fostering optimism about the future of truck safety.

3.4 Safer Speeds

3.4.1 Education and Enforcement

Safer speeds are crosscutting in the Safe System approach. Education and enforcement are often at the forefront of wise vehicle speed decisions. People have roles as operators in trucks, vehicles around large rigs, enforcement, education, and dispatch centers to understand appropriate speeds, braking, and following distances. These faucets are typically all impacted to the need for appropriate conditions governance with winter weather and road conditions. As noted, road design and maintenance also impact safe winter traffic speeds. As discussed in the literature review, these impacts may differ in winter weather for trucks and other vehicles (p 10).

3.4.2 Wind Blowing Over Vehicles – Wyoming DOT Study Briefing and Legislative Implementation

Special treatment may be needed for complex issues such as truck blow overs. Although not a widespread safety issue, specific sites and/or corridors can be susceptible to blow over or blow-off-the-road winter crashes. Wyoming has dedicated resources to understanding this issue on its roads, specifically about susceptible truck types. Over a dozen factors were used to analyze a blown over vehicle while in motion on a highway. These include vehicle height, weight, drag force, lift force, road superelevation, and more, as shown in Figure 13.

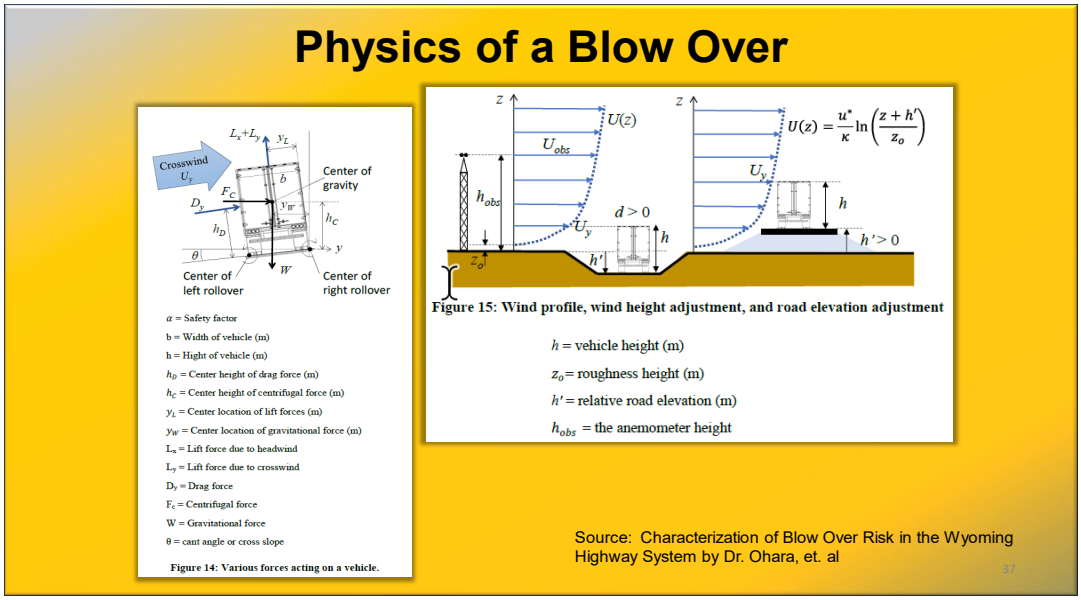


Figure 13. Heavy significant truck stability association with truck weight and wind speed

Blow-over crashes typically involve lighter vehicles with large, flat surface areas. The wind direction is usually not relevant for a vehicle of less than 10,000 lbs. with a sustained wind of 24 mph. Heavy vehicles weighing more than 45,000 lbs. are more stable. Wind speeds need to reach over 46 mph before there is a blow-over risk. At 50 mph wind speeds, an angular wind vs a 90-degree side wind creates a great risk for a blow over. At 66 mph sustained wind, the direction of the wind is irrelevant. From 2018 to 2022, blow overs in Wyoming significantly increased from 87 to over 150 annually.

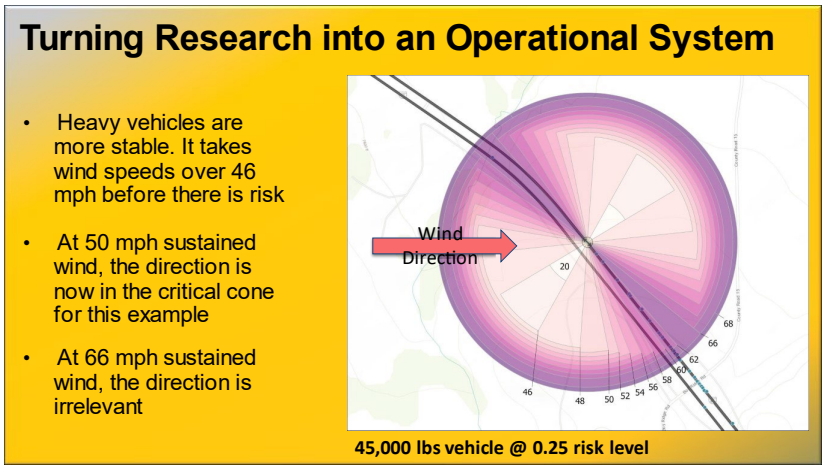


Figure 14. Truck Blow Over and Speed, WYDOT

The most common types of vehicles prone to blow overs include truck box trailers and dual trailers, pickup trucks and livestock trailers, recreational vans, and towed camping vehicles. Some truck types are not prone to blow overs. These configurations include tanker trucks, belly dumps, flatbed trailers, school buses, and odd-shaped loads on flatbeds. See Figure 15.

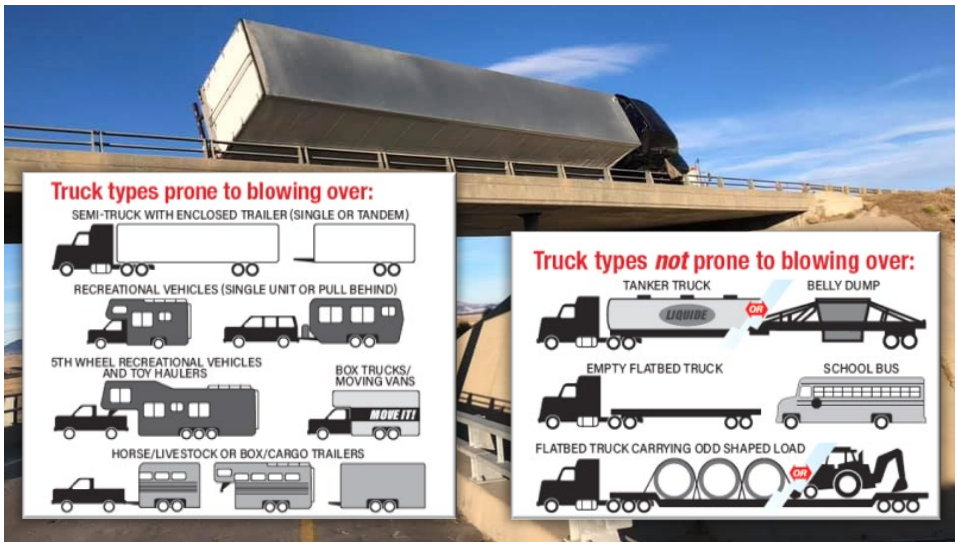


Figure 15. Truck Types Prone to Blow Over, WYDOT

In 2023, Wyoming implemented an operational system for road closures to prevent blow overs. This system includes five steps: identifying road features, developing tables for weather stations, linking real-time wind speed and direction to these tables, providing weight restriction notices to the Transportation Management Center, and making the information available at the roadside. The Wyoming legislature passed law WS 24-1-108 to allow for the closure of roads to light and high-profile vehicles. Fines include $1,000 for the first offense, $2,500 for the second offense, and reckless driving, which generally results in losing one's commercial driver's license. With this system in place, blow overs were reduced from 170 per year to 67 in 2023.

Figure 16. Wyoming Blow-Over Policy

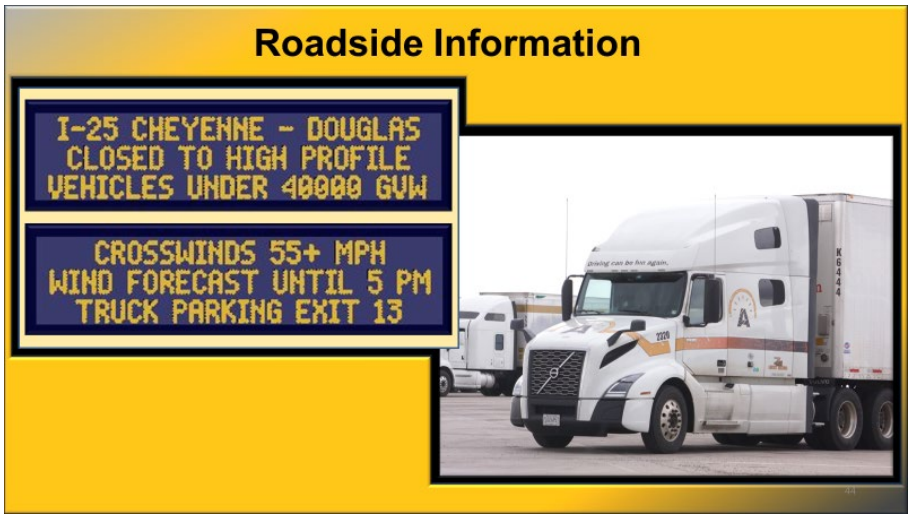


Figure 17. Wyoming Roadside Information Example

4. WINTER TRUCK-INVOLVED CRASH EVENT ANALYSIS

4.1 I-94 Winter Crash Data

State crash records for law enforcement reports were collected for the most recent five-year period on the I-94 corridor in North Dakota. During the sample period from January 2019 to December 2023, the winter months January, February, March, November, and December were selected. The crashes during these months were summarized to differentiate the truck involved from all crash events. These I-94 winter crashes created an initial winter crash profile in a series of descriptive statistics. Overall, 594, or 28.2%, of the 2,105 I-94 crashes reported to law enforcement involved a truck during the 25-month winter study period.

4.2 Description Statistics

Contributing factors in the winter crashes were summarized in relation to law enforcement reports. Based on the literature scan, road and climate conditions are highlighted as frequently associated with the events. About 82% of the I-94 winter truck-involved crashes reportedly had road surfaces with reduced friction from snow, slush, or ice cover compared with all crashes. Truck-involved crashes more frequently involve winter climate contributing factors at 84% compared with all crashes 78%.[1] The crash share involving lane departures was also similar, with trucks at 82% compared with 78% overall. The last two statistics have a notable difference with a jackknife rate of 40% among the truck-involved crashes, compared with less than 15% overall.

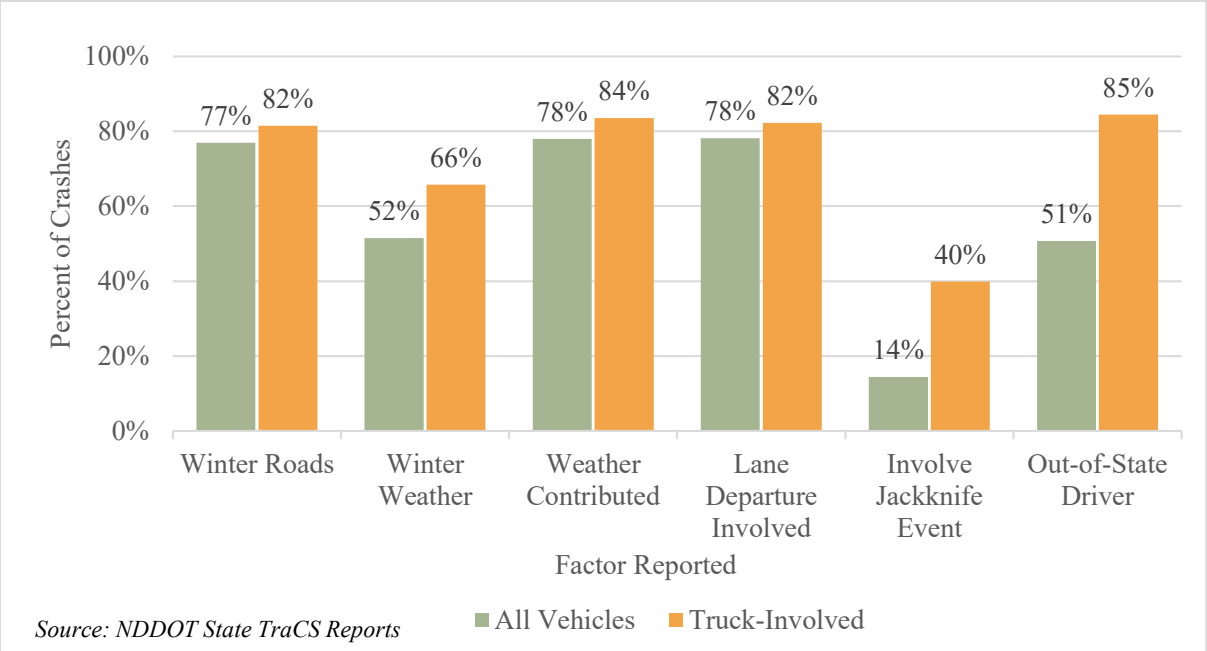


Figure 18. I-94 Winter Crash Features, 2019-2023

[1] Winter road conditions are either when roads have ice/frost, snow or slush on them, or when there is snow, blowing snow, freezing rain, sleet or hail, or both.

Citations issued with the winter I-94 crash subpopulation are also informative in regard to contributing factors. Law enforcement reportedly issued 1,152 citations for I-94 crashes during the winter study period. Comparing citation rates among crash types, single-vehicle truck crashes most frequently involved a citation at 38%. Among drivers in truck-involved multiple-vehicle crashes, truck drivers accounted for 21% of citations issued, compared with 32% issued among other drivers. Care-required was the most common citation in single-vehicle crashes, accounting for about two-thirds of the offenses. Care-required citations are also most frequent in multiple vehicle crashes: 39% and 41% for truck and other drivers, respectively. Another common driver error is following-too-close. Both offenses could be associated with driver experience and judgment in gauging decisions about appropriate conditions for winter roads and climates. A final note is compared to the most recent Truck Safety Brief, highlighting the careless driving citation rate of 1% among drivers in truck-involved crashes (NDSU-UGPTI, 2024). This rate is substantially higher at 6% and 3% citation rates in this winter month crash study.

Table 2. I-94 Winter Crash Traffic Citations

	Single-Truck	**Multi-Vehicle**	
		Truck	**Other**
No Citation	62%	79%	68%
Among Citations Issued, Offense			
Care Required	66%	39%	41%
No Insurance - 18	5%	0%	4%
Driver's License, NCC	5%	1%	4%
Left Crash Scene, NCC	4%	1%	2%
DUI (Alcohol)	3%	0%	3%
Careless Driving	1%	6%	3%
DUI (Drugs)	0%	0%	0%
Overtaking	0%	1%	1%
Open Container	0%	0%	0%
Failed To Yield	0%	0%	6%
Failed To Stop	0%	0%	1%
Following Too Close	0%	15%	17%
Improper Turning	0%	4%	2%
Improper Backing	0%	0%	0%
Wrong Way	0%	0%	0%
Speeding	0%	0%	0%
Defective Equipment	0%	0%	0%
Illegal Parking	0%	0%	0%
Other Offense	16%	31%	15%

Note: Not Contributing to Crash (NCC)

The out-of-state driver feature may indicate driver experience with winter storm safe mobility decisions. A significant highlight is that 85% of the drivers in the truck-involved crashes are from other states, compared with about one in two drivers overall.

Table 3. I-94 Winter Crash Features Table Version, 2019-2023

Table 1. I-94 Table Version		
Crash Factors	**I-94 Crashes for All Vehicles**	**I-94 Truck Crashes**
Winter Weather Conditions	78%	83%
Winter Roads (Ice/Frost, Snow or Slush)	77%	81.5%
Winter Weather (Snow, Blowing Snow, Freezing Rain, Sleet or Hail)	51.5%	65.8%
Lane Departure	78.2%	82.3%
Jackknife Event	14.4%	39.9%
Out-Of-State Driver Involved Crashes	50.7%	84.5%

Winter I-94 Crashes for All Vehicles, 2019–2023

- Total: 2,105
- Approximately 7.7% percent of all winter crashes in the state occur on I-94.
- 1,620, 77%, of I-94 crashes occur when roads have ice/frost, snow, or slush.
- 1,084, 51.5%, of I-94 crashes occur with blowing snow, freezing rain, sleet, or hail.
- 1,641, 78%, of I-94 crashes are related to winter weather conditions.[2]
- 1, 647, 78.2%, of I-94 crashes are lane departure crashes.[3]
- 303, 14.4%, of I-94 crashes involve a jackknife event.
- 1,068, 50.7%, of I-94 crashes involve an out-of-state driver.

Winter I-94 Truck Crashes, 2019-2023

- Total: 594
- 484, 81.5%, of these truck crashes occur when roads have ice/frost, snow, or slush.
- 391, 65.8%, of these truck crashes occur when there is blowing snow, freezing rain, sleet, or hail.
- 496, 83.5%, of these truck crashes are related to winter weather.
- 489, 82.3%, of these truck crashes are lane departure crashes.
- 241, 39.9%, of these truck crashes involve a jackknife event.
- 504, 84.5%, of these truck crashes involve an out-of-state driver.

[2] Winter road conditions are either when roads have ice/frost, snow or slush on them, or when there is snow, blowing snow, freezing rain, sleet or hail, or both.

[3] A lane departure crash is defined as a crash that has at least one of the following events in sequence of events: overturn/rollover; immersion, full or partial; jackknife; ran off roadway right; ran off roadway left; parked motor vehicle; impact attenuator/crash cushion; bridge pier or support; bridge rail; cable barrier; culvert; curb; ditch; embankment/approach; guardrail face; guardrail end; concrete traffic barrier; other traffic barrier; tree; utility pole/light support; traffic sign support; traffic signal support; other post, pole, or support; fence; mailbox; other fixed object (building, wall).

Additional Statistics About Truck Crashes and Truck Drivers During Sample Period

The total number of vehicles in the truck-involved crash subpopulation shows that 59% (350 out of 594) were single-truck crashes. About 30% (176 out of 594) of crashes involved one truck and at least one other vehicle configuration. Among the crashes, 7.2% (43) involved two trucks. Law enforcement reports showed the most vehicles involved in a truck-involved crash event was 18. Four trucks were reportedly involved in that event.

Table 4. Vehicles in Truck-Involved Crash Events

Total Truck	Total Number of Vehicles						
	1	**2**	**3**	**4**	**10**	**18**	**Total**
1	350	176	11	1	0	0	538
2	0	43	4	4	0	0	51
3	0	0	1	2	1	0	4
4	0	0	0	0	0	1	1
Total	350	219	16	7	1	1	594

Total Truck: Total number of trucks in truck-involved crashes.
Total Number of Vehicles: Total number of vehicles in truck-involved crashes

Based on previous research, it is evident that single- and multiple-vehicle crashes often have different characteristics and injury risk factors. Among the 361 truck occupants in truck-involved winter crashes, 7 occupants suffered severe injuries; these fatal and disabling injuries comprised 1.9% of the cases. Among occupants in other vehicles, injuries resulting from among 322 resulted in 1 fatality and 14 serious injuries, comprising 5.3% of cases (Table 5).

Table 5. Occupant Injuries, Winter I-94 Sample Truck Involved in Multi-Vehicle Crash

	Vehicle Type		
Injury Status	**Non-truck**	**Truck**	**Total**
No Injury	252	332	584
Fatal	3	1	4
Serious	14	6	20
Minor	26	9	35
Possible	27	13	40
Total	322	361	683

*Note: Data is I-94 winter storm sample, all drivers and occupants in the trucks-involved in multi-vehicle crashes.

Among the 683 occupants of vehicles in crashes involving multiple vehicles, the injury risk ratio was 77% greater for the non-truck vehicle occupants. Given the size and weight differences between trucks and passenger vehicles, the relatively higher risk for occupants of smaller vehicles is unsurprising.

Jackknife crashes are more common with severe crosswind weather conditions – often causing lane closures and long-term traffic disruptions. A severe crosswind weather condition was also reported in about 55% of truck jackknife events (Table 6). Among all crashes, 16% involved a jackknife truck event during severe crosswind weather; only 8% involved a jackknife event when no associated severe crosswind was present.

Table 6. Jackknife Crash by Severe Crosswind Weather

Severe Crosswind Weather	Jackknife Crash		
	No	Yes	Total
No	325	198	523
Yes	32	39	71
Total	357	237	594

Overall, 2,833 drivers were involved in the 2,105 crashes over the 25-month winter sample period. The state of licensure in truck-involved crashes was summarized. Overall, 58% of drivers in truck-involved crashes were North Dakota licensed drivers. Vehicle configuration showed 614 drivers (22%) were operating trucks. Among the truck drivers, 22% held an ND license, 23% held a license from a neighboring state, and 51 were licensed in other states or provinces. These were most commonly from Minnesota (16%), Canada (12%), Florida (8%), Texas (4%), and Washington (4%). In comparison, among the cohort of other drivers in these truck-involved crashes, 72% held ND licenses. Minnesota was the next most commonly reported licensure state, accounting for 14%. Other driver licensure was dispersed, with less than 2% attributed to another state or providence.

Table 7. Driver Licensure State

Table 4. Driver License State				
	Truck Driver		All Vehicle Driver	
License State	**Count**	**Percent**	**Count**	**Percent**
ND	133	20.27%	1,731	58.38%
Neighboring State	149	22.71%	540	18.21%
Other	332	50.61%	563	18.99%
Missing	42	6.4%	131	4.42%
Total	656	100%	2,965	100%
Neighboring State: SD, MT, MN, WY, MB, SK				

Driver licensure state in the involved truck crashes was also studied in a year-over-year sequence in Table 8. Compared with 2019, the total number of drivers involved in truck crashes increased by nearly 80% in 2023. Out-of-state drivers originating beyond neighboring states accounted for 77% of the increase.

Table 8. Driver License State by Crash Year

	Truck Driver						All Vehicle Driver					
License State	**Crash Year**						**Crash Year**					
	2019	**2020**	**2021**	**2022**	**2023**	**Total**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
ND	29	14	18	35	37	**133**	457	222	233	433	386	**1,731**
Neighboring State	31	15	11	46	46	**149**	124	65	54	164	133	**540**
Other	43	29	46	101	113	**332**	89	52	67	171	184	**563**
Missing	10	2	7	15	8	**42**	34	17	19	34	27	**131**
Total	113	60	82	197	204	**656**	704	356	373	802	730	**2,965**

Truck driver age cohorts show that the 35–44 age group accounted for 26% of truck drivers involved in crashes, followed by drivers aged 25–34 (23%) and 45–54 (20%) (Table 9). Among other drivers, those ages 25–34 accounted for a similar 23%, but drivers ages 18–24 and 35–44 accounted for 19% of the cases over the study period, as shown in Figure 19. Driver age group distribution considered cases where the driver's age was known. Age was not missing for 6.4% of truck drivers and 4.4% of other drivers – these could include cases where the driver had left the scene.

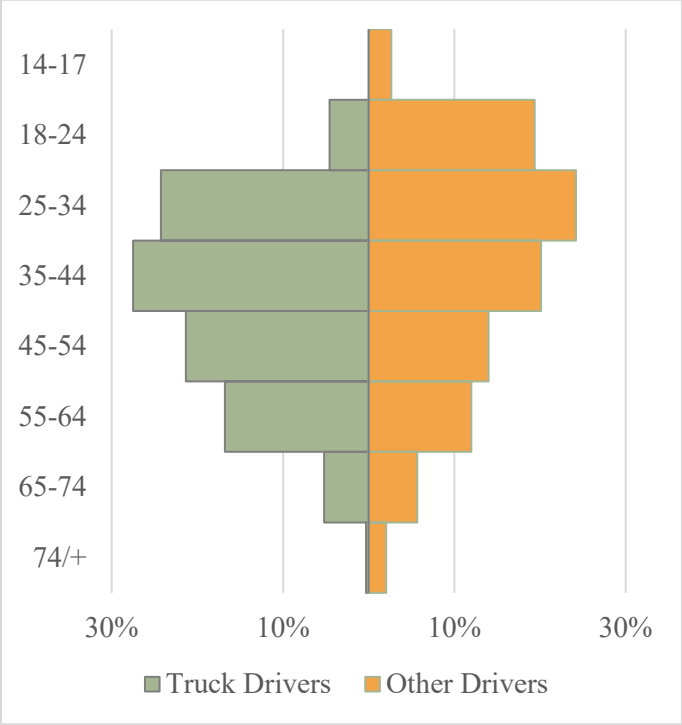


Figure 19. Driver Age Cohorts

Table 9. Driver Age Groups, Truck, and All Drivers

	Truck Drivers		All Vehicle Driver	
Age	**Count**	**Percent**	**Count**	**Percent**
14–17			75	2.5%
18–24	28	4.3%	549	18.5%
25–34	149	22.7%	686	23.1%
35–44	169	25.8%	570	19.2%
45–54	131	20.0%	397	13.4%
55–64	103	15.7%	339	11.4%
65–74	32	4.9%	160	5.4%
74/+	2	0.3%	58	2.0%
Missing	42	6.4%	131	4.4%
Total	656	100%	2,965	100%

Yearly data on the age of drivers involved in truck-related crashes show that compared with 2019, the number of drivers aged 25–34 increased by 152% in 2023, followed by drivers aged 34–44 (150% increase) (Table 10). As mentioned in Table 5, the total number of truck crashes also increased by 80% in 2023 compared with 2019. Also note that drives aged 18–24 were also overrepresented, although the count was fewer than 30 and therefore insufficient to draw a statistical conclusion.

Table 10. Driver Age by Crash Year

	Truck Drivers						All Vehicle Driver					
Age	**Crash Year**						**Crash Year**					
	2019	**2020**	**2021**	**2022**	**2023**	**Total**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
14-17							15	9	19	18	14	75
18-24	3	2	4	7	12	28	139	75	69	139	127	549
25-34	21	15	13	47	53	149	155	89	82	188	172	686
35-44	24	9	24	52	60	169	117	58	69	165	161	570
45-54	26	13	16	37	39	131	100	37	46	112	102	397
55-64	26	12	11	29	25	103	101	39	40	84	75	339
65-74	3	7	7	10	5	32	30	25	25	46	34	160
74/+	0	0	0	0	2	2	13	7	4	16	18	58
missing	10	2	7	15	8	42	34	17	19	34	27	131
Total	113	60	82	197	204	656	704	356	373	802	730	2,965

As mentioned in the description of Table 4, out-of-state drivers who were not from neighboring states accounted for 50.6% of total drivers in truck-related crashes; this group was especially overrepresented in ages 25–34 (63.7%), 35-44 (59.7%) and 18–24 (53.6%). For ND drivers, truck drivers aged 45–54 were a high-risk group (Table 11).

Table 11. Driver State by Age

Driver State	Age									
	14-17	18-24	25-34	35-44	45-54	55-64	65-74	74/+	missing	Total
Truck Drivers										
ND		5	20	33	39	23	12	1	0	133
Neighboring State		8	34	35	35	24	12	1	0	149
Other		15	95	101	57	56	8	0	0	332
Missing		0	0	0	0	0	0	0	42	42
Total		28	149	169	131	103	32	2	42	656
All Vehicle Drivers										
ND	64	361	423	310	228	191	108	46	0	1,731
Neighboring State	11	124	111	106	75	68	34	11	0	540
Other	0	64	152	154	94	80	18	1	0	563
Missing	0	0	0	0	0	0	0	0	131	131
Total	75	549	686	570	397	339	160	58	131	2,965

Truck driver license class by driver state shows 81% of drivers held Class A licenses. About 3% of drivers held Class D licenses, of which 42% were out-of-state drivers who were not from neighboring states (Table 12).

Table 12. Truck Driver License Class by Driver State

Driver License Class	Truck Driver State				
	ND	Neighboring State	Other	Missing	Total
A	103	129	277	0	509
AM	15	3	5	0	23
B	6	0	2	0	8
C	0	0	4	0	4
D	8	3	8	0	19
DM	1	0	0	0	1
Other	0	14	36	42	92
Total	133	149	332	42	656

Driver licensure state in relation to crash severity showed that 83.1% of drivers were not injured (Table 13). Out-of-state drivers not from a neighboring state had a higher percentage of serious injuries. However, the count was fewer than 30 observations, so it is insufficient for confidential statistical inference.

Table 13. Truck Driver State by Crash Severity.

Truck Driver State	Injury Severity					
	No Apparent Injury	Fatal	Serious	Minor	Possible	Total
ND	102	1	2	14	14	133
Neighboring State	127	1	4	11	6	149
Other	283	2	11	18	18	332
Missing	33	1	3	3	2	42
Total	545	5	20	46	40	656

5. WINTER STORM CRASH CASE STUDIES

Most North Dakota residents are acutely aware that winter driving can quickly change drastically. Understanding the relative severity of a state's winter weather helps elevate crash risk more broadly. The climate maps (Figures 1–4) present specific features that might impact driving conditions. The Accumulated Winter Season Severity Index (AWSSI) is a cumulative metric that objectively quantifies the relative severity of a winter season (Figure 20). A scientifically validated approach includes daily observations of minimum/maximum temperature, snowfall, and snowfall depth in daily observations. State winter road maintenance spending and AWSSI are summarized for a five-year average and a relatively severe winter in 2022–23 (Figure 21).

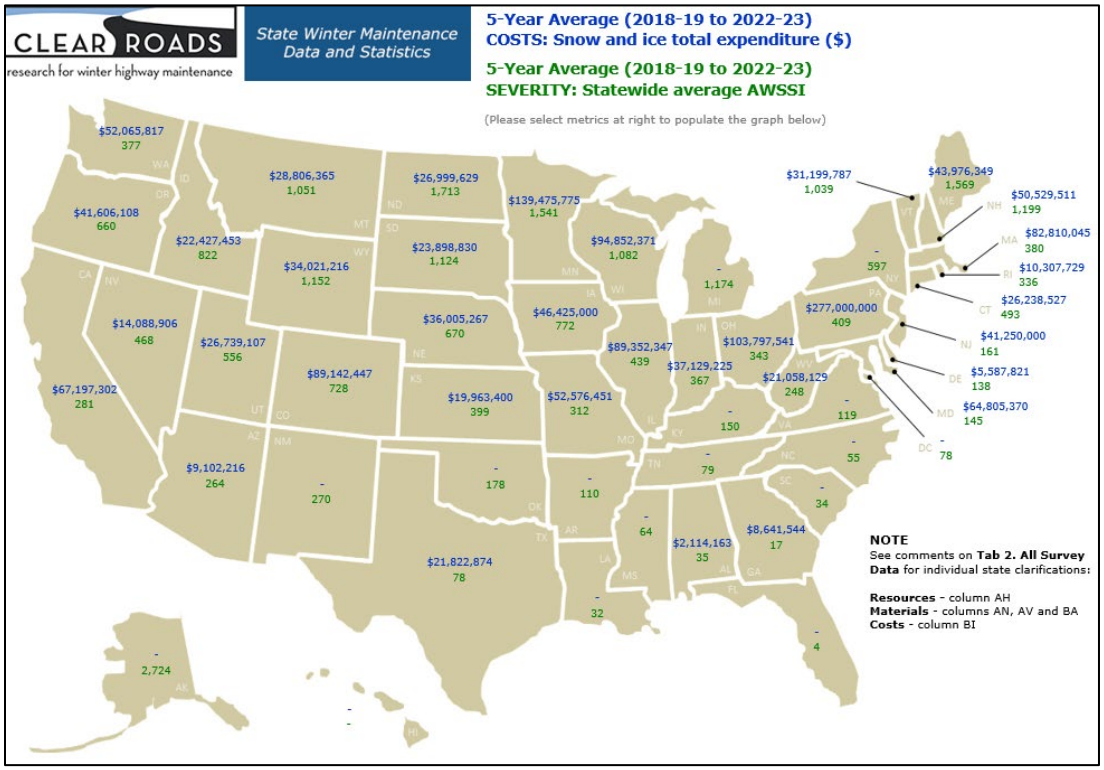


Figure 20. Winter Severity Metrics, Five-year Average

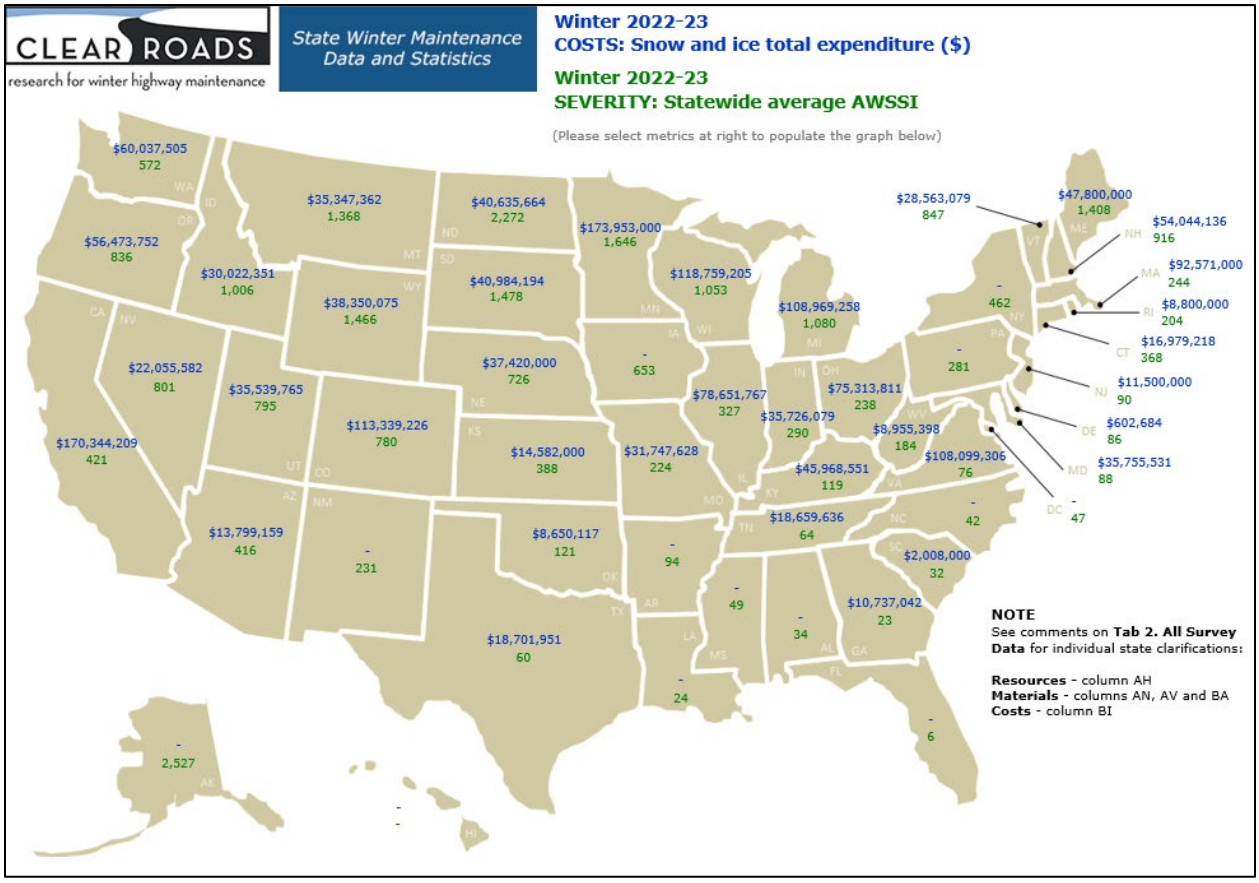


Figure 21. Winter Severity Metric, 2022-23

5.1 Case Study Data

Local experts, including the ND Highway Patrol (NDHP) and NDDOT, were also queried about notable winter storm events. Based on these discussions, the case study crash was to be selected from the past three years. Law enforcement reported crashes were collected from the state for the three most recent years. Related climate, driver, and traffic data were also collected from the state, National Weather Service (NWS), and other sources as attributed. The crashes that occurred along the I-94 corridor during the winter study months between 2021 and 2023 were mapped by severity to understand dispersion in Figure 22.

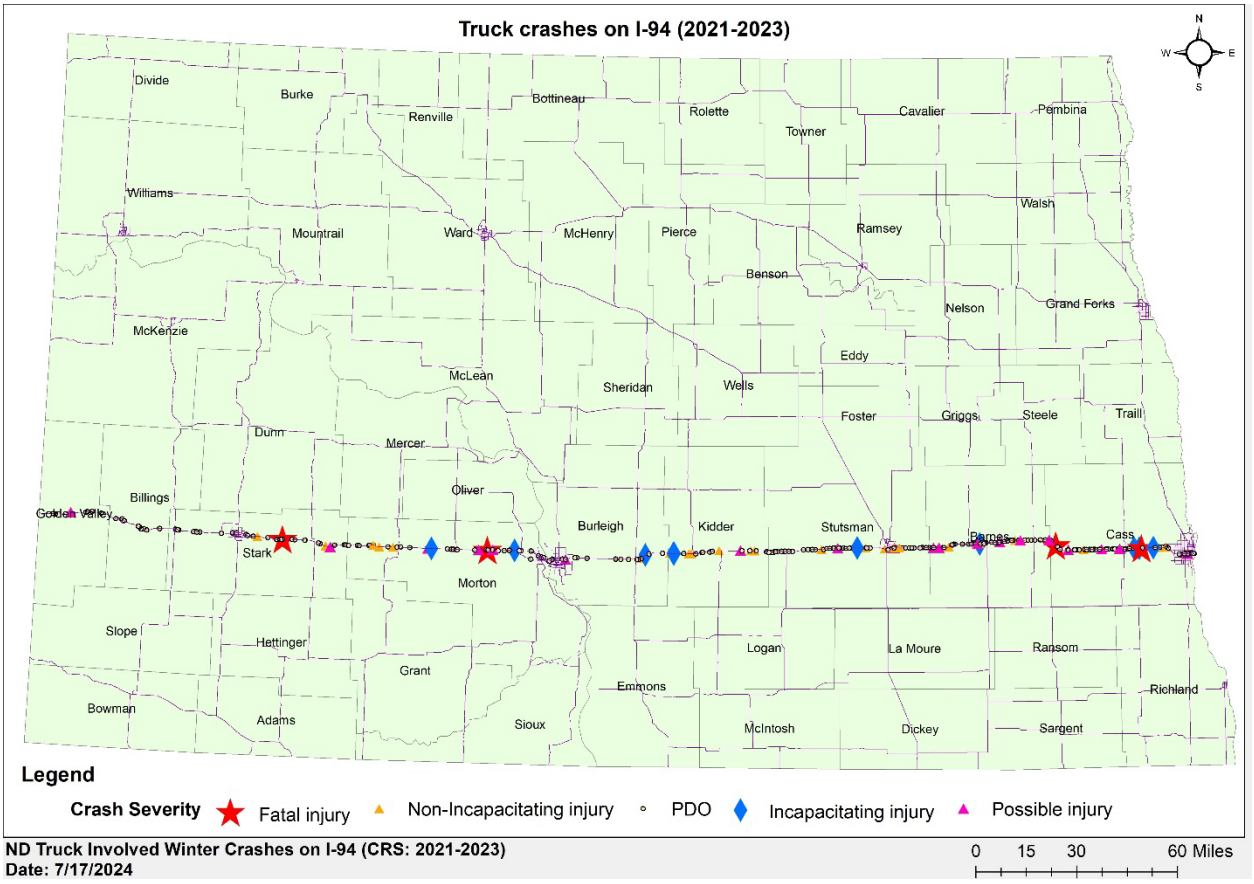


Figure 22. I-94 Winter Crash Map, 2021-2023

5.2 Storm Event Case Analysis

Eighteen Crashes During March 15–17, 2023, Statewide Storm

This section examines 18 crashes on I-94 in North Dakota during severe winter conditions on March 15–17, 2023, ahead of a statewide road closure of I-94 for more than 15 hours on March 17, 2023. All crashes are weather-related. Sixteen crashes occurred on ice- or frost-covered roadway surface, and one occurred on a snowy surface. In terms of weather conditions, there were nine crashes solely during blowing snow, two crashes occurred during both snowfall and blowing snow, one crash happened amid

blowing snow and severe crosswinds, two crashes took place in severe crosswinds alone, and two crashes occurred in clear weather conditions but on icy or frosted roads.

Weather

According to the NWS, two events in mid-March 2023 were considered unusual weather phenomena (NWS). During the night of March 10, surface low pressure moved from near the Montana and Wyoming border into North Dakota. As the low approached, snow began to fall, and blizzard conditions developed over northwest and much of central North Dakota due to increasing southeasterly winds, which combined with the falling snow and existing deep loose snow on the ground. The strong winds behind the cold front brought blizzard conditions to the southwest and far south-central North Dakota, while blizzard conditions persisted in other areas. Prior to the onset of the blizzard, light snow and blowing snow over northwest North Dakota caused icy roads. As a result, Dickinson and New Salem had more than 1 inch of snow on the 10th and more than 6 inches on the 11th. New Salem had 1.2 inches of snow on the 12th as well. Bismarck had 2.9 inches of snow on the 10th and 2.7 inches on the 11th. Jamestown had 1.5 inches of snow on the 10th, 3 inches on the 11th, and 4 inches on the 12th. Fargo had 3.5 inches of snow on the 11th and 0.4 inches on the 12th. Streeter had 2.5 inches of snow on the 10th and 6 inches on the 13th. Temperatures were 5°F to 25°F, below average temperatures over March 10–17 statewide.

On March 17, deep low pressure over the Great Lakes and high pressure over Montana brought gusty northwest winds of around 40 mph to much of North Dakota. The falling snow was light, often just flurries, which caused only minor visibility reductions. However, the primary impacts were blowing snow and significant drifting due to the area's existing deep and loose snowpack. Road surface temperatures rose above freezing during the daytime in many locations, causing drifting snow to stick to the roads and re-freeze, leading to numerous vehicle accidents.

Three Severe Crashes

The first severe crash was a fatal collision that involved two trucks. It occurred 2.5 miles west from exit 338 to Mapleton on March 15, 2023, at 1:50 pm. A 52-year-old male driver from Ontario was driving a truck tractor pulling a trailer (Truck A) carrying hazardous materials weighing more than 26,000 lbs. GCWR (gross combination weight rating) was traveling westbound on I-94. A 72-year-old male truck driver from British Columbia was pulling a semi-trailer weighing more than 26,000 lbs. GCWR was traveling in the same direction. Truck A driver operated the truck in an inattentive, careless, negligent, or erratic manner and caused a rear-to-back crash. Truck B driver tried to avoid a truck crash by steering left. After the crash, Truck B was on fire and exploded and its driver was fatally injured, but Truck A driver was not injured. Both trucks suffered disabling damage. Truck A driver had a violation that was not documented in detail. "Motor vehicle in transport" was identified as the first and the most harmful event. Both drivers were wearing shoulder and lap seatbelts. This crash happened during daylight hours, and the road was dry and the sky was clear. Although this crash does not seem directly related to winter weather conditions, winter-related factors not documented in the crash report, such as low visibility, may still have had a role in this crash. (Can be removed if not too related)

The second severe crash happened at 11:18 p.m. on March 15, 2023, six miles west from exit 200 to Steele. This was a two-vehicle angle crash involving a truck and a sport utility vehicle (SUV), with both drivers seriously injured. Both vehicles were traveling eastbound on I-94 on an uphill. The environmental conditions were dark, no lighting, with blowing snow, and the road surface was icy/frosty. The truck

driver was a 24-year-old male from Florida. Possibly due to extremely low driving visibility caused by darkness and blowing snow, he stopped his truck, which weighed more than 26,000 lbs. GCWR. The pickup driver was a 31-year-old ND male traveling in the same direction on I-94 behind the truck in an inattentive, careless, negligent, or erratic manner before the crash. The pickup driver was driving too fast for conditions and was trying to brake to avoid a crash. The initial crash point on the truck was clock point 7 direction, and the initial crash point on the pickup was clock point 12 direction. The pickup driver was cited as "Care required." "Motor vehicle in transport" was identified as the first and most harmful event. Both vehicles suffered disabling damage. Both drivers were wearing shoulder and lap seatbelts.

The third severe crash happened seven miles west of exit 257 to Jamestown on I-94 heading eastbound at 2:28 p.m. on March 17, 2023. This was a two-vehicle crash involving a truck and a pickup, with the pickup driver seriously injured. The environmental conditions were daylight with blowing snow, and the road surface was icy/frosty. A 41-year-old male driver from Florida was driving a truck tractor pulling a semi-trailer weighing more than 26,000 lbs. GCWR was traveling eastbound on the right lane of I-94. The pickup driver, a 51-year-old ND male was traveling in the same direction on I-94 in the left lane. Possibly due to poor driving visibility caused by blowing snow, the truck driver failed to keep the truck in his lane while the pickup driver was trying to pass the truck when the crash occurred. The initial crash point on the truck was the left back half, and the initial crash point on the pickup was the right. The pickup driver was taking evasive action by steering to the left. The truck driver had a violation of "care required" and cited as driving "too fast for conditions." The sequence of crash events was (1) motor vehicle in transport, (2) separation of units, and (3) run off the roadway left. "Motor vehicle in transport" was identified as the first and most harmful event. The truck sustained minor damage, and the pickup suffered disabling damage. The truck driver was not injured but the pickup driver was seriously injured. Both drivers were wearing shoulder and lap seatbelts.

Three Crashes near Glen Ullin

The first crash occurred on I-94, 9.5 miles west of exit 108 to Glen Ullin, at 8:18 p.m. on March 16, 2023. This was a single-vehicle crash involving a truck. The environmental conditions were dark, with no lighting, severe crosswinds, and ice and frost on the road surface. A 28-year-old male driver from Florida was driving a truck tractor pulling a semi-trailer weighing more than 26,000 lbs. GCWR traveling eastbound on I-94. While traveling downhill, the driver swerved to avoid an unexpected condition, possibly due to wind. The vehicle then lost control, ran off the left side of the roadway, overturned, and came to a stop in the median. The driver was taking evasive action by braking and steering to the right. Overturn/rollover was identified as the first and the most harmful event. The initial contact/crash point was located on the truck's right side. The truck sustained minor damage, but the driver was not injured. He was wearing a shoulder and lap seatbelt and had no violations.[4]

The second crash occurred one mile east of exit 108 to Glen Ullin at 1:00 p.m. on March 17, 2023. This was a two-truck crash that happened on the two-way, four-lane section during daylight while there was blowing snow in the air and snow on the road surface. A 28-year-old male driver from California was driving a truck tractor (Truck A) pulling a semi-trailer, traveling westbound on the right lane of I-94. A 39-year-old driver from Washington was also driving a truck tractor (Truck B) pulling a semi-trailer, traveling

[4] Due to limited access to the state crash data, the crash descriptions are based on non-PII crash data received in data row/column format. For detailed crash narratives, please refer to state crash report directly.

the same direction on I-94 on the left lane, behind Truck A. Possibly due to poor driving visibility caused by blowing snow Truck A's driver failed to keep the truck in his lane and crossed the centerline. Truck A got hit by Truck B on the left side. "Motor vehicle in transport" was identified as the first and most harmful event. Truck A driver had a violation of "care required." Truck A sustained minor damage and Truck B suffered functional damage, but neither driver was injured. Both drivers were wearing shoulder and lap seatbelts.

The second crash occurred at 2:00 p.m. on March 17, 2023, one mile from exit 97 to Hebron and 10 miles west from exit 108 to Glen Ullin. This was a single-vehicle crash involving a truck. This crash happened during daylight, but there was blowing snow, severe crosswinds, and ice and frost on the road surface. A 45-year-old female driver from Utah was driving a truck tractor pulling a semi-trailer, traveling westbound on I-94, while her 27-year-old male passenger, also from Utah, rested in the sleeper section of the cab. While traveling downhill, the truck jackknifed and ran off the left side of I-94. There was no record showing the driver's action when the jackknife happened, nor was there any evasive action to avoid the jackknife. Jackknife was identified as the first and most harmful event. The initial contact/crash point was clock point 05, in the direction of the vehicle. The truck sustained minor damage, but the driver and passenger were not injured. The driver was wearing a shoulder and lap seatbelt and had no violations.

Five Crashes Near Medina

The first crash occurred on I-94 near Medina, 2.5 miles west of exit 228 to Medina at 9:50 a.m. on March 17, 2023. This was a single-truck crash. The environmental conditions were daylight, with no lighting, blowing snow, and ice and frost on the road surface. The truck driver was a 35-year-old male from Iowa, driving a single-unit truck weighing 10,000–26,000 lbs. GCWR, and traveling eastbound on I-94. While traveling uphill, the driver oversteered, assuming it was to avoid crashing into another vehicle as the first event in this crash is "motor vehicle in transport." The truck then lost control, ran off the right side of the roadway, and stopped in the ditch. The driver was taking evasive action by braking. His speed was marked as "too fast for conditions." "Ditch" was identified as the first harmful event, and "motor vehicle in transport" was the most harmful event. The initial contact/crash point was located on the left side of the truck. The truck sustained disabling damage, but the driver was not injured. He was wearing a shoulder and lap seatbelt and had no violations.

The second crash occurred on I-94 near Medina, 3.5 miles west of exit 228 to Medina at 11:38 a.m. on March 17, 2023. This single-truck crash happened within a mile of the first crash near Medina at 9:50 a.m. The environmental conditions were daylight, snowing, blowing snow, and ice and frost on the road surface. The truck driver was a 64-year-old male from South Dakota, driving a truck pulling a trailer, traveling eastbound on I-94. The driver operated the truck in an inattentive, careless, negligent, or erratic manner and was noted as driving "too fast for conditions," then the truck jackknifed. The driver was cited for an offense not listed in the crash report. The initial contact/crash point was located on clock point 12 direction. The truck sustained minor damage, but the driver was not injured. He was wearing a shoulder and lap seatbelt.

The third crash occurred near Medina at 12:17 p.m. on March 17, 2023, three miles west of exit 228 to Medina. This was a two-vehicle, front-to-rear crash involving a truck and a passenger. This crash happened within 0.5 miles of the second crash near Medina at 11:38 a.m. Individuals served as traffic control devices to slow the traffic, possibly related to the crash 40 minutes prior. The environmental

conditions were daylight with blowing snow, and the road surface was icy/frosty. A truck was pulling trailers eastbound on the right lane of I-94. The truck driver was a 57-year-old male from Montana. The passenger in the second vehicle was a 25-year-old ND female traveling in the same direction on I-94 following the truck. The crash occurred as the two vehicles traveled on a hill. After traveling uphill, the truck slowed while going downhill as the passenger car still traveled uphill. The passenger car was traveling too fast for the conditions. The passenger car driver tried to avoid the crash by braking hard until the tires locked up. The initial crash point on the truck was clock point 6 direction, and the initial crash point on the passenger car was clock point 1 direction. "Motor Vehicle in Transport" was identified as the first and most harmful event. The truck sustained no damage and the passenger car suffered functional damage. Neither driver was injured. Both drivers were wearing shoulder and lap seatbelts. No citation was issued for this crash.

The fourth crash occurred four miles east from exit 228 to Medina on I-94 at 2:28 p.m. on March 17, 2023. This was a single-vehicle crash involving a truck. The environmental conditions were daylight with snow, blowing snow in the air, and ice/frost on the road surface. A 28-year-old male driver from California was driving a truck tractor pulling a trailer, traveling eastbound on I-94. The truck jackknifed and caused minor damage to the truck, but the driver was not injured. The driver was driving too fast for the conditions and trying to avoid a crash by braking. Jackknife was identified as the first and most harmful event. The driver was wearing a shoulder and lap seatbelt and was cited for "care required."

The fifth crash occurred three miles east from exit 228 to Medina on I-94 at 3:00 p.m. on March 17, 2023. This was a single-vehicle crash involving a truck. This crash happened within one mile of the crash near Medina at 2:28 pm. The environmental conditions were daylight with snow blowing in the air and ice/frost on the road surface. A 40-year-old male driver from Colorado was driving a truck tractor pulling a semi-trailer, traveling eastbound on I-94. When traveling downhill, the driver drove too fast for the conditions, then failed to keep the truck in his lane, and the truck ran off the roadway to the left. As driver swerved to avoid this, the truck jackknifed. The truck was functionally damaged, but the driver was not injured. Jackknife was identified as the first and most harmful event. The initial contact/crash point was at clock point 12 in the direction of the truck. The driver was wearing a shoulder and lap seatbelt and had no violation.

Crash near Tappen

The first crash occurred five miles west from exit 228 to Medina and nine miles east from exit 214 to Tappen on I-94 at 1:27 p.m. on March 17, 2023. Although this crash was closer to Medina, it was in Kidder County. This was a single-vehicle crash involving a truck. The environmental conditions were daylight with snow blowing in the air and ice/frost on the road surface. A 28-year-old male driver from Florida was driving a truck pulling a trailer, traveling eastbound on I-94. The driver failed to keep the truck in his lane while driving too fast for conditions. The truck jackknifed and caused functional damage to the truck, but the driver was not injured. The passenger car driver was trying to avoid a crash by steering left. Jackknife was identified as the first and most harmful event. The initial contact/crash point was at clock point 7 in the direction of the truck. The driver was wearing a shoulder and lap seatbelt and was cited for "care required."

The second crash near Tappen occurred five miles east of exit 214 to Tappen on I-94 at 3:07 p.m. on March 17, 2023. This was a single-vehicle crash involving a truck. The environmental conditions were daylight, with snow blowing in the air and ice/frost on the road surface. A 34-year-old male driver from

Illinois was driving a tractor pulling a semi-trailer traveling westbound on I-94. The driver failed to keep the truck in his lane while driving too fast for conditions. The truck jackknifed and caused functional damage to the truck, but the driver was not injured. Jackknife was identified as the first and most harmful event. The initial contact/crash point was at clock point 7 direction of the truck. The driver was wearing a shoulder and lap seatbelt and was cited for "care required."

Four Crashes near Jamestown

The first crash happened at 11:33 a.m. on March 16, 2023, five miles west of exit 257 to Jamestown. This was a two-truck crash that happened on the two-way, four-lane section. This crash happened during daylight, with ice and frost on the road surface. A 50-year-old male driver from Pennsylvania was driving a truck pulling a trailer (Truck A), traveling eastbound on I-94, with his 56-year-old female passenger from ND in the passenger seat. Another 50-year-old ND driver was also driving a single-unit truck (Truck B) traveling in the same direction on I-94. After Truck A driver failed to keep the truck in his lane, the crash occurred. Truck A had functional damage with an initial contact/crash point on the left back half of the vehicle. Truck B had minor damage with initial contact on the right back half of the vehicle. Truck A driver received a violation of "careless driving." "Motor vehicle in transport" was identified as the first and most harmful event. Luckily, both drivers were not injured. Both drivers were wearing shoulder and lap seatbelts.

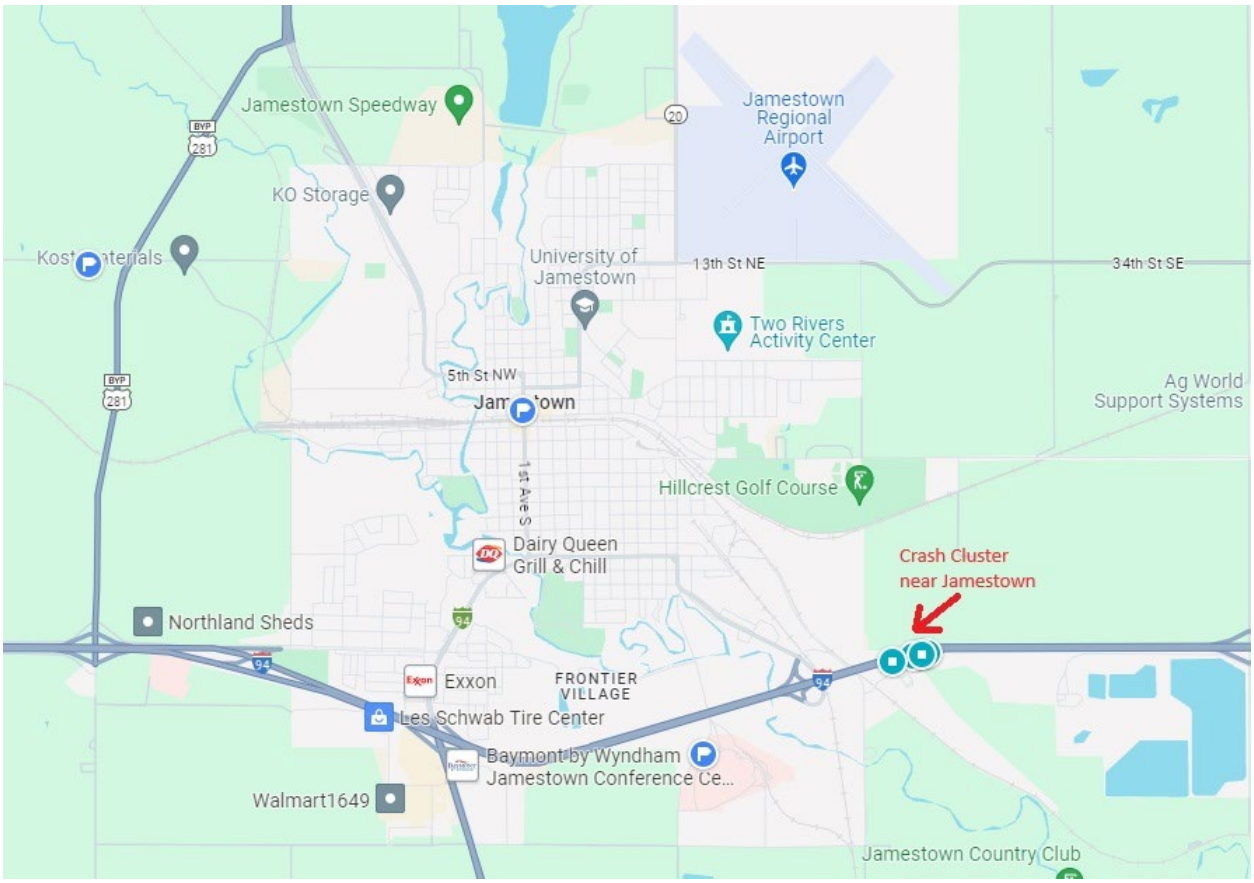


Figure 23. I-94 Case Study Crash Map, Near Jamestown 2022

The second crash occurred 11 miles east from exit 260 to Jamestown on I-94 at 9:54 a.m. on March 17, 2023. This was a single-vehicle crash involving a truck. The environmental conditions were daylight, with snow blowing in the air and ice/frost on the road surface. A 42-year-old ND male was driving a truck tractor pulling two trailers weighing more than 26,000 lbs. GCWR, traveling eastbound on I-94. The truck jackknifed and caused disabling damage to the truck, but the driver was not injured. Jackknife was identified as the first and most harmful event. The initial contact/crash point was at the left back half of the truck. There was no record showing the driver's action when the jackknife happened or any evasive action taken to avoid the jackknife. The driver was wearing a shoulder and lap seatbelt and had no violations.

The third crash occurred near Jamestown at 10:00 a.m. on March 17, 2023, 10 miles east of exit 260 in Jamestown. This crash location was only 0.8 miles from the 9:54 a.m. crash location. This was a two-vehicle crash involving a truck and an SUV. The environmental conditions were daylight with blowing snow, and the road surface was icy/frosty. A truck tractor pulling a semi-trailer weighing more than 26,000 lbs. GCWR was parked on the roadside toward eastbound on the right lane of I-94. The driver was a 62-year-old male from Montana. The SUV driver was a 31-year-old ND male, who was traveling in the same direction on I-94 trying to pass the parked truck when the crash happened. The initial crash point on the truck was clock point 6 direction, and the initial crash point on the SUV was in the right front half. "Parked motor vehicle" was identified as the first and most harmful event. The truck sustained no damage, and the pickup suffered functional damage. Neither driver was injured. Both drivers were wearing shoulder and lap seatbelts, and no citations were issued for this crash.

The fourth crash occurred on I-94, four miles east of exit 260 to Jamestown, at 12:40 p.m. on March 17, 2023. This was a single-vehicle crash involving a truck. The crash occurred during daylight when there were severe crosswinds and the road surface was icy/frosty. A 33-year-old male driver from Iowa was driving a truck tractor pulling a semi-trailer, traveling westbound on I-94. After the driver took a contributing action not recorded in detail, the truck ran off to the right side of the roadway, jackknifed, and stopped in the ditch. "Ditch" was identified as the first and most harmful event. The initial contact/crash point was at clock point 11 direction of the truck. It was unknown whether the driver took evasive action to avoid the crash, but the driver was issued a citation for an offense not recorded in the crash record. The truck had minor damage and the driver was not injured. It was unknown whether the driver was wearing a seatbelt.

Crash near Valley City

This crash occurred four miles west of exit 290 to Valley City on I-94 at 11:25 a.m. on March 17, 2023. This was a single-vehicle crash involving a truck. The environmental conditions were daylight and ice/frost on the road surface. A 55-year-old ND male was driving a truck weighing over 10,000 lbs. GCWR, traveling westbound on I-94. When traveling uphill, the driver was going too fast for the conditions and took a contributing action that was not recorded in detail; the truck then lost control. It ran off the roadway to the right and rolled over. The driver was trying to avoid a crash by braking. Overturn/rollover was identified as the first and most harmful event. The initial contact/crash point was at clock point 11 direction of the truck. The truck was functionally damaged, but the driver was not injured. The driver was wearing a shoulder and lap seatbelt and was cited for "care required."

Level of Service Recovery Time After Reopen

The trucks' average hourly speeds were used to estimate the level of service (LOS) recovery time after reopening. After a data quality control process, data collected from three stations were used in this study: (1) WIM station 1, located 7 miles west of Belfield toward eastbound I-94; (2) WIM station 14, located 3.5 miles east of Bismarck toward eastbound I-94; and (3) WIM station 15, located 8 miles east of Bismarck toward westbound I-94. Unfortunately, no data were collected from the Fargo location during sample time. Therefore, data extracted from Station 1 and Station 15 were used to estimate the LOS recovery time of I-94 after the Dickinson to Bismarck sections reopened, and data from Station 14 and Station 15 were used for the Bismarck to Fargo section estimation from the Bismarck side.

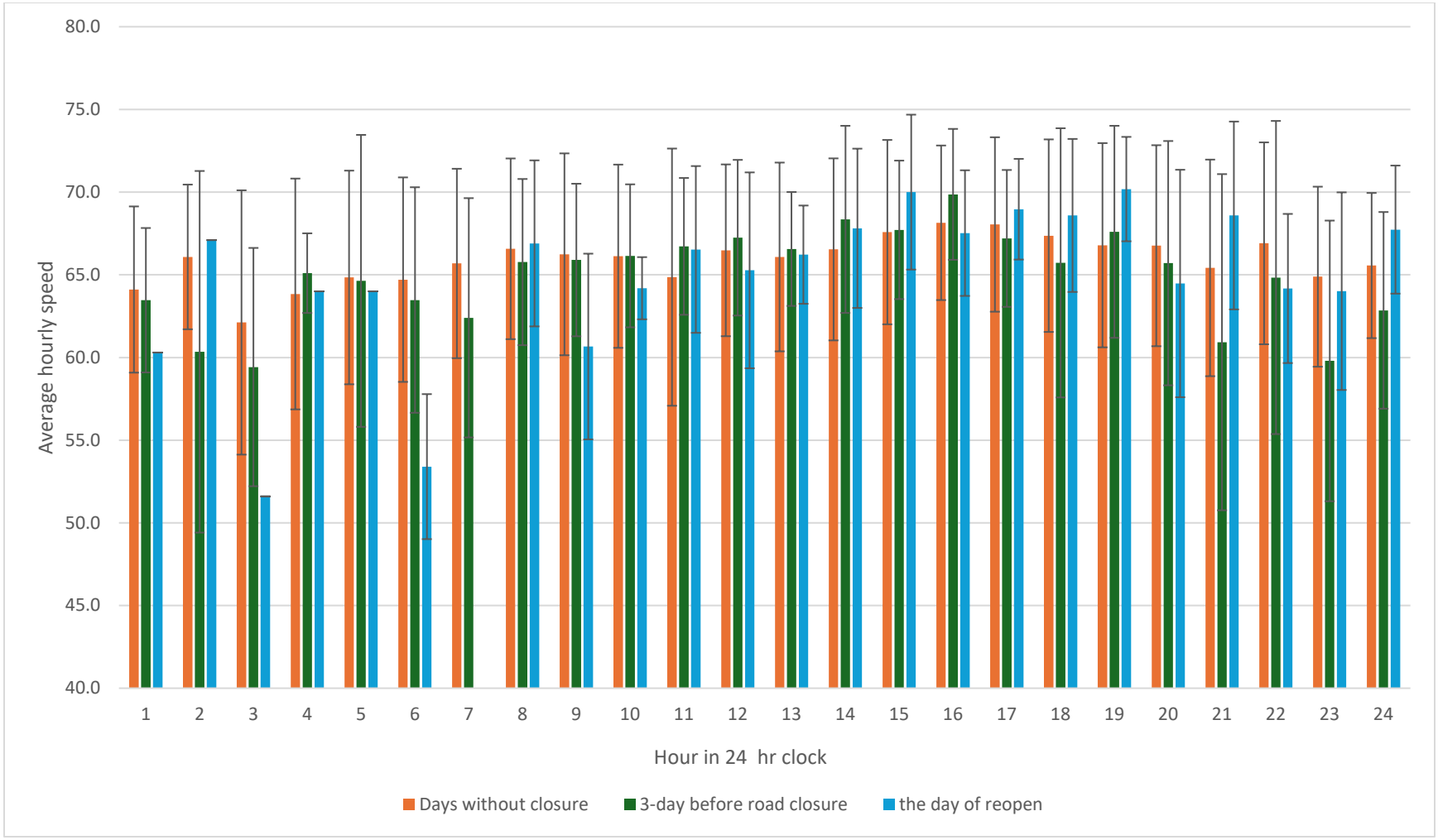


Figure 24. WIM Station 1 Average Hourly Speed for Truck with Standard Deviations

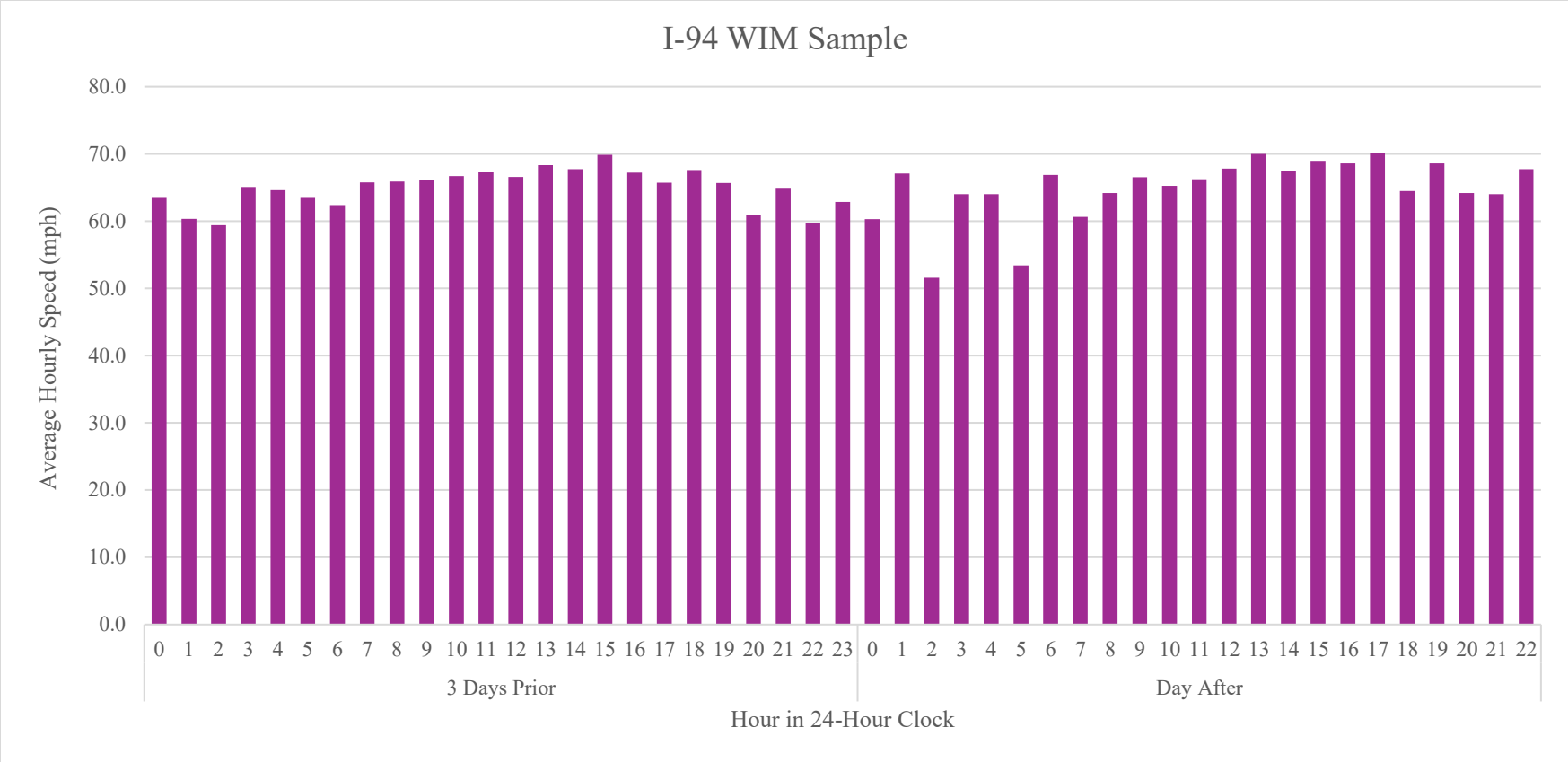


Figure 25. WIM Station 1 Average Hourly Speed for Trucks

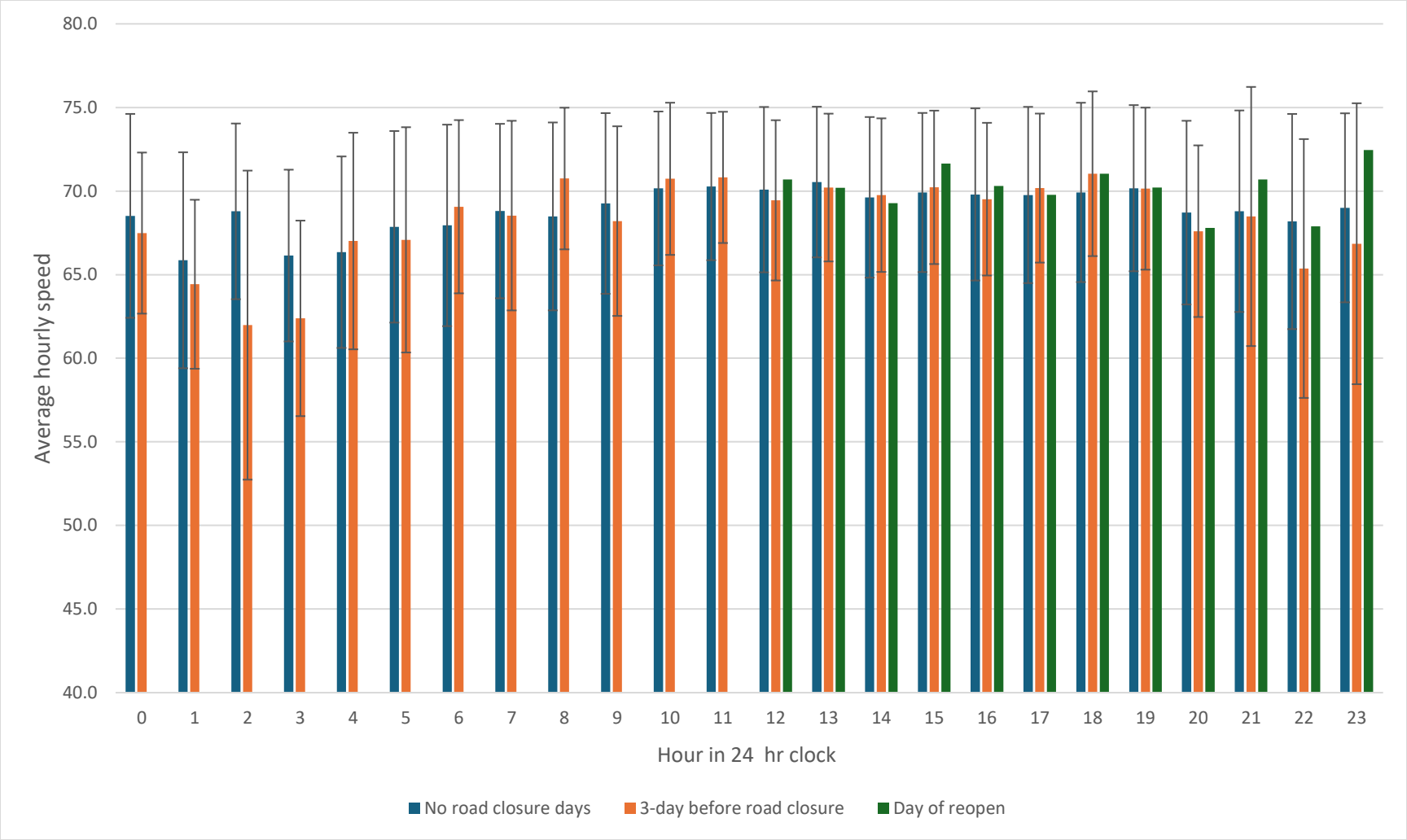


Figure 26. WIM Station 14 Average Hourly Speed for Truck with Standard Deviations

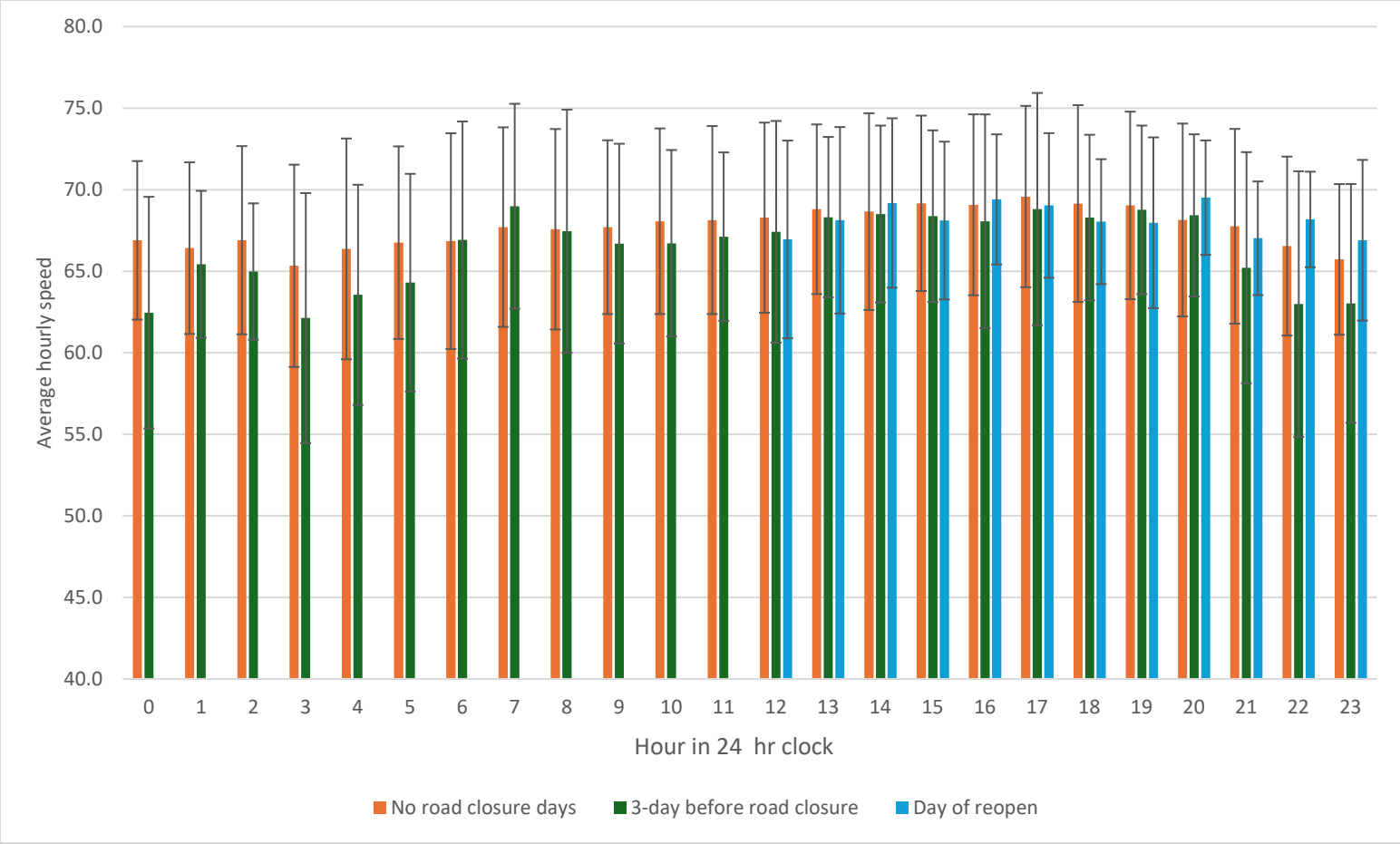


Figure 27. WIM Station 15 Average Hourly Speed for Truck with Standard Deviations

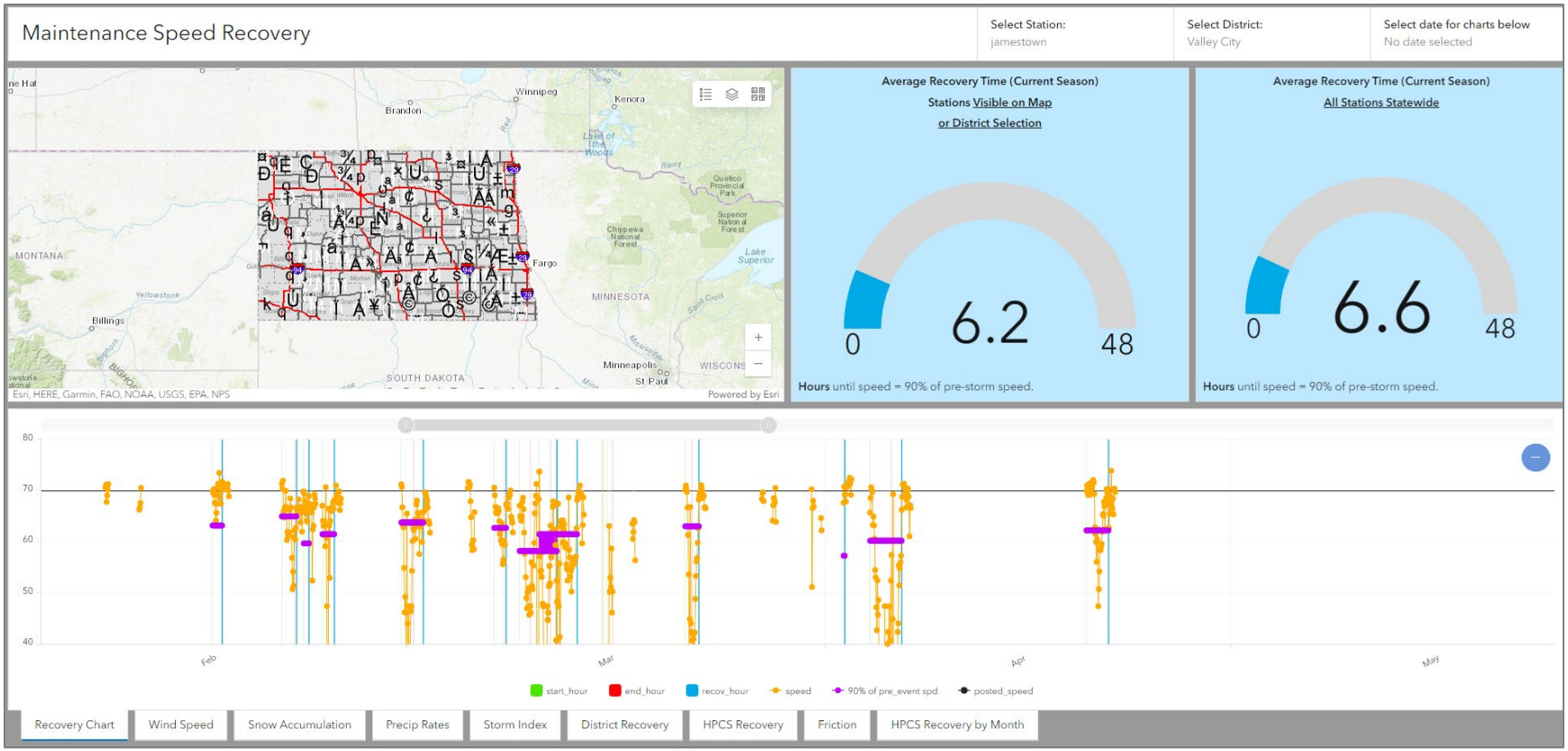


Figure 28. Recovery Time Sample from Road Maintenance Speed Recovery, NDSU-UGPTI DOTSC

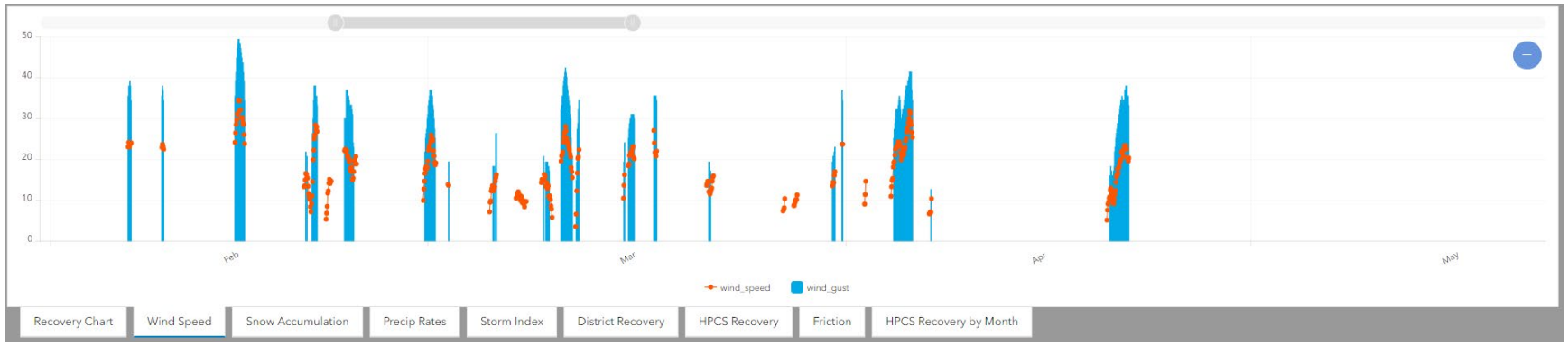


Figure 29. Wind Speed Sample from Road Maintenance Speed Recovery Valley City District, NDSU-UGPTI DOTSC

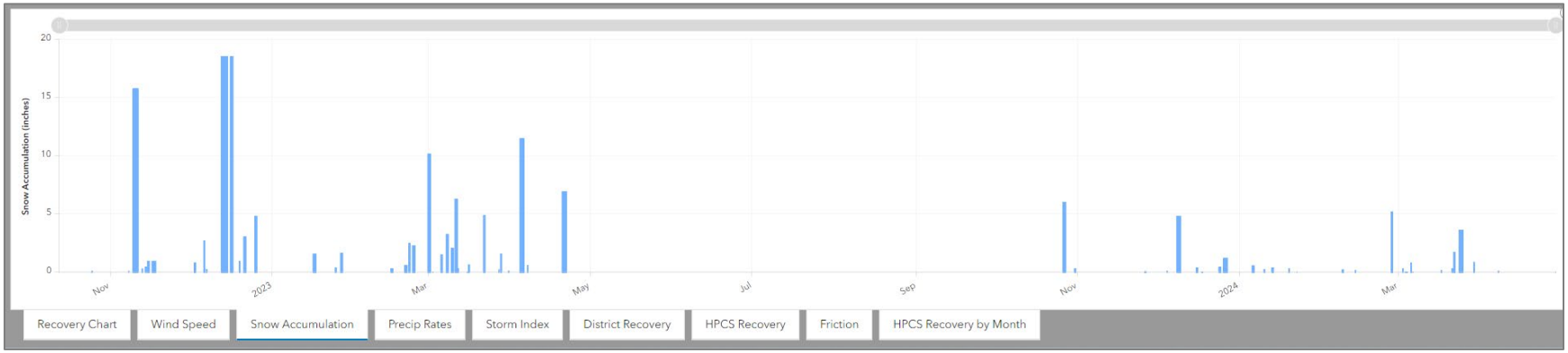


Figure 30. Snow Accumulation Sample from Road Maintenance Speed Recovery Valley City District, NDSU-UGPTI DOTSC

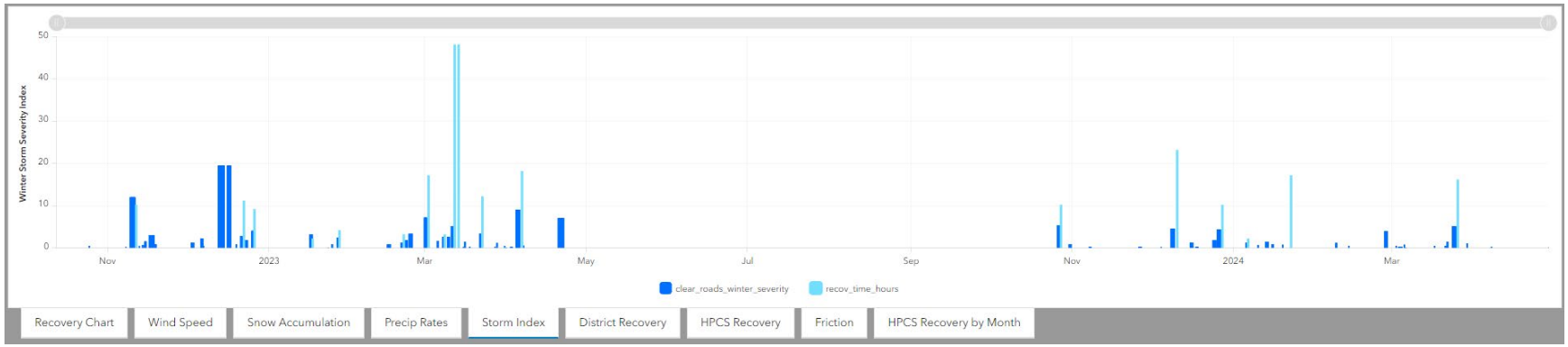


Figure 31. Storm Index Sample from Road Maintenance Speed Recovery Valley City District, NDSU-UGPTI DOTSC

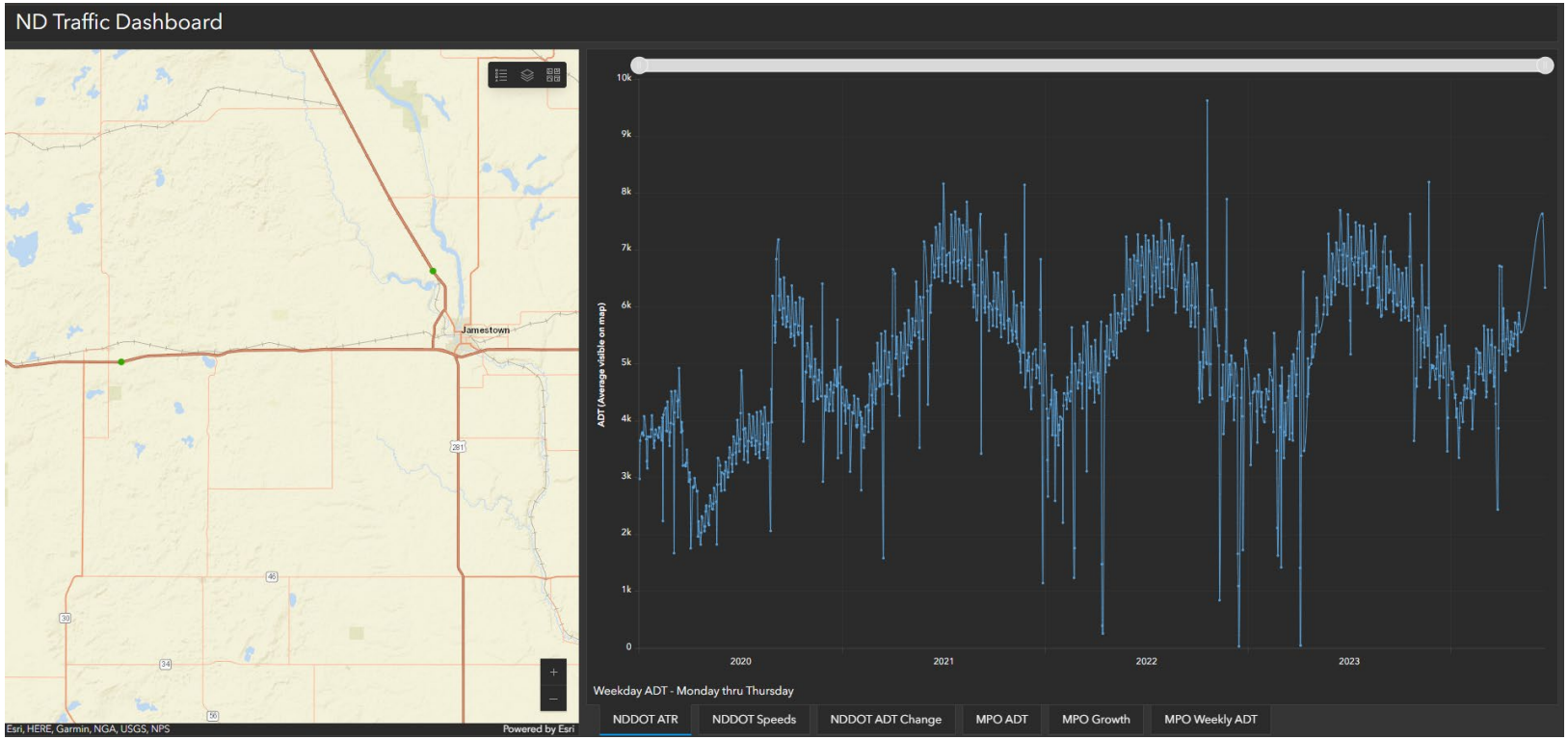


Figure 32. ATR Traffic Station Daily Vehicle Counts Jamestown Area Sample from ND Traffic Dashboard, NDSU-UGPTI DOTSC

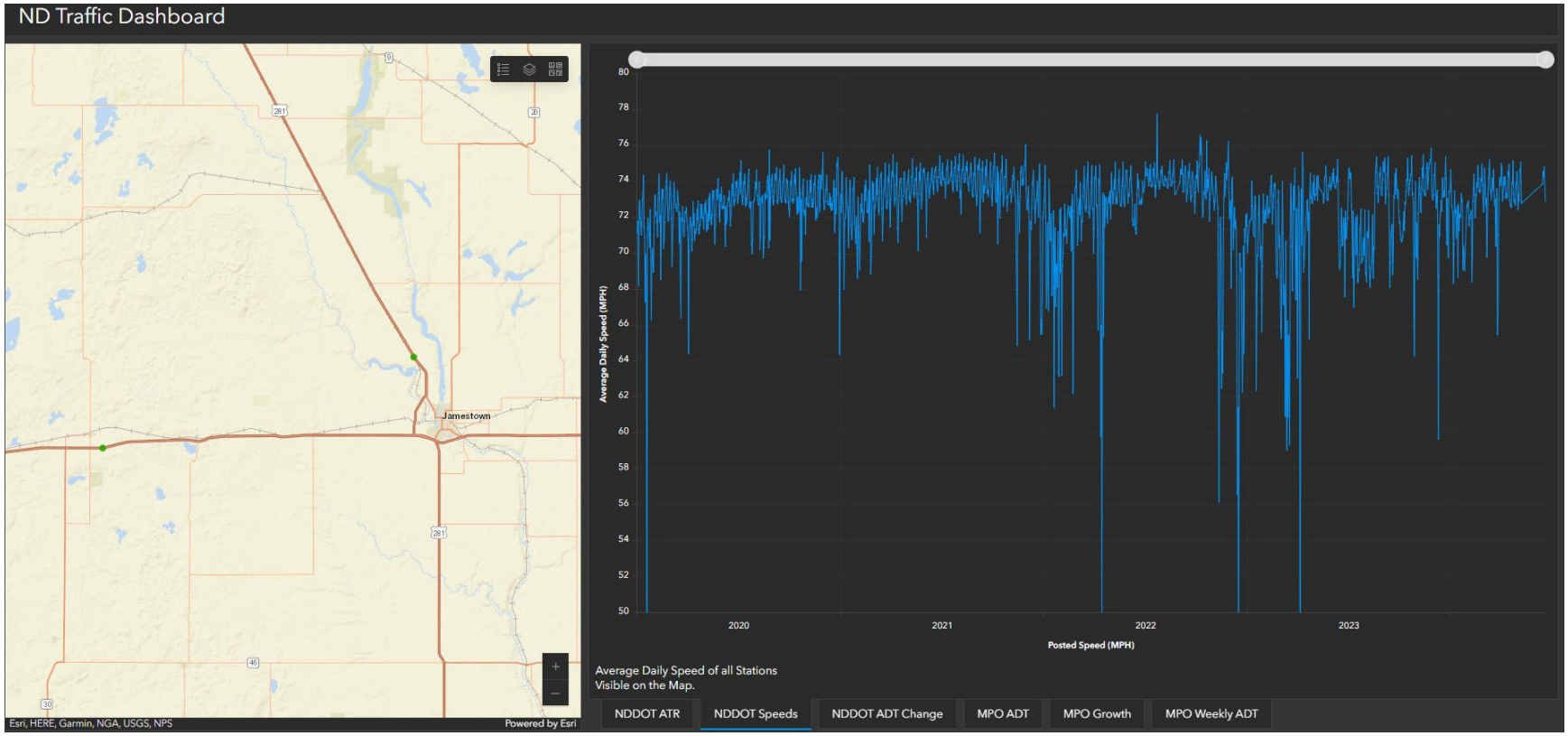


Figure 33. ATR Traffic Station Daily Vehicle Speeds Jamestown Area Sample from ND Traffic Dashboard, NDSU-UGPTI DOTSC

Crash Cluster Near Jamestown November 2022

On November 9, 2022, seven crashes occurred between 6:23 and 6:35 p.m. in Jamestown, 0.5 miles from Exit 260. Among those crashes, the farthest two were only 0.2 miles apart, creating a crash cluster in Jamestown, which blocked traffic and caused a road closure for three hours and 20 minutes on I-94 between Jamestown and Valley City. In these seven crashes, 19 vehicles were involved, including an NDHP vehicle, 12 trucks, four SUVs, one pickup, and one passenger car. It was dark, with no lighting, freezing rain/drizzle, and the road surface was icy. The NDHP trooper observed a truck jackknife at this location, partially blocking the roadway. The trooper parked at the scene of the crash with the emergency lights activated on the patrol vehicle. Shortly after stopping, the patrol vehicle was struck by a passenger car. The trooper was not inside the vehicle at the time and had to jump into the median to avoid being hit. Fortunately, the trooper was not injured in the crash. After that, seven drivers parked their vehicles on the roadside. However, nine drivers were driving too fast for the conditions and hit the parked vehicles. All crashes were identified as winter-weather-related crashes. A fine mist was falling at the time, which caused the roadway to ice up prior to the crashes. As a result, 14 vehicles, including the NDHP vehicle, had disabling damage (Figure 34), and, thankfully, four drivers suffered only minor injuries.

Figure 34. NDHP Patrol Car that was Struck, 2022

Severe winter weather contributed to this winter-weather-related crash and affected I-94's overall level of service. According to data collected by sensors of ND Maintenance Speed Recovery Dashboard, developed by NDSU-UGPTI for NDDOT, the freeze rain/snow was identified as a winter storm in the Jamestown area, which started around 7:00 a.m. on November 9 and ended around 4:00 a.m. on November 11. As a result of this winter storm, I-94 was closed from Bismarck to Jamestown from November 10 at 3 p.m. until November 11 at 9 a.m. According to the dashboard, at 2 p.m., the average speed recovered back to pre-storm speed, so the traffic took about five hours to recover to pre-storm speed after the road reopened.

6. STATE AGENCIES' TRUCK-RELATED WINTER STORM SAFETY POLICY AND DECISION PROCESS

6.1 North Dakota Winter Storm Safety Decision-Making

Winter storm events were described as fluid with pre-planning well ahead of a predicted event. The NDHP and NDDOT are the lead agencies for winter storm planning and decisions, with any ultimate road closure decisions assigned to the NDHP for management and execution with troopers making the gate closures (Figure 35). While ongoing conversations occur with a consulting climatologist and continuous monitoring of climate conditions, including factors such as snowfall rate and wind velocity, the best information comes from troopers and maintenance operators in the field. The decision to close a road is not taken lightly. Recently, the NDHP has moved to a road closure sequence to notify the traveling public in advance so they can safely exit the corridor to locations that can accommodate spikes in public and truck traffic. Almost as soon as a road closure is made, planning begins to effectively reopen the roadway with periodic updates to travelers about dynamic storm and road conditions. A significant factor in the responsiveness of reopening corridors is the ability to focus on road clearing and travel surface friction. These activities can suffer substantial impediments if lane blockage or other abandoned vehicle tow activities draw on initial resources and winter travel recovery time.

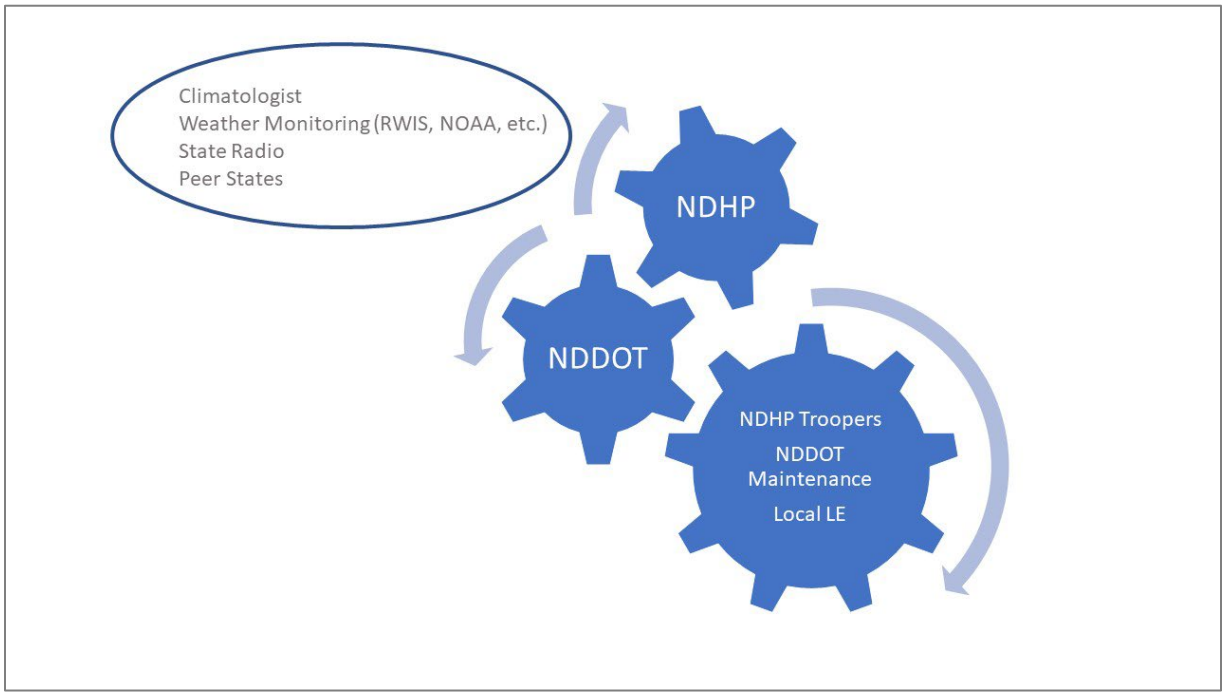


Figure 35. Winter Storm Safe Mobility Decisions

6.2 Peer State Profiles and Interviews

6.2.1 Peer State Profiles

Information was gathered to present brief profiles of the region's peer states. This group of six peer states contrasts the United States overall regarding North Dakota's crash, climate, and traffic features. Traffic and weather information shows the prominence of rural road fatalities and climate extremities (Table 14). The prevalence of rural road traffic and fatalities is evident compared with the United States overall. The combination of crash locations is prominently beyond the more service-dense urban post-crash response area, and the extreme climates highlight safe mobility challenges in traffic features.

Table 14. Peer State Profiles Related to Truck Winter Traffic

TRAFFIC SAFETY PERFORMANCE (CORE OUTCOME) MEASURES IN 2021									
CORE OUTCOME MEASURES		IA	MN	MT	NE	ND	SD	WY	USA
Traffic Fatalities	Total	356	488	239	221	101	148	110	42,939
	Rural	247 (69%)	262 (54%)	181 (76%)	164 (74%)	77 (76%)	121 (82%)	86 (78%)	25,598 (60%)
Fatalities per	Total	1.08	0.85	1.77	1.04	1.09	1.48	0.99	1.37
100 million	Rural	1.24	1.07	1.92	1.38	1.22	1.71	1.05	1.74
LARGE TRUCK INVOLVED		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	USA
Crashes	CY 2020-2023	295	263	103	201	81	83	104	20,839
CLIMATE		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	
Avg. Snowfall (in.), NOAA 1981-		39.4	54.0	38.1	25.9	51.2	43.9	91.4	
Avg. Temperture, NOAA 1971-20		47.8	41.2	42.7	48.8	40.4	45.2	42	52.7
Temperature Rank 1971-2010		36	47	45	30	49	38	46	*AK 50th*
SHARE WITHIN ROAD CLAS S AVMT 2021 % BY VEHICLE TYPE (RURAL)									
Truck Travel		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	
	Insterstate	31.3	26.8	23.2	36.8	31.2	21.4	16.9	
	Arterials	17.3	8.5	10.0	11.0	26.7	17.1	11.8	
	Other	11.1	10.0	6.8	8.1	19.0	10.5	12.7	
DISTRIBUTION OF AVMT 2021 MILES (MILLIONS) (RURAL)									
		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	
Insterstate	All Traffic	5,246	3,769	2,853	3,208	1,526	2,319	2,715	263,691
Total	All Traffic	19,954	24,548	9,449	11,869	6,292	7,087	8,202	984,281
URBAN AVMT	All Traffic	13,086	32,623	4,033	9,341	2,964	2,907	2,894	2,148,130
Sources: USDOT, NOAA, NHTSA									

6.2.2 Peer State Interviews

Semi-structured interviews were conducted with two peer states, Wyoming and South Dakota. The peer state profiles and discussions with the NDHP determined that these states should be prioritized with regard to their winter storm procedures, decision tools, and safe truck mobility strategies. All states in the region, though relatively less so in Minnesota and Nebraska, have a vested interest in safe rural road mobility. Along with the typical storm tracking from west to east and shared extreme climate features noted in recommendations for the state peer interview candidates, Wyoming and South Dakota were selected for interviews with state transportation and highway patrol agencies.

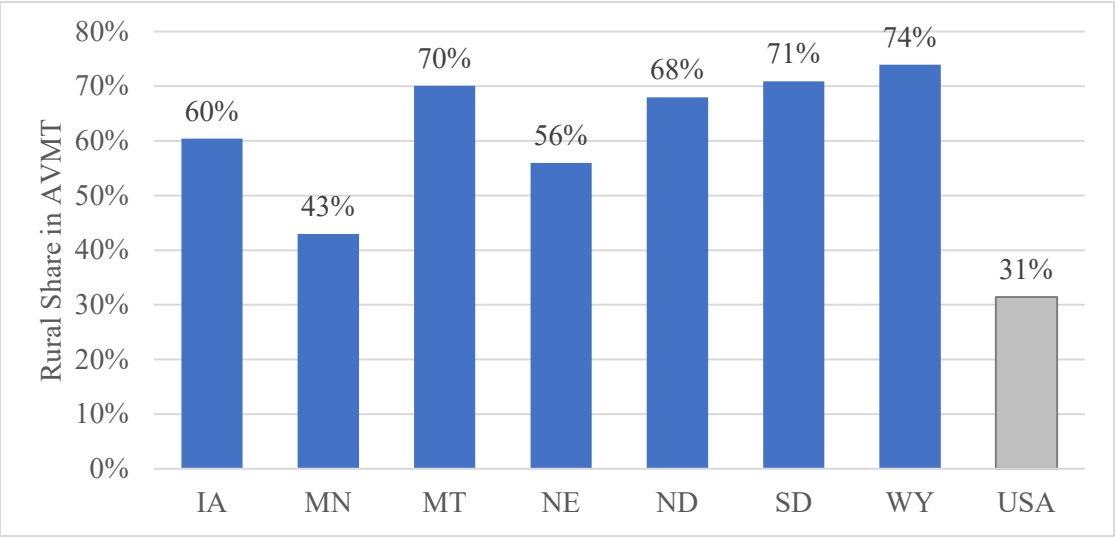


Figure 36. Rural Share in State AVMT, Total Traffic

A framework was developed to cover primary topic threads. Secondary questions were listed as optional depending on time constraints and discussions that may have previously touched on these topics. Interviews were about an hour long, with two to six attendees from the peer state highway patrol or state DOT maintenance division. Related to the I-94 corridor case study, a supplemental interview was completed with a district maintenance office. The interview topics were similar in all cases, with the questions slightly modified to fit the specific group. Primary topic threads were (Figure 37):

- Safety/Mobility Balance During Severe Winter Storms
- Current Winter Storm Practices, Any Specific to Truck Traffic
- Strategies to Improve Safety and Minimize Mobility Impacts
- Open-ended questions for Exploratory Analysis.

TOPIC THREADS WITH QUESTION DRAFTS

Safety/Mobility Balance During Severe Winter Storms

Q1: How does your state patrol division currently manage and monitor commercial motor vehicle (CMV) traffic during severe winter storms to ensure safety?

Q2: What specific challenges do you face in maintaining a balance between safety and mobility for truck traffic during these extreme weather conditions?

Q3: Can you share any successful strategies or countermeasures your division has implemented to enhance safety while minimizing mobility impacts?

Current Winter Storm Practices, Any Specific to Truck Traffic

Q1: How does your state patrol division adapt its winter storm practices to address the unique challenges and safety considerations associated with truck traffic?

Q2: Can you provide examples of specific protocols or practices implemented for monitoring and regulating truck traffic during severe winter weather conditions?

Q3: How does your division collaborate with trucking industry stakeholders to ensure alignment with and understanding of winter storm practices?

Current Winter Storm Traffic Operations Decision Process (with Sub-threads of Road Closure Decision Process & Policy/Practices to Truck Traffic)

Q1: How is the decision-making process for road closures during winter storms different when it comes to truck traffic, and what factors influence these decisions?

Q2: Can you describe the specific criteria and protocols your state patrol division follows when determining whether to close roads frequented by commercial motor vehicles during severe winter weather?

Q3: Are there any unique policy considerations or practices in place to address the safe and efficient movement of truck traffic during winter storms?

Strategies to Improve Safety and Minimize Mobility Impacts (with Sub-threads of Policy, Education, Enforcement, & Engineering Low-Cost Variety)

Q1: How does your state patrol division integrate policies aimed at improving safety and minimizing mobility impacts for truck traffic during winter storms?

Q2: What educational initiatives are in place to raise awareness among commercial truck drivers regarding safe practices in adverse winter weather conditions?

Q3: Can you share examples of enforcement measures specifically designed to enhance safety and mobility for truck traffic during severe winter storms?

Open-Ended Questions for Exploratory Analysis

Figure 37. Semi-Structured Interview Topic Threads

Interview Topic Threads and Insights

Focused interviews were conducted with stakeholder groups in North Dakota and South Dakota. As a result of these meetings, three main areas emerged as most important: safety, logistics, and decision-making.

1: How do we ensure driver/operator safety during winter weather events?

Communication needs to be effective.

- Dynamic message signs are used to ensure "we get the truck stopped where there is truck parking" and can further be used to alert drivers in multiple directions about "both sides of a trouble spot" (Interviewee 2).
- Social media and travel map messaging include multiple categories, and end users are provided with information about "log travel alerts, no travel, and closed roads" (Interviewee 2).
- Collaboration with stakeholders is essential to ensure effective communication. For example, some teams provide the Sheriff's Department access during the evening shift "to change those messages" on state radio and travel maps (Interviewee 2). Others hold conversations with local and state leaders. When appropriate, these groups initiate Pathfinder messaging through the National Weather Service and local authorities to alert drivers/operators about potentially dangerous local conditions (Interviewee 6).
- Issuing travel alerts is a major decision impacting many people, so there is "a big discussion…on when to issue them, how to handle them, and all of that" (Interviewee 6).

Information sent out directly by agencies must be correct and supersede incorrect information readily available to drivers via third-party apps and mobile technology.

- The biggest challenge during poor weather occurs when drivers try to "route themselves around the event" (Interviewee 1). Multiple interviewees noted that Google would suggest drivers go off major highways onto local roads because "their objective is to route traffic, not stop traffic" (Interviewee 10). With the onset of Google Maps, it has become relatively easy for drivers to find a route that "goes the same direction," even though it may be a two-lane road with minimal maintenance at the time of the storm (Interviewee 4). One interviewee noted that when the agency categorized a road as impassable, "navigation apps did not interpret that as a closed road and would still send traffic down an impassable or blocked road" (Interviewee 8). As a result, some agencies are partnering with Google or other navigation apps "to try to figure out a way that will not route them on a bad road" (Interviewee 1).
- Ultimately, it was advised that end users "just watch the travel map" offered by state agencies because it provides "the most current information" (Interviewee 1). Although these maps "are utilized by thousands of people" daily (Interviewee 4), the de facto decision by most drivers is to use a navigation app first. Local knowledge of road conditions should be prioritized over popular third-party applications.

The following items were identified as effective countermeasures that promote safety:

- Median cable guardrail (Interviewee 1)
- Rumble strips help drivers "feel their weight" in zero visibility (Interviewee 1)
- Value-added meteorologists (Interviewee 1) who predict what the "conditions are going to be on the roadway" (Interviewee 2)
- Living snow fences and mechanical snow fences (Interviewee 1)
- Improving and upgrading equipment, including road closure gates (Interviewee 1)

- Clearing ice, snow, and everything off the roadway in a timely and safe manner (Interviewee 1)
- High friction surfaces, which lead to crash reductions (Interviewee 12)

2: What items need to be considered when a road is closed/detoured?

Planning is essential.

- Agencies "have to methodically plan out where road closure points are going to be" because it is not prudent to "close a road where you have no truck storage" (Interviewee 1). For example, in North Dakota, a common practice along I-94 is to use a "segmented closure" in which the interstate is closed "at Jamestown or Fargo to prevent Valley City from getting too full" (Interviewee 5). South Dakota interviewees noted a similar approach: "We end up making our closure points further away from the actual storm event or the conditions best to handle the truck traffic" (Interviewee 8). More recently, some agencies have chosen to "say another state road is closed even though we do not have gates to block the traffic" to deter drivers from traveling in unsafe road conditions (Interviewee 10).
- Another approach is to proactively message that there is "no truck parking available" in certain spots and provide information about an alternative space at which there will "be truck parking at another exit" (Interviewee 9). Agencies try to ensure that rest areas are kept "open even though the interstate may be closed" (Interviewee 8).
- Once roads are officially closed, one of the biggest challenges is ensuring "enough available truck parking" (Interviewee 1). As a result, agencies emphasized the need to work "with our neighboring states" to either "start backing them up earlier or divert them on a detour" (Interviewee 1). For example, some agencies "try to detour them down another corridor," such as asking drivers/operators to use I-90 when I-94 is closed (Interviewee 1). In these situations, officials coordinate with regional entities such as the Highway Patrol to allow local traffic to use the roadways: "We will let local traffic go, [but] you have to prove that you are local and not just trying to get around [the road closure]" (Interviewee 1).
- When roads are opened after the weather event, a general timeframe for reopening, such as "today" or "this morning," is preferred as agencies "do not give a time until it is opened" (Interviewee 1).

The following items were recommended to make operations run smoothly:

- Agencies recommend providing "extended hours" during major snowstorm events. It is especially critical to "sand or salt to keep the trucks moving" in uphill road segments (Interviewee 8).
- Having "three separate shifts" allows optimal coverage and ensures eyes are always on the roadways (Interviewee 5).
- For large regions, preemptively "moving some equipment or moving some human power into the area that is going to be affected" helps ensure adequate preparations are made (Interviewee 6).
- Having heavier staffing along main corridors is recommended (Interviewee 6).
- Ensure that the Highway Patrol and emergency responders can access rest areas if a prolonged closure occurs and the rest area(s) run out of resources (Interviewee 8).
- Proactive interagency/stakeholder EMS planning activities around road closure decisions, communication processes, and traffic recovery planning (Interviewee 8).
- Encourage the trucking industry to sign up to receive messaging about "road closures, no travels, and anything like that across the corridor" (Interviewee 1).

- Provide kiosks at rest areas containing real-time information about travel conditions (Interviewee 8).
- When reopening a highway, have a law enforcement presence at the gate "to maintain sanity" among drivers (Interviewee 7).

3: What are the characteristics of effective decision-making?

Effective decision-making requires collaboration.

- The North Dakota Department of Transportation Maintenance Division recently initiated a coordination process that includes a conference call with multiple stakeholders such as the Highway Patrol, state radio, all DOT districts, and leadership teams, where the conversation centers on the forecasted weather event and how to prepare accordingly (Interviewee 1). The South Dakota Department of Transportation Maintenance Division looks at the forecast. Then, it reaches out to area offices, maintenance supervisors, and Highway Patrol partners to begin preparations for a potential closure (Interviewee 12). Additionally, in South Dakota, the secretary of the Department of Transportation and the Department of Public Safety "have to concur on any closures" (Interviewee 8). At the Valley City Maintenance Division, the National Weather Service and local emergency management officials are included (Interviewee 6). Interviewees at the Valley City Maintenance Division mentioned the importance of having Highway Patrol coordinate with districts since they are "monitoring the roads all the time" (Interviewee 6). As one interviewee noted, "If we feel we are going to close a road, we will be getting ahold of Highway Patrol right away and letting them know" (Interviewee 6).

The following recommendations were made to enhance decision-making efforts:

- A snow and ice manual is used by the NDDOT Maintenance Division to get each district on the same page (Interviewee 2).
- An integrated corridor map is being created (Interviewee 1).
- Pushing messaging notifications via Pathfinder, social media, and DMS is highly recommended (Interviewee 1).
- Creating a banner on the travel/road condition website makes it clear where closures are for end users (Interviewee 8).
- The South Dakota Trucking Association receives press releases from state agencies to be alerted about changing road conditions (Interviewee 11).
- At the South Dakota Department of Transportation Maintenance Division, the commercial vehicle permitting system is being integrated with closure announcements to ensure that proper permit holders are notified based on date of closure (Interviewee 10).

6.3 Trucking Company Winter Storm Policy and Driver Guidance SMEs/Scan

A local truck subject matter expert (SME) group that included private trucking companies, industry organizations, insurance firms, and state agencies was queried about trucking company policies for winter storm events. Generally, companies were seen to leave decisions to individual drivers. While companies can provide guidance and dispatchers may suggest alternative routes, no sample firm procedure or decision model was identified.

According to the Transwest Trucking company, extreme weather can mean delays, fleet issues, and potential safety risks for drivers (2021). Trucking companies need to think ahead about potential weather events that might have a negative impact on their operations.

The key is to purchase the right trucks, follow critical safety protocols, and have policies and procedures in place before a big winter storm. Best practices should include the following:

1. Keep the fleet well-maintained. Carry winter fuel treatment containers and fuel filters with the units at all times. Check tire inflation pressures and the air brake dryer system daily. Read the FMCSA 6.3.10 guideline on hazardous weather conditions. Carry tire chains and tire inflation equipment at all times.
2. Offer training to all drivers. Be sure they know how to operate their trucks on snow and ice-covered roads and bridges.
3. Require drivers to have the proper clothing, gloves, caps, and footwear for below-zero temperatures. Drivers should have an emergency safety kit to keep them warm and safe when needed.
4. Train drivers to understand the terminology used by the National Weather Service, including a winter storm watch, blizzard warning, winter storm warning, ice storm warning, and winter weather advisory.
5. Drivers need to watch for messages on NDDOT boards concerning road closures and plan to reach a safe destination well before the road is closed.

7. CONCLUSION AND FINDINGS

Winter storms can create dangerous travel conditions. Severity can be affected by cumulative winter events or characteristics in an individual storm event that combine extreme winds and mixed or high moisture accumulation. Preparation, communication, and resiliency are crucial to safe mobility and minimizing crash risk and traffic disruptions. This investigation provides an overview of winter storm truck safety challenges with prominent factors, strategies, and past storm event analyses.

Analysis shows several opportunities for proactive efforts with safe mobility during winter storm events. The literature review was used for context in discussing winter storm truck safety challenges and countermeasures. Discussions with subject matter experts made communications an evident key in this planning and dynamic decision process.

- Safe Users
    - Winter driving information safe mobility campaign – public, businesses
    - Out-of-state truck driver/company education
    - Driver trip planning, driving applications, and/or dispatch centers prevent secondary road re-routing (e.g., SDDOT Google Map)
    - Local resources for truck driver storm diversion communities beyond the urban centers
    - Truck parking inventory/information
    - Tiered penalty approach for drivers with winter storm-related violations
- Safe Speeds
    - Greater storm event visibility in real-time and geographic coverage
        - Weather stations
        - Cameras
        - Road sensors
        - Traffic recorders
    - Coordination with neighboring states in communications, technology, and policies
    - Planning closures with lead time for truck parking
    - Variable speed limit corridors
    - Blow off/blow over vehicle type policy, consider speed and weight
- Safe Roads
    - Periodic desktop planning exercise as an emergency response to severe winter storms in terms of intensity and/or duration
    - Communicate road closures with the public and the trucking industry
        - Real-time information at rest stop kiosks
        - General updates and plan to reopen roadways
    - Living snow fences, timely road clearing/coordinated operation, winter plowing techniques, DMS
    - High friction surfaces, rumble strips, cable median barriers, guardrails, improved road closure gates, reliable equipment

- Safe Vehicles
    - Truck permit system for travel alerts
    - Tiered penalty approach for companies with winter storm-related violations
- Post-Crash Care
    - Law enforcement crash response challenges beyond major travel corridors
    - Access to EMS and hospital care during winter storm events

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9. APPENDIX. SUPPLEMENTAL RESOURCES

9.1 Peer States Profile (Estimated Metrics)

TRAFFIC SAFETY PERFORMANCE (CORE OUTCOME) MEASURES IN 2021									
Core Outcome Measures		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	USA
Traffic Fatalities	Total	356	488	239	221	101	148	110	42,939
	Rural	247 (69%)	262 (54%)	181 (76%)	164 (74%)	77 (76%)	121 (82%)	86 (78%)	25,598 (59.6%)
	Urban	107 (30%)	225 (46%)	56 (23%)	57 (26%)	24 (24%)	27 (18%)	24 (22%)	17,103 (39.8%)
Vehicles Involved in Fatal Crashes	Total Vehicles	491	672	287	311	139	179	142	61,332
	Large Trucks	76 (15.5%)	79 (11.8)	34 (11.8%)	50 (16.1%)	13 (9.4%)	19 (10.6%)	20 (14.1%)	5,700 (9.3%)
Fatalities per 100 million VMT	Total	1.08	0.85	1.77	1.04	1.09	1.48	0.99	1.37
	Rural	1.24	1.07	1.92	1.38	1.22	1.71	1.05	1.74
	Urban	0.82	0.69	1.39	0.61	0.81	0.93	0.83	1.19
LARGE TRUCK INVOLVED (All Dom		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	USA
Traffic Fatalities	CY 2020 (MCMIS	71	61	19	51	18	26	23	4,989
	CY 2021 (MCMIS	71	80	35	50	14	17	16	5,816
	CY 2022 (MCMIS	77	58	28	50	26	19	29	5,413
	CY 2023 (MCMIS	76	64	21	50	23	21	36	4,621
FATAL MOTOR VEHICLE CRASHES INVOLVING A LARGE TRUCK 2021									
Crashes		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	USA
	2021 Total	62	75	33	46	12	19	18	5,149
	Winter Share	35%	33%	39%	35%	33%	47%	44%	36%
	Winter (Nov-M	22	25	13	16	4	9	8	1859
By Atmospheric Conditions	Clear/Cloudy	47	43	18	39	11	13	13	3,635
	Rain (Mist)	2	5	1	0	0	0	0	333
	Sleet, Hail	0	0	0	0	0	0	0	5
	Snow	0	3	2	3	0	2	1	75
	Fog, Smog, Smo	2	5	0	0	0	0	0	88
	Severe Crosswi	1	1	0	1	0	0	1	10
	Blowing Sand, S	0	0	0	0	0	0	0	8
	Other	0	0	0	0	0	1	0	5
	Cloudy	9	16	9	3	0	3	2	793
	Blowing Snow	1	1	3	0	0	0	1	9
	Freezing Rain o	0	0	0	0	0	0	0	3
	Unknown/Not I	0	1	0	0	1	0	0	185
	Total	62	75	33	46	12	19	18	5,149

Table Continued on Following Page.

(table continued)

CLIMATE		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	
Avg. Snowfall (in.), NOAA 1981-20		39.4	54.0	38.1	25.9	51.2	43.9	91.4	
Avg. Temperture, NOAA 1971-200		47.8	41.2	42.7	48.8	40.4	45.2	42	52.7
Temperature Rank 1971-2010		36	47	45	30	49	38	46	
DISTRIBUTION OF ANNUAL VEHICLE DISTANCE TRAVELED 2021 % BY VEHICLE TYPE (RURAL)									
		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	
Insterstate	Single-Unit Tru	4.28	5.18	3.44	2.08	5.89	2.9	4.98	
	Combination Tr	26.98	21.58	19.73	34.71	25.29	18.5	11.96	
Other Arterials	Single-Unit Tru	4.53	3.11	3.31	2.13	11.24	3.9	3.24	
	Combination Tr	12.81	5.42	6.66	8.87	15.44	13.2	8.52	
Other	Single-Unit Tru	5.72	3.54	3.16	2.81	7.74	2.8	5.27	
	Combination Tr	5.4	6.43	3.66	5.27	11.26	7.7	7.45	
DISTRIBUTION OF ANNUAL VEHICLE DISTANCE TRAVELED 2021 MILES (MILLIONS) (RURAL)									
		Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming	
Insterstate	All Traffic	5,246	3,769	2,853	3,208	1,526	2,319	2,715	
Other Arterials	All Traffic	6,301	7,321	2,694	3,341	1,972	1,997	1,707	
Sources: USDOT, NOAA, NHTSA									

9.2 Living Snow Fences in South Dakota, Contract Resources: Brochure, Easement Agreement, and Payment Example

Help Save Lives!

Improving the safety of the traveling public is a primary goal of the SDDOT. The addition of snow fences and other mitigation methods along interstate corridors at strategic locations is an effective option to help mitigate problematic blowing and drifting snow that impacts interstate corridors. Landowners along interstate corridors have a unique opportunity to help SDDOT accomplish their goal by providing land for snow fence installation and maintenance or by leaving crops standing in specific locations. The SDDOT will work towards an agreement with landowners who would like to participate.

To learn more about how you can help and compensation options, please contact the SDDOT Team.

TO LEARN MORE ABOUT BLOWING & DRIFTING SNOW MITIGATION EFFORTS CONTACT:

Danny Varilek

Winter Maintenance Engineer

700 East Broadway

Pierre, SD 57501

Phone: 605-773-2153

E-mail address: daniel.varilek@state.sd.us

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South Dakota DOT
Connecting South Dakota and the Nation

MITIGATING BLOWING & DRIFTING SNOW

THE PROBLEM

If anyone has ever driven in the winter, they have firsthand experience with blowing and drifting snow on the roadways of South Dakota. Not only does blowing and drifting snow create serious safety hazards such as snow drifts, black ice, and poor visibility; it also significantly increases costs for road maintenance and down-time due to road closures.

In an effort to help mitigate the safety hazards related with blowing and drifting snow, SDDOT is considering the use of snow fences and other methods.

BLOWING SNOW MITIGATION METHODS

Structural Snow Fences

Standing Crops & Living Snow Fence

1. **Structural** - A fence that is constructed using wooden or composite rails.
2. **Living** – Trees, shrubs, or standing crops planted in rows to trap snow.
3. **Obstructions** – Remove, replace, or modify existing features causing blowing & drifting snow issues (ie. signs, trees, fences, etc.)

SNOW FENCE BENEFITS

Improved Safety

- Snow fences prevent snow and ice accumulation on roadways, helping reduce crash rates
- Mitigating blowing snow improves visibility for drivers.

Reduced Snow Removal and Salts

- Reduced snow and ice on the roadways result in reduced time and money spent plowing and other maintenance activities.
- Road surfaces protected by snow fences stay warmer, reducing black ice and the need for salt and other treatments that may damage roads and vehicles.

Less Road Closures

- Roads stay open longer making travel easier for everyone.

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
HIGHWAY USE EASEMENT
FOR AN ESTABLISHED LIVING SNOW FENCE

This Highway Use Easement Agreement ("Easement") is made and entered into by and between the State of South Dakota, acting by and through its Department of Transportation, 700 Broadway Avenue East, Pierre, South Dakota 57501, referred to in this Easement as the "STATE," and , whose post office address is , referred to in this Easement as the "LANDOWNER."

1. PURPOSE

The STATE, for the purpose of reducing highway maintenance costs, providing greater service to the traveling public, and promoting conservation, wants to enter into agreements for highway use easements with private landowners for maintaining established living snow fences, consisting of trees, bushes, and shrubs, as may be appropriate for the soil type and location. The LANDOWNER, possessing the necessary suitable land, shares these concerns and is willing to enter into an agreement for a highway use easement as further defined in this Easement.

2. HIGHWAY USE EASEMENT

The LANDOWNER grants a highway use easement to the STATE and the STATE, in turn, agrees to purchase a highway use easement from the LANDOWNER for the real property shown on **Exhibit A**, attached to and incorporated in this Easement, and as legally described as follows:

Insert Legal Description

3. TERM OF HIGHWAY USE EASEMENT

This Easement will run for a term of ten (10) years from the date this Easement is approved and signed by the Secretary of the South Dakota Department of Transportation. The STATE will have the exclusive option to renew the Easement for an additional period of ten (10) years by notifying the LANDOWNER of the STATE'S intent to renew, in writing, no later than the date of expiration of this Easement, including any renewal. Such written notice will become a part of this Easement.

4. PAYMENT

In addition to the mutual benefits to be derived from this Easement, the STATE will pay the LANDOWNER annual payments, each in the amount of $, for this Easement. The STATE will make its initial annual payment on or before Insert Month/Day/Year, and will make annual payments in like amount, on or before Insert Month/Day, of each succeeding year of this Agreement.

DOT Legal: _____

SDDOT Summary Snow Fence Agreements

DOT 999 - Permanent Snow Fence Easement

- Terms:
  - 10 years
  - Annual Payments based on

(Round all numbers to the *second decimal point)*

The length of the snow fence = _____ lineal feet.

In order to convert to acres (area) a width of 20 feet plus the width of the structures shall be used for the width.

Annual compensation for protecting the snow fence, providing snow storage and the inconvenience of farming around it may be based on the annual County Assessment Year Productivity. https://dor.sd.gov/businesses/taxes/property-tax/agriculture-tax/ times a 1.5 multiplier, if there is no property specific data

Annual compensation for snow fence of $ per lineal foot of snow fence installed for lineal feet, for a baseline payment of $ _____.

The baseline payment (p_0) will be annually adjusted by the Assessment Year Productivity. SDDOT agrees to not pay less than the baseline payment dollar amount at sign up for the remaining life of this agreement.

DOT 961 – Living Snow Fence

- Terms :
  - 10 years
  - Annual payments based on

(Round all numbers to the *second decimal point)*

The length of the snow fence = _____ lineal feet.

In order to convert to acres (area) a width is the fenced area of the planting shall be used for the width.

Annual compensation for protecting the snow fence, providing snow storage and the inconvenience of farming around it may be based on the annual County Assessment Year Productivity. https://dor.sd.gov/businesses/taxes/property-tax/agriculture-tax/ times a 1.5 multiplier, if there is no property specific data

Annual compensation for snow fence of $ per lineal foot of snow fence installed for lineal feet, for a baseline payment of $ _____.

The baseline payment (p_0) will be annually adjusted by the Assessment Year Productivity. SDDOT agrees to not pay less than the baseline payment dollar amount at sign up for the remaining life of this agreement.

Example SDDOT's Permanent Snow Fence Annual Payment Assessment Year Productivity Information

Assumptions

Income in 2018 in Minnehaha County $529 an acre from https://dor.sd.gov/businesses/taxes/property-tax/agriculture-tax/. This should be a starting point to determine the baseline payment. If the property owner can provide more accurate income or rental data, that data should be used.

Income per acre times 1.5 multiplier - $529 x 1.5 = $793.50

Area of Living Snow Fence Planting (700 feet long by 100 feet wide) – 700 x 100 = 70,000 sf

There are 43,560 sf in an acre so the total acreage of the living snow fence is 70,000/43560= 1.6 acres

Cost per lineal foot = ($793.50 X 1.6)/700 = $1.81

Converted to $1.81 cents per lineal foot payment $1.81 cents X 700 feet = $1270 is SDDOT's Baseline Payment.

DOT 997 – Standing Corn Row Agreement

- Terms:
  - 1 year
  - Annual payments on or before April 30
  - Payment formula in agreement
  - Ask property owner for average bushel yield per acres
  - Check with local elevator for market value of bushel

DOT 998 - Hay Bale/Silo Bag

- Terms:
  - 1 year
  - Annual payments on or before April 30
  - Payment for lineal feet
  - Area Engineer should work with landowner to determine cost

Example: Corn, 2 of 2 pages

DOT-997 T
(09/2023)

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
LIVING SNOW FENCE
STANDING CORN ROW AGREEMENT

This Agreement is made and entered into between Name of Participant, of Address, City, State Zip Code, referred to in this Agreement as the "PARTICIPANT," and the State of South Dakota, acting by and through its Department of Transportation, referred to in this Agreement as the "STATE."

1. **PURPOSE:**

   The PARTICIPANT agrees to leave standing corn rows along South Dakota Highway _____, by refraining from harvesting _____ acres of corn stalks setback _____ feet from the right of way until Date. After this date, the PARTICIPANT may remove the standing corn rows without notification from the STATE. In consideration for this service, the STATE will pay the PARTICIPANT according to Paragraph 3., below, provided the STATE certifies the terms and conditions of this Agreement have been met.

THE STATE AND PARTICIPANT MUTUALLY AGREES TO THE FOLLOWING:

2. **TERM:**

   The term of this Agreement will be from October 1, Year, through April 30, Year.

3. **PAYMENT:**

   The STATE will pay the PARTICIPANT the lump sum amount of $_____, based on the formula provided in line 3.d., on or before April 30, Year, upon certification that the terms and conditions of this Agreement have been met.

   a. Acres of corn left standing = Length _____ feet X width _____ feet ÷ 43,560 feet ^{2} = _____ acres (round to the second decimal point)

   b. Average bushel yield = _____ per acre

   c. Cost per bushel = Market value per bushel $_____ + $3 = _____ per bushell

   d. Multiply line 3.a., 3.b., and 3.c., above, _____ X _____ X _____ = $_____

4. The PARTICIPANT will allow the STATE, and any servant, agent, contractor, or worker authorized by the STATE, the right of ingress and egress from the public highway to the subject real property, to inspect the standing corn rows.

5. PARTICIPANT will receive a W-9 verification form requiring further information to register as a vendor with the State of South Dakota. PARTICIPANT will receive a 1099 form, which reports the amount received from the State of South Dakota from this Agreement and agrees to its terms and conditions.

6. CERTIFICATION OF NO PROHIBITED STATE LEGISLATOR INTEREST

   The PARTICIPANT (i) understands neither a state legislator nor a business in which a state legislator has an ownership interest may be directly or indirectly interested in any contract with the State that was authorized by any law passed during the term for which that legislator was elected, or within one year thereafter, and (ii) has read South Dakota Constitution Article 3, Section 12 and has had the opportunity to seek independent legal advice on the applicability of that provision to this Agreement. By signing this Agreement, the PARTICIPANT hereby certifies that this Agreement is not made in violation of the South Dakota Constitution Article 3, Section 12.

This Agreement is binding on the STATE, the PARTICIPANT, and the PARTICIPANT's successors and assigns.

PARTICIPANT

By: _____

Printed Name: _____

Date: _____

State of South Dakota
Department of Transportation

By: _____

Printed Name: _____

Its: _____

Date: _____

Example: Hay Bale/Silo Bag Example, 1 of 2 pages

DOT-998_T
(09/2023)

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
LIVING SNOW FENCE
HAY BALE/SILO BAG AGREEMENT

This Agreement is made and entered into between Name of Participant, of Address, City, State Zip Code, referred to in this Agreement as the "PARTICIPANT," and the State of South Dakota, acting by and through its Department of Transportation, referred to in this Agreement as the "STATE."

1. **PURPOSE:**

   The PARTICIPANT agrees to place hay bales/silo bags along South Dakota Highway _____, by placing the hay bales/silo bags in a row setback _____ feet from the right of way until Date. After this date, the PARTICIPANT may remove the hay bales/silo bags without notification from the STATE. In consideration for this service, the STATE will pay the PARTICIPANT according to Paragraph 3., below, provided the STATE certifies the terms and conditions of this Agreement have been met.

THE STATE AND PARTICIPANT MUTUALLY AGREE TO THE FOLLOWING:

2. **TERM:**

   The term of this Agreement will be from October 1, Year, through April 30, Year.

3. **PAYMENT:**

   The STATE will pay the PARTICIPANT the lump sum amount of $_____, based on a rate of _____ ($_____) per linear foot of hay bale/silo bag, on or before April 30, Year, upon certification that the terms and conditions of this Agreement have been met.

4. The PARTICIPANT will allow the STATE, and any servant, agent, contractor, or worker authorized by the STATE, the right of ingress and egress from the public highway to the subject real property to inspect the hay bales.

5. PARTICIPANT will receive a W-9 verification form requiring further information to register as a vendor with the State of South Dakota. PARTICIPANT will receive a 1099 form, which reports the amount received from the State of South Dakota from this Agreement and agrees to its terms and conditions.

6. CERTIFICATION OF NO PROHIBITED STATE LEGISLATOR INTERES

   The PARTICIPANT (i) understands neither a state legislator nor a business in which a state legislator has an ownership interest may be directly or indirectly interested in any contract with the State that was authorized by any law passed during the term for which that legislator was elected, or within one year thereafter, and (ii) has read South Dakota Constitution Article 3, Section 12 and has had the opportunity to seek independent legal advice on the applicability of that provision to this Agreement. By signing this Agreement, the PARTICIPANT hereby certifies that this Agreement is not made in violation of the South Dakota Constitution Article 3, Section 12.

[SIGNATURE PAGE FOLLOWS]

9.3 Wyoming Truck Blow Over

9.3.1 Information Brochure

511 Travel Information definitions

Strong Winds
Wind gusts of 40 mph with any road condition.

Blowing Snow
Snow propelled by the wind across or along the road surface at least 1 foot above the ground.

Reduced Visibility
Visibility of less than 400 feet for any reason.

Slick
Long, continuous sections of icy or snow-packed roads. Greater than 50 percent of the road section is icy or snow packed.

Slick in Spots
Short, non-continuous sections of icy or snow-packed road. Less than 50 percent of the road section is icy or snow packed.

Drifted Snow
Drifts of any size that cross the white line and cause a driver to feel a bump or a pull on the steering wheel.

Please comply with variable speed limit signs, vehicle blow-over advisories and closures.

To check road conditions visit *www.wyoroad.info* or dial 511 in Wyoming or 1-888-WYO-ROAD (1-888-996-7623) nationwide.

Download WYDOT's free 511 mobile app from the Apple Store or Google Play.

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Blow-over hazards

Advisories, closures and definitions

a WYDOT publication

Blow-over hazards
Light trailers and high-profile vehicles often blow over on Wyoming highways due to high winds that can occur even during summer. Controlling a vehicle during a strong wind event can be even more difficult in winter, when roads are slick.

There is no specific research that shows at what wind speeds and load weights trucks will blow over. Therefore, when WYDOT issues a blow-over risk advisory or closure, it cannot cite a specific weight or wind speed that will cause a trailer to blow over.

However, research does show that, when wind gusts exceed 60 mph, it is almost certain multiple vehicles will be blown over or be involved in a crash caused by loss of control. These crashes often result in debris on the highway and a road closure to all vehicles.

Extreme Blow-Over Risk
In locations where wind gusts are 60 mph or higher, but adequate signage to indicate a closure to light, high-profile vehicles is not available, WYDOT will issue an "Extreme blow-over risk" warning.

This warning is targeted at vehicles prone to being blown over, such as moving vans, campers, recreational vehicles, small trailers and empty or lightly-loaded commercial vehicles.

Blow-Over Risk
"Blow-over risk" messages are posted on roadside electronic message boards when wind gusts are greater than 50 mph with any road conditions.

This advisory pertains to trailers of any size, commercial and non-commercial, and to recreational vehicles and other vehicles loaded with light materials or empty, and having a profile that is subject to catching wind gusts.

Drivers of such vehicles are advised not to travel when a "Blow-over risk" advisory is posted to avoid strong wind gusts that could result in the loss of control of their vehicle or the potential for the vehicle to blow over.

Any driver who fails to comply with a "Blow-over risk" advisory and is involved in a crash may be subject to a fine and can expect to pay the cleanup costs and fees associated with repairing any damage caused to public or private property.

Closure to Light, High-Profile Vehicles
In locations where wind gusts are 60 mph or greater and adequate signage to indicate the limited closure is available, WYDOT will initiate a closure to light, high-profile vehicles. This closure is targeted at vehicles prone to being blown over, such as moving vans, campers, recreational vehicles, small trailers and empty or lightly-loaded commercial vehicles.

Drivers who fail to heed this type of closure will be considered in violation of Wyoming Statute 24-1-109 and could be subject to a fine of up to $750 and 30 days in jail.

No Unnecessary Travel
This advisory means the road is open, but travel is not recommended due to hazardous driving conditions.

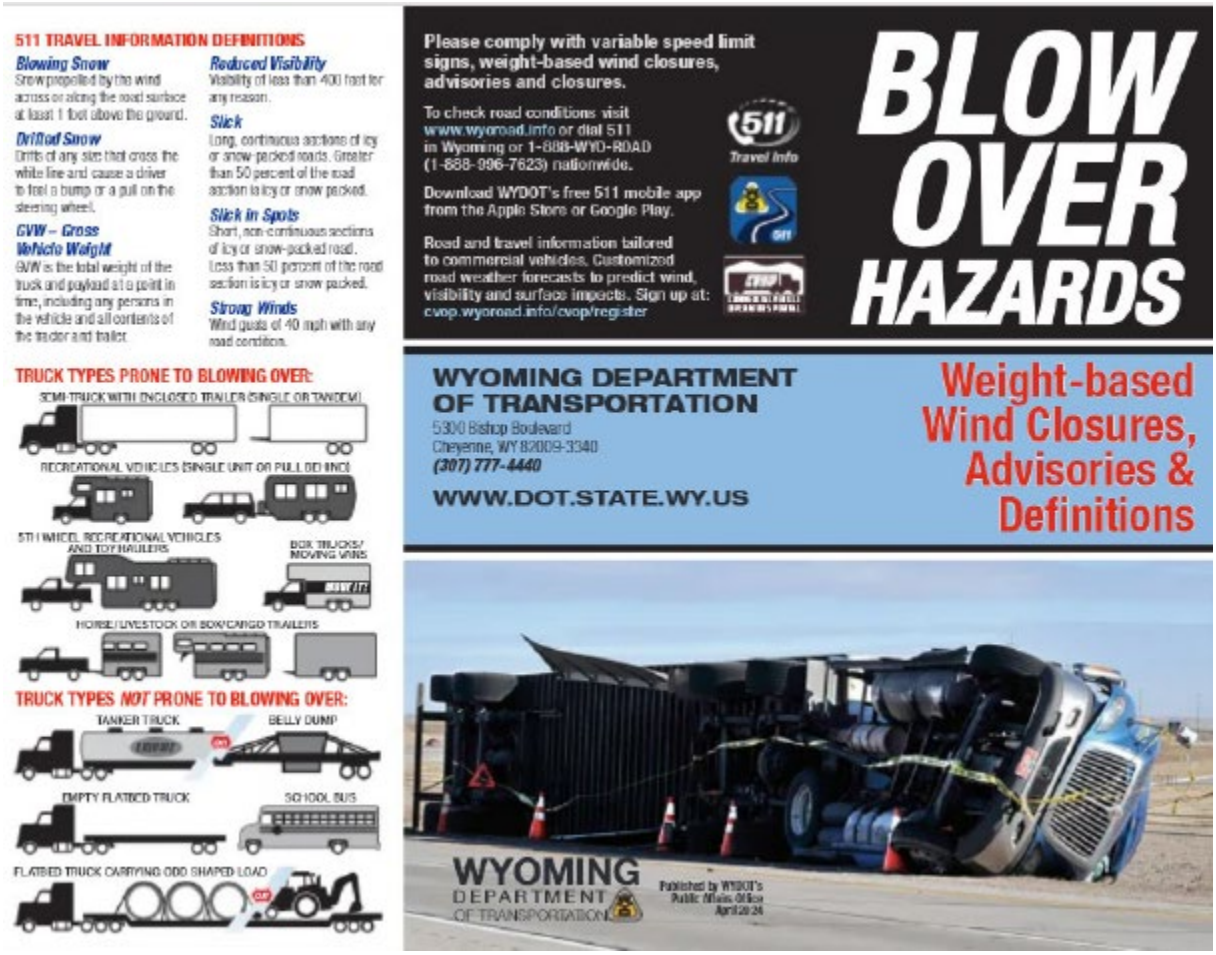
Generally, this advisory is posted during winter months due to extremely icy conditions, when visibility is limited due to blowing snow, or when a combination of conditions makes travel ill-advised.

Only the most urgent of situations should warrant travel under a "No unnecessary travel" advisory. Drivers who attempt such travel should be familiar with local conditions and be very experienced with winter driving.

Oversize loads will not be allowed to move if the highway is restricted to no unnecessary travel. A load may proceed or return to the nearest parking area or town. At no time shall the move continue beyond those points unless approved by the Wyoming Highway Patrol.

Traveling during a "No unnecessary travel" advisory may interfere with maintenance crews' efforts to improve highway safety.

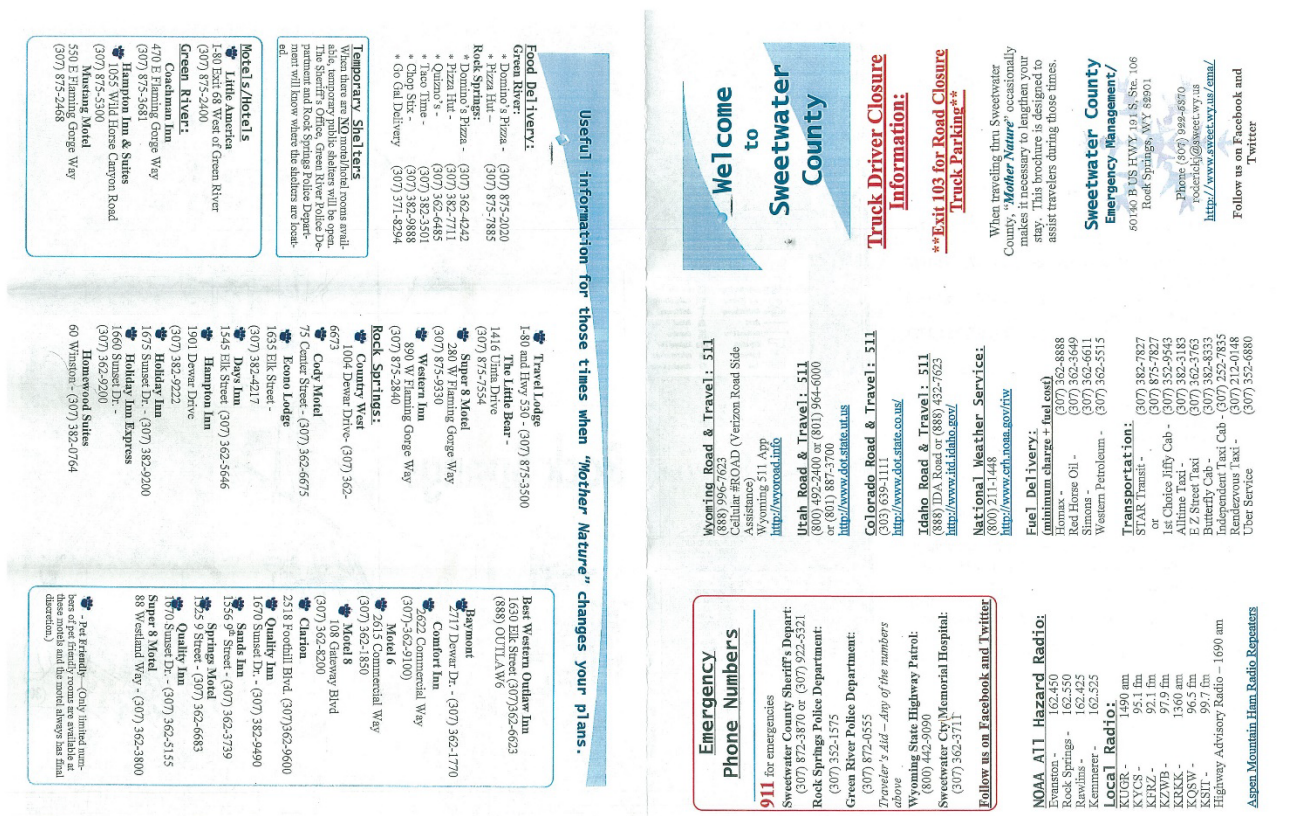
9.3.2 Blow Over Legislative Action



Wyoming Legislature 2024 Senate File No. 0113 anyone “who willfully fails to observe any sign, marker, warning, notice or direction” for closers to light, high-profile vehicles is guilty of a misdemeanor and can be fined up to $1,000 plus face imprisonment for no more than 30 days. If a driver reoffends within three years of the first offense, the fine increases to $2,500 and becomes a reckless driving conviction. Source: Transport Topics News [TTNews], July 15, 2024.

9.4 Public Information and Planning Samples

9.4.1 Wyoming Traveler Community Winter Storm Guide



Useful information for those times when "Mother Nature" changes your plans.

Food Delivery:
Green River:
+ Domino's Pizza - (307) 875-2020
+ Pizza Hut – (307) 875-7885
Rock Springs:
+ Domino's Pizza - (307) 362-4242
+ Pizza Hut - (307) 382-7711
+ Quizno's - (307) 362-6485
+ Taco Time - (307) 382-3501
+ Chop Stix - (307) 382-9888
+ Go Gal Delivery (307) 371-8254

Temporary Shelters
When there are NO normal hotel rooms available, temporary shelters may be opened. The Sheriff's Office, Green River Police Department and Rock Springs Police Department will know where the shelters are located.

Motels/Hotels
Little America
I-80 Exit 68 West of Green River
(307) 875-2400
Green River:
Coachman Inn
470 E Flaming Gorge Way
(307) 875-3681
Hampton Inn & Suites
1055 Wild Horse Canyon Road
(307) 875-5300
Mustang Motel
550 E Flaming Gorge Way
(307) 875-2468

Travel Lodge
I-80 and Hwy 530 - (307) 875-5300
The Little Bear -
1416 Uinta Drive
(307) 875-7554
Super 8 Motel
280 W Flaming Gorge Way
(307) 875-9830
Western Inn
890 W Flaming Gorge Way
(307) 875-2840
Rock Springs:
Country West
1004 Dewar Drive- (307) 362-6673
Cody Motel
75 Center Street - (307) 362-6675
Econo Lodge
1655 Elk Street - (307) 382-4217
Days Inn
1545 Elk Street (307) 362-5646
Hampton Inn
1901 Dewar Drive
(307) 382-9222
Holiday Inn
1675 Sunset Dr. - (307) 382-9200
Holiday Inn Express
1660 Sunset Dr. - (307) 362-9200
Homewood Suites
60 Winston - (307) 382-0764

Best Western Outlaw Inn
1630 Elk Street (307)362-6623
(888) OUTLAW6
Baymont
2717 Dewar Dr. - (307) 362-1770
Comfort Inn
2622 Commercial Way
(307)-362-9100)
Motel 6
2615 Commercial Way
(307) 362-1850
Motel 8
108 Gateway Blvd
(307) 362-8200
Clarion
2518 Foothill Blvd. (307)362-9600
Quality Inn
1670 Sunset Dr. - (307) 382-9490
Sands Inn
1556 9th Street - (307) 362-3739
Springs Motel
1525 9 Street - (307) 362-6683
Quality Inn
1670 Sunset Dr. - (307) 362-5155
Super 8 Motel
88 Westland Way - (307) 362-3800

- Pet Friendly—(Only limited numbers of pet friendly rooms are available at these motels and the motel always has final discretion.)

Emergency Phone Numbers

911 for emergencies
Sweetwater County Sheriff's Depart: (307 872-3870 or (307) 922-5321
Rock Springs Police Department: (307) 352-1575
Green River Police Department: (307) 872-0555
Traveler's Aid – Any of the numbers above
Wyoming State Highway Patrol: (800) 442-9090
Sweetwater Cty Memorial Hospital: (307) 362-3711
Follow us on Facebook and Twitter

NOAA All Hazard Radio:
Evanston - 162.450
Rock Springs - 162.550
Rawlins - 162.425
Kemmerer - 162.525
Local Radio:
KUGR - 1490 am
KYCS - 95.1 fm
KFRZ - 92.1 fm
KZWB - 97.9 fm
KRKK - 1360 am
KQSW - 96.5 fm
KSIT - 99.7 fm
Highway Advisory Radio – 1690 am

Aspen Mountain Ham Radio Repeaters

Wyoming Road & Travel: 511
(888) 996-7623
Cellular #ROAD (Verizon Road Side Assistance)
Wyoming 511 App
http://wyoroad.info

Utah Road & Travel: 511
(800) 492-2400 or (801) 964-6000
or (801) 887-3700
http://www.dot.state.ut.us

Colorado Road & Travel: 511
(303) 639-1111
http://www.dot.state.co.us/

Idaho Road & Travel: 511
(888) IDA Road or (888) 432-7623
http://www.itd.idaho.gov/

National Weather Service:
(800) 211-1448
http://www.crh.noaa.gov/riw

Fuel Delivery:
(minimum charge + fuel cost)
Horace - (307) 362-8888
Red Horse Oil - (307) 362-3649
Simms - (307) 362-6611
Western Petroleum - (307) 362-5515

Transportation:
STAR Transit - (307) 382-7827
or (307) 875-7827
1st Choice Jiffy Cab - (307) 352-9543
Alltime Taxi - (307) 382-3183
E Z Street Taxi (307) 362-3763
Butterfly Cab - (307) 382-8333
Independent Taxi Cab - (307) 252-7835
Rendezvous Taxi - (307) 212-0148
Uber Service (307) 352-6880

Welcome to Sweetwater County

Truck Driver Closure Information:

Exit 103 for Road Closure Truck Parking

When traveling thru Sweetwater County, "*Mother Nature*" occasionally makes it necessary to lengthen your stay. This brochure is designed to assist travelers during those times.

Sweetwater County
Emergency Management/
60 W B US HWY 191 S, Ste. 106
Rock Springs, WY 82901

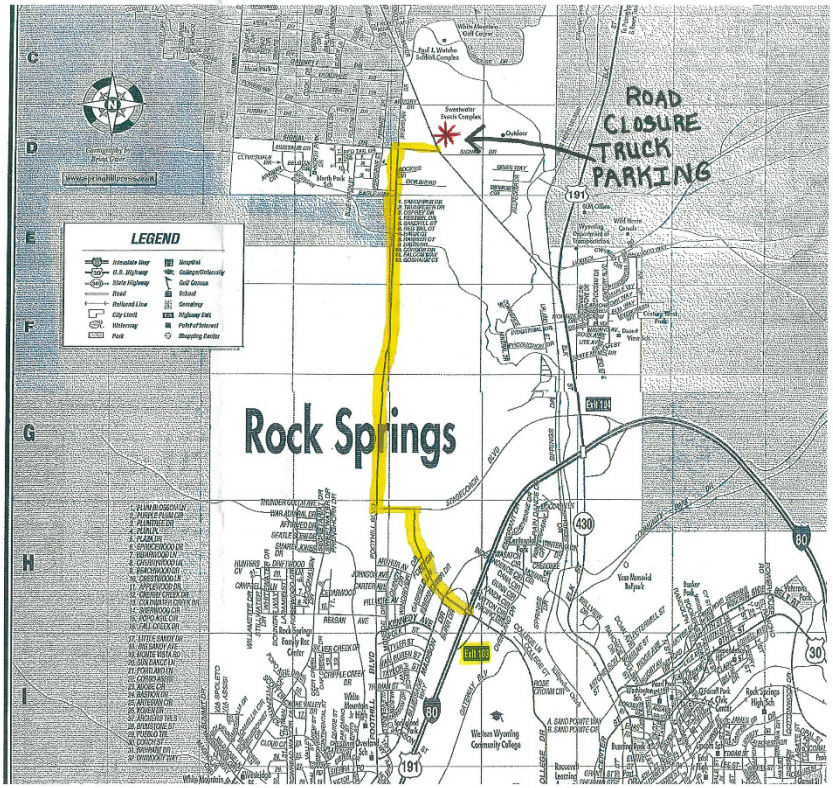
Phone (307) 989-6870
roderichj@sweet.wy.us
http://www.sweet.wy.us/ems/

Follow us on Facebook and Twitter

9.4.2 Wyoming Road Closer Resource Package

Useful and Important Locations:

- Red Desert Insta-Care:
2761 Commercial Way, Rock Springs, WY (307) 382-3064
- Cedars Health
1453 Dewar Dr. Ste. A, Rock Springs, WY (307) 382-2466
- Walgreens Pharmacy:
70 Gateway Blvd, Rock Springs, WY (307) 382-2536
- Albertsons Pharmacy:
1323 Dewar Drive, Rock Springs, WY (307)362-9734
- Walmart Pharmacy:
201 Gateway Blvd, Rock Springs, WY (307) 362-1967
- Smith's Pharmacy:
2531 Foothill Blvd, Rock Springs, WY (307) 362-1841
- Chamber of Commerce:
1897 Dewar Drive, Rock Springs, WY (307) 362-3771
- Aspen Medical Center:
4401 College Dr., Rock Springs, WY (307) 352-8900
- Floyd's Truck Repair:
925 Stagecoach Dr., Rock Springs, WY (307) 382-2124
- Dan's Tire Service:
1164 Dewar Drive, Rock Springs, WY (307)362-2111
- Tire Den Factory:
202 Industrial Drive, Rock Springs, WY (307-382-4700)
- AutoZone Auto Parts:
1285 Dewar Drive, Rock Springs, WY (307-362-2700)
- NAPA Auto Parts:
1300 Dewar Drive, Rock Springs, WY (307-382-2442)
775 Uinta Drive, Green River, WY (307-875-7020)
- O'Reilly Auto Parts:
1265 Dewar Drive, Rock Springs, WY 307-362-1284)
80 Uinta Drive, Green River, WY (307-466-8018)
- Marshall's Truck Repair –Large Truck and Towing:
50096 HWY 191 South, Rock Springs, WY (307-362-2460)
- Rizzi's Automotive & Towing:
1556 9th Street, Rock Springs, WY (307-362-7101)
- Norberg Towing
91 Uinta Drive, Green River, WY (307-875-3575)



Road Closure Parking

Road closure, large vehicle parking is available at the Sweetwater County Events Complex

GPS location:

41° 38' 0.546" N 109° 14' 51.5292" W

Information about the road closure:

Dial- 511

Website- https://wyoroad.info/

Directions from Exit 104/ Elk Street:

1. Head north on Elk St also known as Highway 191 North for ½ mile to the Desert Blvd light.
2. Go about ¼ mile north, past the Desert Blvd light (the light is near the Kum and Go gas station and Subway restaurant).
3. Turn left onto Yellowstone Road (the second left after the Desert Blvd light).
4. Head north about 1 mile (go past the Greene's Energy Building which is on the right).
5. Turn right into the truck parking lot.

Sweetwater County Resources

Directions from Exit 104/ Elk Street Map:

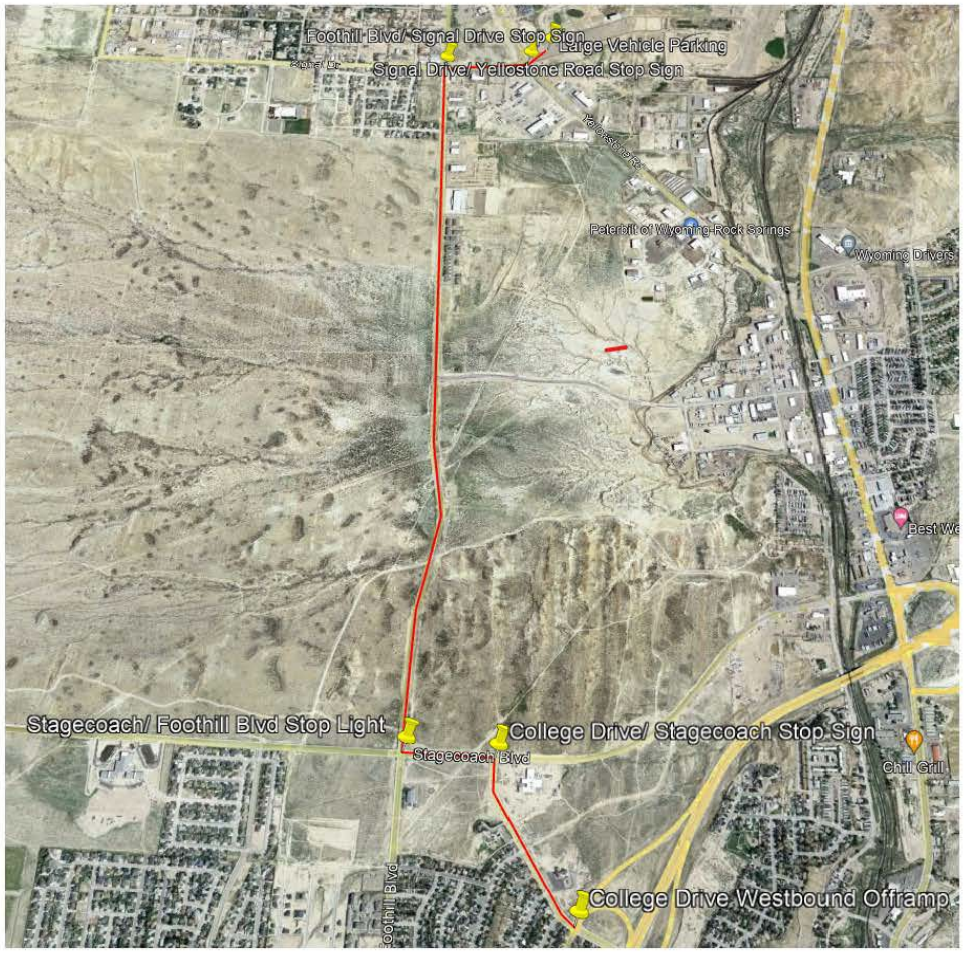
Sweetwater County Resources

Directions from Exit 103/ College Drive:

1. Head north on College Drive until you get to the stop sign (at the intersection of College Dr and Stagecoach).
2. Turn right and head west until you get to the first light (Stagecoach and Foothill Blvd).
3. Turn right and stay on the road for about 1.5 miles until you get to the next stop sign (the intersection of Foothill Blvd and Signal Drive).
4. Turn right and go to the stop sign (the intersection of Signal Drive and Yellowstone Road).
5. Proceed straight into the truck parking lot.

Sweetwater County Resources

Directions from Exit 103/ College Drive Map:



Sweetwater County Resources

Emergency Services

Police 911 (Non emergency Line for Police, Fire and Ambulance **307-352-1575**)
(Police number includes Sweetwater County Sheriff's Office, Rock Springs Police Department and Green River Police Department)

Wyoming Highway Patrol 307-777-4321 (non-emergency number)

Fire 911

Ambulance 911

Emergency Room (Memorial Hospital of Sweetwater County) 307-362-3711 (**1200 College Drive Rock Spring)**

Memorial Hospital of Sweetwater County

Community Nursing (Public Health) 307-922-5390

(Call for an appointment.) **333 Broadway #110 Rock Springs**

Department of Family Services 307-352-2500

PHYSICIANS & CLINICS: (accept Medicaid)

Castle Rock Medical Clinic (Green River) 307-872-4500 Doctors and PA's

Memorial Hospital (MHSC) 362-3711 or 875-7730

MHSC Medical Clinic (Walk-in Clinic) 307-352-8125 Doctors and PA's (3000 College Dr. Rock Springs)

RS Community Health Center 307-212-5116 2620 Commercial Way #140, Rock Springs (including dental & behavioral health)

Sterling Urgent Care 307-382-3064 2761 Commercial Way, Rock Springs (Doctor/PA's)

Dr. Hunter Family Medical Center 307-382-7414 2751 Commercial Way, Rock Springs (Doctor/PA's)

Dr. Poyer (& PA) 307-362-0083

Wyo Cancer Resource Services (@MHSC) 307-212-7517

Sweetwater County Resources

Women's Health: MHSC OB/GYN Clinic 307-352-8383

Dr. Kattan, Dr. Wheeler, Starla Leete CNM; Emily James NP for GYN

Maternal Mental Health Hotline 833-852-6262 (833-TLC-MAMA)

Postpartum Support Intl. Hotline 800-944-4773 www.postpartum.net

PEDIATRICS:

Castle Rock Medical 307-872-4500

MHSC: Tammy Walker CPNP-PC; Juli Forrester FNP-C 212-7717

Dr. Yeshlur (1101 Gateway Blvd) 307-362-5500

Dentists (RS) Community Health Center 307-212-5116

Dr. Jones – Pediatric (1208 Hilltop Dr #209) 307-362-3395

O'Farrell Family Dental (916 Dewar Dr.) 307-362-1720

Dr. Romney – Pediatric (657 Pilot Butte) 307-362-3125

Drs. Clifford & Olguin (Mtn View exit) 307-786-2273

White Mountain Dental (2701 Foothill Blvd) 307-362-2220

St. Christopher's Highway (Travelers Only) 307-922-2380

Emergency transportation, lodging, food, and clothing. (7 am-9 pm)

Suicide Bereavement Group 207-504-6581

Meets 1st Monday of each month, 6 – 7 pm, at C Street Library, RS

(Jim Horan: Facilitator Email: jimhoran01@yahoo.com Website: survivesuicideloss-wy.com

Suicide Prevention Hotline (800-273-8255) 988
www.suicidepreventionlifeline.org/

Sweetwater County Resources

Thrift Stores:

Broadway Bargains	**307-**362-8128	Thrift store at 429 Broadway (Mon – Fri 10-12 & 1-4; Sat 12:30-4)
Eileen's Attic	307-362-3834	Thrift store at 507 5th Street (Tues – Sat: 10:00 am – 3:00 pm)
Goodwill Industries	**307-**382-8000	1254 Dewar Dr.
St. John's (GR)	**307-**875-5955	68 E 2nd S, Green River
New Life Ministries	**307-**382-4680	Corner of 5th & K Street (Thurs-Sat: 10:00 am – 4:00 pm)
sweetwaterccc@yahoo.com		Sweetwater County Children's Closet: Email to p/u FREE clothing.

Loaves & Fishes soup kitchen	M-F, 12-12:45	Catholic Church: Bridger Ave. & M St.

(Catholic Church 362-2611 for emergency assistance.)

9.4.3 Severe Winter Weather, Barnes County Tabletop Exercise

The Wyoming State Patrol practice of EMS Tabletop Exercise planning was transferred to North Dakota in the first known Severe Winter Weather (SWW) Emergency Exercise Tabletop.

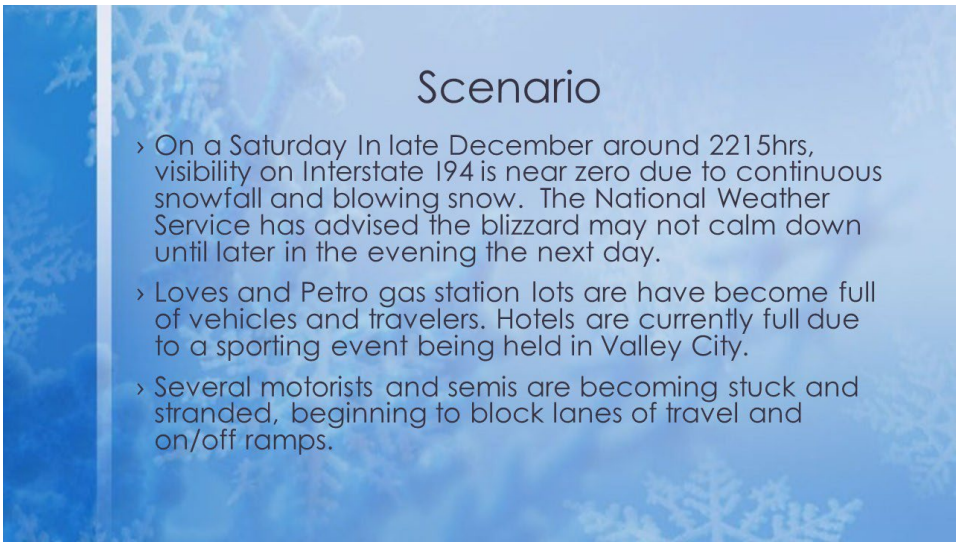
Organizers: Barnes County Dispatch and Barnes County Emergency Management

Duration: Two Hours

Agencies Hosted: Barnes County Sheriff's Department, Barnes County Highway Department, Valley City Police Department, Valley City Public Works Street Department, Gille Auto (towing), North Dakota Highway Patrol, North Dakota Department of Transportation. NDSU-UGPTI was invited to observe the exercise.

Goal: Connecting local and state partners to review response, procedures, and communication during a severe winter weather event.

Scenario: Extended severe winter snowstorm event along I-94, with stranded motorists, blocked roads, and limited hotel space.



Overview:
In an open discussion format, key agencies and critical responders were presented with a severe winter storm scenario. A storm caused near-zero visibility, stranded motorists, and overwhelmed local accommodations for an extended duration. Participants shared their roles, procedures, capabilities, experiences, and available resources in response to severe winter weather. The discussion covered critical topics such as road closures, assisting stranded motorists, managing high-risk areas, ensuring emergency mobility during closures, and safely and efficiently reopening roadways to conclude the scenario. The casual, participatory format was valuable in the process of maximizing safety and minimizing mobility disruptions from severe winter weather. The group had several learning points:

policy clarification, standard operating process refinement, TIMS training/participants, and critical state information streams.

Tabletop Semi-Structured Open Discussion Framework:

- What is the process to determine interstate closure?
  - How are interstate closure points/times determined?
  - Who has the authority to close local roads?
- Once the decision to close interstate is made, what is the chain of events for notifications?
  - Public agency
  - General public
- How to manage and coordinate for stranded motorists?
  - Managing truck parking
    - Agreements to utilize lots for truck parking pre-storm
    - Information on local resources
  - Managing rural stranded people/motorists
    - Vehicles located abandoned – ARE or NOT a traffic hazard
    - Towing Data Management – limitations, documentation best practices?
    - Local club or agency snowmobile or side-by-side options for rescues?
  - Managing the influx of people with limited resources: food, restrooms, parking, sleeping
    - Temporary emergency shelters
    - Red Cross Trailers and other emergency resource inventory and pre-storm staging plan
  - Emergencies during road closures
    - Medical, fire, etc.
    - Power/fuel outages
    - Road plow contacts/resources
- What determines the interstate road recovery is sufficient to reopen?

Figure 38. Barnes County Severe Winter Weather Tabletop Event

9.4.4 Barnes County Traveler Information Tri-Fold Brochure

Slide 1

Important Numbers

Emergencies
911
Barnes County Sheriff's Office
701-845-8530
Valley City Police Department
701-845-3110
ND Highway Patrol
800-472-2121
or 701-328-9921
Mercy Hospital
701-845-6400

Tow Wrecker Service
Gille Auto..... 701-845-0171

Fuel Delivery Service
Kotaco Fuel & Propane
(cash on delivery service)
701-845-0732

VC Taxi Service.... 701-840-1406

ND Roads & Travel 511
ND Roads Map
https://travel.dot.nd.gov

Local Radio
KOVC ..... 1490 AM
KQDJ .....101.1 FM
KYNU .....95.5 FM
KFNW .....97.9 FM
KRVX .....103.1 FM
Local Weather
WXK42 .....162.475MHz

Truck Parking/ Fuel Areas

I-94:
Exit 307
-Tower City Travel Stop
24 hr pumps (Tractor Trailer & Auto)
Exit 304-305
-Oriska Rest Area
Exit 294
-ND Wintershow
Exit 292
-Love's Travel Stop
-24 hr pumps (Tractor Trailer & Auto)
- Petro Serve USA
-24 hr pumps (Tractor Trailer & Auto)
Exit 290
-Grace Free Church

Hwy 46/Hwy 1 South:
-City View Gas Station 24 hr pumps
Hwy 1 South:
-Cenex Gas Station Litchville
Hwy 1 North:
-Rogers Elevator
Old Hwy 10:
-Didier's Ag Sanborn
24 hr pumps (Tractor Trailer & Auto)
Hwy 9:
-Cenex Wimbledon
24 hr pumps (Tractor Trailer & Auto)

Barnes County Traveler Information

QR Code Quick Reference

Alert Barnes County Everbridge Sign-up

Barnes County Dispatch Facebook

ND DOT Road Conditions Map

Slide 2

Hotels

AmericInn
701-845-5551
Bridges Bar & Grill
701-845-9899
280 Wintershow Rd

EconoLodge
701-845-5333
Tavern 94 Bar & Grill
701-845-2525
455 Wintershow Rd

Grand Stay Inn
701-490-3500
271 Wintershow Rd

All hotels can be reached by Exit 292 or 294

Food Options

Delivery
Jimmy's Pizza
701-845-1234
Pizza Corner
701-845-3423
Pizza Ranch
701-845-4455

Door Dash
Burger King
701-845-5275
McDonald's
701-490-3637
Casey's Pizza
701-845-6279
Subway
701-845-5489
Dairy Queen
701-845-2622
Taco Johns
701-845-5495
James Bon Bon (Thai)
701-490-4854

Additional Restaurants
Budget Burger
701-845-1918
VC Eagles Club
701-845-2192
Kirin House
701-845-9998
El Valle Taco
701-490-3460
Sabir's Dining & Lounge
701-845-0274
Trestle's Bar & Grill
701-845-4626
Wild Prairie Bakery
701-490-3393

Additional Resources

Valley City Veterinary Hospital
701-845-3662
24 hour Emergency On-call
& Boarding Facilities

Salvation Army
701-252-0290
(Based out of Jamestown)

Maytag Laundry
231 8th Ave SW, Valley City
8am-8pm

Truck Service/Repair
Berger Auto & Diesel Repair
701-845-4989
Love's Travel Stop
701-760-5015
Puklich Chevrolet
701-712-9617
Quality Alignment
701-845-0060
Quality Auto Body
701-845-4844
RKS Sales & Service
701-845-0229
Stoudt/Miller Dealership
701-845-1671
Valley Service
701-845-1020
Wendel Auto Body
701-845-5026