COLORADO
Department of Transportation
Freight Mobility & Safety Branch

Colorado Freight Plan

Technical Analysis

2024

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List of Abbreviations

AADT	Average Annual Daily Traffic
AADTT	Average Annual Daily Truck Traffic
AAR	Association of American Railroads
AASHTO	Association of State Highway and Transportation Officials
ACMI	Aircraft, Crew, Maintenance, Insurance
ACT rule	Advanced Clean Trucks rule
ADAS	Advanced Driver Assistance Systems
ADS	automated driving system
AFB	Air Force Base
AI	artificial intelligence
AID	Accelerated Innovation Deployment
AQCC	Air Quality Control Commission
ATP	Assembly, Testing, and Packaging
ATRI	American Transportation Research Institute
AV	automated vehicle
B2C	business-to-consumer
BCO	beneficial cargo owners
BIL	Bipartisan Infrastructure Law
BTE	Bridge and Tunnel Enterprise
CRS	Colorado Revised Statute
CAGR	compound annual growth rate
CASP	Colorado Air and Space Port
CAV	connected and automated vehicle
CCTV	closed-circuit television
CDL	commercial driver’s license
CDLPI	Commercial Driver's License Program Implementation
CDOT	Colorado Department of Transportation
CDOT-OTIS	Colorado Department of Transportation-Online Transportation Information System
CDPHE	Colorado Department of Public Health and Environment
CFP	Colorado Freight Plan

CHIPS	Creating Helpful Incentives to Produce Semiconductors for America
CLEAR	Colorado Low Emission Automobile Regulation
CMAQ	Congestion Mitigation and Air Quality
CMCA	Colorado Motor Carriers Association
CMV	commercial motor vehicle
CPW	Colorado Parks & Wildlife
CRFC	Critical Rural Freight Corridors
CRS	Colorado Revised Statute
CSP	Colorado State Patrol
CUFC	Critical Urban Freight Corridors
DCFC	direct current fast charging
DEN	Denver International Airport
DERA	Diesel Emissions Reduction Act
DG-QRAM	Dangerous Good Quantitative Risk Assessment Model
DI	disproportionately impacted
DOD	Department of Defense
DOT	department of transportation
DRCOG	Denver Regional Council of Governments
DRO	Durango-La Plata County
EDL	electronic data logger
EIAF	Energy/Mineral Impact Assistance Fund
EJMT	Eisenhower-Johnson Memorial Tunnel
EPA	Environmental Protection Agency
EV	electric vehicle
FAA	Federal Aviation Administration
FAC	Freight Advisory Council
FAST Act	Fixing America's Surface Transportation Act
FFSS	fixed fire suppression system
FHWA	Federal Highway Administration
FIP	Freight Investment Plan
Fleet-ZERO	Feet Zero-Emission Resource Opportunity
FMCSA	Federal Motor Carrier Safety Administration

FPWG	Freight Plan Working Group
FRA	Federal Railroad Administration
FSP	freight signal priority
FTG	Front Range Airport
FY	fiscal year
GHG	greenhouse gas
GIS	Graphical Interface System
GJT	Grand Junction Regional
GPS	Global Positioning System
HDN	Yampa Valley Regional Airport
HDV	heavy duty vehicle
HP	high priority
HP-ITD	High Priority Innovative Technology Deployment
HSIP	Highway Safety Improvement Program
HUTF	Highway User Tax Fund
HVAC	heating, ventilation, and air conditioning
IH	Interstate Highway
IHS	Interstate Highway System
IIJA	Infrastructure Investment and Jobs Act
INFRA	Nationally Significant Multimodal Freight and Highway Projects Program
IT	information technology
ITD	Innovative Technology Deployment
ITS	Intelligent Transportation Systems
JOA	Joint Operating Agreement
JPAC	Joint Project Advisory Committee
LED	light-emitting diode
LEV	Low Emission Vehicle
LVC	Longer Vehicle Combination
M/HD	Medium- and Heavy-Duty
MAP-21	Moving Ahead for Progress in the 21st Century
MEGA	National Infrastructure Project Assistance Program
MOU	Memorandum of Understanding

Mph	miles per hour
MPO	Metropolitan Planning Organization
N/A	not applicable
NAACP	National Association for the Advancement of Colored People
NACFE	North American Council for Freight Efficiency
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
NBI	National Bridge Inventory
NCHRP	National Cooperative Highway Research Program
NDAA	National Defense Authorization Act of 2021
NESCAUM	Northeast States for Coordinated Air Use Management
NFPA	National Fire Protection Association
NHFN	National Highway Freight Network
NHFP	National Highway Freight Program
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NPMRDS	National Performance Management Research Data Set
NWCCOG	Northwest Colorado Council of Governments
OSOW	oversize and overweight
PD	Policy Directive
PHFS	Primary Highway Freight System
PHMSA	Pipeline and Hazardous Materials Safety Administration
PM	particulate matter
POE	port of entry
PPP	Power Projection Platform
PROTECT	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation
PSR	Precision Scheduled Railroading
PTC	Positive Train Control
QQ	Quality/Quantity
QRAM	Quantitative Risk Assessment Model
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
RDC	Automobile Retailer

REV	Regional Electric Vehicle
REX	Rockies Express Pipeline
RMI	Rocky Mountain Industrials, Inc.
RnR	Risk and Resilience Analysis Procedure
ROW	Right of Way
RR	railroad
RSTP	Rural Surface Transportation Grant Program
RTD	Regional Transportation District
SAE	Society of Automotive Engineers
SCOHT	Special Committee on Highway Transport
SDDC	Surface Deployment and Distribution Command
SGCN	Species of Greatest Conservation Need
SMART Act	State Measurement for Accountable, Responsive and Transparent Act
SPR	State Planning & Research
STAC	Statewide Transportation Advisory Committee
STB	Surface Transportation Board
STIP	Statewide Transportation Improvement Program
STP	Surface Treatment Program
STRACNET	Strategic Rail Corridor Network
STRAHNET	Strategic Highway Network
SWAP	State Wildlife Action Plan
SWP	Statewide Transportation Plan
TAMP	Transportation Asset Management Plan
TBD	to be determined
TMC	Traffic Message Channel
TMS	Transportation Management System
TPA	Truck Parking Assessment
TPIMS	Truck Parking Information Management System
TPR	Transportation Planning Region
TSM&O	Transportation Systems Management and Operations
TTTR	Truck Travel Time Reliability Index
TxDOT	Texas Department of Transportation

UAV	unmanned aerial vehicle
UPRR	Union Pacific Railroad
USDOT	United States Department of Transportation
USMCA	United States-Mexico-Canada Agreement
USPS	United States Postal Service
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
VC	Velocity Center
VEHT	Vehicle Excessive Hours of Travel
VHET	Vehicle Hours of Excess Travel
VHU	Vehicle Hours of Unreliability
VMT	vehicle-miles traveled
WASHTO	Western Association of State Highway and Transportation Officials
WATCO	Rail Operator
WIG	Wildly Important Goal
WIM	weigh-in-motion
WISHH	Western Interstates Hydrogen Hub
ZEV	zero emissions vehicle
ZF	Technologies Company – ZF Friedrichshafen AG

1

Planning for the Future and Delivering for Colorado

1.1 About This Plan

The 2024 Colorado Freight Plan (CFP) guides improvements and investments on the freight systems and supports Colorado's vision of a safe, efficient, coordinated, and reliable system for the movement of goods. This plan supports the Statewide Transportation Plan and serves as a guiding document for ongoing and coordinated planning efforts at CDOT addressing issues such as aviation, passenger rail, transportation system management and operations, transportation safety, and other freight specific studies and analyses. The CFP is a plan for all of Colorado, not just CDOT. Ongoing freight planning and implementation efforts will be supported by the Colorado Freight Advisory Council (FAC) and public agency and private industry partners. The CFP positions Colorado to better understand and improve the complex freight systems that Colorado businesses and consumers rely upon.

The CFP is organized as follows:

- **Chapter 2: Engaging Stakeholders**—A description of outreach efforts and input from freight stakeholders across Colorado. This informs the CFP through the development and leveraging of partnerships between public and private planning partners.
- **Chapter 3: Connecting the Economy**—A description of freight movements by mode into, out of, and within Colorado and foreseen industry trends, such as e-commerce, which may impact them in the future.
- **Chapter 4: Assessing Safety, Mobility, and Asset Conditions on Colorado's Highway Network**—A description of highway assets and their use. This includes the roadway infrastructure as well as other operational support features like truck parking and runaway truck ramps as well as information on safety.
- **Chapter 5: Assessing Safety, Mobility, and Asset Conditions on Colorado's Non-Highway Freight Networks**—A description of non-highway assets, such as rail and air cargo facilities, and their use. This includes the transportation infrastructure along with major freight developments such as inland commercial ports.
- **Chapter 6: Technological and Environmental Tie Ins to Colorado's Freight Network**—A description of upcoming freight technologies, such as drone usage and electric vehicles, as well as impacts of

freight on the environment and how it could be mitigated, such as through the implementation of wildlife crossings.

- **Chapter 7: Moving Forward**—A description of Colorado's freight vision and goals; performance based approach; key strategy and action framework; implementation activities to plan for Colorado's freight future; and how National Highway Freight Funding will be directed within the state.

1.2 Fulfilling Federal Requirements

The Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law (BIL), was signed in November 2021 and replaced prior Federal transportation laws, namely the Fixing America's Surface Transportation (FAST) Act. The IIJA enhanced provisions and provided further guidance on how states should plan for and address multimodal freight issues.

Revised guidance for state freight plans was developed as part of the Bipartisan Infrastructure Law and encompasses 17 required elements. These elements are listed below, along with where within the CFP they may be found.

- Identification of significant freight system trends, needs, and issues (Chapters 4 and 5)
- Description of freight policies, strategies, and performance measures that will guide freight-related transportation investment decisions (Chapter 7)
- Listing of multimodal critical rural freight facilities and corridors; and critical urban and rural freight highway corridors (Appendix A)
- Description of how the plan will improve Colorado's ability to meet national multimodal freight policy goals and national highway freight program goals (Chapter 7)
- Description of how innovative technology and operational strategies that improve the safety and efficiency of freight movement were considered (Chapters 4 through 7)
- Description of improvements that may be required to reduce or impede roadway deterioration from heavy vehicles (Chapters 4 and 7)
- Inventory of freight mobility issues and strategies Colorado is employing to address those issues (Chapters 4 and 7)
- Consideration of significant congestion or delay caused by freight movements and strategies for mitigation (Chapters 4 and 7)
- Freight Investment Plan which includes a list of priority projects and how funds made available to carry out 23 U.S.C. 167 will be invested and matched (Appendix B)
- Most recent commercial motor vehicle parking facilities assessment conducted by Colorado (Chapters 4 and 7)
- Most recent supply chain cargo flows in Colorado, by mode (Chapter 3)
- Inventory of commercial ports in Colorado (Chapter 5)
- Consideration of findings or recommendations made by any multi-State freight compact to which Colorado is a party (Chapter 1)

- Impacts of e-commerce on freight infrastructure in Colorado (Chapter 3)
- Considerations of military freight (Chapter 5)
- Strategies and goals to decrease the severity of impacts of extreme weather and natural disasters on freight mobility; impacts of freight movement on local air pollution; impacts of freight movement on flooding and stormwater runoff; and impacts of freight movement on wildlife habitat loss (Chapters 6 and 7)
- Consultation with the Colorado Freight Advisory Committee (Chapter 2)

1.3 Aligning with Colorado's Statewide and Regional Planning

CDOT's roadmap for the next 25 years is the Statewide Transportation Plan (SWP). This plan identifies future needs for Colorado's transportation system and provides strategic direction to meet these needs. The 2045 SWP balances the need for Colorado to maintain the existing system along with important needs to expand the system to provide more travel choices, and to increase efficiency and safety.

The three goal areas are defined as: Mobility, Safety, and Asset Management

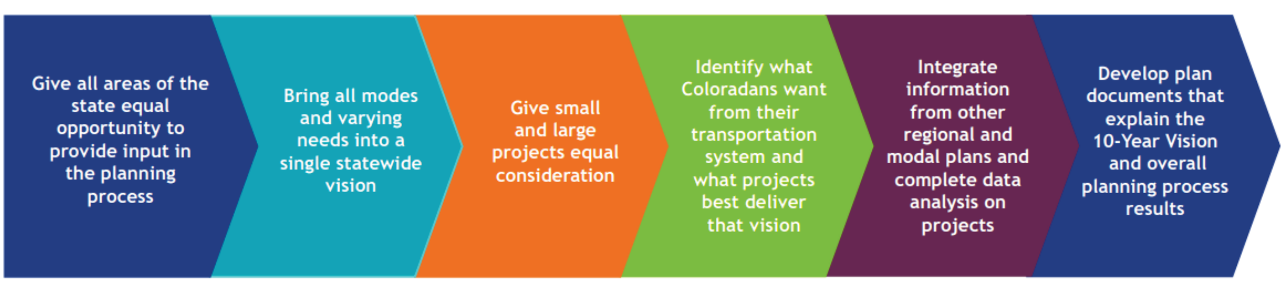
Mobility:
Reduce travel time lost to congestion and improve connectivity across all modes with a focus on environmental impact, operations, and transportation choice statewide.

Safety:
The future of Colorado is zero deaths and serious injuries so all people using any transportation mode arrive at their destination safely.

Asset Management:
Maintain a high-quality transportation network by working to maintain a state of good repair for all assets and a highly traversable road network.

The statewide planning process is a continuous cycle with work on plan development, stakeholder outreach, performance management, and implementation steps in preparation for the update of the plan every five years. The high level steps of this process are shown in the graphic below.

Figure 1.1 Statewide Planning Process



The SWP is the umbrella for CDOT's family of regional, modal and operational plans including: safety, operations, asset management, transit, freight and passenger rail, and the CFP. These plans are fully integrated and support the overall goals of the state to ensure that CDOT is moving forward with policies and projects that leverage limited funding and provide the best return on our investments.

For the CFP, the SWP provides high-level guidance and sets strategic goals. The CFP goals, discussed further in Chapter 7, are aligned with statewide goals, objectives, and performance measures. The CFP focused on extensive stakeholder outreach and data analysis to develop strategic priorities, identify needs, and develop an investment approach specific to the multimodal freight system. The CFP's priority strategies and implementation recommendations support and advance the SWP and will be integrated into future statewide plans.

1.3.1 Other Statewide Planning Efforts

The CFP is not the only freight-specific planning effort in Colorado. CDOT continuously examines the needs of Colorado's freight systems and freight-reliant businesses to address critical issues. CDOT develops statewide plans that address safety, asset management, freight and passenger rail, mobility and operations, and other critical issues and modes of transport and these prior planning efforts help to inform the CFP. The following section provides a summary of recent plans relevant to the CFP. Additional information and plans can be found online through CDOT's website.

Colorado State Freight and Passenger Rail Plan, CDOT Division of Transit and Rail, 2018. This plan is the most recent comprehensive plan to address freight and passenger rail transportation across the state. The rail plan defines a vision and goals for Colorado's rail systems; analyzes the role of rail in state and regional economies; identifies current conditions, needs, and issues; and develops implementation actions to keep Colorado moving by rail.

Smart Mobility Plan, CDOT Division of Mobility and Operations, 2019. This plan established a vision for maximizing the benefits of new transportation technologies and defines goals to improve safety and efficiency through the use of those technologies. This plan will help CDOT identify and prepare assets, data management, communications systems and infrastructure to facilitate technologies, including connected and autonomous commercial vehicles.

Statewide Transportation Demand Management Plan, 2019. This plan was developed in two phases to establish statewide operations and management strategies and to identify potential congested highway corridors which may receive benefits from implementing demand management strategies, including technologies and operational tactics benefiting commercial vehicles.

Colorado Strategic Transportation Safety Plan, 2020. This statewide safety plan established a collaborative and shared vision and mission for transportation safety in Colorado. This plan identifies the key safety needs in Colorado for guiding investment decisions towards strategies and countermeasures with the highest potential to save lives and prevent injuries.

Transportation Asset Management Plan, 2022. This plan describes how CDOT will manage all transportation assets effectively. This will enable CDOT to support, maintain, and expand the transportation system, and to play a proactive role in the economic vitality of the state and quality of life of its people.

I-70 Corridor Risk and Resilience Pilot, 2017. This study developed a data-driven approach to proactively identify and address vulnerabilities of the transportation system from potential physical threats such as rock fall, flooding, and landslide. The plan will help CDOT identify the most cost-effective solutions for I-70 that can be implemented at specific sites to reduce risk from future hazard events and improve system redundancy, including commercial vehicle travel along critical interstate routes.

Truck Parking Assessment, 2019. This assessment update's CDOT's inventory of truck parking space, quantifies current and future truck parking needs, and recommends solutions for alleviating shortages. The incorporation of this plan into the CFP is one of the required Federal elements.

This previously completed work by CDOT is incorporated and updated throughout the CFP to ensure that prior planning efforts and outreach are considered as CDOT determines the goals and strategies to enhance Colorado's freight system.

1.4 Cooperation with Colorado's Neighboring States

The national freight network and supply chains transcend state boundaries, necessitating cooperation with neighboring states to create the most efficient freight network. Summarized below are several associations and initiatives CDOT is involved with.

Western Association of State Highway and Transportation Officials (WASHTO). CDOT is actively involved with WASHTO at all levels, coordinating with state department of transportation(DOT) officials from other western states to advance transportation policies, legislation, and initiatives important to Colorado.

WASHTO Special Committee on Highway Transport (SCOHT). SCOHT, in partnership with the motor carrier industry, promotes uniform laws, regulations and practices among member jurisdictions and other jurisdictions for the efficient movement of goods and services while ensuring the safety of all highway users and preserving the highway infrastructure. A focus of this committee is to promote standardization of laws, rules, and regulations relating to the movement of over-dimensional loads between states. CDOT was instrumental in forming and leading a Freight Planning subcommittee to SCOHT whose mission is to "facilitate, through multi-state coordination, efficient, safe, sustainable, and forward-looking multimodal freight transport across the Western U.S., helping to foster economic opportunities." The Freight Planning subcommittee is comprised of state DOT freight planners and program managers who meet virtually every other month to share best practices and coordinate freight planning efforts.

Mountain Rules Campaign. CDOT developed this leading edge communication program to inform and educate in-state and interstate trucking companies and drivers on the challenges of driving in Colorado's mountains. It includes information on preventing and avoiding hazards, resources to consider, and a consistent reminder to drive slowly and steadily to be safe for the long haul. CDOT's partners in this effort are the Colorado State Patrol, Colorado Motor Carriers Association, and in-cab driver alert providers, PrePass Safety Alliance and Drivewyze. CDOT has shared this program with several motor carrier associations, state DOTs, and commercial vehicle enforcement agencies outside of Colorado.

Ports of Entry and Weigh-In-Motion Stations. There are ten stationary port of entry (POE) facilities located in key positions throughout the state on major highways that a motor carrier operator would use to either enter or exit Colorado. CDOT is conducting a site inspection of each POE location and weigh-in-motion (WIM) system to identify and prioritize the needed improvements, and secure funding to repair or replace WIM scales.

Project Coordination. In addition, and as applicable, CDOT coordinates regularly with neighboring states on freight projects near state borders. For instance, CDOT is currently coordinating with New Mexico DOT to address truck parking and chain control needs on I-25 at Raton Pass.

Regional Electric Vehicle (REV) West. Colorado, in partnership with Arizona, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming, has signed the REV West memorandum of understanding to create an Intermountain West Electric Vehicle (EV) Corridor to make it possible to drive an EV across the Signatory States' major transportation corridors. Signatory states committed to educate consumers on EVs to reduce range anxiety and increase EV adoption, coordinate on charging stations, apply minimum standards for charging stations (related to site selection, access, power output, signage, uptime, and others), incorporate EV charging stations into planning and developing (including in building codes, metering policies, and renewable energy generation projects), encourage manufacturers to stock a wide variety of EVs, collaborate on funding opportunities, and support buildout of direct current fast charging (DCFC) along EV corridors. Senior leadership from each state meet on a quarterly basis and report on progress. [1]

Western Interstates Hydrogen Hub. Colorado, New Mexico, Utah, and Wyoming signed a Memorandum of Understanding (MOU) in 2022 to coordinate, develop, and manage a regional clean hydrogen hub called the Western Interstates Hydrogen Hub (WISHH). The states applied for a portion of the $8 billion allocated in the 2021 Infrastructure Investment and Jobs Act towards four or more regional hydrogen hubs. [2]

[1] https://www.naseo.org/issues/transportation/regional-collaboration.

[2] https://energyoffice.colorado.gov/climate-energy/western-interstates-hydrogen-hub.

2

Engaging Stakeholders

CDOT is committed to fostering a collaborative freight planning process through partnerships with businesses, agencies and guidance from the FAC. Building upon the 2019 Colorado Freight Plan, the 2024 CFP collects conversations, concepts and feedback from freight planning partners ranging from the traveling public, advisory committees and industry personnel.

This chapter outlines how CDOT engaged with key stakeholders and community members, with particular consideration of disproportionately impacted (DI) communities. Ongoing outreach will continue as CDOT implements the 2024 CFP to advance future freight solutions.

2.1 Outreach and Engagement Activities

To ensure the CFP considers the concerns and needs of all stakeholders, the plan development process involved extensive outreach to members of the traveling public, DI communities, freight-reliant businesses, freight service providers, economic development representatives, local and regional planning partners, regulatory agencies, and municipal committees and councils with a significant role in freight transportation. For a complete list of businesses, agency partners, industry representatives and stakeholders that participated through outreach and engagement activities see the Section 2.5.

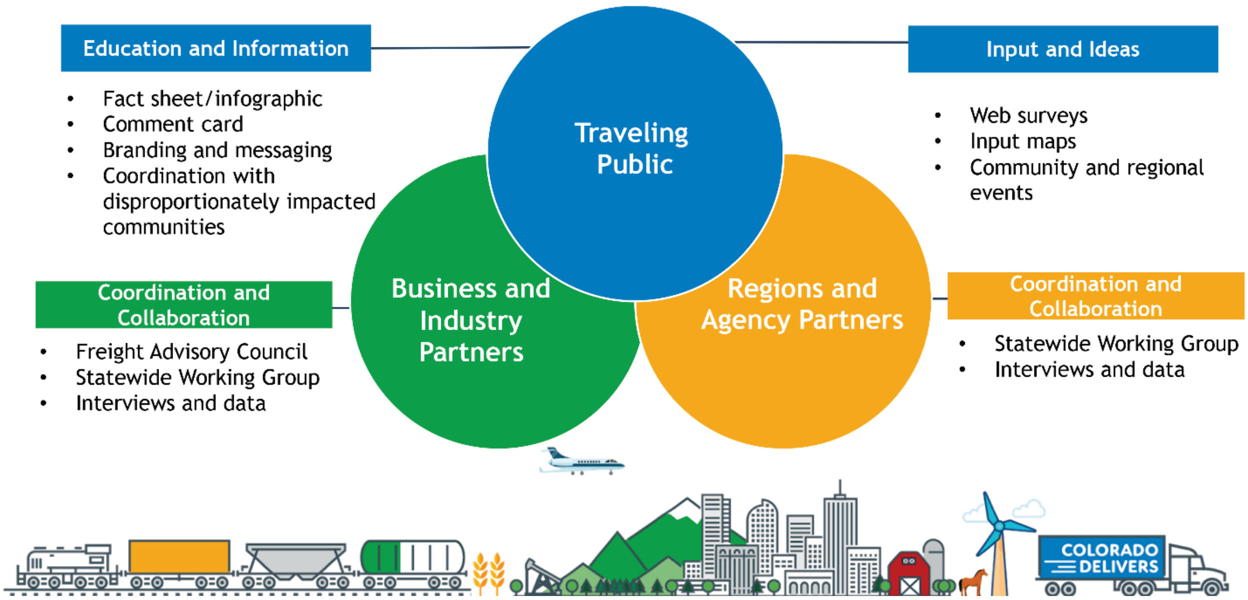
General stakeholder feedback gauged online shopping expectations as related to cost, reliability and efficiency, overall perception of trucks in Colorado, and how the state should prioritize transportation dollars for freight delivery of products and packages. CDOT compared information gathered from stakeholders to the department's Wildly Important Goals (WIGs) of fiscal year 2023-24 which include: Advancing Transportation Safety, Accountability and Transparency, and Clean Transportation. CDOT's WIGs are ambitious, short-term goals that align the Governor's Key Priorities with the CDOT's strategic priorities.

Feedback from industry and business partners addressed what is necessary for maintaining a business in Colorado, the costs of congestion to those businesses and what factors preclude improving operational efficiencies. They also indicate perspectives for how existing infrastructure compares to the rest of the Nation, the rate at which businesses adopt technology efficiencies for the near future, and identify business priorities for freight policies and investments.

2.1.1 Engagement and Outreach Approaches

Stakeholders participated in the development of the 2024 CFP by attending meetings, writing emails, providing ideas at in-person events, filling out surveys and by responding to social media posts. Figure 1 below illustrates CDOT's approach to outreach and engagement.

Figure 2.1 Engagement and Outreach Approach

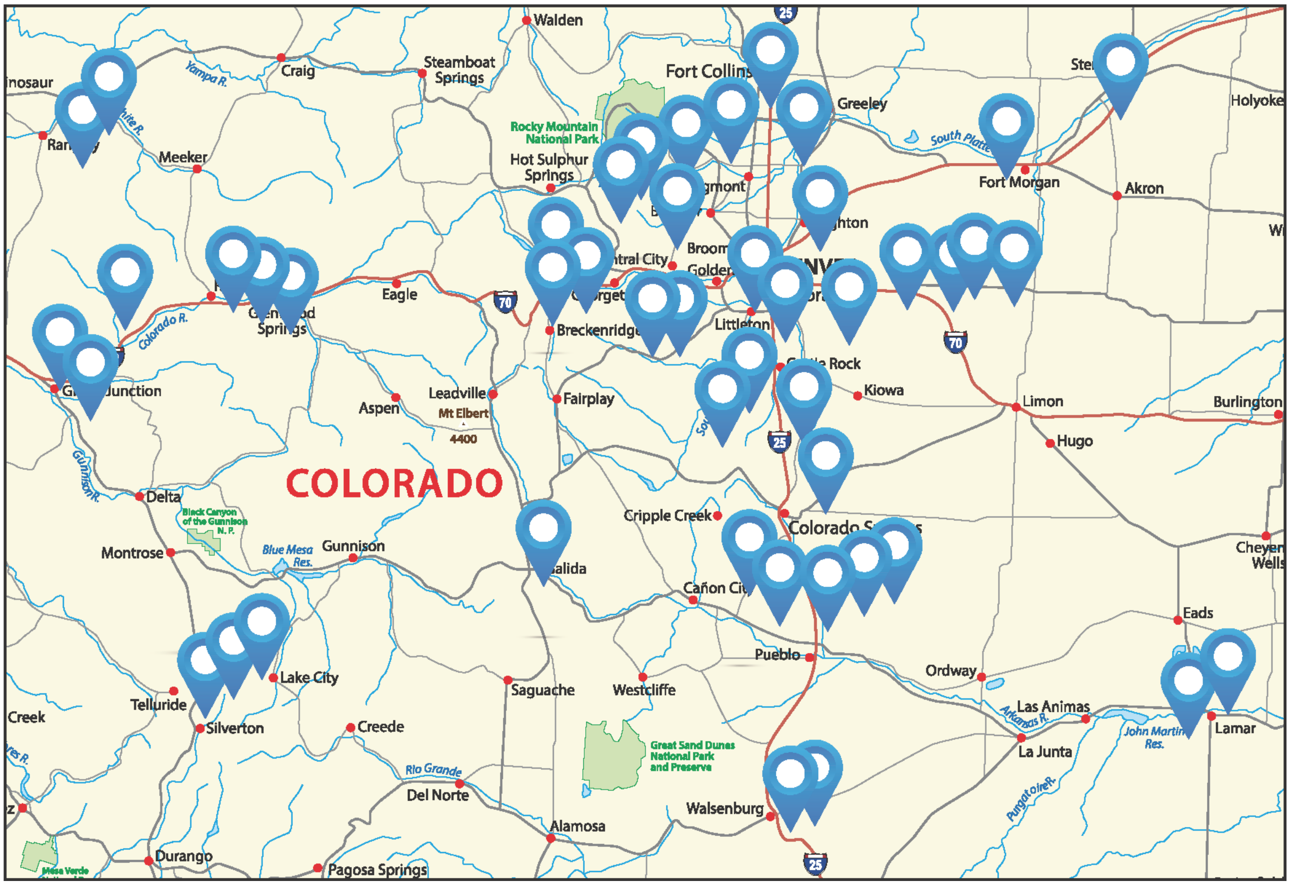


2.1.2 Stakeholder Surveys

CDOT surveyed a variety of statewide stakeholders on the future of freight solutions in Colorado. One survey addressed the needs of industry while the other focused on the needs and opinions of the general public. They were available between September and December 2023; stakeholders received them at in-person events, via email, and posted online through CDOT's social media platforms. Available in English and Spanish, in print and digitally, the surveys reached more than 380 people.

The map below shows the geographic distribution of responses across the state. An analysis of survey responses is available in later sections of this chapter.

Figure 2.2 Colorado Freight Plan Survey Participants



2.1.3 Committee and Working Group Involvement

To guide the CFP development, CDOT engaged businesses, freight transportation providers, industry representatives, local governments, regional planning organizations, state agency partners, a plan-development working group, and elected officials who served as members of advisory committees. Together, these stakeholders supplied information, recommendations, and insights to shape an implementable and actionable plan that can proactively address Colorado's freight issues and priorities.

CDOT appreciates the following partners who contributed to and guided the CFP:

- Created by state statute (CRS 43-1-11, Transportation Planning), the **Statewide Transportation Advisory Committee (STAC)** advises CDOT on transportation needs in Colorado, including budget and finance decisions, the statewide transportation improvement program, transportation planning, and state policies. STAC members include elected officials and regional planning staff from each of Colorado's Transportation Planning Organizations and Tribal governments. STAC acted as a forum for the meaningful discussion of regional freight transportation issues, providing feedback and guidance to CDOT on key strategies within this plan.
- Established in 2015, the **Colorado FAC** provides an independent forum where private-sector and public partners work together to advocate for commercial transportation, influence transportation policy,

and effectively collaborate to implement solutions. The FAC and includes over two dozen public and private-sector representatives from key industries, associations, transport modes, and planning partners. This council reviewed state and regional freight-related issues and guided the development of key strategies and recommendations included within this plan. The FAC will continue to work on freight planning efforts, including ongoing implementation of the CFP.

Colorado Freight Advisory Council

Advocate. Collaborate. Connect. Deliver.

- A **Freight Plan Working Group**, composed of members of the FAC's Steering Committee, met bimonthly throughout planning efforts to evaluate key findings and outreach results, identify and prioritize needs and issues, and provide critical oversight to support the strategic direction of the CFP. Working Group members, highlighted in Figure 2.3 below, included representatives from geographically diverse regions in Colorado; they included participants from fields such as shipping, trucking carriers, railroads, production and more.

Figure 2.3 Participating Organizations in the Colorado Freight Plan Working Group

- A **Public Working Group** allowed additional statewide stakeholders to hear about the CFP and offer feedback. CDOT hosted two virtual meetings throughout the planning process. The first provided an overview of the CFP process and its components, while delineating elements outside of its scope. Members learned about and discussed the timeframe, the requirements to complete it, and CDOT's strategies for engagement and outreach. The second virtual meeting highlighted the finalization of the plan, reviewed feedback gathered from statewide surveys, and focused on policy-driven strategies to meet freight plan goals.

2.2 Methods of Outreach and Key Themes

This section summarizes key issues and common themes identified from reviewing stakeholder feedback. It captures themes extrapolated from input received through various engagement methods during the plan's development.

Outreach targeted a wide range of constituents across the state, accounting for regional diversity and inclusive efforts to gain feedback from Colorado's multivarious DI communities. In addition to surveys, CFP outreach strategies included the creation and distribution of fact sheets, webpage content, social media engagement and other media. Materials incorporated English and Spanish. CDOT attended several community events throughout the state to facilitate direct interpersonal exchanges with citizens about freight priorities.

CDOT's outreach to stakeholders such as the traveling public and business partners will continue beyond this planning effort with ongoing public communications campaigns. Future topics will include the movement of goods and the links between transportation and economic competitiveness. These continuing efforts will provide educational and engagement opportunities between CDOT and the public, industry representatives and businesses who shape Colorado's transportation future.

2.2.1 DI Community Outreach and Engagement

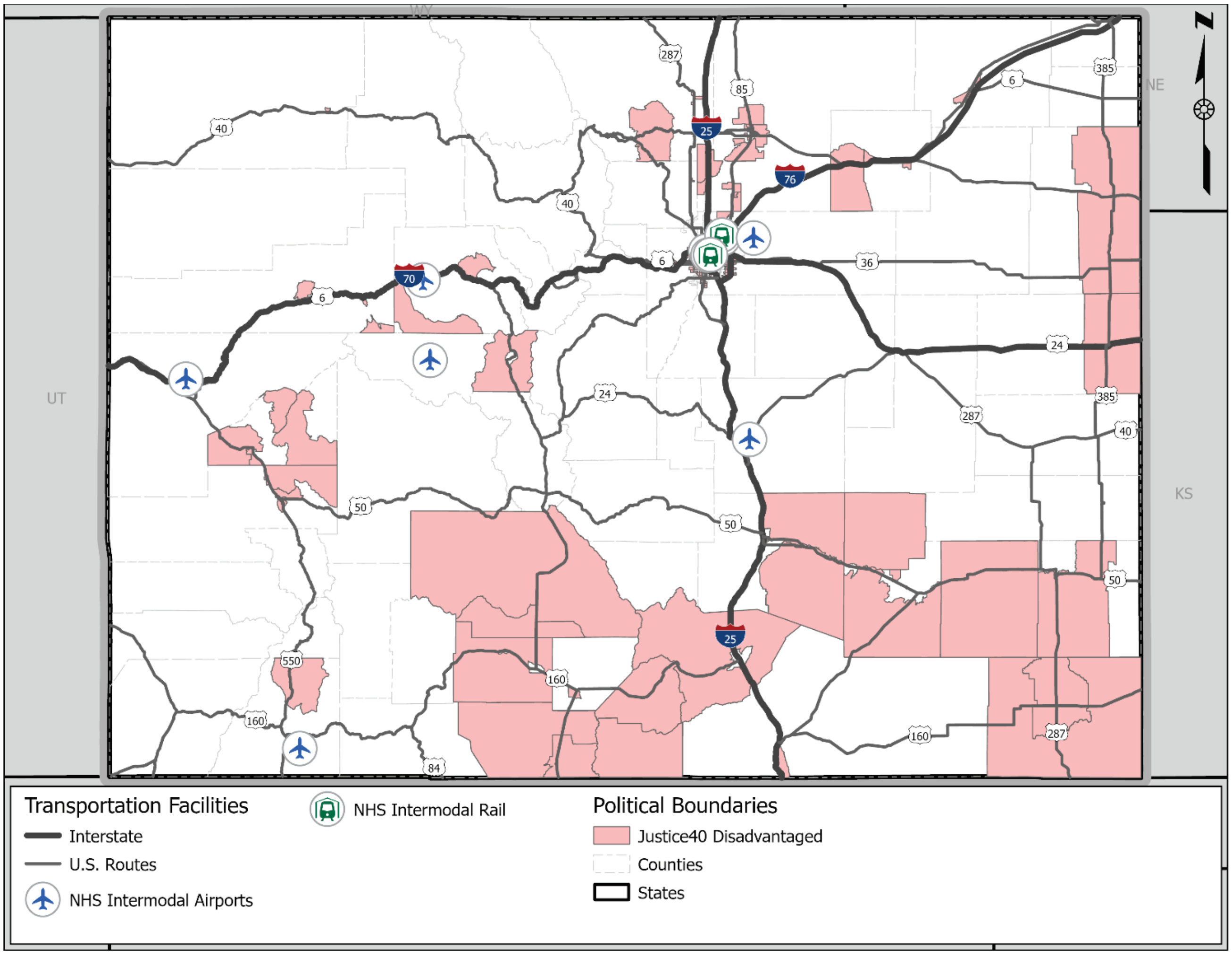
Integral to outreach and engagement efforts is demonstrating CDOT's focus on equity and inclusion. One of the 2024 CFP's central goals has been to adopt methods that specifically include DI community members (as defined by HB23-1233) and, in turn, incorporate their concerns directly into the development of freight initiatives.

In Colorado, this includes areas and populations historically and disproportionately impacted by exclusionary policies. The importance of such outreach helps to identify potential environmental justice impacts among members of all Colorado communities. CDOT partnered with a broad network of nonprofit organizations, Government agencies and community leaders to distribute the CFP survey to historically DI communities. The following partners helped ensure extensive and inclusive outreach:

- Office of International and Immigrant Affairs (City of Aurora)
- Adelante Community Development (Commerce City)
- Office of Immigrant and Refugee Affairs (City and County of Denver)
- Denver Indian Center (West Denver)
- Latino Northern Colorado Podcast (Ft Collins)
- Servicios de la Raza (Pueblo Branch)
- African Leadership Group (Aurora)
- Vietnamese Network (West Denver)

From the outset, the CFP's development relied on consultations with CDOT's Environmental Justice and Equity Branch. This interaction helped ensure a more equitable outreach process—developing survey questions, creating media content and targeting events that prioritized inclusive methods of engagement. Recognizing that diversity and inclusion are ongoing processes, CDOT created a series of environmental justice maps. Figure 2.4 identifies traditionally excluded communities in Colorado and guided outreach strategies throughout the state.

Figure 2.4 Statewide CDOT Environmental Justice Outreach Map



Source: USDOT Justice40 Overall Disadvantaged, 2022.

CDOT consulted these maps alongside relevant transit reports, freight issues and statistics specific to each area. Such data ensured the prioritizing of thoughtful conversations about their interests and concerns of multifaceted communities throughout the state.

2.2.2 *In-Person Engagement Events*

Attending multiple events allowed CDOT to gain specific insight into the freight priorities of many of Colorado's geographically diverse communities. At each, opportunities for engaging directly with residents resulted in meaningful conversations, sometimes the first opportunity to have these dialogues, regarding the future of freight and infrastructure. This section includes key themes and responses from each of those events.

There were dozens of interactions and exchanges between project team members and the general public at these events, with more than 200 handouts, stickers and fact sheets distributed.

Colorado Springs Labor Day Lift Off, Sept. 2-4 (CDOT Region 2)

One of the ten largest balloon events in the country, the annual Labor Day Liftoff attracts thousands of visitors from around Colorado. Centrally located in southern Colorado Springs, the event represents a cross-segment of Coloradans. As a center for military activity, many conversations revolved around military readiness and its effects on local infrastructure. Other comments focused on the viability of commercial trucking. Examples include:

- "Fort Carson has a flat-bed problem. With the amount of trucks entering—and the amount of construction clogging up the area—it's near impossible for military interests to share those roads with commuters."
- "I wanna talk about how inefficient the area south of the Springs is getting [Fort Carson]. More rail could help alleviate the clogging."
- "Commercial driver's licenses are too cost prohibitive. It is getting more difficult to recruit and retain young drivers. Maybe CDOT and other agencies could create scholarships or help incentivize drivers specifically in Colorado."
- "I wish there were more ways to better educate the public about how hard it is to drive freight."

Grand Junction Downtown Car Show, Sept. 16 (CDOT Region 3)

Every year, 2,500-5,000 car enthusiasts descend upon downtown Grand Junction to examine the latest vehicle models and the best rides of the recent past. The 2023 show had many registrants, including for the first-time electric vehicles. The freight concerns of the Western Slope are uniquely different from those on the Front Range. Comments reflected this geographic distinctiveness.

- "Mitigation efforts in Glenwood Canyon are not optimal; the cliff keeps coming down and, when it does, everything stops on the Western Slope. Rockslides and floods should alert policy-makers to the fact that drainage and rock wall protections need to be reinforced."

- "Cottonwood Pass is not a good go-around when the Canyon gets closed. Cars and trucks do not mix; S-turns are a nightmare. Roads have to be wider for that to work."
- "Fires are the biggest concern along I-70. The smoke, the danger to the road—especially if bottlenecks occur."
- "Items and goods keep getting discontinued in small Western Slope cities because freight cannot get in. Commerce is in trouble over here."
- "There is a lot of toxic waste being shipped through here—chemicals and minerals from Utah. Transportation of this concerns me a great deal."

Sheridan Celebrates Festival, Sept. 30 (CDOT Region 1)

Sheridan Celebrates is an annual festival where family, friends, community partners and businesses come together. Exhibits include local artists, a parade, food vendors, community organizations and live entertainment. At the crossroads of Denver's suburban and DI communities, comments here reflected growing (sub)urban priorities:

- "Small businesses rely heavily on our freight industry. Sometimes we cannot get our supplies in a timely manner, and that affects our ability to complete customer orders."
- "We need a law that mandates contractors collaborate on the transportation of heavy goods. It's ridiculous if Kraemer orders a load of concrete and Kiewit orders a load of concrete to the same location but needs different trucks for transport when it could have been moved together. What a waste—and is terrible for traffic and the environment!"
- "Small businesses rely heavily on our freight industry. Sometimes we cannot get our supplies in a timely manner, and that affects our ability to complete customer orders."

Lamar Oktoberfest and Car Show, Oct. 7 (CDOT Region 2)

The annual Oktoberfest in Lamar features a slew of local and state vendors. A Chamber of Commerce funded event, the all-day celebration begins with a 5K and, after the vendor-fair closes in the evening, moves into a Biergarten. Lamar sits at the busy intersection of CO 50 and U.S. 287, a major hub in Colorado's eastern plains and a convergence of alternative freight routes to southeastern states (e.g., Kansas, Oklahoma, Texas). The city relies on freight as a source of economic revenue. In addition to service industries, a Port of Entry is on the outskirts of town.

- "Truck traffic is so significant it's destroying roads all around and through the city. It is nearly impossible to keep up with repairing roads at this rate."
- "The Port [of Entry] north of here creates an incentive for drivers. Northbound folks drive through the city because they do not want to be overweight. We get all the southbound traffic because they need gas after the Port."

A near universal theme was the desire for residents to avoid a bypass because of its perceived negative effects on the region's economy:

- "We do not need a bypass; it'll kill our economy. Kill it!"
- "Have you seen what happened to Boise City, [Oklahoma]? After the bypass went in there, the downtown died. Their economy totally cratered. In Lamar, so business has come to Main Street, a bypass around us would be devastating."

2.2.3 *Survey Results: Key Themes*

After a successful outreach campaign, CDOT received more than 380 surveys and 283 comments. Responses highlighted concerns such as roadway safety, infrastructure longevity and multimodal freight solutions. The safety of current transportation methods and the availability of multimodal transportation options also featured prominently.

Figures 2.5 - 2.9 provide deeper insight into results and demographic information regarding the survey's participants. Most survey respondents indicated this was their first time participating in a transportation plan. When asked about trucks in Colorado, with several options to choose from, most respondents understood that trucks are essential to filling store shelves and delivering packages.

When people shop online, they prioritize cost as the most important area for concern. Followed by the reliability of deliveries and then, efficiency, it is clear Coloradans would like freight solutions that address pocketbooks above time and regularity.

When ranking how Colorado should prioritize limited transportation dollars for easier freight deliveries, participants ranked infrastructure maintenance as the top priority, followed by improvements to equity, safety, greenhouse gas, mobility and, finally, freight resiliency. Survey comments confirmed this hierarchy; many of them specifically addressed concerns about the state and the functionality of roads.

Figure 2.5 First-time Participation

Is this your first time participating in a transportation plan?

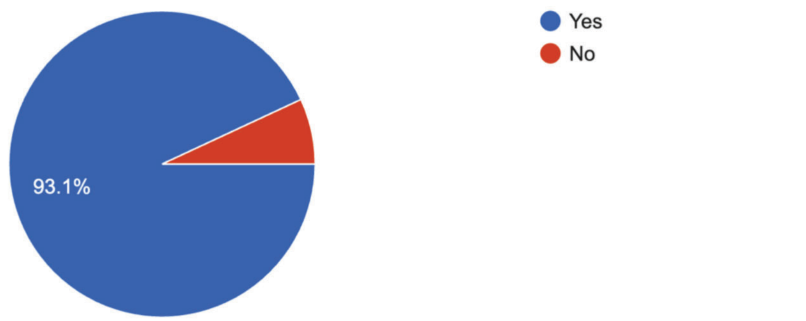


Figure 2.6 Age of Respondents

What is your age?

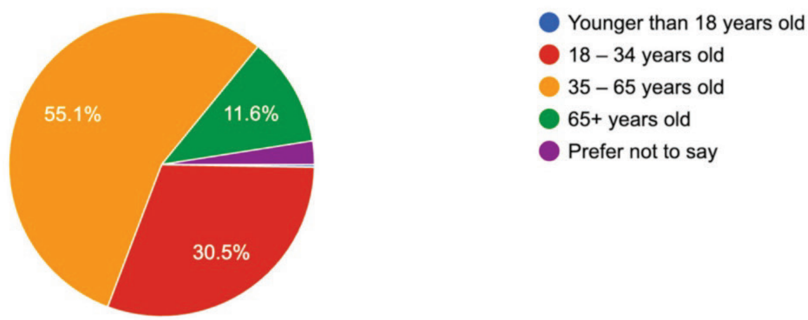


Figure 2.7 Survey Participant by Gender

What is your gender?

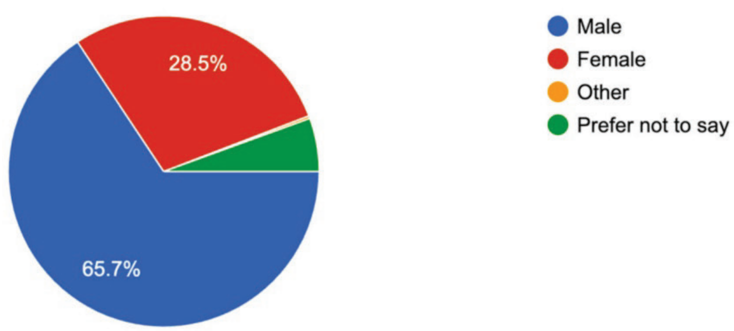


Figure 2.8 Ethnicity of Participants

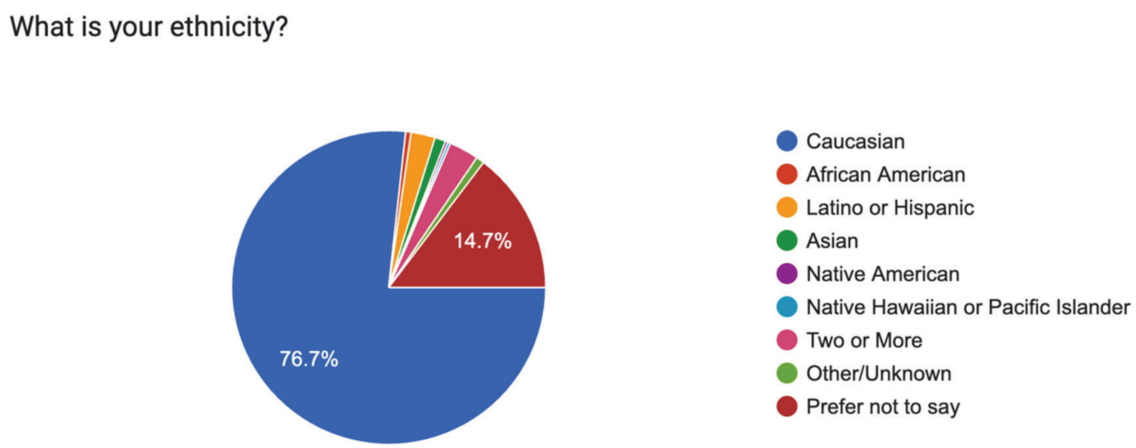
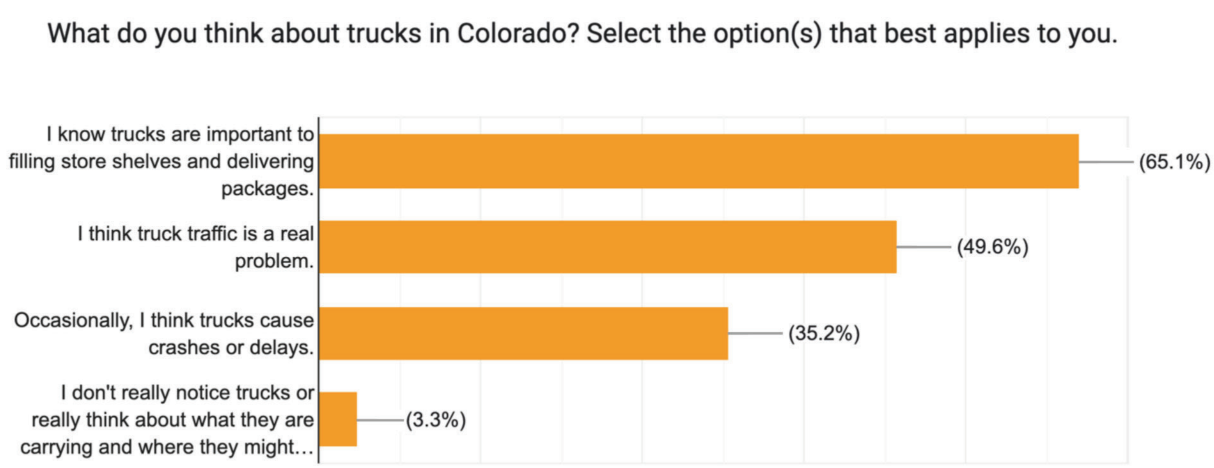


Figure 2.9 Respondents Experience with Trucks in Colorado



2.2.4 Survey Themes

The following is a selection of survey comments. The general themes reflect commonly repeated responses and reinforce CDOT's Wildly Important Goals.

1. **Advancing Transportation Safety:**

   Safety was a top concern for survey respondents. Participants want a Colorado transportation system that allows all travelers to arrive at their destinations safely.

   - More truck parking. Improve road quality. Some parts if I-70 are so dangerous the pavement is so bad. If Kansas can do it Colorado can too!!

- Colorado would benefit enormously in terms of highway safety and congestion easing from an I-70 truck train similar to those in Switzerland that runs between Grand Junction and E-470 interchange in Denver. In such a concept, trucks would drive onto flatcars and drivers could sleep/rest in a passenger train car for the journey between Grand Junction and Denver. CDOT would only need to fund the two terminal sites on either end, and both Union Pacific and BNSF railroads could bid for operations since both railroads have rights to the alignment. For safety reasons, we need to get intermodal and hazardous through-traffic that is not bound for Colorado off of I-70.
- Provide increased public education regarding safe driving practices for private vehicles (cars/trucks) that are sharing the highway with semi trailers.

2. **Accountability and Transparency:**

   Many respondents greatly value freight priorities that ensure an efficient use of taxpayer funds that focus on construction project delivery.

   - Freight traffic causes slowdowns particularly on uphill mountain roads and the extra wear and tear it causes on the roads.
   - From what I have read large heavy trucks disproportionately damage roadways which are funded primarily by the taxpayer. I would like to see fees/costs to trucking/shipping companies that lessons the burdens on taxpayers and disincentivizes damages to our infrastructure. I think bolstering alternative freight options would also help this.
   - Keep up with infrastructure maintenance.

3. **Clean Transportation:**

   Survey participants clearly desired freight policies that work to reduce pollution.

   - Trains seem far more efficient and environmentally friendly. They just take longer.
   - I am concerned about our reliance on trucking over freight rail, when freight rail is better for the environment and safer. I would like to see Colorado prioritize freight rail (and overall) decarbonization, maintenance, safety, and equity. I support and encourage a truck train to take trucks off our roads, especially in the I-70 and mountain corridors. I also want to see CDOT plan with passenger traffic in mind on our rail and freight corridors as well to anticipate population growth and its impact on freight movement.

4. **Efficiency of Statewide Transit:**

   Traffic congestion connected to statewide transit systems and rail services was a significant theme among survey respondents.

   - Trucks should be encouraged to use routes other than the I-70 corridor.
   - Widening and adding to more belt routes eliminates the need for trucks to be in the downtown areas. The Front Range is large enough now for a bigger belt route around Denver between fort Collins and Denver. I-25 should be a priority.
   - Freight transport should be reduced to train bound where applicable.

2.3 Critical Concerns: Industry Stakeholders and Freight Plan Working Group

CDOT engaged industry partners throughout the development of the 2024 CFP. In addition to a survey targeting business and industry stakeholders, outreach included regular meetings with the Freight Plan Working Group (FPWG).

The FPWG included members of the FAC steering committee, industry partners and members of private businesses. The FPWG voiced critical concerns, making recommendations to address freight issues. Concerns reinforced the vision, goals and strategies of the 2024 CFP. The ongoing dialogue suggested areas for investment and criteria to prioritize and assess freight program funding.

The survey asked members of industry about the costs and issues facing operating a business in Colorado. Further, it had respondents identify and prioritize freight barriers that preclude development. Most participants answered that the availability of freight and access to multimodal freight infrastructure (e.g., truck, rail or air) were top priorities. Workforce readiness and financial constraints—such as taxes or the regulatory environment—were also of concern.

The greatest factor survey respondents identified as preventing businesses from improving operational efficiencies was congestion (including traffic caused by the presence of freight). On the other hand, many are optimistic about adopting new technology within the next 5-10 years, including features related to automation, improvements to warehouses, advanced truck features, vehicle location systems, truck platooning, and computer-aided dispatch systems.

Business interests suggested the urgency of equity in freight. Specifically, comments suggest freight policies should prioritize practices that do not negatively impact disadvantaged groups. Partnerships should foster freight networks across modes, jurisdictions and the public-private sector.

The list below identifies broad themes and specific comments the project team gathered from conversations with industry stakeholders in direct communication and via surveys.

1. **Economic Partnerships**

   A common theme for industry and business partners was to improve internal and external networks for growth.

   - Work with rural economic development groups (such as the Farmers Union).
   - Businesses have turned away from our region because we do not have sufficient rail access.
   - We need to be a distribution center and freight hub for the Rocky Mountain Region. We were in the past, but no longer.
   - Coordinating with New Mexico to get rail access to southwest Colorado, and better air cargo service in smaller markets.

2. **Capacity & Bottlenecks**

   Responses focused on barriers to growth included capacity limits and the presence of bottlenecks.

- Finish infrastructure improvements to aid in reducing bottlenecks and allowing new businesses to come to Colorado
- Address unmet demand interests for jobs and capital infrastructure.
- Plan needs to take a closer look at deficiencies in the national highway system through Colorado and a plan to get money for upgrades.

3. **Modal Diversity**

   Participants saw the state prioritizing highway freight often at the expense of other forms.

   - I would like to see a stronger focus by CDOT on rail issues and in the plan areas for funding short line infrastructure needs.
   - The rail industry does not work with/respond to CDOT or local agency staff.
   - CDOT's focus is largely related to highway issues and should be broader to include other modes.
   - We probably need greater involvement from the air freight sector. May look at the fuels sector for greater involvement.
   - Short line railroads are almost always in poor condition because of lower traffic volumes, but are also vital to rural communities.

4. **Safety and Environmental Concerns**

   Often addressed simultaneously, participants often connected safety and innovation to environmental priorities.

   - Identify a realistic (phased) timeframe on implementation of electrification of heavy-duty vehicles and available infrastructure.
   - There should be a bigger focus on highway maintenance and diversity, improved maintenance, and increasing fees and fines.

2.4 Conclusion

Outreach and engagement efforts for the 2024 CFP surpassed those of previous plans in geographic and demographic extent. In addition to a more concerted cultivation of public comment, surveys and other methods reached across Colorado's dynamic and geographically diverse communities to include constituent priorities. Business and industry leaders provided insight into Colorado's freight successes and concerns.

Ongoing efforts will ensure that CDOT continues to include a diverse range of voices in the development of Colorado's freight policies and reflect back up on the efforts gained and comments made from a robust outreach and engagement process.

2.5 List of Participating Businesses, Agency Partners, Industry Representatives and Stakeholders

- Colorado Transportation Commission
- Colorado Traffic Management Center
- Western States Freight Consortium (now WASHTO Freight Planning)
- Colorado Department of Local Affairs
- Colorado Department of Labor and Employment
- Colorado Department of Public Health and Environment
- Colorado Energy Office
- Colorado State Patrol
- National Renewable Energy Laboratory
- Colorado/Wyoming Petroleum Marketers Association
- Farm Bureau
- Department of Housing & Urban Development
- North Front Range Metropolitan Planning Organization
- Boulder East Transportation Options
- Downtown Denver Partnership
- eGo Carshare
- Sand Creek Regional Greenway
- Transportation Solutions
- Northeast Transportation Connections
- Denver South Transportation Management Association
- Commuting Solutions
- The I-70 Coalition
- Smart Commute Metro North and North Area Transportation Alliance
- 21st Century Transportations for Colorado
- Upper Arkansas Area Council of Governments
- San Luis Valley
- Southwest Colorado Council of Governments
- Federal Highway Administration
- E-470
- Jefferson Parkway Public Highway Authority
- MOVE Colorado
- Pro 15
- Action 22
- Colorado Counties Inc.
- Club 20
- Colorado Municipal League
- Colorado Board of Veterans Affairs
- Northwest Parkway
- Regional Transportation District
- Colorado Association of Transit Agencies
- Transit and Rail Advisory Committee
- Roaring Fork Transit Authority
- Bicycle Colorado
- Bike JeffCo
- Bicycle Aurora
- Fort Collins Cycling Club
- Team Evergreen
- Bikes Together
- Broomfield Bikes
- Routt County Riders
- Safe Routes to School Community
- NoCo Bike Ped Collaborative
- Strategic Action Planning Group on Aging

- AARP Livable Communities
- Office of Health Equity at CDPHE
- American Lung Association
- Be Well Health and Wellness
- Rural Health Network
- Center for African American Health
- Department of Local Affairs
- Urban League of Denver
- Family Resource Center Association
- Latino Community Foundation
- Colorado Latino Leadership Advocacy & Research Organization
- 100 Black Men of Denver
- City of Denver African American Commission
- National Association for the Advancement of Colored People (NAACP) Colorado Chapter
- Colorado Black Chamber
- United Way of Pueblo
- Groundwork Denver
- Sustainable Resilient Longmont
- Citizens for Clean Air
- Regional Air Quality Council
- Clean Energy Action
- 350 Colorado
- Colorado Renewable Energy Society
- Western Colorado Alliance
- Inland Ocean Coalition—Colorado Chapter
- Northwest Colorado Council of Governments (NWCCOG) Water Quality/Quantity Committee (QQ)
- Southern Colorado Institute of Transportation Technology

Connecting the Economy

Safely, efficiently, and reliably moving goods is critical for all Coloradans, particularly for exporters, businesses, manufacturers, and farmers and ranchers, as well as visitors in every region of the state. About 18 percent of the state's economy relies on the day-to-day movement of goods as a core business function. [3] With a growing population, expanding economy, and increasing demands on the transportation system, connecting the economy is more critical than ever. This chapter explores the connections between economic competitiveness and Colorado's multimodal freight transportation system.

3.1 Transportation Costs to Business

The Federal Highway Administration's Freight Analysis Framework, version 5.5, estimates that the nation's multimodal freight transportation network carried an average of over 54 million tons of freight worth more than $51 billion per day in 2022. [4] Every carload, truckload, pallet, box, and package represents critical inventory, supplies, inputs, and consumer products that keep the national economy, and Colorado's economy, moving.

Businesses in natural resources, construction, and warehousing industries depend on Colorado's multimodal transportation systems to move goods as part of their core daily business functions. Retailers and manufacturers depend on predictable and reliable transport for supplies and inventories. Entrepreneurs and exporters rely on access to global markets. Growers and ranchers require efficient connections to ship perishable products on time. Consumers expect fast and reliable deliveries to homes and offices.

The Council of Supply Chain Management Professionals estimates U.S. companies spent nearly $2.3 trillion on business logistics costs, or 9.1 percent of national economic activity, in 2022 (Figure 3.1). Transportation costs comprise the largest share of logistics costs, followed by inventory carrying costs and other costs. Inventory carrying costs increased more than 50 percent year-over-year and accounted for more than 70 percent of growth in logistics costs. Escalating logistics costs impact economic competitiveness and prices passed on to consumers, and a more efficient freight transportation system can improve Colorado's efficiency and cost of doing business.

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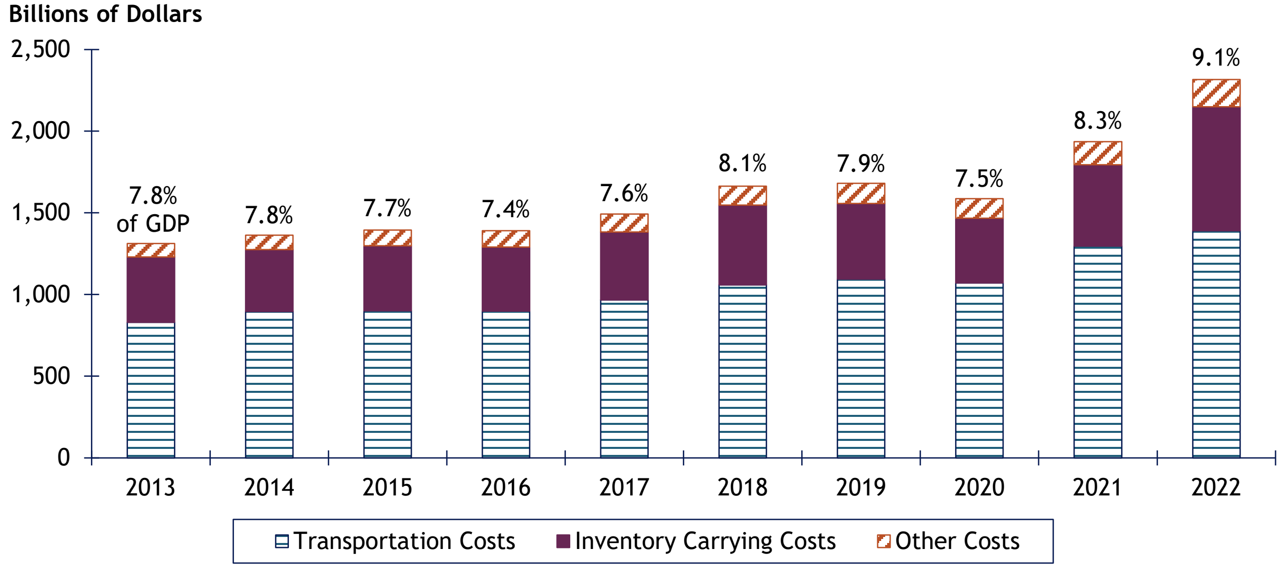
3 Bureau of Labor Statistics, QCEW Annual 2022. https://data.bls.gov/cew/apps/data_views/data_views.htm#tab=Tables.

4 Federal Highway Administration. Freight Analysis Framework, version 5.5. May 16, 2023. https://www.bts.gov/faf.

Figure 3.1 U.S. Business Logistics Costs, 2013-2022



Source: Council of Supply Chain Management Professionals, 34th State of Logistics Report, 2023.

Transportation represents a significant cost for businesses and consumers. When ordering online, shipping and handling charges are a visible portion of the final cost. What is less evident are the thousands of miles that package may travel to reach your doorstep and the warehouse workers, shipping clerks, inventory managers, customs brokers, crane or forklift operators, truck drivers, rail yard workers, and delivery persons that make that trip possible. The safety, efficiency, and reliability of transportation systems can have significant impacts on the bottom line of businesses and costs to consumers.

Table 3.1 highlights examples of illustrative economic costs to businesses across Colorado's multimodal freight industries. This data highlights costs that are borne directly by transportation providers and shippers, as well as expenses that are ultimately passed on to consumers or that are borne by the state economy.

Table 3.1 Illustrative Business and Economic Costs

Cost	Example
Safety	The Federal Motor Carrier Safety Administration estimates that commercial vehicle crashes in the U.S. cost $134 billion in medical and legal expenses, damage, and lost productivity.[1]
Delay and Congestion	Trucks in Colorado face over 3.6 million vehicle hours of delay on congested roadways.[2] This adds up to $312 million in direct costs to due to lost time, wasted fuel, and increased operating expenses as a result of bottlenecks.[3,4]
Cost of Transportation	U.S. companies spent nearly $2.3 trillion on business logistics costs, or 9.1 percent of national economic activity, in 2022.[5]
Road Conditions	The CEO of FedEx testified to the U.S. Congress in 2017 that FedEx trucks were using twice as many tires as 20 years ago due to the poor condition of the nation's roads.[6]
Efficiency	Truck delays on Colorado's congested highway corridors costs commercial carriers additional fuel and resulted in 115 million pounds of excess carbon dioxide emissions from trucks.[7]

1 Federal Motor Carrier Safety Administration (FMCSA), Pocket Guide to Large Truck and Bus Statistics, 2022.

2 WSP Analysis of 2022 National Performance Management Research Data Set (NPMRDS)—total delay hours at bottlenecks.

3 2021 Urban Mobility Report, Texas A&M Transportation Institute.

4 Calculated using an average value of delay time of $87.8 per hour derived from average marginal cost of trucking of $2.251 per mile (2023 Analysis of Operational Costs of Trucking, American Transportation Research Institute [ATRI]) and a weighted average truck speed of 39 miles per hour (2021 Urban Mobility Report, Texas Transportation Institute).

5 Council of Supply Chain Management Professionals, State of Logistics Report, 2023.

6 FedEx testimony to U.S. House Transportation and Infrastructure Committee, February 2017.

7 Colorado's Most Congested Roadways, Texas A&M Transportation Institute, 2018.

3.2 Colorado Trade and Commodity Flows

3.2.1 Colorado's Commodity Flows

This section provides a statewide overview of 2021 commodity flows and forecasted flows through 2040 for Colorado. The commodity flow analysis examines inbound, outbound, and internal flows for domestic and international freight. TRANSEARCH, a commodity flow dataset published by S&P Global, and the Confidential Waybill Sample, published by the Surface Transportation Board, comprised the two primary sources of commodity flow data utilized in developing this analysis. The TRANSEARCH dataset provided commodity flow estimates for all modes except rail (i.e., truck, air, pipeline, marine, and other modes). Specifically, estimated 2019 commodity flows and forecasted 2040 commodity flows for these modes in Colorado were combined to interpolate 2021 flows. Estimated rail flows for 2021, on the other hand, were derived from the 2021 Surface Transportation Board (STB) Confidential Waybill Sample for Colorado made available for this analysis. Forecasted 2040 commodity flows were also made available for both datasets.

Overall, the commodity flow analysis provides estimates of freight tonnage and freight value moved in Colorado across the following dimensions:

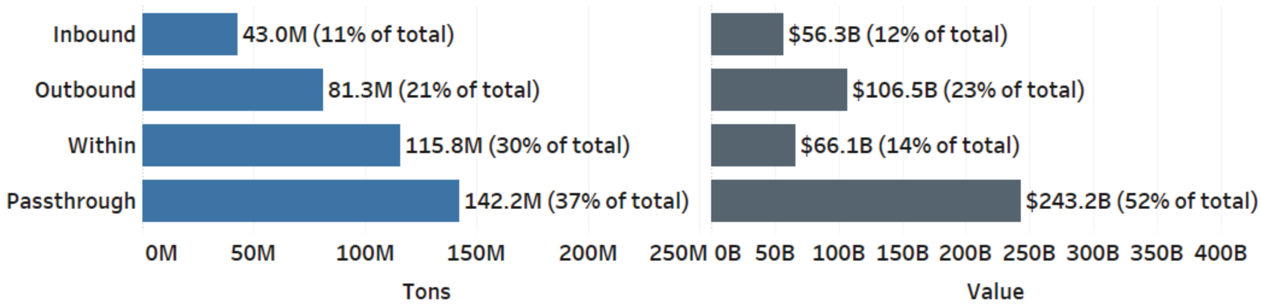
- **Direction—**Direction of commodity flow into/out of Colorado classified by their origin and destination at the county and state level. Commodity flows are broken out by whether they are inbound to Colorado, outbound from Colorado, completed wholly within Colorado, or are passthrough flows with external origins and destinations. While international trade is included and presented in this analysis, specific details on international origins and destinations are absent beyond United States-Mexico-Canada Agreement (USMCA) trade partners (Canada and Mexico).
- **Transportation Modes—**Six modes of transportation are included in the analysis—truck, rail, pipeline, air, marine (water), and other modes.
- **Commodity Type—**While commodity classifications at the four-digit level of the Standard Transportation Commodity Code are available for all flows in this analysis, flows are presented in the form of commodity groupings relevant to Colorado's industries and supply chains. Examples of these commodity groupings include Construction, Food & Agriculture, Distribution, Energy, Lumber & Paper, and Metals & Machinery.
- **Trade Type**—Flows were classified as domestic (strictly restricted to continental United States and Hawaii), USMCA (to and from Canada and Mexico), Alaska (to and from Alaska), or import and export (to and from other international partners).

Analysis by Direction

Overall, Colorado's freight network moved more than 382 million tons of freight worth nearly $472 billion in 2021. About 62 percent of these freight tons either originate or terminate in Colorado, while the remaining 37 percent of tons are passthrough and use the Colorado freight system to move to/from external origins and destinations (Figure 3.2). Overall, Colorado-based freight flows (i.e., flows with a Colorado origin or destination) amounted to over 220 million tons of freight worth over $229 billion in 2021.

In Colorado, outbound flows (i.e., freight originating from the state and moved to elsewhere in the United States and beyond) are nearly double that of inbound flows (i.e., freight received by Colorado from elsewhere) by tonnage and value. Specifically, outbound flows constitute over a fifth of all freight moves by tonnage and value, while inbound flows constitute only about a tenth of all freight moves by tonnage and value. Further, a full 30 percent of freight in tonnage terms stays wholly within the state, being both generated by Colorado supply chains and consumed by Colorado industries and consumers. However, these internal freight moves tend to be of lower value commodities than inbound and outbound moves, constituting only 14 percent of the freight value transported.

Figure 3.2 Freight Flows by Direction—Tonnage and Value



Source: S&P TRANSEARCH with Confidential Waybill.

Freight movement in Colorado is expected to grow substantially by 2040. TRANSEARCH projections indicate that Colorado is projected to move an additional 66 million tons by 2040, an approximately 17 percent increase in freight moved by tonnage (Table 3.2). Additionally, the mix of shipments being moved is estimated to trend to significantly higher value and the value of freight moved is expected to increase by over 50 percent during the same time period, for an increase of $240 billion. Further attesting to the projected growth in Colorado's economy, the highest increase in freight moves is expected to be in flows internal to Colorado, with freight forecast to increase 26 percent by tonnage and 70 percent by value.

Table 3.2 Freight Flow Forecasts by Direction (Includes Pass-through)—Tonnage and Value

	Tonnage (Millions)				Value (Billions $)			
Direction	2021	2040	CAGR [5]	% Increase	2021	2040	CAGR[5]	% Increase
Inbound	43.0	52.4	1.05%	21.9%	56.3	82.4	2.02%	46.3%
Outbound	81.3	93.6	0.75%	15.2%	106.5	163.9	2.30%	53.9%
Passthrough	142.2	156.6	0.51%	10.2%	243.2	352.4	1.97%	44.9%
Within	115.8	146.0	1.23%	26.1%	66.1	113.9	2.90%	72.2%
Total	**382.3**	**448.7**	**0.85%**	**17.4%**	**472.2**	**712.6**	**2.19%**	**50.9%**

Source: S&P TRANSEARCH with Confidential Waybill.

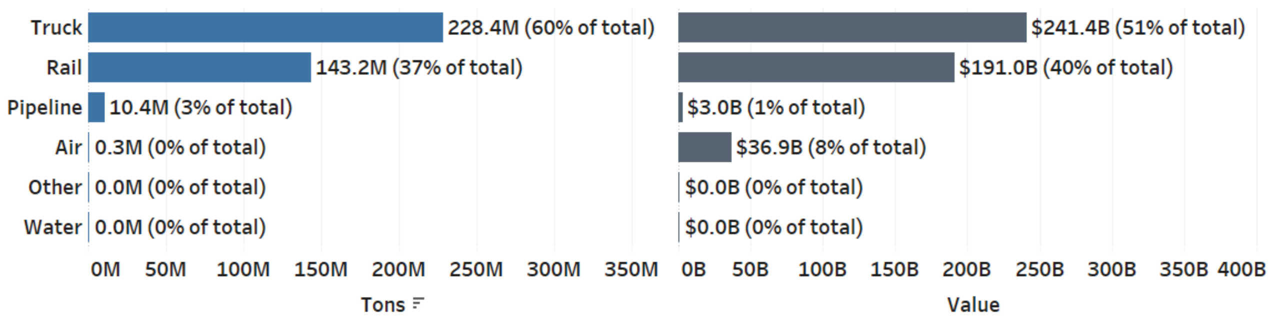
Analysis by Mode

Truck and rail flows (including passthrough traffic) constitute the majority of freight moves in Colorado, with over 97 percent of flows by tonnage and 91 percent of flows by value in 2021 (Figure 3.3). Truck traffic accounts for the majority of Colorado freight traffic by tonnage (60 percent of total, equating to over 228 million tons) and accounts for just over half of the total freight value moving in the state ($241 billion). Almost all types of commodities are moved by truck in or through Colorado, with construction industry-related flows and food and agriculture shipments constituting a combined 60 percent of truck flows by tonnage. Rail flows comprise a variety of commodity moves (37 percent of total tonnage and

5 CAGR refers to Compounded Annual Growth Rate.

40 percent of total value) and include significant coal shipments that are passing through Colorado from Wyoming to Texas, as well as terminating in Colorado. Rail moves also include large quantities of grain shipments, as well as chemical products and lumber. Air freight, which generally includes priority and time-sensitive items and high-value goods, accounts for 8 percent of freight moved by value (about $37 billion) despite accounting for less than 0.1 percent of freight tonnage. Pipeline moves in TRANSEARCH are limited to USMCA trade; domestic activity is not covered in the database. The USMCA pipeline traffic generally constitutes energy flows such as petroleum, crude oil, and byproducts, accounted for about 10 million tons in 2021 or 3 percent of total tonnage. Marine and other freight do not account for a significant portion of total freight moves in Colorado (less than 0.1 percent by tonnage and value).

Figure 3.3 Freight Flows by Mode (Includes Pass-through)—Tonnage and Value



Source: S&P TRANSEARCH with Confidential Waybill.

Truck and air moves are both expected to contribute to the 17 percent increase in total tonnage estimated by 2040 in Colorado, with air freight growing close to 70 percent by both tonnage and value, while truck freight is expected to grow 31 percent by tonnage and 53 percent by value (Table 3.3). Pipeline and rail freight, on the other hand, are both expected to see slight declines in total freight by tonnage. Reduction in petroleum and crude (pipeline) movements and coal movements (rail) drive the estimated declines in usage of these two modes.

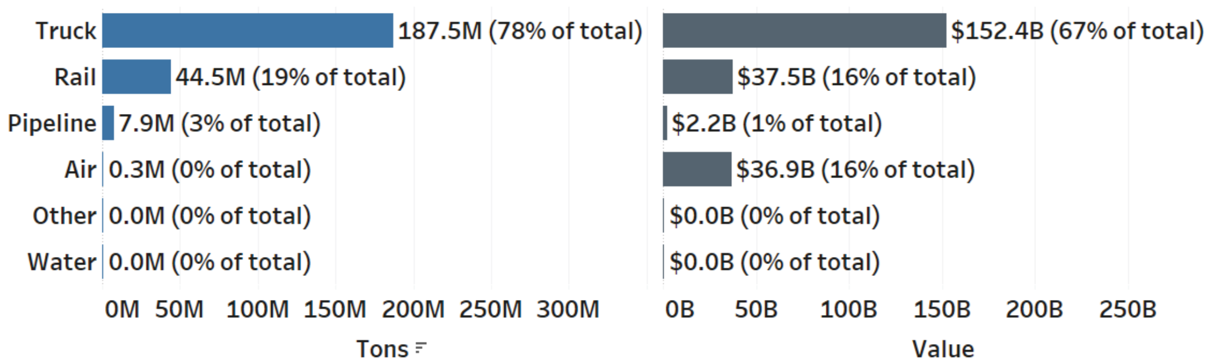
Table 3.3 Freight Flow Forecasts by Mode (Includes Pass-through)—Tonnage and Value

	Tonnage (Millions)				Value (Billions $)			
Mode	2021	2040	CAGR	% Increase	2021	2040	CAGR	% Increase
Air	0.3	0.5	2.74%	67.1%	36.9	62.5	2.82%	69.6%
Other	0.0	0.0	1.50%	32.8%	0.0	0.0	2.42%	57.7%
Pipeline	10.4	10.0	-0.21%	-3.9%	3.0	2.9	-0.21%	-3.9%
Rail	143.2	137.9	-0.20%	-3.7%	191.0	278.7	2.01%	45.9%
Truck	228.4	300.3	1.45%	31.5%	241.4	368.5	2.25%	52.7%
Water	0.0	0.0	2.21%	51.6%	0.0	0.0	2.33%	54.8%
Total	**382.3**	**448.7**	**0.85%**	**17.4%**	**472.2**	**712.6**	**2.19%**	**50.9%**

Source: S&P TRANSEARCH with Confidential Waybill.

Trucks, on the other hand, constitute a much larger share of overall freight flows that are Colorado-based (i.e., have a Colorado origin or destination), accounting for 78 percent of total flows by tonnage and 67 percent of total flows by value (Figure 3.4). The value of freight moved by air is almost as large as the value of freight moved by rail, with each accounting for about 16 percent of total value.

Figure 3.4 Freight Flows by Mode (Excludes Pass-through)—Tonnage and Value



Source: S&P TRANSEARCH with Confidential Waybill.

Colorado-based freight flows (21 percent increase by 2040) are expected to increase faster than overall flows that include passthrough traffic (17 percent) (Table 3.4). Truck and air moves are both expected to contribute to the 21 percent increase in total tonnage estimated by 2040 in Colorado, with air freight growing close to 70 percent by both tonnage and value, while truck freight is expected to grow 31 percent by tonnage and 58 percent by value. Pipeline and especially rail freight are both expected to see declines in total freight by tonnage. Reduction in petroleum and crude (pipeline) movements and coal movements (rail) drive the estimated declines in usage of these two modes.

Table 3.4 Freight Flow Forecasts by Mode (Excludes Pass-through) - Tonnage and Value

	Tonnage (Millions)				Value (Billions $)			
Mode	2021	2040	CAGR	% Increase	2021	2040	CAGR	% Increase
Air	0.3	0.5	2.74%	67.1%	36.9	62.5	2.82%	69.60%
Other	0.0	0.0	1.50%	32.8%	0.0	0.0	2.42%	57.66%
Pipeline	7.9	7.6	-0.21%	-3.9%	2.2	2.2	-0.21%	-3.90%
Rail	44.5	38.6	-0.74%	-13.1%	37.5	56.0	2.14%	49.47%
Truck	187.5	245.4	1.43%	30.9%	152.4	239.5	2.41%	57.19%
Water	0.0	0.0	2.21%	51.6%	0.0	0.0	2.33%	54.78%
Total	**240.1**	**292.0**	**1.04%**	**21.6%**	**229.0**	**360.2**	**2.41%**	**57.33%**

Source: S&P TRANSEARCH with Confidential Waybill.

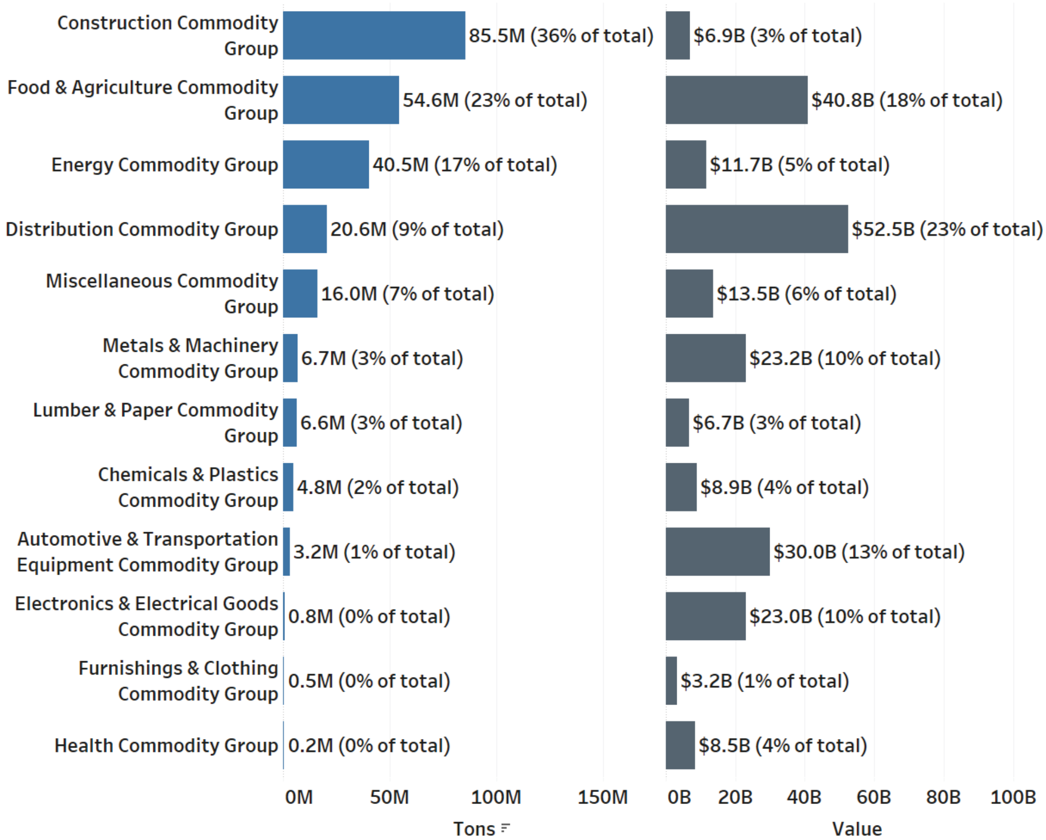
Analysis by Commodity Groups

Four-digit Standard Transportation Commodity Code commodity details provided in the TRANSEARCH and Waybill data were used to develop groups of commodities relevant to the main industries and supply chains in Colorado. These commodity groups are mutually exclusive and cover all commodities moved by the Colorado freight system.

Only freight moves with either a Colorado origin or destination are presented in this section. Passthrough moves, while relying on Colorado roadway and transport infrastructure, do not contribute to Colorado industry or household consumption of goods, and are therefore excluded from this analysis.

Commodities associated with construction comprised the largest group by tonnage moved, accounting for 86 million tons or 36 percent of total tonnage (Figure 3.5). However, these goods tend to be of relatively lower value and account for only 3 percent of total freight value moved. Food & Agriculture is the next largest commodity group by tonnage, accounting for 23 percent of total tonnage and 18 percent of total freight value. Distribution moves, which constitute flows to and from warehouses and distribution centers as well as drayage to and from ports and rail, are the fourth largest category by tonnage (17 percent of total) but the largest by value moved, accounting for over a fifth of value. Other significant high-value commodity groups in Colorado include automotive and transportation equipment (13 percent of total value and 1 percent of total tonnage), electronics and electrical equipment (10 percent of total value and less than 1 percent of tonnage), metals and machinery, and health-related commodities such as pharmaceuticals.

Figure 3.5 Freight Flows by Commodity Group (Excludes Pass-through)—Tonnage and Value



Source: S&P TRANSEARCH with Confidential Waybill.

Freight moves associated with distribution and health are anticipated to see the largest increase in both tonnage and freight value, with both categories nearly doubling (or more) by 2040 (Table 3.5). Construction, the largest category by tonnage in 2021, is expected to grow at approximately the same rate as the average (about 17 percent by tonnage). Notably, higher-value commodities, such as electronics, health, distribution, automotive and transportation equipment, are expected to grow the fastest by both tonnage and value, indicating Colorado's economy will climb up the value chain over the next two decades.

Table 3.5 Freight Flow Forecasts by Commodity Groups (Excludes Pass-through)—Tonnage and Value

	Tonnage (Millions)				Value (Billions $)			
Commodity Group	2021	2040	CAGR	% Increase	2021	2040	CAGR	% Increase
Automotive & Transportation Equipment	3.2	5.0	2.4%	57.1%	30.0	49.9	2.7%	66.4%
Chemicals & Plastics	4.8	7.4	2.3%	52.8%	8.9	14.4	2.6%	61.9%
Construction	85.5	100.4	0.9%	17.4%	6.9	9.2	1.6%	34.3%
Distribution	20.6	45.0	4.2%	118.5%	52.5	103.2	3.6%	96.5%
Electronics & Electrical	0.8	1.3	2.7%	66.5%	23.0	39.1	2.8%	69.7%
Energy	40.5	29.3	-1.7%	-27.8%	11.7	11.9	0.1%	1.6%
Food & Agriculture	54.6	67.0	1.1%	22.8%	40.8	54.4	1.5%	33.2%
Furnishings & Clothing	0.5	0.8	1.8%	40.3%	3.2	4.2	1.5%	32.0%
Health	0.2	0.3	3.5%	91.3%	8.5	16.1	3.4%	89.5%
Lumber & Paper	6.6	7.6	0.8%	15.5%	6.7	8.2	1.0%	21.2%
Metals & Machinery	6.7	8.5	1.2%	25.8%	23.2	31.1	1.6%	34.3%
Miscellaneous	16.0	19.5	1.0%	21.4%	13.5	18.6	1.7%	37.1%
Total	**240.1**	**292.0**	**1.0%**	**21.6%**	**229.0**	**360.2**	**2.4%**	**57.3%**

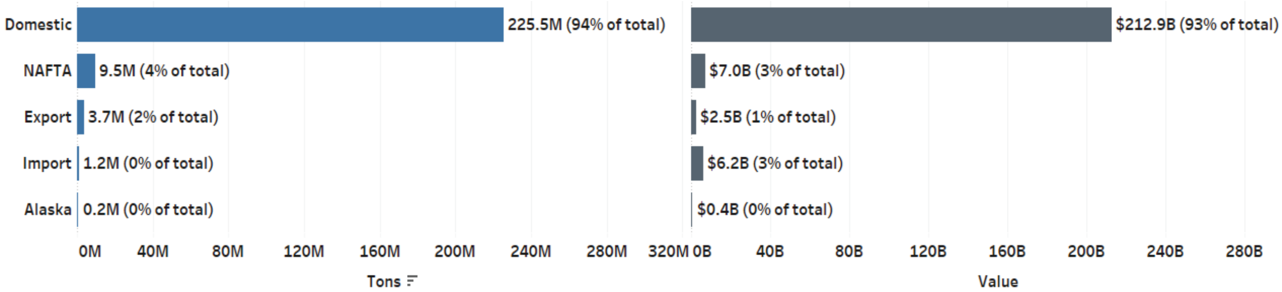
Source: S&P TRANSEARCH with Confidential Waybill.

While similar in nomenclature to the industry clusters described in Section 3.3, these commodity groups have been developed to classify and better understand the nature of overall freight flows in Colorado. These commodity groups are mutually exclusive and exhaustive of all freight flows in Colorado. On the other hand, flows associated with specific industry clusters described in Section 3.3 may span multiple commodity groups, and various commodities may interact with multiple industry clusters and supply chains (e.g., a commodity that acts as an input to one supply chain may be the output of another supply chain). As such, commodity overlap exists across multiple industry clusters, and each of the industry clusters presented in Section 3.3 must be studied noting this distinction.

Analysis by Trade Type

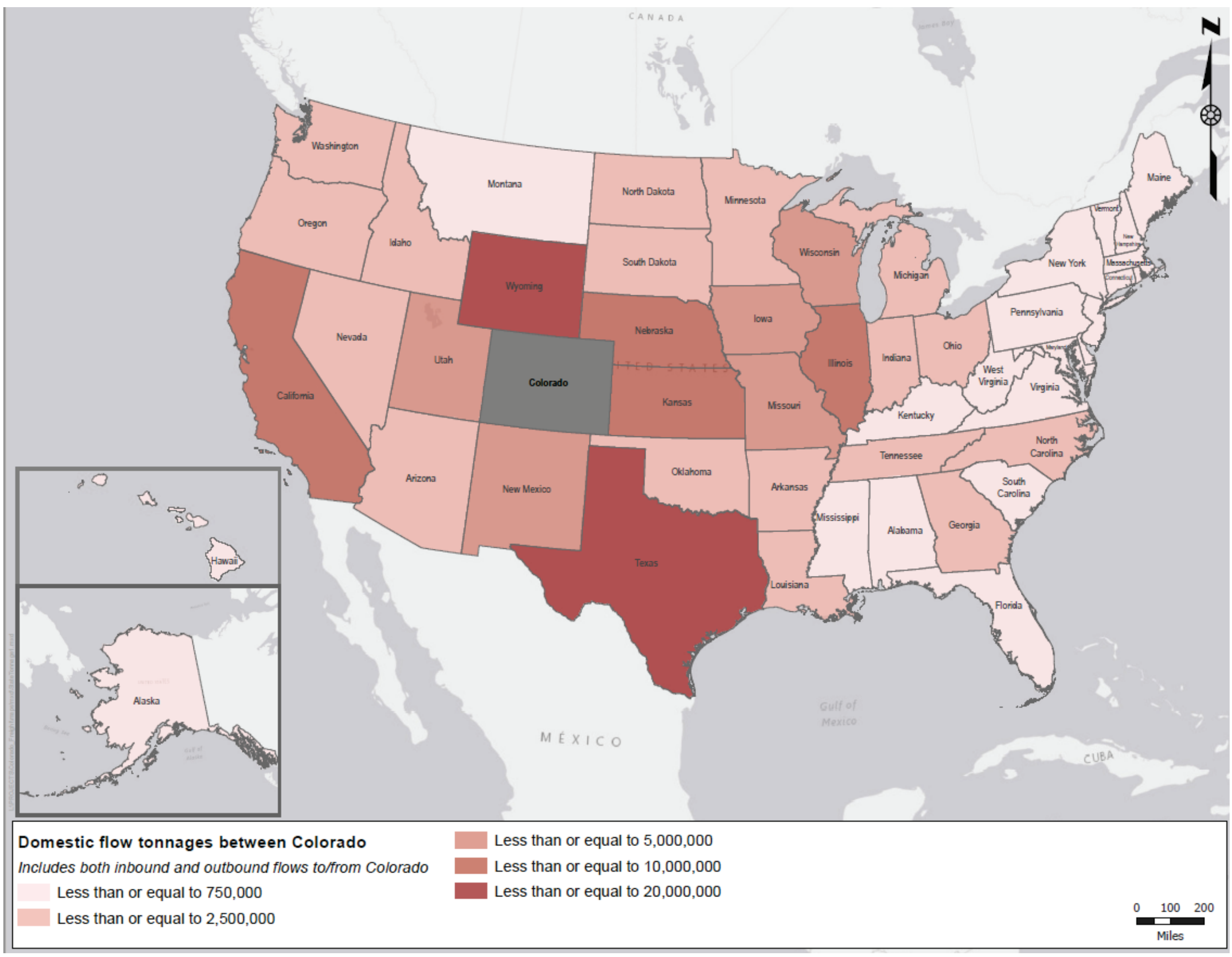
The vast majority of freight flows in Colorado are domestic movements to and from other states in the continental United States, which account for 94 percent of total tonnage and 93 percent of total value (Figure 3.6). Texas, Wyoming, Illinois, and California are some of the top domestic state trading partners to Colorado (Figure 3.7).

Figure 3.6 Freight Flows by Trade Type (Excludes Pass-through)—Tonnage and Value



Source: S&P TRANSEARCH with Confidential Waybill.

Figure 3.7 Top Domestic State Trading Partners for Colorado-based Freight Movements (by Tonnage)



Source: Interstate Highway System (IHS) TRANSEARCH, 2021.

USMCA trade with Canada and Mexico, accounting for 4 percent of total tons and 3 percent of total value, is the next largest category. Energy movement by pipeline from Canada and electronics/electrical and agricultural exports by truck from Colorado were some of the biggest categories of USMCA flows in 2021. Colorado also imports a significant number of high-value items from other international trading partners, with imports accounting for 3 percent of total value despite being less than 1 percent of total tonnage. By value the largest imports into Colorado are automotive and transportation equipment, electronics and electrical goods, and mixed freight shipments by rail.

Freight flows associated with key Colorado supply chains (such as automotive, food and agriculture, distribution, and electronics) are described in more detail in Section 3.3.

3.2.2 Colorado's International Trade

Colorado's international trade is naturally smaller than that of large-population coastal states, but the state's position in trade varies significantly by mode and commodity.

For imports Colorado's share of total U.S. trade value was 0.6 percent in 2021, but just 0.3 percent of imports by marine vessels. The state's share of imports by air was 0.6 percent in 2021 and 0.9 percent of imports by land (from Canada and Mexico). Colorado's 0.5 percent share of total U.S. exports in 2021 was just under the 0.6 percent share of imports, but state exports by vessel were a higher 0.4 percent share of the U.S. total. The share of U.S exports by air was higher at 0.8 percent, but Colorado's share of exports by land was lower at 0.5 percent.

Top Colorado Import Commodities

The top five commodities imported by Colorado in 2021 accounted for 64 percent of the state's total import value (Table 3.6). These commodities are defined by three-digit North American Industry Classification System (NAICS) codes.

Table 3.6 Top Colorado Import Commodities by Value and Share

Commodities	2021 Value	Share
334 Computer & Electronic Products	3,989,757,260	25%
211 Oil & Gas	2,886,024,925	18%
333 Machinery, Except Electrical	1,421,836,777	9%
336 Transportation Equipment	1,129,364,743	7%
335 Electrical Equipment, Appliances, & Components	895,001,020	6%
Subtotal	**10,321,984,725**	**64%**
All Commodities	**16,223,621,521**	**100%**

Source: U.S. Census Bureau.

Machinery, except Electrical was Colorado's third leading import commodity, with 2021 import value representing 0.7 percent of the U.S. total.

The top countries of origin of Colorado's 2021 imports were Germany, Canada, China, and Mexico. The top supplier to the United States in 2021 was China, followed by Japan, Mexico, Germany, and Canada.

Transportation Equipment, the state's fourth largest import commodity, at $1.1 billion in 2021, was the only top-five commodity with a relatively low 0.3 percent state share of U.S. imports.

In 2021 Switzerland was the top country of origin of Colorado's import value, followed by Canada and Mexico, while Mexico, Japan, and Canada were the top three counties of origins of U.S. import value.

Electrical Equipment, Appliances and Components, with imports of $0.9 billion, was the state's fifth largest import commodity in 2021.

The top suppliers of import value in 2021 to both Colorado and the United States were China and Mexico.

Top Colorado Export Commodities

Colorado exports totaled $9.1 billion in 2021, or 56 percent of the value of Colorado imports. State export value is also more concentrated in a few top commodities, with just four commodity groups comprising 66 percent of the state's total export value (Table 3.7).

Table 3.7 Top Colorado Export Commodities by Value and Share

Commodities	2021 Value	Share
311 Food & Kindred Products	2,221,814,443	24%
334 Computer & Electronic Products	1,955,656,919	22%
333 Machinery, Except Electrical	967,492,961	11%
325 Chemicals	842,074,812	9%
Subtotal	**5,987,039,135**	**66%**
All Commodities	**9,086,385,881**	**100%**

Source: U.S. Census Bureau.

Food and Kindred Products was by far the top state export commodity in 2021, comprising 24 percent of total state export value. Meat products and meat packaging products (NAICS 3116) represented almost all of that value at $2.0 billion of the $2.2 billion total. Based on this concentration, Colorado's exports of meat products amounted to 7.2 percent of the U.S. total in 2021.

The top five country destinations for exports from Colorado in 2021 were Mexico, South Korea, Canada, China, and Japan. These same five countries were the top destinations for U.S. exports, but with Canada the leading destination ahead of Mexico.

Computer and Electronic Products was the state's second largest valued export commodity at $2.0 billion, accounting for 22 percent of total state export value in 2021. This export value was about half the value of state imports noted above.

The top Colorado export destinations in 2021 were Malaysia, China, Taiwan, and Canada, while top U.S destinations were Mexico, Canada, China, and Hong Kong.

Machinery, Except Electrical was the third largest state export commodity, with a value of $1.0 billion in 2021, or 11 percent of the state's total export value.

In 2021 Canada was by far the top destination country for exports from Colorado as well as from the United States. Other top destinations for both Colorado and U.S. exports were China, Mexico, and South Korea.

Chemicals was the fourth largest Colorado export commodity in 2021 with a value of $0.8 billion and a 9 percent share of total state exports. This export value represented a low 0.3 percent of total U.S exports of chemicals.

The top country destinations for chemical exports from Colorado in 2021 were Canada, Switzerland, China, the Netherlands, and Mexico.

Canada, Mexico, and China were also top destinations for U.S. total exports.

3.3 Colorado's Key Industry Clusters

3.3.1 Auto/Aero + Supply Chain

Industry Overview

Several products from various economic sectors were selected for further analysis in relation to their supply chain within Colorado, as well as nationally and globally. These critical supply chains include all aspects of a product's lifecycle, encompassing raw materials, production facilities, warehousing, local distribution, retail outlets, recycling/waste, and receipt or distribution of various contributing inputs and outputs. As materials move through the supply chain, they often rely on multiple modes. A disruption to any one process or movement can dramatically impact the overall supply chain. Analyzing the transportation trends associated with these supply chain activities and movements supports the efficient movement of freight throughout Colorado.

This section focuses on the Transportation Manufacturing sector of Colorado's economy. This industry includes a wide range of commodities used in a variety of products, including motor vehicles, aerospace vehicles, rail vehicles, and ships. The Transportation Manufacturing industry is defined in this section by NAICS codes (Table 3.8). At the top level, the Transportation Manufacturing industry includes one three-digit NAICS code, 336 Transportation Equipment Manufacturing, with six commodity components, each with its own four-digit NAICS code. These NAICS codes do not include contributions from physical transportation of goods, warehouse/distribution of manufactured components or finished products, or dealer channels and retail points-of-sale to customers. Only manufacturing within the following industries is included.

Table 3.8 Definition of Transportation Manufacturing Subsectors and Industries (4-digit NAICS)

Industry	Subsector
Automotive	3362 Motor vehicle body and trailer manufacturing
Automotive	3363 Motor vehicle parts manufacturing
Aerospace	3364 Aerospace product and parts manufacturing
Transportation Equipment	3365 Railroad rolling stock manufacturing
Transportation Equipment	3366 Ship and boat building
Automotive	3369 Other transportation equipment manufacturing

The following analysis provides an overview of the Transportation Manufacturing sector and commodities, including their importance to Colorado and global economies. The analysis also drills down into the supply chain for the Aerospace subsector that falls under the Transportation Manufacturing category. This section also assesses the industry's contribution to Colorado's economy, and opportunities and constraints affecting the Transportation Manufacturing industry and aerospace subsector. Overall, the Transportation Manufacturing industry in Colorado represents 11,546 employees, nearly 200 establishments, and annual wages of more than $1.5 billion (Table 3.9). Aerospace is an important subsector in Colorado, comprising 76 percent of employment, 24 percent of establishments, and 88 percent of wages in the Transportation Manufacturing industry.

Table 3.9 Employment, Establishments, and Wages for Transportation Mfg. Industry, 2022

	Employment		Establishments		Total Annual Wage ($M)	
Subsector	Total	% of Industry	Total	% of Industry	Total	% of Industry
Aerospace	8,760	76%	48	24%	1,329	88%
Automotive	2,786	24%	140	71%	187	12%
Transportation Equipment	N/A	N/A	8	4%	N/A	N/A
Total	**11,546**	**100%**	**196**	**100%**	**1,515**	**100%**

Source: Quarterly Census of Employment and Wages, Bureau of Labor Statistics.

N/A Data suppressed for confidentiality.

Table 3.10 provides employment, establishment, and wage metrics for Colorado as a whole, as well as for all industries in the Manufacturing sector in Colorado. As a proportion of the all manufacturing-related industries, the Transportation Manufacturing industry represents 7.5 percent of employment and 12.0 percent of wages in Colorado. This represents approximately 0.41 percent of total statewide employment and 0.72 percent of total statewide wages in Colorado.

Table 3.10 Employment, Establishments, and Wages for Colorado Industries, 2022

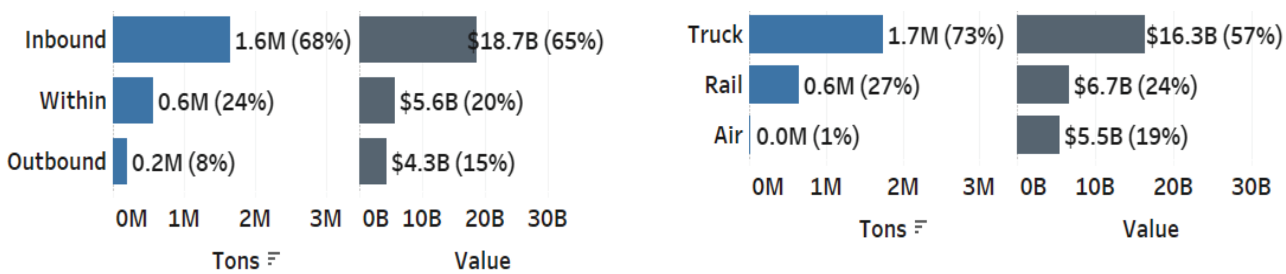
State	Employment	Establishments	Total Annual Wage ($M)
Colorado—Overall	2,814,732	245,461	$209,435
Colorado—Manufacturing	153,372	6,051	$12,671

Source: Quarterly Census of Employment and Wages, Bureau of Labor Statistics.

Commodities and Forecast

Figure 3.8 shows the split of Colorado commodity flows between outbound, inbound, and internal movements in the Transportation Manufacturing industry for tons and value, as well as by mode. As the data shows, by tonnage, most (68 percent) Transportation Manufacturing goods flow inbound. By value, a similar amount (65 percent) is moved inbound. By mode, most (73 percent) tonnage is moved by truck, with 27 percent by rail. Movement by air is generally reserved for higher-value goods, as 19 percent of value is moved by air, compared to only 1 percent of tonnage. Transportation equipment that is time-sensitive or fragile may also be moved by air.

Figure 3.8 Commodity for Transportation Mfg. Industry, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.11 shows projected changes in tonnage and value for the Transportation Manufacturing industry. Tonnage and value are both expected to grow 2.8 percent per year between 2021 and 2040. Vehicles currently represent 75.3 percent of tonnage and 79.0 percent of value. Vehicle and Manufacturing Inputs tonnage and value are expected to grow 3.1 percent and approximately 2.0 percent annually, respectively. Aerospace tonnage and value are expected to grow 1.6 percent annually through 2040.

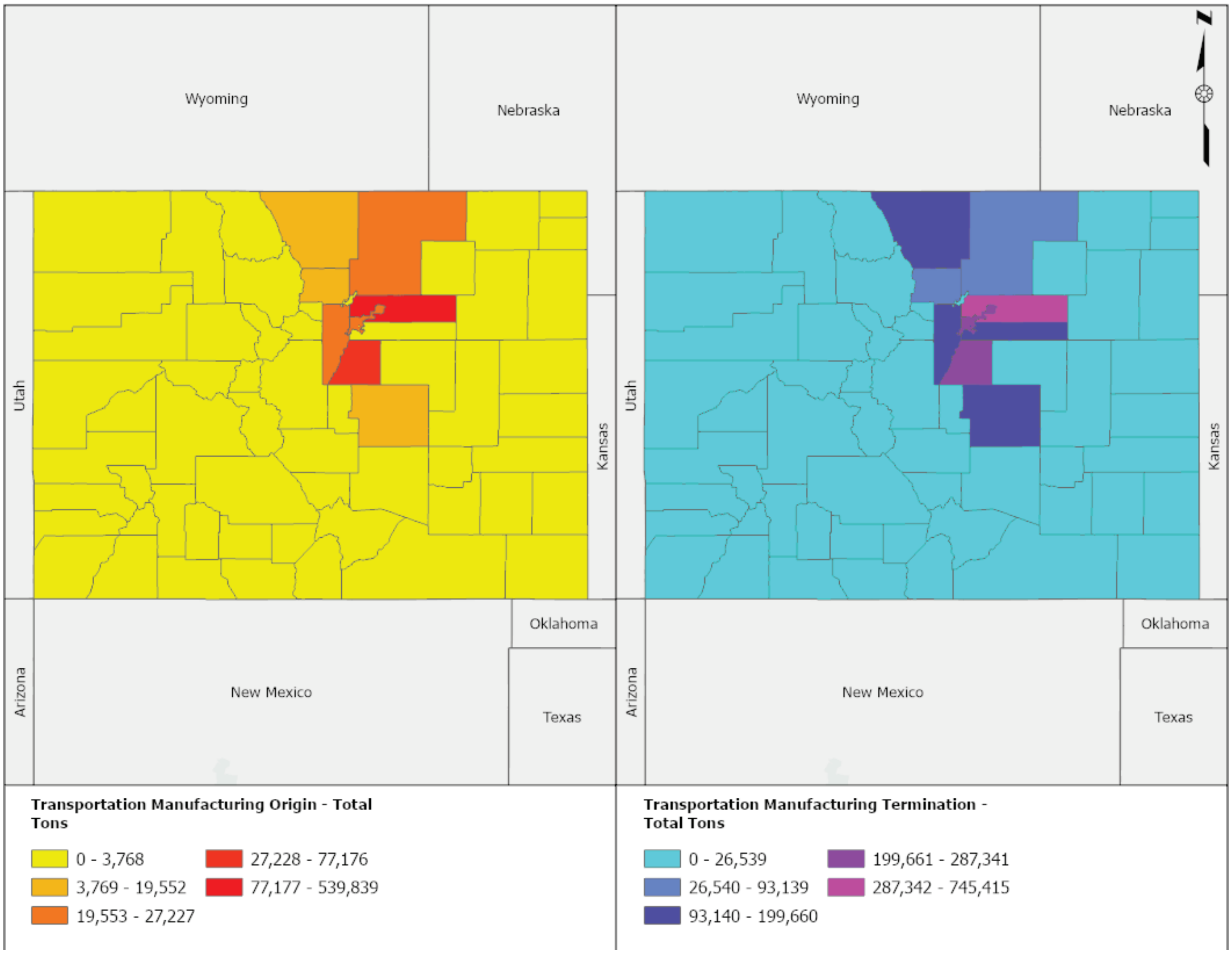
Table 3.11 Commodity Flows by Subsector in Transportation Manufacturing Industry, 2021 and 2040 Forecast

	Tons				Value			
Subsector	Tons M	% of Total	% Change to 2040	Forecasted CAGR	Value ($B)	% of Total	% Change to 2040	Forecasted CAGR
Aerospace	0.01	0.2%	35.5%	1.6%	1.18	4.1%	35.6%	1.6%
Manufacturing Inputs	0.59	24.6%	44.8%	2.0%	4.81	16.9%	43.7%	1.9%
Vehicles	1.80	75.2%	78.4%	3.1%	22.41	79.0%	77.6%	3.1%
Total	**2.39**	**100.0%**	**70.1%**	**2.8%**	**28.40**	**100.0%**	**70.1%**	**2.8%**

Source: S&P TRANSEARCH.

Figure 3.9 shows the origin and destination of tonnage for Transportation Manufacturing in Colorado. Origins and destinations are highly concentrated in a few counties. Most tonnage (540 thousand tons) originates in Adams County, followed by 77 thousand tons in Douglas County. Destinations are more dispersed through central Colorado, but are concentrated in Adams County, Arapahoe County, Douglas County, El Paso County, Jefferson County, Boulder County, Larimer County, and the city of Denver. Adams County is the destination for 745 thousand annual tons, followed by 287 thousand tons for Douglas County.

Figure 3.9 Origination and Termination of Transportation Manufacturing Tonnage by Colorado County, 2021



Source: S&P TRANSEARCH.

International Trade

As shown in Table 3.12 and Table 3.13, imports exceed exports for both the United States and Colorado. However, Colorado differs from the United States in the composition of trade. For the United States as a whole, Motor Vehicle Parts is the top import commodity, more than 10 times the value of the next highest commodity in Transportation Manufacturing. U.S. exports are led by Aerospace products, followed by Motor Vehicle Parts. Aerospace Products are by far the leading import and export commodities in the Transportation Manufacturing industry in Colorado. Aerospace Products represent 1.5 percent of imports and 0.4 percent of exports (Table 3.13). Additionally, the top international trading partners in Colorado's Transportation Manufacturing industry were identified. For exports, Canada and France each account for 16 percent of value, followed by Germany (12 percent), Mexico (10 percent), and Brazil (9 percent). For imports, Switzerland accounts for 41 percent of value, followed by Canada (18 percent) and Mexico (13 percent).

Table 3.12 U.S. and Colorado Transportation Manufacturing Industry Imports

	2021 Import Value ($ Millions)		
Commodity by NAICS	All States	Colorado	Share
Transportation Manufacturing	184,234	1,034	0.6%
3362 Motor Vehicle Bodies & Trailers	4,343	39	0.9%
3363 Motor Vehicle Parts	122,618	197	0.2%
3364 Aerospace Products & Parts	42,552	652	1.5%
3365 Railroad Rolling Stock	1,120	39	3.5%
3366 Ships & Boats	2,956	8	0.3%
3369 Transportation Equipment, Nesoi	10,645	99	0.9%

Source: U.S. Census Trade Data, 2021.

Table 3.13 U.S. and Colorado Transportation Manufacturing Industry Exports

	2021 Export Value ($ Millions)		
Commodity by NAICS	All States	Colorado	Share
Transportation Manufacturing	158,708	429	0.3%
3362 Motor Vehicle Bodies & Trailers	11,557	13	0.1%
3363 Motor Vehicle Parts	45,759	50	0.1%
3364 Aerospace Products & Parts	93,305	334	0.4%
3365 Railroad Rolling Stock	2,257	1	0.0%
3366 Ships & Boats	2,245	6	0.3%
3369 Transportation Equipment, Nesoi	3,585	25	0.7%

Source: U.S. Census Trade Data, 2021.

Trends, Opportunities, and Constraints

According to the Alliance for Automotive Innovation, Colorado's automotive industry employs 121,000 people and 3.1 percent of the state's employment is dependent on the industry. This data includes not only the Transportation Manufacturing industry discussed in this section but related automotive businesses such as car dealerships. The industry accounts for $8.3 billion in annual labor income and $750 million in state tax revenue. The Alliance for Automotive Innovation also reports the presence of several automaker facilities in the state (Table 3.14), although none of them are manufacturing or assembly plants.

Table 3.14 Automaker's Facilities in Colorado [6]

Automaker	Facility	Location	Employees
Ford Motor Company	Ford Credit Colorado Springs Business Center	Colorado Springs	381
	Denver High Velocity Center (VC)	Denver	29
	Denver Regional Office	Greenwood Village	20
General Motors	Customer Care & Aftersales—Parts Distribution Center—Denver	Aurora	73
	GM Financial—Denver Branch Office	Greenwood Village	1
Honda	Denver Test Lab	Denver	N/A
	American Honda Motor Co., Inc. Zone Office	Englewood	N/A
	American Honda Education Corp	Estes Park	N/A
Stellantis	Denver Parts Distribution Center	Denver	50
Subaru of America	RDC-Denver	Aurora	17
	Subaru Service Training Center—Denver	Aurora	2
	Western Region	Glendale	21
	Western Region—Zone 1 Denver	Glendale	15

Source: Alliance for Automotive Innovation, 2021.

Producing an automobile or aerospace vehicle requires successfully integrating tens of thousands and sometimes millions of parts. These parts are typically sourced from hundreds of suppliers around the world. Improper assembly of either vehicle t could also lead to costly recalls, injuries, and even death but for aerospace components there are additional international security and safety concerns, depending on the vehicle/aircraft. Due to the complexity of the Transportation Manufacturing industry, as well as the importance of the industry's outputs to daily life and national security, there are several key challenges to the supply chain:

- **Just-in-time production schedules—**Input materials are frequently received, in some cases daily, from suppliers and intermediate storage facilities and inventory for key input products may be small, in an effort to reduce costly storage costs. When the supply chain functions properly, this just-in-time production arrangement operates incredibly efficiently, but delays in individual parts, including those transported from across the globe, can result in detrimental snowball effects.
- **Transport reliability—**Most Transportation Manufacturing goods are transported by truck and rail. Highway congestion has worsened in fast-growing areas, including parts of Colorado, complicating the supply chain and transport of goods. In many parts of the country, the COVID-19 pandemic resulted in a decline in peak hour auto demand and reduced peak hour congestion due to fewer workplace commute trips, but in many areas, vehicle miles traveled has recovered to pre-pandemic levels. Related to roadway reliability and congestion is maintenance and state of good repair. Maintaining a state of good repair requires constant vigilance and significant annual public expense. With the rising cost of construction materials, maintenance is likely to represent an even larger cost burden, potentially impacting the ability of public and private sector infrastructure owners to invest in

[6] https://www.autosinnovate.org/resources/insights/co.

additional capacity and new services. Railroad reliability has trended positively with "precision scheduled railroading" strategies emphasizing timely train moves, similar to just-in-time production schedules. Likewise, when freight rail service is functioning properly, precision scheduled railroading operates efficiently, but if not, the supply chain can be disrupted. Among rail customers, the automotive, aircraft, and aerospace industry tends to be in the top tier of customers, and railroads make serving them a priority.

- **Supplier points-of-failure—**Performance failures by even one key supplier can disrupt production. One well-documented example includes faulty control modules provided to Boeing for its 777 Dreamliner, which delayed production. Another example includes the challenges of auto manufacturers to secure semiconductors for automotive control systems during the COVID-19 pandemic, which impacted the availability of materials necessary for semiconductor production.
- **Trade dependency—**Transportation Manufacturing commodities are truly global. Materials suppliers and manufacturers are both international and domestic. Transportation Manufacturing is therefore highly dependent on the health of trading relationships, the physical performance of land border crossings (truck and rail) and other international gateways (seaports and airports), and the impacts of trade and regulatory incentives, barriers, and trade agreements (particularly USMCA).
- **Commercialization of space—**With rapidly growing interest in commercial space travel for tourism, lower launch costs for satellites, manufacturing in a zero-gravity environment, and potentially other uses, and with highly visible investment by SpaceX and Blue Origin, commercialization of space is likely to drive substantial growth in aerospace operations, and the demand for necessary parts and products at key operating hubs. Blue Origin leases 36,000 square feet of office space in Highlands Ranch and as of April 2023 was advertising for nearly 150 jobs in the Denver area. [7]
- **Advanced vehicle technology—**The push to vehicle electrification has been fast and appears to be accelerating, not only because of environmental and regulatory considerations but also because of widespread consumer interest and demand. Over the coming decades, current electric vehicle makers and suppliers are likely to expand, new ones are almost certain to enter the market, and traditional original equipment manufacturers will need to complete or accelerate their efforts to bring attractive and cost-effective electric vehicles to market. The increased adoption of electric vehicles will also place an added burden on electricity consumption. A study from the U.S. Department of Energy concluded that increased electrification from all sectors of the economy could boost consumption nationally by up to 38 percent by 2050. [8] Electric vehicle adaptation by the trucking industry will probably depend on battery life/range improvements that permit drivers to complete their full daily hours of service on a single charge. Advanced battery manufacturing will probably be the most important and fastest growing Tier 1 input for this process, so the supply chains related to battery manufacturing—from raw materials to recycling—will be increasingly important. Finally, the transition to electric vehicles will profoundly affect the supply and transportation of auto parts to original equipment manufacturers and the after-market. GM estimates that its electric Bolt uses 80 percent fewer parts than a comparable car with an internal combustion engine. [9]

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[7] https://www.costar.com/article/1182878936/blue-origin-doubles-down-on-real-estate-expansion-with-latest-lease-in-denver-area.

[8] https://www.nrel.gov/news/program/2018/analysis-demand-side-electrification-futures.html.

[9] Shift to electric vehicles will radically change auto factories", The Detroit News, 1/5/19.

Supply Chain Highlight: Aerospace

The production of aerospace commodities follows a pattern similar to motor vehicles, albeit with many more parts. Parts are produced through a tiered system of domestic and international suppliers. Manufacturers then assemble the parts into finished aircraft or helicopters, or into engines and other components to be used by manufacturers in other states and countries. Suppliers in the aerospace and larger transportation manufacturing industries fall into one of three tiers:

- **Tier 1—**supply parts or systems directly to original equipment manufacturers (businesses that make the final product for the consumer). Typically manufacture components such as engine parts, steering and suspension systems, air conditioning systems, and electronic components. [10]
- **Tier 2—**often experts in a specific sub-field can also support non-transportation customers. They manufacture the components needed by Tier 1 suppliers, including specialized forged parts, die casting, plastic parts, and machined parts.
- **Tier 3—**suppliers of raw or near-raw materials like metal or plastic. Typically sell to Tier 2 suppliers.

According to the Colorado Chapter of the Aerospace States Association, Colorado has the second largest space economy in the United States, as well as ranking first in private aerospace employment concentration, second in private aerospace employment concentration, and fourth in the National Aeronautics and Space Administration (NASA) prime contracts. More than 500 employers in Colorado provide space-related products and services for commercial, military, and civil uses. [11] These companies employ more than 34,000 people and generate $5.3 billion in annual payroll.

Additionally, the state caters to each of the four U.S. military commands and three of the country's six Space Force bases. Established in 2019, the United States Space Force was created as a result of the widespread recognition that space is a national security imperative. Space Force facilities in Colorado include Buckley Space Force Base in Aurora, and the Peterson and Schriever Space Force Bases in Colorado Springs. The Buckley Space Force Base is estimated to contribute $1 billion annually to the local economy and includes 3,100 active-duty members and 4,000 National Guard personnel, according to the United States Space Force. Colorado Springs is also home to the United States Air Force Academy which educates cadets for the Air Force and Space Force.

Colorado's aerospace industry has grown by 30 percent in the past five years, outpacing nationwide growth by 12 percentage points. This growth is fueled in part by the numerous educational initiatives and resources in the state devoted to aerospace, including the following examples:

- The Colorado Air and Space Port (CASP) offers pilot services, a spaceport, and development sites for space-related businesses. The CASP spaceport envisions serving as America's hub for commercial space transportation, research, and development. Horizontal launch facilities like CASP are developing around the world and have the potential to become the foundation for a global suborbital transportation network. With 3,349 acres of land, CASP houses one of the largest general-aviation airports in the United States and is surrounded by 7,000 additional acres of non-residential, master-

[10] https://policy.tti.tamu.edu/freight/moving-texas-exports/the-vehicle-part-supply-chain.

[11] An affiliate of the Metro Denver Economic Development Corporation, with data provided by Development Research Partners, Inc.

planned industrial complexes with access to heavy rail and highways. Located 7 miles from the Denver International Airport, CASP also boasts access to skilled workforce, research universities, major aerospace and defense companies, and highway and freight rail infrastructure.

- The University of Colorado Boulder receives more NASA funding than any other public university.
- The Metropolitan State University of Denver houses multiple disciplines to meet workforce needs of aviation and aerospace and partnered with York Space Systems to move its headquarters and establish a new manufacturing facility and Mission Operations Center on campus.
- The Colorado Space Grant Consortium includes 21 universities and institutions providing students access to space through innovative courses and training.
- The Colorado School of Mines offers the Space Resources Program, the world's first multi-disciplinary graduate program focused on educating scientists, engineers, and others in the developing field of space resources.
- The University of Colorado-Colorado Springs is designated as the Space Education Consortium's lead university to educate the nation's future aerospace workforce.

Further, of the five states with the most aerospace workers, Colorado has the highest percentage of residents with bachelor's degrees (42.7 percent). Colorado also has several dozen laboratories and research institutions contributing to the aerospace field:

- The National Oceanic Atmospheric Administration, University Corporation for Atmospheric Research, and National Center for Atmospheric Research in Boulder conduct research in atmospheric and related sciences, including the space environment.
- The Laboratory for Atmospheric & Space Physics in Boulder is the world's only university-based institution to have designed and built space instruments for NASA that have been launched to every planet in the solar system.
- Colorado State University's Cooperative Institute for Research in the Atmosphere partners with the National Oceanic Atmospheric Administration to provide global climate research, satellite observations, and air quality measurements.
- The National Solar Observatory's headquarters in Boulder houses scientists, engineers, and administrative staff to manage all data analysis and instrument development.
- The National Institute of Standards and Technology in Boulder promotes innovation and industrial competitiveness by advancing measurement science, standards, and technology.
- The Cooperative Institute for Research in Environmental Sciences in Boulder conducts research in Earth system science, including atmospheric and climate dynamics and solar-terrestrial environment.

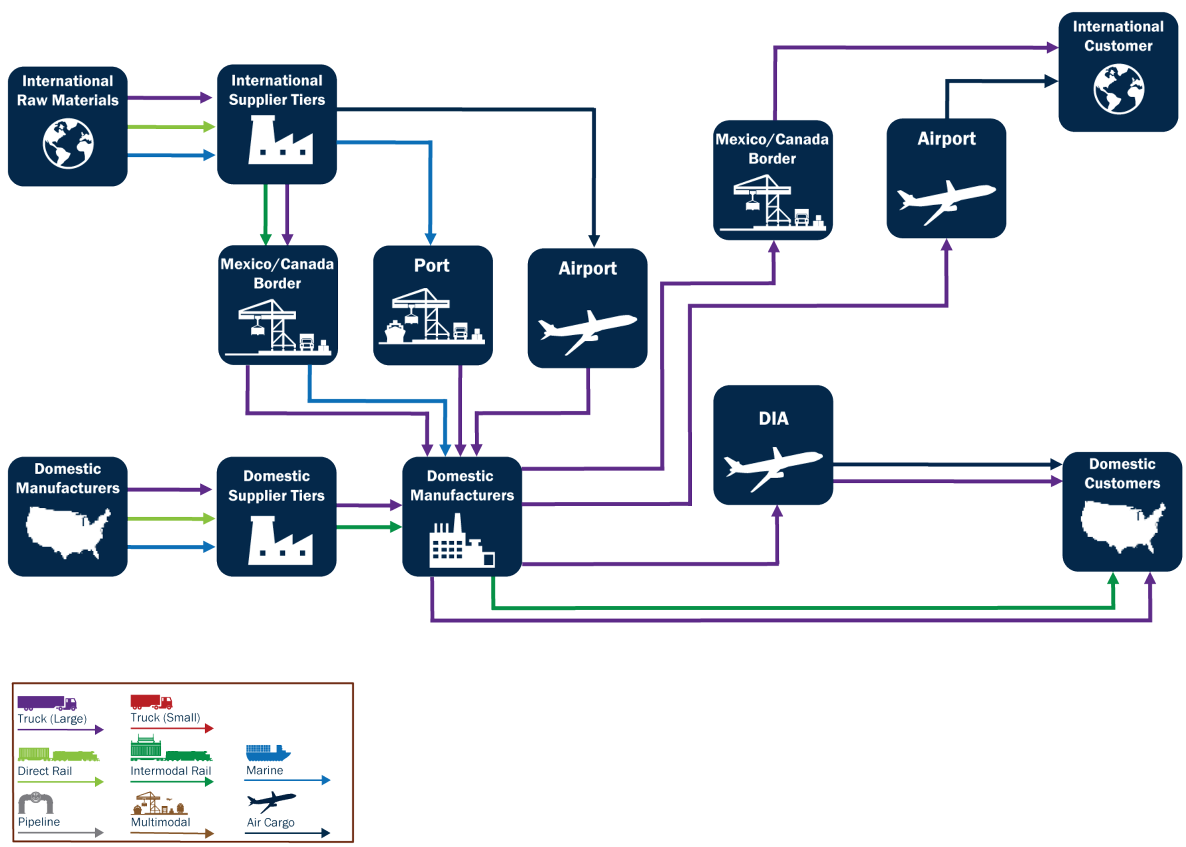
Finally, eight of the national's leading aerospace contractors are headquartered in Colorado and numerous international and national aerospace companies maintain a significant presence in the state, including Boeing, Raytheon, Lockheed Martin, and L3Harris.

Supply Chain Flows

Figure 3.10 presents a generalized description of the main supply chain steps for the aerospace subsector's production in Colorado. The subsector has tiered suppliers (discussed earlier) feeding manufacturing and assembly plants that then pass on finished products to end users. These suppliers can be domestic or international. However, the customer base for these products tends to be other businesses rather than consumers. Compared to a passenger car that can have 30,000 individual parts, a civilian airplane can have up to 1 million individual parts, requiring the coordination of more suppliers, materials, and input products. The manufacturing steps, though, are otherwise comparable.

The Aerospace supply chain begins with international raw materials and domestic manufacturers. Within North America, goods move via rail and truck into the United States and Colorado to domestic manufacturers. Inputs from elsewhere move via ship to U.S. maritime ports, or via air cargo, and then reach domestic and Colorado manufacturers by truck. From these manufacturers, goods then are transported either: 1) to the Mexico/Canada borders via truck onto international customers, 2) by truck to international airports and via air cargo to international customers, 3) to Denver International Airport by truck and domestic customers by a combination of air cargo, truck, and rail, or 4) direct to domestic customers from Colorado by truck or rail.

Figure 3.10 Aerospace Supply Chain Diagram



Source: WSP 2023.

The following tables and figures present data concerning the domestic flows of goods in the aerospace supply chain to and from Colorado. As shown in Table 3.15 , Kansas and Washington are the top two origins of inbound tonnage, accounting for 23 percent and 17 percent, respectively. Both states are major centers of aircraft manufacturing, featuring companies such as Boeing, Cessna and Beechcraft. The top destinations for outbound tonnage are Florida (18 percent), New York (13 percent), Texas (12 percent), and Arizona (11 percent). As shown, the top three or four domestic trading partners account for the majority of inbound and outbound tonnage to Colorado.

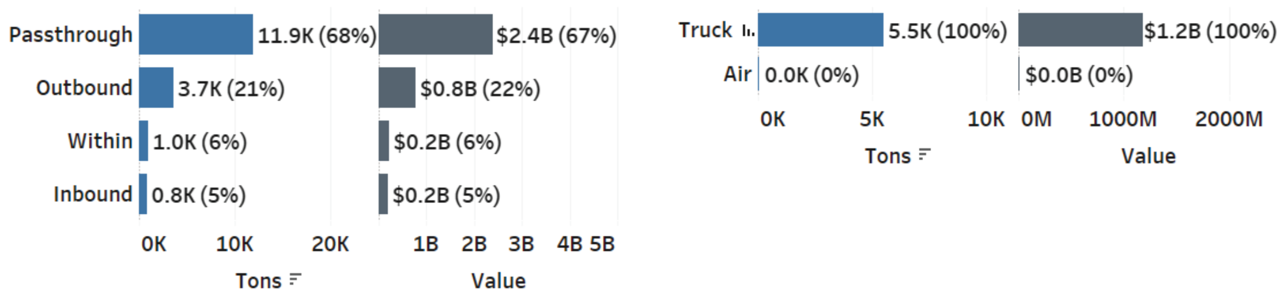
Table 3.15 Top Domestic Trading Partners for Aerospace Supply Chain, 2021

	Inbound			Outbound		
Rank	State	Tons	%	State	Tons	%
1	Kansas	184	23%	Florida	657	18%
2	Washington	132	17%	New York	478	13%
3	Ohio	73	9%	Texas	438	12%
4	South Carolina	63	8%	Arizona	391	11%
5	Tennessee	63	8%	California	327	9%
6	California	45	6%	Washington	282	8%
7	Alabama	37	5%	Kansas	162	5%
8	Oklahoma	25	3%	Missouri	128	4%
9	Nebraska	20	3%	Georgia	99	3%
10	Texas	19	2%	Utah	72	2%
	Other	137	17%	Other	548	15%
	Total	**797**	**100%**	**Total**	**3,581**	**100%**

Source: S&P TRANSEARCH.

Figure 3.11 shows tonnage and value for the aerospace subsector by direction and mode in Colorado. As the data shows, most tonnage and value are passthrough traffic, with outbound tonnage far exceeding inbound and internal movements. Two-thirds of tonnage and value were passthrough trips (moving through Colorado but neither originating nor terminating in the state), and 21 to 22 percent of tonnage and value were outbound trips. A nearly equal share of tonnage and value were moved inbound and internally within Colorado. Nearly all tonnage in Colorado's aerospace subsector was transported by truck.

Figure 3.11 Flows of Aerospace Supply Chain, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.16 provides the import and export value of the Aerospace Products & Parts subsector in Colorado and the United States. Since Colorado's share of the U.S. population is about 1.7 percent, the data shows that Colorado's shares of imports and exports are underrepresented compared to its population though imports constitute a significantly higher share than exports.

Table 3.16 Aerospace Products & Parts Components Value

Trade	U.S. Total ($M)	Colorado ($M)	State Share
Imports	42,552	652	1.5%
Exports	93,305	418	0.4%

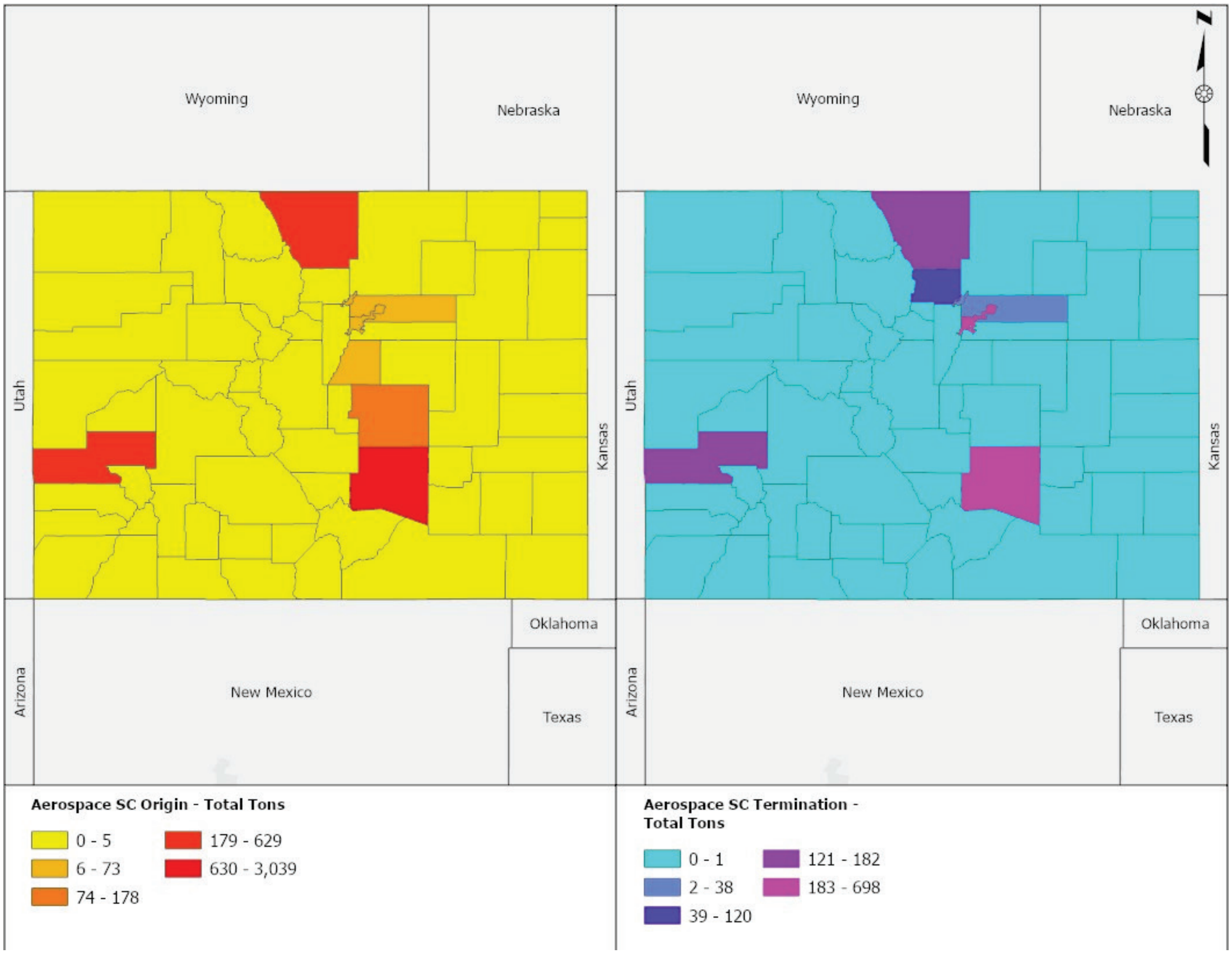
Source: U.S. Census Trade Data, 2021.

Colorado's 2021 imports of Aerospace Products and Parts were highly concentrated from three origins (Switzerland, Canada, and France) that together accounted for 96 percent of total state imports. Canada and France were also top suppliers to the United States, but together represented less than half of the U.S. total value. Imports from Switzerland almost entirely include lightweight (2,000–15,000 kg) fixed wing aircraft.

For 2021 exports, the top destinations of Aerospace Products and Parts from Colorado were France, Germany, Canada, and Brazil, which together accounted for 57 percent of the state's export value. These same countries were the top four destinations for U.S. exports but together accounted for a much smaller portion (31 percent) of the export total.

Figure 3.12 shows the origin and destination, respectively, of tonnage in the aerospace industry in Colorado. The primary origin counties by tonnage are El Paso, Larimer, and Montrose Counties. Each of these counties is the origin of more than 500 annual tons, with El Paso County (which contains Colorado Springs and a large defense and aerospace industry) originating more than 3,000 annual tons. The primary destination counties by tonnage are Pueblo, Larimer, and Montrose Counties and the city of Denver. Each of these counties is the destination of more than 150 annual tons, with El Paso County receiving 700 annual tons.

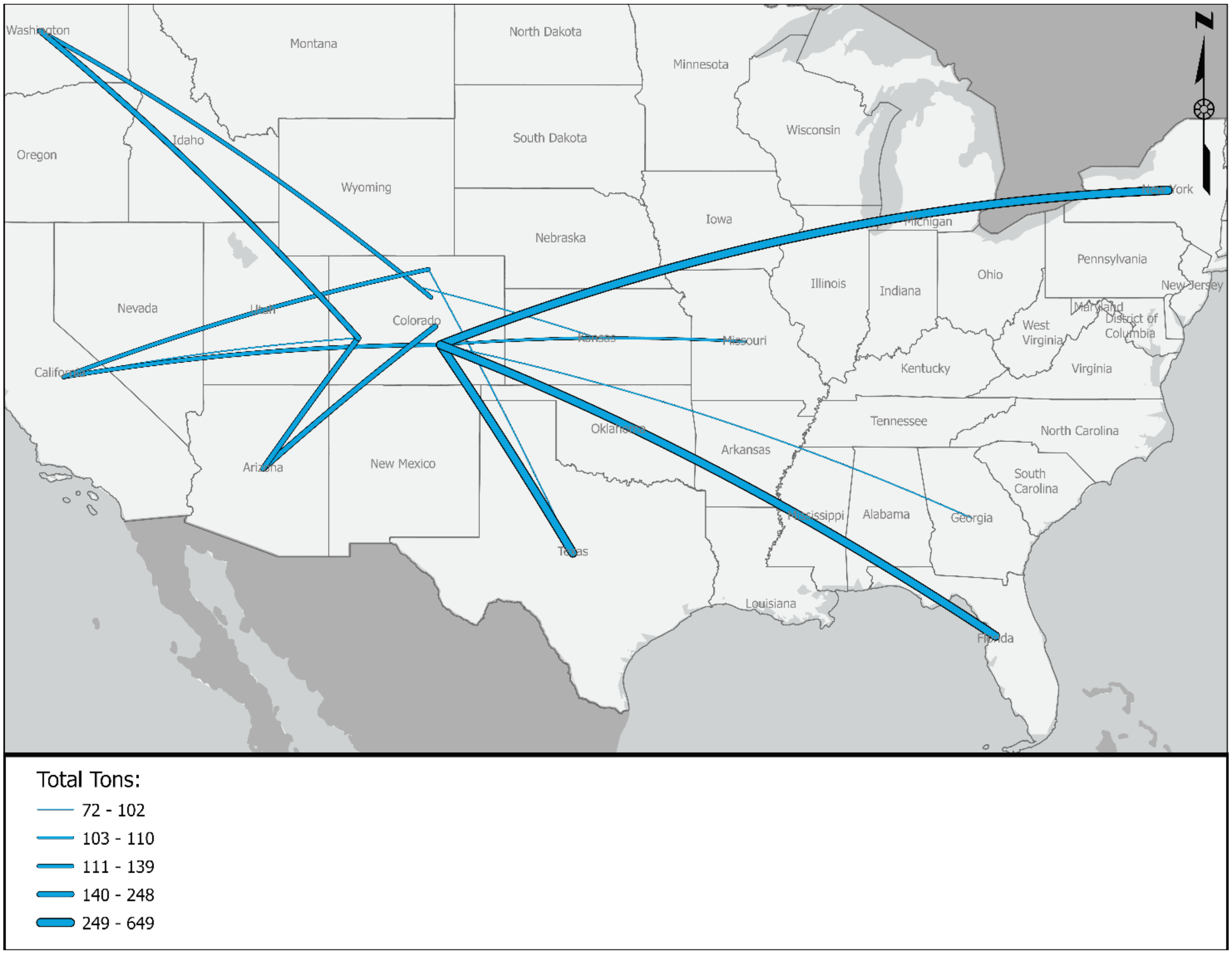
Figure 3.12 Origin and Destination of Tonnage in Aerospace Supply Chain, 2021



Source: S&P TRANSEARCH.

Figure 3.13 shows the domestic tonnage flows for the Aerospace industry to and from Colorado counties. As shown in the map, the top domestic trading partners are the states of Washington, New York, Arizona, Texas, and Florida.

Figure 3.13 Aerospace Supply Chain (Domestic Tonnage Flows)



Source: WSP analysis of S&P TRANSEARCH data.

3.3.2 Construction + Supply Chain

Industry Overview

The construction supply chain is a broader definition than the construction commodity category discussed earlier in this chapter. For example, the construction supply chain includes commodities that have separate categories such as lumber, wood products, metals, and finished building supplies. Excluding passthrough freight (moves through the state that are not originated or terminated in Colorado), construction defined as a supply chain in Colorado accounted for 90 million tons of material or 40 percent of the 220 million total tons of freight originating, terminating or moving within the state. Construction supply chain freight was valued at $10.4 billion, or 4.5 percent of the state's total $229 billion in 2021. [12] The construction industry supply chain employs 219,000 people, or 7.8 percent of total Colorado

[12] S&P TRANSEARCH. Summary statistics will vary slightly due to rounding.

employment and generated $16 billion in annual wages in 2021. [13] Demand on infrastructure from construction is predominantly on interstate and mountain roads, with 86 percent of tonnage moving by truck and 14 percent via rail.

Less than 1 percent of construction industry tonnage moves in international trade to and from Colorado. The freight that does move in this segment is primarily between USMCA countries of Canada and Mexico, where more than half of the inbound freight tonnage from outside the United States is lumber and wood products coming from Canada. [14]

The construction industry is an essential economic driver for the state of Colorado, particularly in metropolitan areas where housing, building, and civil infrastructure expansion and maintenance are not only a primary source of state commerce but also an enabler for other businesses and industries. Construction is also an essential input to resilience projects that either proactively address deficiencies or must be expedited to construction sites when recovery from weather events and natural disasters occur.

The construction industry is different from some of the other supply chains analyzed because the industry largely does not transport the end product. With the exception of mobile homes and other prefabricated structures, buildings are usually assembled on site and not transported further. Similarly, civil infrastructure is assembled on site with no additional transportation. Consequently, transportation in this sector consists of shipments of production materials inbound to construction locations, along with contractor equipment such as earth movers. Outbound transportation is limited to the return of empty supply vehicles, equipment, unused materials, and construction waste. Demolition of former structures also occurs at some sites and generates waste material; however, the principal activity is inbound materials, which is the focus of this analysis.

This analysis will generally focus on the building construction supply chain, although the analysis will relate to other subsectors as well. For example, many of the same materials used for building construction are also used for civil construction and its trade contractors, so the supply chains that feed building construction are in many cases the same or similar to the supply chains that feed civil construction. As an example, both buildings and civil infrastructure typically rely on cement and aggregates.

Table 3.17 summarizes the types of materials, manufacturers, equipment, and companies that are involved in Colorado's construction industry and supply chain. Figure 3.18 summarizes the total employment and wages within Colorado for the subsectors outlined in Table 3.17. Within Colorado, total 2022 employment in the construction category was 219,090 spread across 14,053 establishments. The materials subsector accounted for 15 percent of employees working and 14 percent of the wages within the construction industry in Colorado. The remaining share were employed in the construction establishments subsector. 2022 construction wages totaled $16.3 billion across the entire sector.

Construction materials move in large volumes and are expensive to ship, so they are often sourced from locations close to where they will be consumed. Therefore, the consumption and production of construction materials tends to congregate around metropolitan areas and constructions sites where much of the building occurs.

[13] Bureau of Labor Statistics, 2022.

[14] S&P TRANSEARCH. Summary statistics will vary slightly due to rounding.

Table 3.17 Definition of Construction Subsectors and Industries (4-digit NAICS)

Construction Materials Subsector	Construction Establishments Subsector
3274 Lime and gypsum product manufacturing	2372 Land subdivision
3351 Electric lighting equipment manufacturing	2379 Other heavy and civil engineering construction
3211 Sawmills and wood preservation	2373 Highway, street, and bridge construction
3241 Petroleum and coal products manufacturing	2371 Utility system construction
3212 Veneer, plywood, and engineered wood product manufacturing	2362 Nonresidential building construction
3279 Other non-metallic mineral product manufacturing	2389 Other specialty trade contractors
3372 Office furniture (including fixtures) manufacturing	2383 Building finishing contractors
3334 Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	2361 Residential building construction
2123 Nonmetallic mineral mining and quarrying	2381 Building foundation and exterior contractors
3271 Clay product and refractory manufacturing	2382 Building equipment contractors
3329 Other fabricated metal product manufacturing	
3339 Other general purpose machinery manufacturing	
3371 Household and institutional furniture and kitchen cabinet manufacturing	
3219 Other wood product manufacturing	
3323 Architectural and structural metals manufacturing	
3273 Cement and concrete product manufacturing	
3261 Plastics product manufacturing	

Table 3.18 Employment, Establishments, and Wages for Construction Industry, 2022

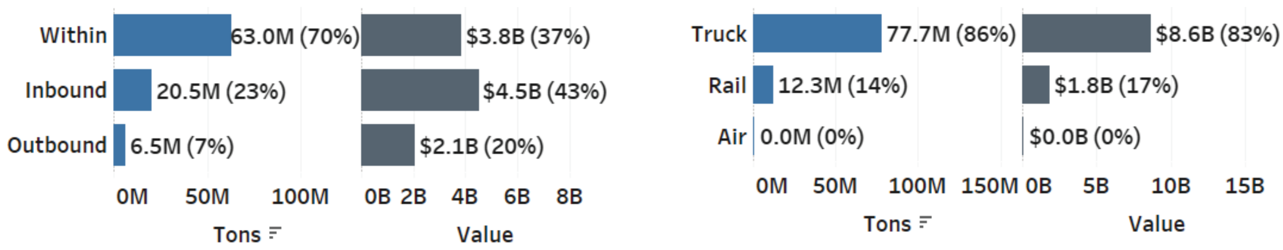
	Employment		Establishments		Total Annual Wage ($M)	
Subsector	Total	%	Total	%	Total	%
Construction Materials	33,009	15%	1,609	7%	2,279	14%
Construction Establishments	186,081	85%	22,423	93%	14,053	86%
Total	**219,090**	**100%**	**24,032**	**100%**	**16,332**	**100%**

Source: Quarterly Census of Employment and Wages, Bureau of Labor Statistics.

Commodities and Forecast

Figure 3.14 illustrates the tonnage of construction freight material moving within Colorado and the associated total value of that material. As is typically the case with heavy, lower-value construction materials, 70 percent of the tonnage moved within the state of Colorado, although this same segment accounted for only 37 percent of the total value. Gravel, sand, broken stone, and riprap from Wyoming, Illinois, and Wisconsin made up half of the inbound construction freight tonnage to Colorado. Outbound construction material accounted for 6.5 million tons and $2.1 billion in value, or 7 percent and 20 percent of the total tons and value, respectively.

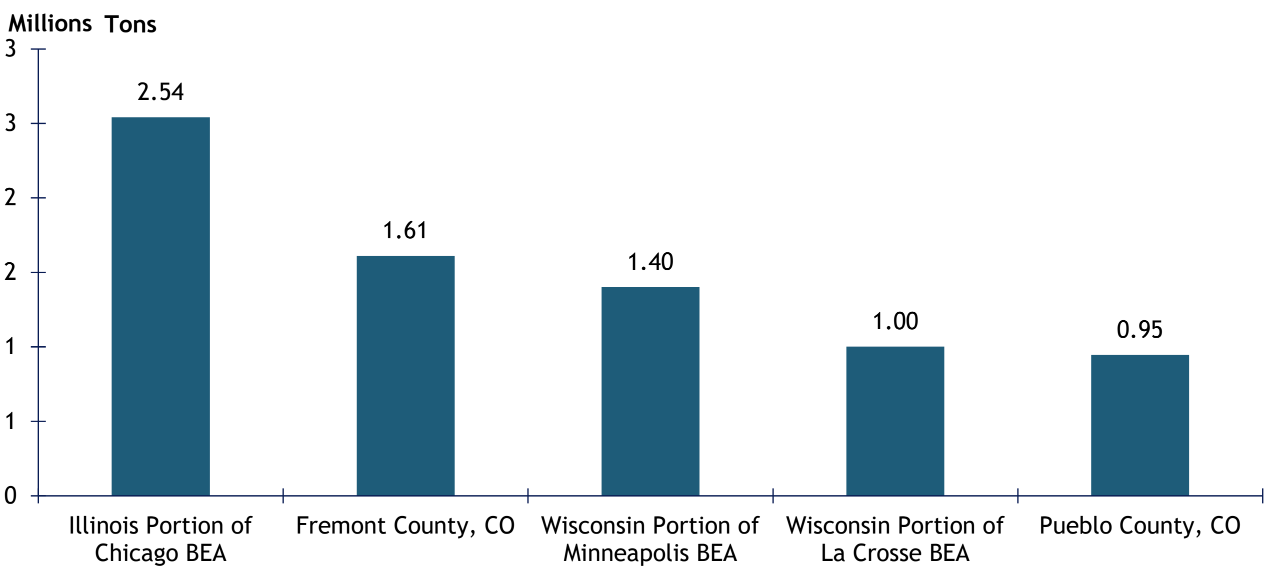
Figure 3.14 Construction Industry Freight Flow, by Direction and Mode 2021



Source: S&P TRANSEARCH.

Figure 3.14 also provides a modal breakdown of how this material flows through Colorado using data from 2021. Air movement is negligible, with trucks handling proportionately 83 percent of the freight value and remainder moving via rail. Of the rail shipments received, Figure 3.15 highlights the top five origination regions by tonnage. Ninety-five percent of shipments from Illinois were gravel or sand. Similarly, gravel and sand made up 99 percent of the material shipped from the two Wisconsin regions, which is known for high quality sand (silica) used in the energy industry. Fremont and Pueblo Counties originate Portland cement, concrete products or broken stone and riprap.

Figure 3.15 Top 5 Origination Regions via Rail Mode



Source: S&P TRANSEARCH.

Table 3.19 summarizes the freight commodity subsectors that make up Colorado's construction industry. Ninety million tons of construction material valued at $10 billion flowed through Colorado in 2021. Collectively, these commodities are expected to grow tonnage moving through Colorado at a compound annual growth rate (CAGR) of 0.8 percent with a corresponding 1.4 percent valuation CAGR through the year 2040.

Asphalt includes the material used for road surfacing, the petroleum-based products used to bind aggregates for pavement, as well as roofing products and other insulation materials. Construction machinery includes heavy equipment such as excavators, bulldozers, large dump trucks, cranes, pumps, air compressors, graders, compactors, and boring machinery.

Metallic building supplies include primary steel products manufactured in Colorado or brought to Colorado from outside suppliers, and finished metal products manufactured in or brought to Colorado for use by the construction industry. Examples include items such as primary iron, aluminum and steel products, sheet metal, fabricated structural products, fabricated plates, metal doors and windows, and architectural metal work.

Lumber and wood products include raw materials brought to Colorado from natural resources outside of Colorado or harvested directly from Colorado forests, as well as finished lumber/wood products that are either manufactured in or brought to Colorado. Examples include primary forest products, lumber, dimension stock, plywood and oriented strand board, veneer, treated wood, engineered wood, millwork, cabinetry, and structural wood products.

Non-metallic minerals and building supplies include raw materials such as aggregates and limestone originating from quarries and mines and processed materials such as cement and concrete. Examples include broken stone or riprap, gravel, sand, ready-mix concrete, concrete products, Portland cement, stone, stone products, flat glass, granite, ceramic fixtures, marble, travertine, and gypsum wallboard.

Table 3.19 also highlights how commodities that are high in tonnage do not necessarily translate to high value. A case in point is non-metallic minerals, which accounted for 91.4 percent of total construction commodity flow tonnage in Colorado in 2021, but correspondingly only accounted for 32.9 percent of the total value. Conversely, metallic building supplies and lumber and wood products accounted for less than 5 percent of total tons, but commanded 23.2 percent and 33.4 percent of the total freight value, respectively.

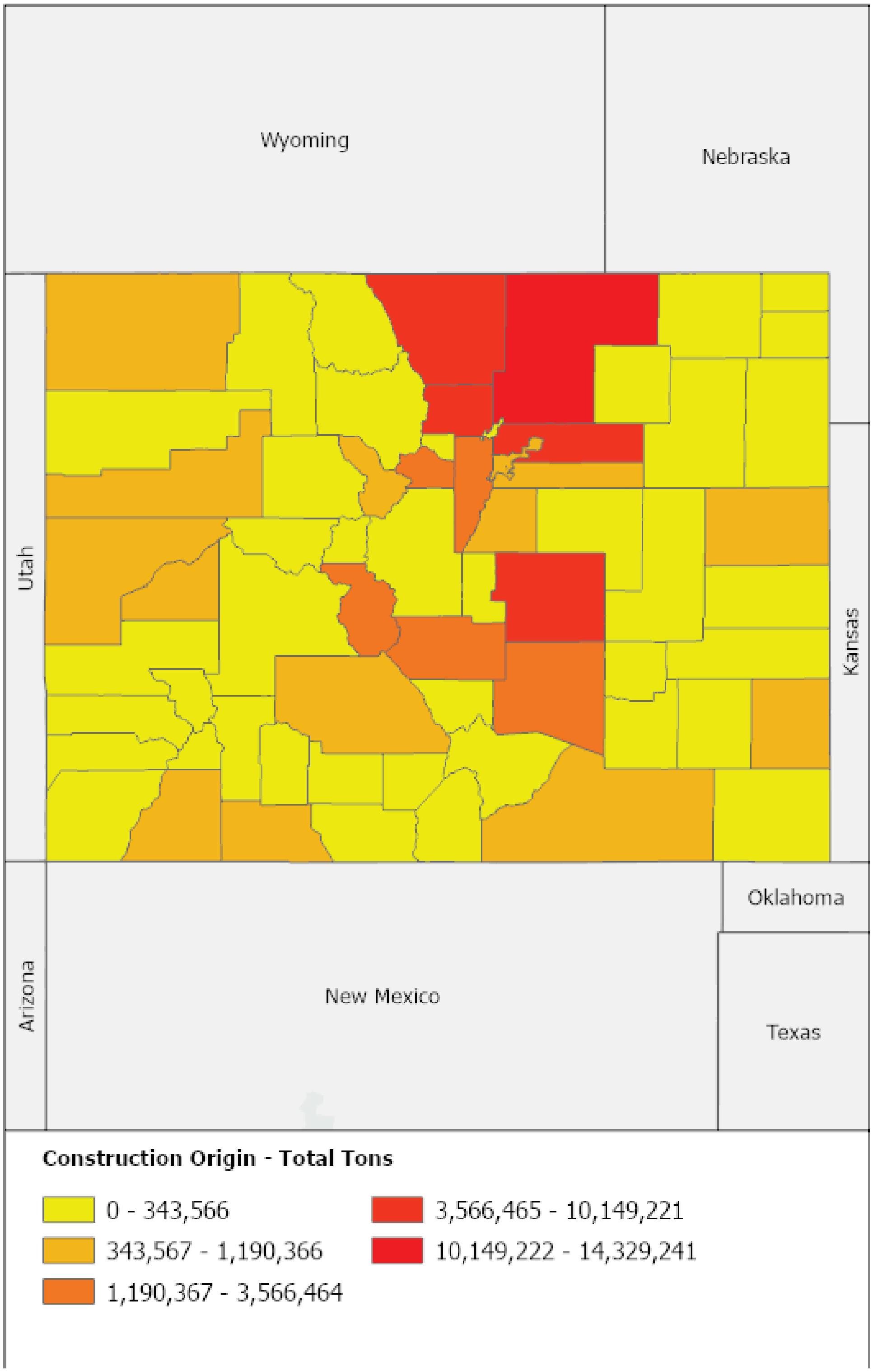
Table 3.19 Commodity Flows by Subsector in Construction Industry, 2021 and Forecasted Compound Annual Growth Rate out to 2040

	Tons			Value		
Subsector Commodities	Total (M) 2021	%	Forecasted compound annual growth rate	Total ($B) 2021	%	Forecasted compound annual growth rate
Asphalt	2.9	3.2%	0.5%	0.4	4.0%	1.2%
Construction machinery	0.1	0.1%	0.0%	0.7	6.6%	1.3%
Lumber and wood products	3.6	4.0%	0.6%	2.4	23.2%	1.0%
Metallic building supplies	1.2	1.3%	1.5%	3.5	33.4%	1.9%
Nonmetallic minerals	82.3	91.4%	0.8%	3.4	32.9%	1.2%
Total	**90.0**	**100%**	**0.8%**	**10.4**	**100%**	**1.4%**

Source: S&P TRANSEARCH.

Figure 3.16 illustrates where originating construction freight tonnage occurs within the state of Colorado, with darker gradient colors representing higher tonnage. The highest originating tonnage (14.3 million tons) occurs in Weld County, which is immediately north of Adams and Denver Counties, both of which includes large segments of the Denver metropolitan area. Adams County originated 10.1 million tons and ranked second in tonnage origination among counties within Colorado. Other counties surrounding Denver including Larimer, Boulder, Jefferson and Clear Creek Counties also originate high construction tonnage levels, which supports construction activity in Colorado's largest metropolitan region. Notably, El Paso County, which includes Colorado Springs, and Pueblo County, which includes the city of Pueblo together originate 9 million tons of construction material in the middle of the state.

Figure 3.16 Origination of Tonnage in Construction Industry

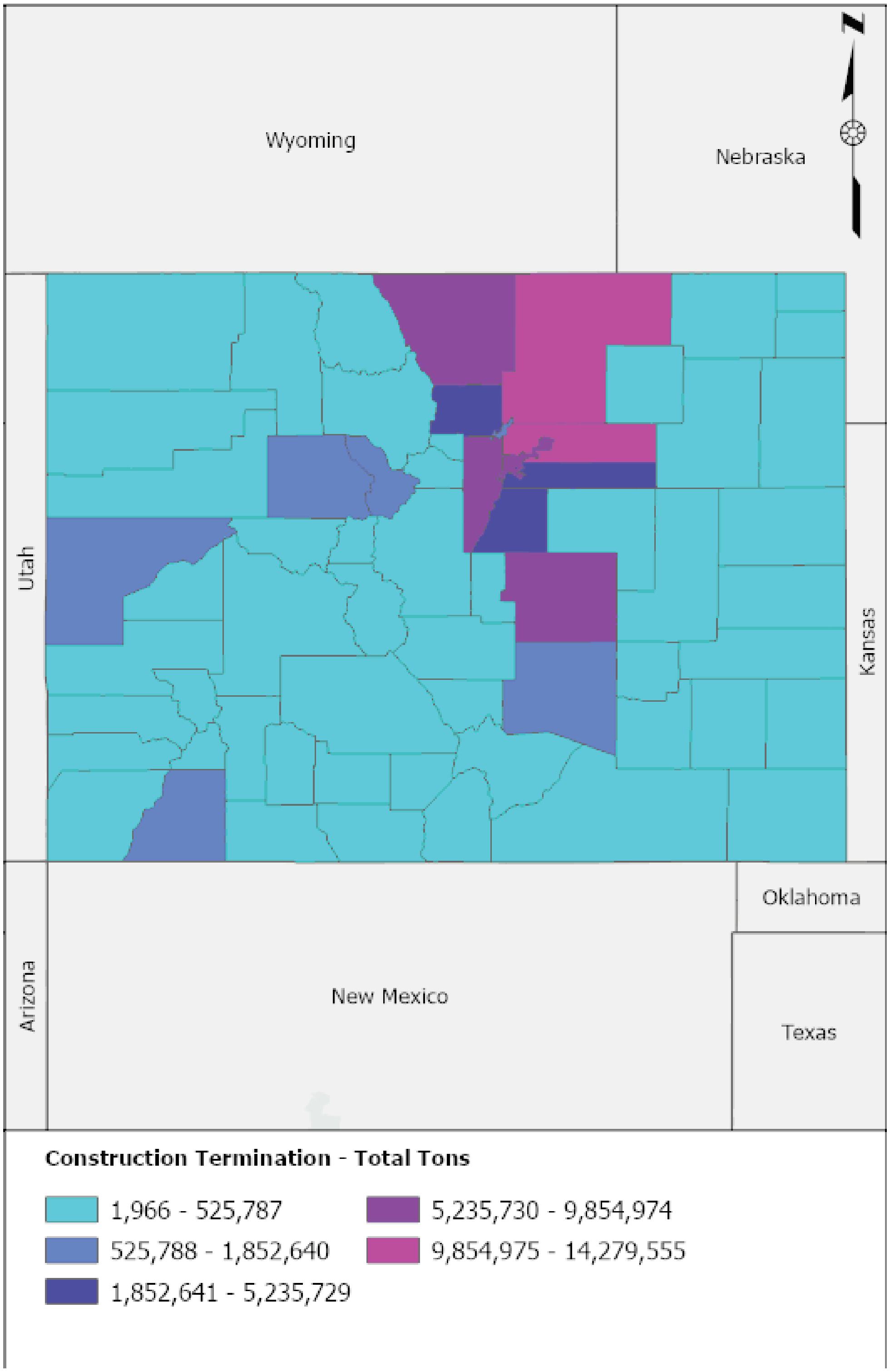


Source: S&P TRANSEARCH.

Counties that originate construction materials within the Rocky Mountains that are near the population centers along the front range include Clear Creek and Summit Counties, which service the I-70 corridor. Clear Creek County originated 1.4 million tons of material, 99 percent of which was gravel and sand. Summit County originated 490 thousand tons, almost all of which was ready-mix concrete. Further south, Fremont, Chafee, and Saguache Counties, accessed by state highways 50 and 285, collectively originated 3.8 million tons of construction material. To the extent that materials are sourced in mountainous regions and shipped longer distances to populations centers along the front range outside of the originating county, cost is added to the overall end product. More fuel and wear and tear on equipment and parts such as drivetrains, tires, and brakes adds cost to transportation providers that is passed on to end users. The counterpart to Figure 3.16 (originations) is Figure 3.17, which illustrates construction tonnage terminations within the state of Colorado, where most of the construction material is destined to counties along the front range of the Rocky Mountains. Weld and Adams Counties received the largest share of tonnage for material terminating within Colorado, taking in 14.1 million and 14.2 million tons, respectively. Surrounding and adjacent counties to the Denver metropolitan area, including Jefferson (9.8 million tons), Denver (8.6 million tons), Arapahoe (5.1 million tons) and Boulder (3.3 million tons) illustrate the large share of construction material tonnage centered around Colorado's largest city. Likewise, El Paso County (6.7 million tons) and Pueblo County (1.8 million tons) in the middle of the state received respectively large shares of construction tonnage servicing Colorado population centers.

All counties within Colorado received some amount of construction material, with the lowest being San Juan County at 1,966 tons. As Figure 3.17 illustrates, notable exceptions to counties receiving significant construction material tonnage that are not along the front range include Mesa, La Plata, Summit and Eagle Counties.

Figure 3.17 Termination of Tonnage in Construction Industry, 2021



Source: S&P TRANSEARCH.

International Trade of Construction and Building Materials

The total tonnage of construction materials moving into and out of Colorado internationally is relatively small (less than 1 percent of total tonnage) when compared to the tonnage moving domestically within the United States to and from Colorado or intrastate within Colorado. Within the international construction materials segment, 81 percent of the total international inbound construction material tonnage into Colorado (442 thousand tons) originated from Canada, where 83 percent (374 thousand tons) was inbound wood products, lumber and dimension stock. Less than 1 percent of imported construction materials originated from Mexico. 9.7 times more international construction freight tonnage was imported to Colorado than exported, which accounted for 57 thousand tons, 52 percent of which was destined for Canada. The limited Colorado international construction material trade notwithstanding, the fact that Canada was the majority importer and exporter underscores the importance of the USMCA in facilitating North American trade. [15]

International imports of construction and building materials into the United States reached $39.9 billion in 2021, of which Colorado accounted for $633 million, or 1.6 percent as shown in Table 3.20. Heavy, non-metallic minerals and cement and concrete products imported to Colorado combined were less than 1 percent of the total value imported into the United States. Colorado had a much larger share of the total sawmill, wood, veneer, plywood, and engineered wood products, which combined amounted to 4.5 percent of the total U.S. import value. As noted earlier, most of the wood-related imports originated from Canada.

Table 3.20 International Imports of Construction and Building Materials

	Import Value $Millions		
Commodity by NAICS	All States	Colorado	CO Share
Building Materials	39,939	633	1.6%
2123 Nonmetallic Minerals	2,875	18	0.6%
3211 Sawmill & Wood Products	14,085	191	1.4%
3212 Veneer, Plywood & Engineered Wood Products	11,738	359	3.1%
3219 Other Wood Products	8,164	57	0.7%
3273 Cement & Concrete Products	2,805	8	0.3%
3274 Lime & Gypsum Products	272	0	0.2%

Source: U.S. Census Trade Data, 2021.

Table 3.21 summarizes exports from the United States to other countries of Construction and Building Materials, which equated to $11.2 billion nationally, with Colorado accounting for 0.2 percent of export share, or $18 million. Compared to imports of the same commodity groups, exports accounted for slightly less than one-third of import value.

[15] Data references from TRANSEARCH database.

Table 3.21 International Exports of Construction and Building Materials

	Export Value $Millions		
Commodity by NAICS	All States	Colorado	CO Share
Building Materials	11,248	18	0.2%
2123 Nonmetallic Minerals	2,371	11	0.5%
3211 Sawmill & Wood Products	4,030	1	0.0%
3212 Veneer, Plywood & Engineered Wood Products	1,558	1	0.1%
3219 Other Wood Products	2,499	4	0.2%
3273 Cement & Concrete Products	490	1	0.2%
3274 Lime & Gypsum Products	299	0	0.0%

Source: U.S. Census Trade Data, 2021.

Supply Chain Highlight: Non-Metallic Minerals and Products

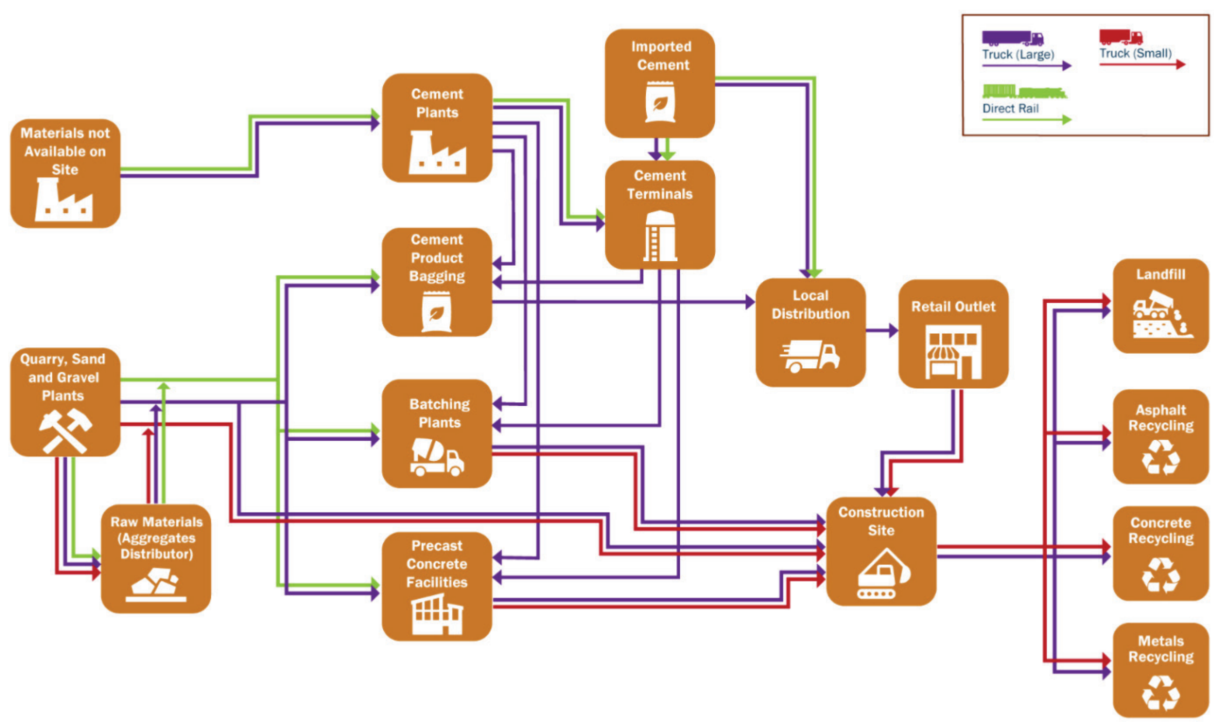
As illustrated in Table 3.19, non-metallic minerals accounted for 82.3 million tons of construction freight moving within, originating in, or terminating in Colorado. This commodity subsector correspondingly accounted for 91.4 percent of all construction material tonnage. Given the high density and heavy weight of these materials, they will have a high propensity to cause wear and tear on the ground transportation infrastructure used to move it, which is 86 percent via truck and 14 percent via rail. Non-metallic minerals and products moved within Colorado in 2021 valued at $3.4 billion and include the common names discussed below.

Aggregates are a range of construction materials, including sand, gravel, crushed stone, or other bulk stone products. They are mined or quarried, then are broken down and sorted into different sizes for construction applications. Crushed stone is quarried and then pulverized using a rock crusher. Crushed stone is then passed through screens and organized according to size. Gravel is naturally occurring stone. Gravel is mined and then sorted by characteristics such as size. Sand is a granular material composed of finely divided rock and mineral particles. It is often of the same base materials as other aggregates like gravel and crushed stone, but the individual pieces are smaller. Like gravel, sand is mined from quarries or sand pits. Limestone is sedimentary rock raw material that is the chemical feedstock for the production of lime used to make cement. It can also be processed into brick, powdered, and used as a filler material. Cement is a binder used in construction that sets, hardens, and adheres to other materials such as rock, gravel, and sand. Concrete is formed when cement is mixed with other aggregates such as sand or gravel. Cement mixed with fine sand aggregates is a called mortar, which is used to bind bricks together. Concrete products are made using forms to produce specific shapes used in construction. These can include cinderblocks, sewer pipes, bridge piers, and highway features such as curb cuts.

This analysis considers both non-metallic minerals, specifically those materials that are produced at quarries and mining operations, as well as non-metallic mineral products, which use non-metallic minerals but require additional processing, such as cement and concrete. Non-metallic minerals and finished non-metallic mineral products are collectively referred to herein as non-metallic minerals and products.

Figure 3.18 illustrates the how the flow of aggregates, construction materials, cement, and concrete move through the supply chain from sources to end users and construction sites. These materials flow in the rail and truck modes, with truck subdivided by small and large vehicles. The opportunities to ship by rail are generally toward the beginning of the supply chain, where large volumes of heavy bulk raw materials, such as rock from quarries, cement, or sand are shipped to central locations for further processing. Ultimately, these products all end up at one common location, namely a construction site, where materials are assembled by contractors into the end product (building, roadway, infrastructure). Construction sites also produce waste materials, which as illustrated are recirculated directly back into production for future uses when feasible and economical. For example, asphalt is 100 percent recyclable and is frequently reused as a base for driveways or as a feedstock for new asphalt. Similarly, metal rebar encased in concrete is removed and recycled. Used concrete is ground down to become a sub base material for road and other construction, known as class VI concrete base. There are four primary cement plants within 120 miles of the Denver area that serve as the primary sources for cement for the metropolitan area. These facilities receive feedstock materials, e.g., lime, and process them into cement that is then distributed to terminals or constructions sites as an ingredient for concrete.

Figure 3.18 Non-Metallic Minerals and Products Supply Chain



Source: WSP 2023.

Most of the aggregates used to support construction in Denver have historically come from quarries 10 to 15 miles west of the city center. Anecdotal observations based on interviews indicate that materials increasingly are coming from longer distances to support Denver construction, as some of the nearby quarries have depleting reserves or are subject to permits that if not renewed will expire. Observations from truckers working in the industry indicate higher costs to moving longer distances, particularly through mountainous terrain with 6 to 7 percent grades. One trucking company notes that a tractor operating in mountainous territory for its useful life will last half the time (mileage) as one not subject to mountainous assignments. New tractors cost $180,000 and trailers supporting aggregates cost $90,000; more frequent replacement of these assets as well as the higher variable costs (fuel and driver time) is passed on to the end user.

Table 3.22 summarizes the top 10 domestic sources and destinations of non-metallic minerals flowing to and from Colorado. Wyoming, Illinois, and Wisconsin together account for 67 percent of all inbound non-metallic minerals. 16 million tons of non-metallic minerals were imported to Colorado from other states, which accounted for 19.5 percent of all non-metallic minerals moved in Colorado. On the outbound side, Texas, New Mexico, and Wyoming accounted for 49 percent of all non-metallic minerals exported to other states. Total exported non-metallic minerals in 2021 were almost 5 million tons, or 6 percent of total non-metallic minerals moving in Colorado. Fifty-five percent of the inbound domestic tons moved by truck, and 45 percent moved by rail. Outbound, the truck/rail modal split was 70 percent and 30 percent, respectively. Illinois, Wisconsin, and Wyoming were the top three states originating tonnage destined for Colorado via rail and accounted for 77 percent (5.6 million tons) of all originated non-metallic minerals and products moving into Colorado in the rail mode.

Outbound, 63 percent (919,000 tons) of non-metallic minerals and products moving via rail were destined for Texas (583,000 tons), South Dakota (204,000 tons), or Nebraska (130,000 tons).

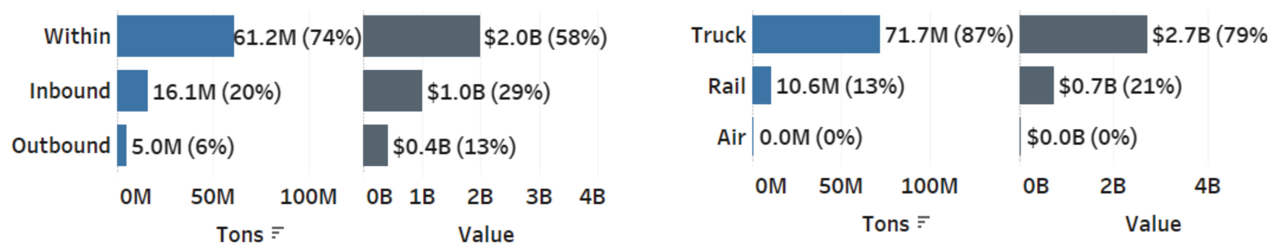
Table 3.22 Top Domestic Non-Metallic Minerals and Products Trading Partners

	Inbound			Outbound		
Rank	State	Tons (k)	%	State	Tons (k)	%
1	Wyoming	5,548	35%	Texas	859	17%
2	Illinois	2,647	16%	New Mexico	791	16%
3	Wisconsin	2,497	16%	Wyoming	774	16%
4	Texas	705	4%	California	467	9%
5	Nebraska	567	4%	Utah	323	7%
6	New Mexico	562	3%	Nebraska	307	6%
7	Minnesota	501	3%	Kansas	281	6%
8	Missouri	468	3%	South Dakota	210	4%
9	Kansas	439	3%	Iowa	123	2%
10	Utah	420	3%	Nevada	97	2%
	Other	1,713	11%	Other	716	14%
	Total	**16,068**	**100%**	**Total**	**4,949**	**100%**

Source: S&P TRANSEARCH.

Figure 3.19 highlights that the majority of the non-metallic mineral tonnage and value moving in Colorado originate and terminate within the state. Also, in a pattern similar to the movement of all construction materials, the movement of non-metallic tonnage is made primarily with truck, which holds 87 percent of the non-metallic mineral movement market share.

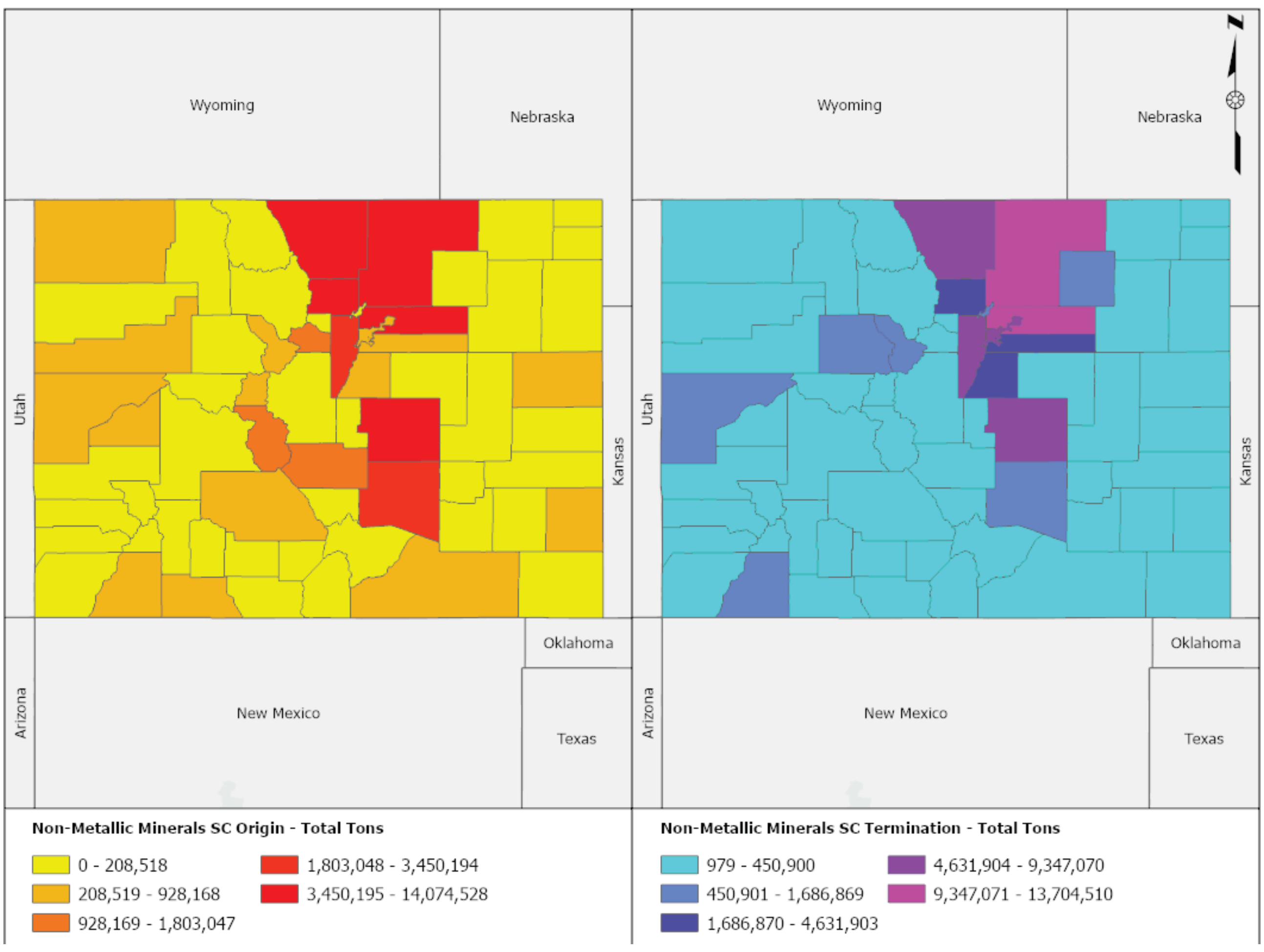
Figure 3.19 Non-Metallic Minerals Supply Chain by Direction and Mode, 2021



Source: S&P TRANSEARCH.

Figure 3.20 illustrates origination (red) and termination (blue) of non-metallic minerals within the state of Colorado by county. Although all counties receive some volume of non-metallic minerals, not all counties originate these materials. Similar to the movement of the broader construction material sector, the origination and termination of non-metallic minerals is concentrated around greater Denver and the Colorado Springs Pueblo metropolitan areas, which parallel the front range of the Rocky Mountains.

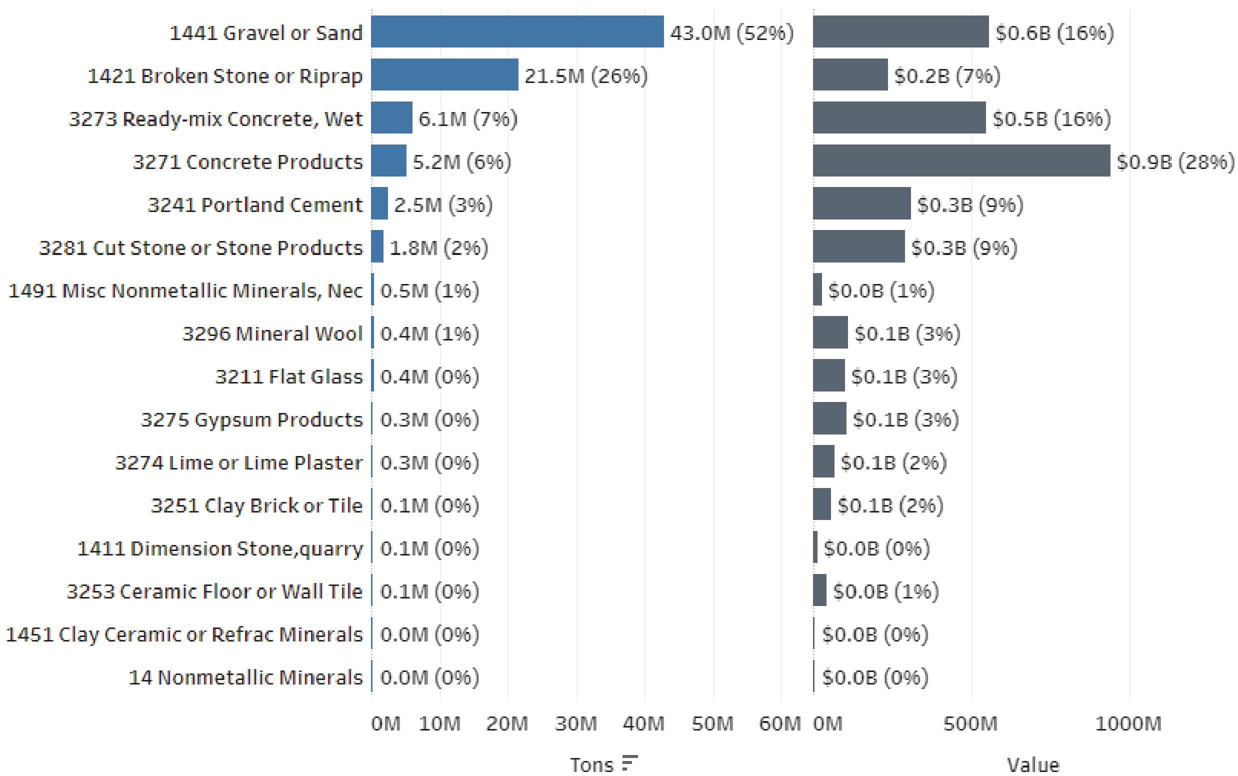
Figure 3.20 Origination and Termination of Non-Metallic Minerals Supply Chain, 2021



Source: S&P TRANSEARCH.

Figure 3.21 illustrates the material classifications within the non-metallic minerals subgroup that account for the total tonnage and value moving to, from and within Colorado. Gravel, sand, stone, and riprap make up 78 percent of the non-metallic tonnage. Concrete products, such as precast blocks and pipes, have additional labor and processing expenses, and account for 28 percent of the total non-metallic minerals value moving through Colorado.

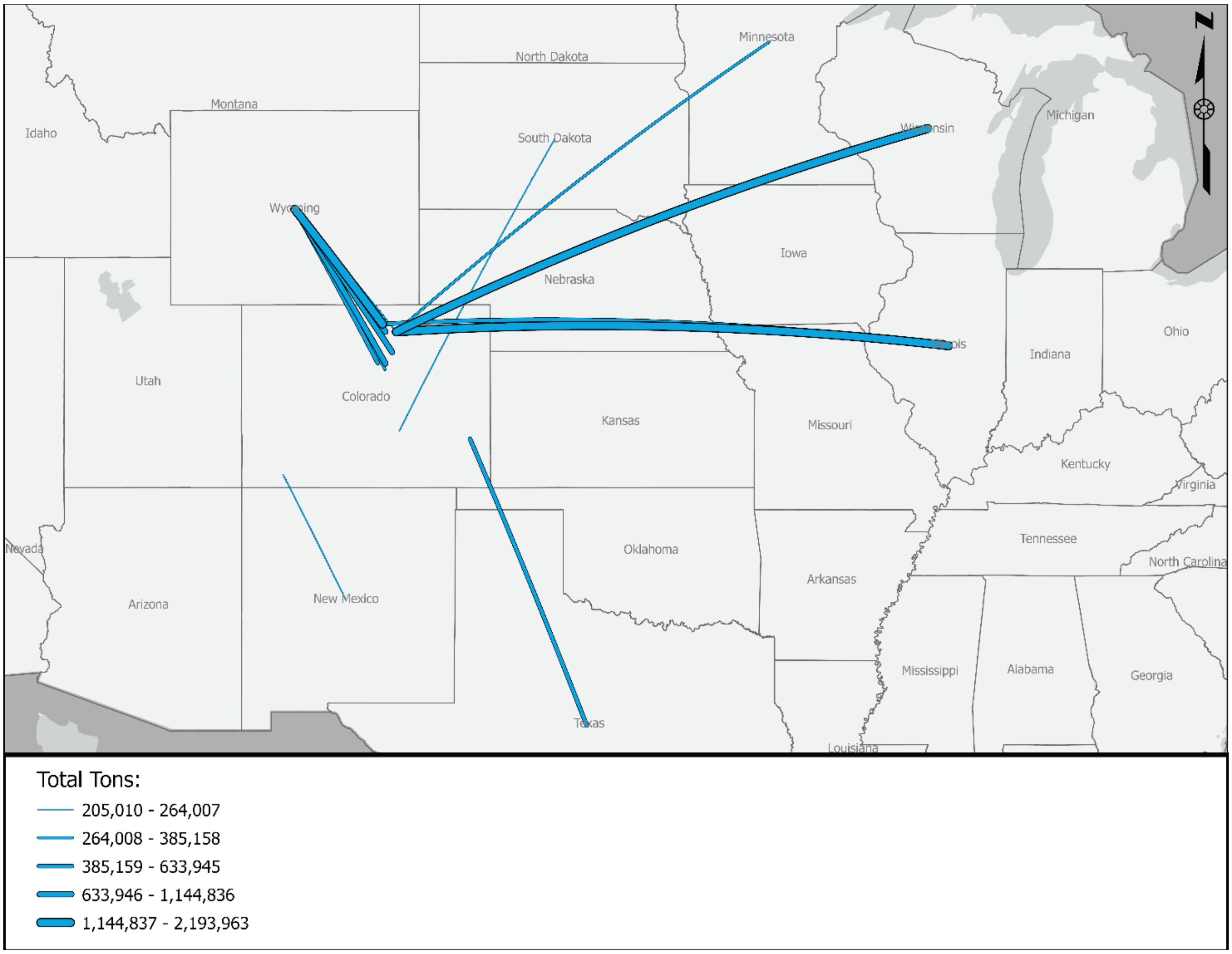
Figure 3.21 Non-Metallic Minerals and Products by Tonnage and Value, 2021



Source: S&P TRANSEARCH.

Figure 3.22 provides a visual representation of the data from Table 3.22, displaying where the top non-metallic minerals trading partners with Colorado are located and, based on the size of the line, how much volume moves between those trading partners and Colorado. Figure 3.22 only displays domestic freight movement in and out of the state of Colorado. Movement within the state is not included. Wisconsin to Weld County, Colorado, represents the largest non-metallic minerals domestic trading partner with Colorado, which saw 2.2 million tons move between these locations in 2021. Illinois ranked second, trading 1.9 million tons with Weld County in 2021. To the northwest, Wyoming traded 1.2 million tons with Larimer Country, Colorado, in 2021.

Figure 3.22 Colorado's Main Trading Partners for Non-Metallic Minerals, 2021



Source: WSP analysis of S&P TRANSEARCH.

3.3.3 Distribution + Supply Chain

Industry Overview

The objective of this section is to describe the importance of warehousing and retail distribution in Colorado.

Nearly all products moving through Colorado depend on a distribution system that includes warehouses of different types and sizes. Whether the products are business-to-business or business-to-consumer (B2C), one or more warehouses are involved in this supply chain. The business-to-business supply chain is a significant user of the network of warehouses around the state. However, for this review, the focus is on the consumer activity in warehousing and retail distribution.

This chapter draws on qualitative and quantitative information to present a picture of the stages of the consumer product supply chain (B2C) in the state, focusing on what happens between the time goods are received in a warehouse and when they arrive at their point of final consumption.

This report focuses on all wholesale and certain retail industries, including health and groceries. These were chosen because of the availability of data associated with the NAICS codes, identifying groupings of similar industries using a two-digit category that is broken down into more specific identification at the four-digit level.

For this section the top levels selected were:

- 42 Wholesale Trade which generally operates from a warehouse
- 44 & 45 Retail Trade involving consumer end use (B2C)
- 49 Warehousing and Storage

The subcategories were selected by reviewing the entire list and selecting commodities within these subsectors: General Retail, General Retail-Health, Grocery, and Warehousing and Distribution. These subsectors are shown in Table 3.23.

Table 3.23 Definition of Distribution Subsectors and Industries

Subsector	4-digit NAICS Code & Industry Description
General Retail	4231 Motor vehicle and motor vehicle parts and supplies merchant wholesalers
General Retail	4232 Furniture and home furnishing merchant wholesalers
General Retail	4233 Lumber and other construction materials merchant wholesalers
General Retail	4234 Professional and commercial equipment and supplies merchant wholesalers
General Retail	4235 Metal and mineral (except petroleum) merchant wholesalers
General Retail	4236 Household appliances and electrical and electronic goods merchant wholesalers
General Retail	4237 Hardware, and plumbing and heating equipment and supplies merchant wholesalers
General Retail	4238 Machinery, equipment, and supplies merchant wholesalers
General Retail	4239 Miscellaneous durable goods merchant wholesalers
General Retail	4241 Paper and paper product merchant wholesalers
General Retail	4243 Apparel, piece goods, and notions merchant wholesalers
General Retail	4245 Farm product raw material merchant wholesalers
General Retail	4246 Chemical and allied products merchant wholesalers
General Retail	4247 Petroleum and petroleum products merchant wholesalers
General Retail	4248 Beer, wine, and distilled alcoholic beverage merchant wholesalers
General Retail	4249 Miscellaneous nondurable goods merchant wholesalers
General Retail	4413 Automotive parts, accessories, and tire retailers
General Retail	4442 Lawn and garden equipment and supplies retailers
General Retail	4452 Specialty food retailers

Subsector	4-digit NAICS Code & Industry Description
General Retail	4453 Beer, wine, and liquor retailers
General Retail	4491 Furniture and home furnishings retailers
General Retail	4492 Electronics and appliance retailers
General Retail	4551 Department stores
General Retail	4552 Warehouse clubs, supercenters, and other general merchandise retailers
General Retail	4581 Clothing and clothing accessories retailers
General Retail	4582 Shoe retailers
General Retail	4583 Jewelry, luggage, and leather goods retailers
General Retail	4591 Sporting goods, hobby, and musical instrument retailers
General Retail	4594 Office supplies, stationery, and gift retailers
General Retail-Health	4561 Health and personal care retailers
General Retail-Health	4242 Drugs and druggists' sundries merchant wholesalers
Grocery	4451 Grocery and convenience retailers
Grocery	4244 Grocery and related product merchant wholesalers
Warehousing & Distribution	4931 Warehousing and storage

The warehousing and retail distribution of consumer goods is a significant contributor to economic activity in Colorado. In 2021, 25,885 establishments employed 326,153 people in this sector in the state. A breakdown of the economic activity for each subsector is provided in Table 3.24 and summarized below:

- The General Retail subsector was the largest employer, with 21,110 establishments employing 225,133 workers, for an average of 11 workers per firm. Total wages paid in this subsector were greater than $14.7 billion. Note that general retail includes workers in wholesale distribution, as defined in Table 3.23.
- The Grocery subsector was the second largest employer, with 2,193 establishments employing 57,460 workers, for an average of 26 workers per establishment.
- The Warehousing and Distribution subsector was the third largest employer, with 276 establishments employing 23,590 workers, for an average of 85 workers per establishment in 2021.
- The General Retail-Health subsector had the fewest establishments and employees, with 2,306 establishments employing 19,970 workers, for an average of 9 workers per establishment.

Table 3.24 Employment, Establishments, and Wages for Distribution Industry, 2021

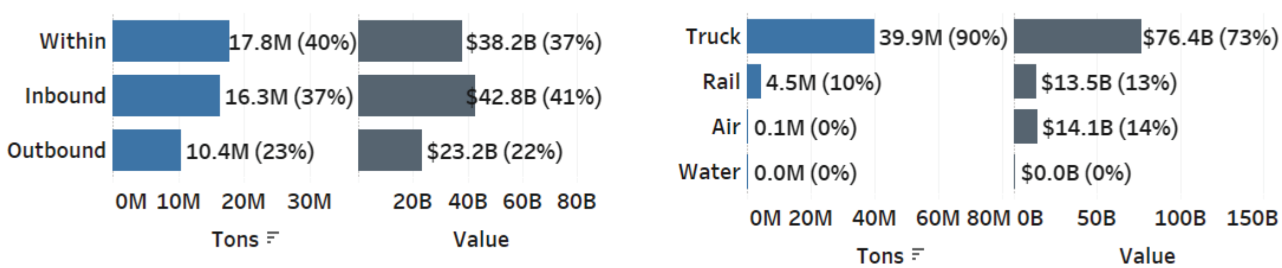
	Employment		Establishments		Total Annual Wage ($M)	
Subsector	Total	%	Total	%	Total	%
General Retail	225,133	69%	21,110	82%	14,769	73%
General Retail-Health	19,970	6%	2,306	9%	1,436	7%
Grocery	57,460	18%	2,193	8%	2,827	14%
Warehousing & Distribution	23,590	7%	276	1%	1,329	7%
Total	**326,153**	**100%**	**25,885**	**100%**	**20,361**	**100%**

Source: Quarterly Census of Employment and Wages, Bureau of Labor Statistics.

Commodities and Forecast

- Figure 3.23 shows that in 2021, the Warehousing and Retail Distribution sector moved 44.5 million tons of cargo with a total value of $104.2 billion. The largest share of this tonnage moved within the state (40 percent), followed by inbound (37 percent) and outbound (23 percent). By value, the largest share of cargo was inbound (41 percent), followed by cargo moving within the state (37 percent) and outbound (22 percent).
- The largest share of Warehousing and Retail Distribution tonnage in the state in 2021 was moved by truck (90 percent). This was followed by cargo moving by rail (10 percent). The rail tonnage most likely reflects intermodal shipments of retail goods. Other modes had negligible volume as measured in tonnage, including approximately 68,000 tons moved by air (possibly including time-sensitive products in the General Retail-Health subsector).
- The largest share of cargo by value for the Warehousing and Retail Distribution sector in 2021 was moved by truck (73 percent), followed by air (14 percent) and rail (13 percent). On a per-ton basis, cargo moved by air had the highest value, at $208,841 per ton. The high cost and low volume of cargo moved by air suggests that this cargo may have included a significant percentage of medical shipments. Seafood and fresh flowers are other commodities that move by air in the retail sector. Cargo moved by rail also had a higher value on a per-ton basis at $3,102 per ton. This value is more reflective of intermodal transport than carload. Cargo moved by truck had a lower-than-average value at $1,916 per ton.

Figure 3.23 Commodity Flows for Distribution Industry, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

As shown in Table 3.25, the Grocery subsector accounted for slightly less than half of the tonnage, while Warehousing and Distribution accounted for a similar volume. The General Retail and General Retail-Health subsectors accounted for very little cargo volume by weight. In terms of value, the Warehousing and Distribution subsector accounted for slightly less than half of the total value for the sector. The Grocery subsector accounted for 29 percent of the total value, while General Retail accounted for 16 percent and General Retail-Health another 7 percent.

Table 3.25 Commodity Flows by Subsector in Distribution Industry, 2021 and Forecasted CAGR out to 2050

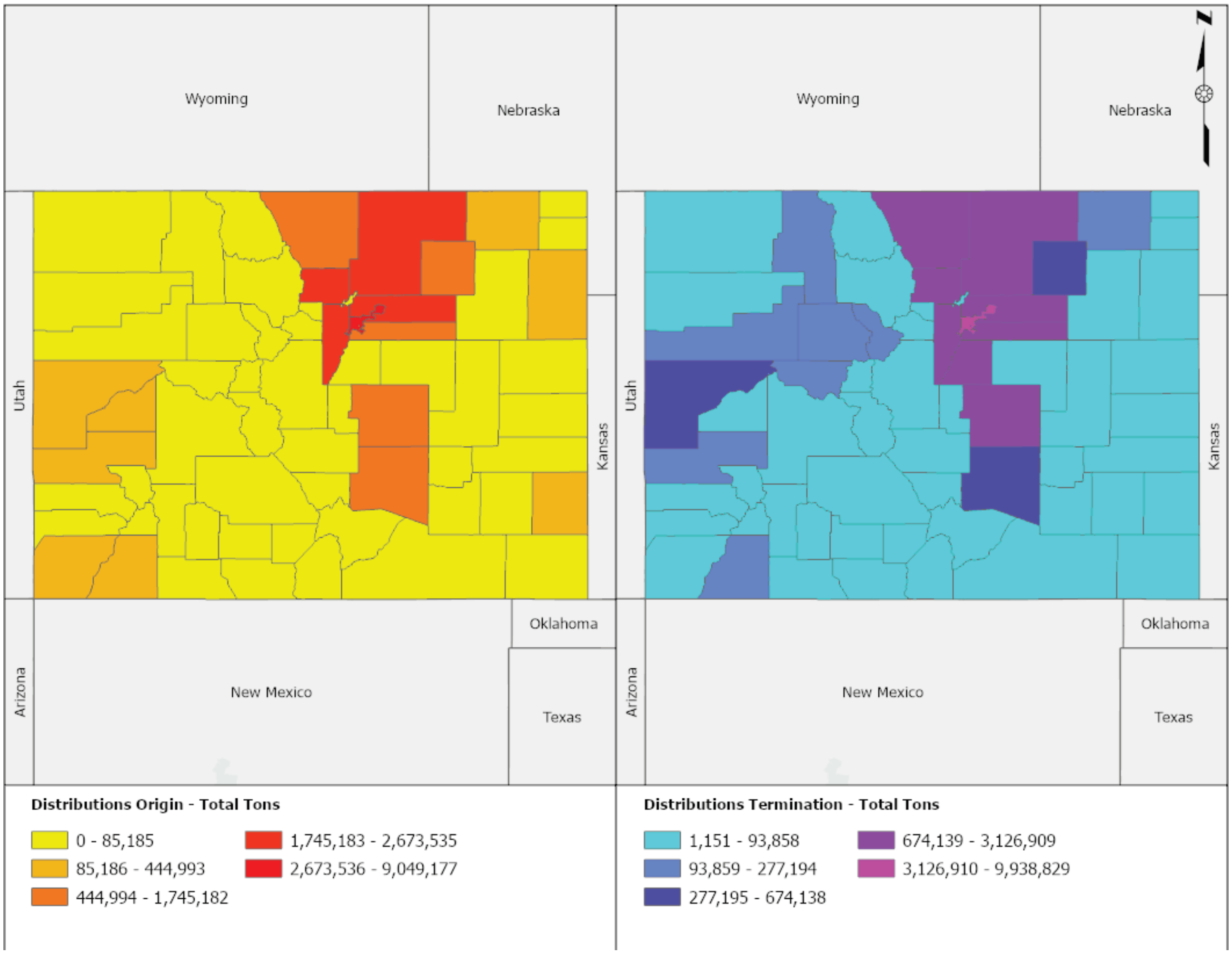
	Tons			Value		
Subsector	Total 2021	%	Forecasted CAGR	Total 2021	%	Forecasted CAGR
General Retail	1.8	4.1%	0.8%	16.4	15.8%	1.5%
General Retail-Health	0.1	0.2%	3.7%	7.5	7.2%	3.4%
Grocery	21.6	48.6%	2.0%	30.3	29.1%	1.9%
Warehousing & Distribution	20.9	47.0%	4.2%	49.9	47.9%	3.7%
Total	**44.5**	**100.0%**	**3.1%**	**104.1**	**100.0%**	**2.9%**

Source: S&P TRANSEARCH.

On a per-ton basis, the average value of all cargo in this sector was $2,347 in 2021. On an average per-ton basis, the General Retail-Health subsector had the highest value at $72,690 per ton. This is likely to be because this subsector includes drugs and healthcare products, which tend to have a high cost on a weight basis. General Retail was also more expensive than the average subsector at $8,922 per ton, while Grocery was lower than the average subsector at $1,406 per ton.

Figure 3.24 shows that in 2021, the counties with the largest origination of Warehousing and Retail Distribution tonnage were Denver, Jefferson, Adams, Weld, and Boulder Counties. There is significant tonnage also originating in Larimer, Morgan, El Paso, and Pueblo Counties. That same year, the counties with the largest termination of Warehousing and Retail distribution tonnage were Denver, Jefferson, Arapahoe, El Paso, and Weld Counties, followed by Boulder, Larimer, and Douglas Counties. The counties correspond with the larger population centers in the state. This is to be expected as population density drives retail volume.

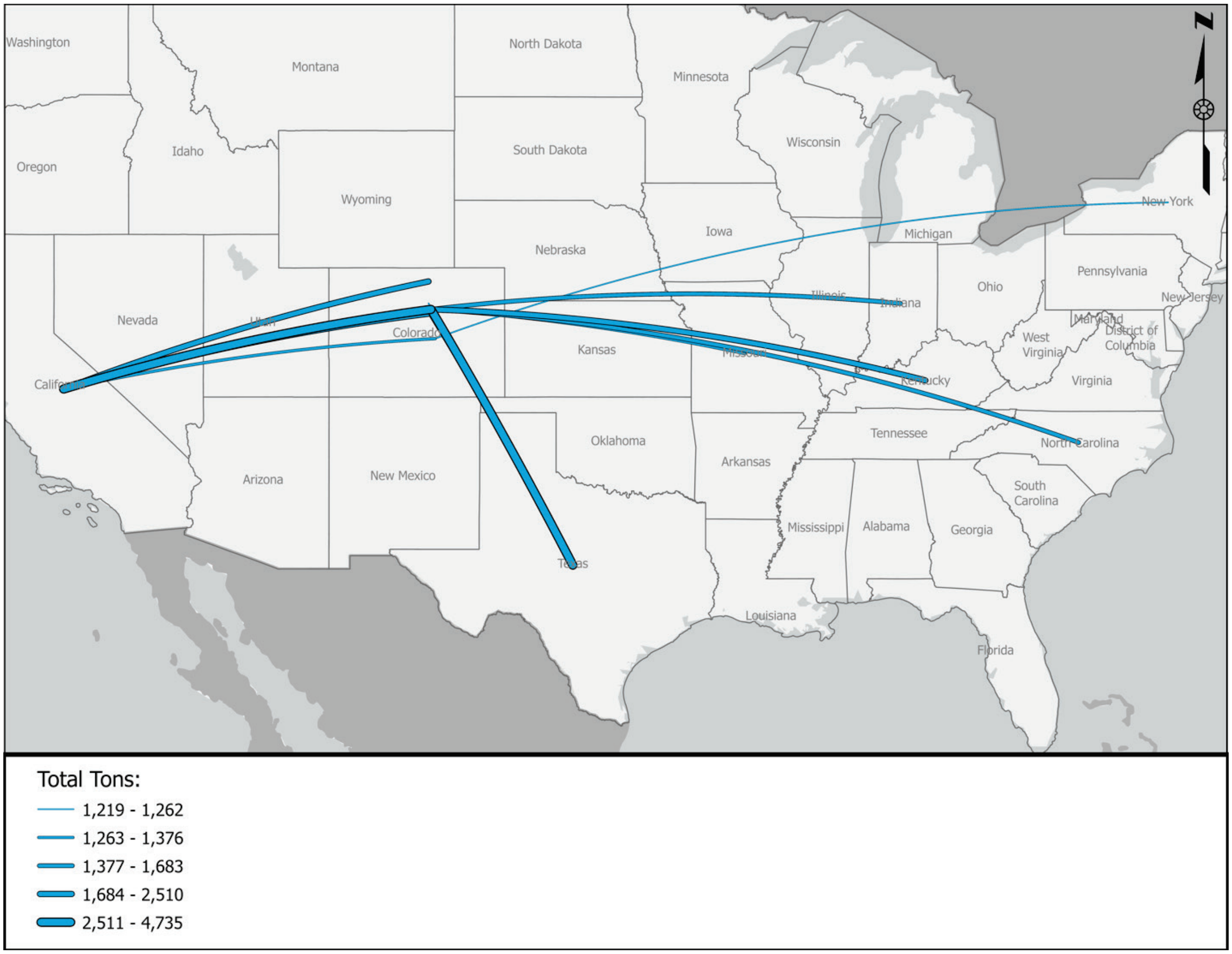
Figure 3.24 Origination and Termination of Distribution Tonnage by Colorado County, 2021



Source: S&P TRANSEARCH.

Figure 3.25 illustrates the volume of two-way traffic between Colorado and the United States. The map highlights significant transportation connections between Colorado and several key states, notably California and Texas, as well as states along the eastern seaboard such as New York, Indiana, Kentucky, and North Carolina. California and Texas are notably major trading partners for Colorado within the General Health-Retail sector, which is to be discussed in the following section.

Figure 3.25 Distribution Supply Chain (Tonnage Flows), 2021



Source: WSP analysis of S&P TRANSEARCH.

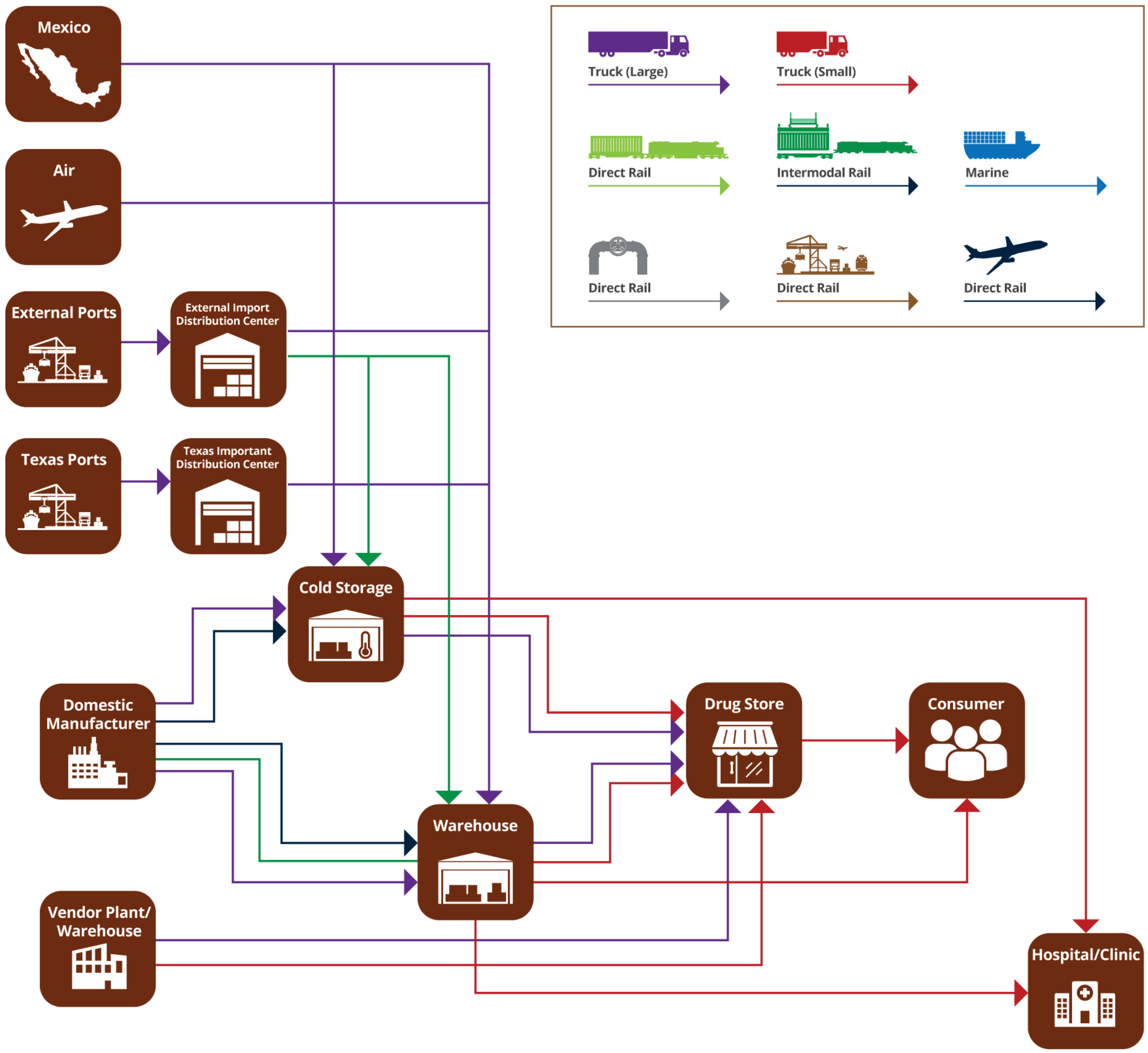
Supply Chain Highlight

General Health—Retail

The General Retail-Health supply chain includes retailers that focus on the sale of pharmaceuticals and other medical products, primarily to consumers. The products reach the individual consumer primarily via drug stores and clinics. Some products are delivered directly to the consumer from a warehouse or distribution center. An example of this would be direct mail prescriptions that are part of many health insurance plans.

General Retail-Health establishments handle a variety of products ranging from prescription pharmaceuticals and general health care products to food and beverages. They can range in size and vary geographically, as the category encompasses everything from large national chains in dense urban neighborhoods to small "mom and pop" stores serving rural communities. Clinics and hospitals also play pivotal roles in the effective delivery of pharmaceutical products to patients while upholding standards of safety and care. They deliver medications to patients, manage inventory, ensure pharmaceutical quality and safety, and establish relationships with suppliers. Figure 3.26 presents the typical supply chain for the General Retail-Health sector.

Figure 3.26 General Retail-Health Supply Chain Diagram



Source: WSP.

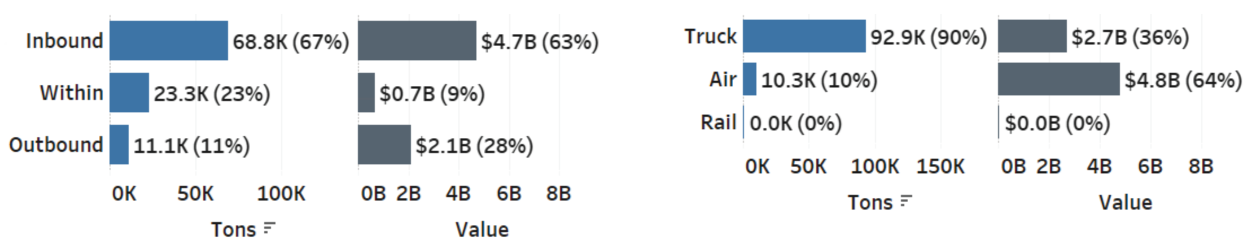
The movement of healthcare products and pharmaceuticals within the state is dominated by trucks and smaller vehicles. Shipments into distribution centers are moved by truck. Delivery to large chain stores, such as Walgreens, may also be made by large trucks. This can create problems when the stores are in congested areas, particularly where there is tighter, legacy infrastructure. Small stores and clinics as well as consumer deliveries are made by smaller vehicles, including different types of box trucks, vans, and cars. While large retailers in some states are increasingly using drones for pharmacy deliveries to consumers, it seems that this trend has not yet taken hold in Colorado.

According to the Colorado Office of Economic Development and International Trade, Colorado has approximately 2,500 bioscience-related companies. Notable companies include Medtronic, Davita, Tolmar Pharmaceuticals, and Quest Diagnostics, among others. The bioscience landscape is predominantly concentrated in the Denver metropolitan region, extending into Boulder and Aurora. The industry benefits from the presence of the University of Colorado and its six medical campuses. One noteworthy hub, the Anschutz Medical Campus, spans 256 acres and encompasses an array of facilities, including the Fitzsimons Innovation Community, UCHealth University of Colorado Hospital, Children's Hospital Colorado, and Rocky Mountain Regional Veterans Affairs Hospital. [16] The Fitzsimons Innovation Community is home to 80 companies, with over 400,000 square feet of working laboratory space, and with an expansion underway. [17]

Figure 3.27 shows that in terms of flow, most of the tonnage (68,800 tons, or 67 percent) and value ($4.7 billion, or 63 percent) for the General Retail-Health supply chain moved in the inbound direction into Colorado in 2021. The second highest directional flow for tonnage was movement within the state, at 23,300 tons (23 percent), while the second highest directional flow for value was outbound, at $2.1 billion (28 percent).

Most of the tonnage for the General Retail-Health category moved by truck in 2021, at 92,900 tons (90 percent), followed by 10,300 tons by air (10 percent). However, the larger share of value moved by air ($4.8 billion, or 64 percent) compared to truck ($2.7 billion, or 36 percent).

Figure 3.27 Flows of Retail Healthcare Supply Chain, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.26 shows that in 2021, California was Colorado’s top inbound domestic trading partner for this supply chain at over 16,000 tons, followed by Texas at 9,500 tons. It should be noted that any imports from foreign countries via ocean shipping would likely arrive through ports in California or Texas and would be included in this inbound trade volume. In terms of outbound tonnage, Texas was the state’s largest domestic trading partner at 2,540 tons, followed by California at 1,850 tons. In addition to ports, these two states have large population centers. Together these two states comprised approximately 38

[16] Sources: https://cdn.choosecolorado.com/wp-content/uploads/2016/06/Colorado-Bioscience-Industry-Factsheet.pdf and https://www.ucdenver.edu/international-admissions/about-cu-denver/anschutz-medical-campus.

[17] https://fitzsimonsinnovation.com/about/vision.

percent to 40 percent of Colorado's inbound and outbound tonnage in the General Retail-Health category in 2021.

It should be noted that the numbers differ between Figure 3.27 and Table 3.26 because Table 3.26 includes only domestic traffic and does not include Mexico or Canada.

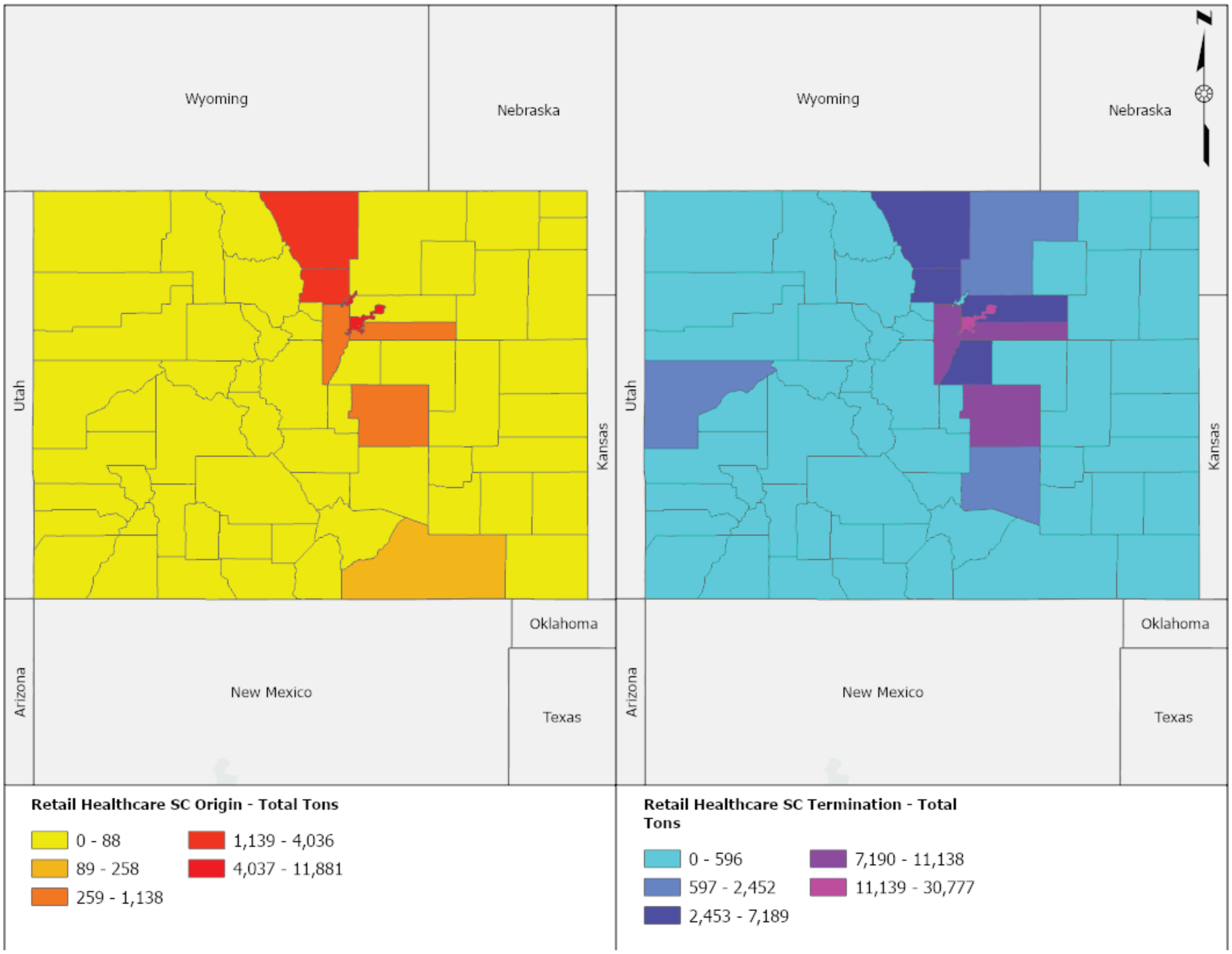
Table 3.26 Top Domestic Trading Partners for Retail Healthcare Supply Chain, 2021

	Inbound			Outbound		
Rank	State	Tons (k)	%	State	Tons (k)	%
1	California	16.32	24%	Texas	2.54	23%
2	Texas	9.50	14%	California	1.85	17%
3	Missouri	5.41	8%	Arizona	0.61	6%
4	Indiana	4.32	6%	Minnesota	0.50	5%
5	Illinois	3.81	6%	New Mexico	0.36	3%
6	Utah	3.78	5%	Washington	0.36	3%
7	Michigan	3.47	5%	Hawaii	0.33	3%
8	North Carolina	3.08	4%	Nevada	0.32	3%
9	Wisconsin	2.48	4%	Florida	0.31	3%
10	Kentucky	1.99	3%	Oklahoma	0.26	2%
-	Other	14.51	21%	Other	3.56	32%
N/A	**Total**	**68.67**	**100%**	**Total**	**10.99**	**100%**

Source: S&P TRANSEARCH.

Figure 3.28 shows the origination and termination of tonnage by county for the General Retail-Health category in 2021. Despite their relatively small geographic size, Broomfield County and Denver County had the largest share of origination tonnage. For termination volume, the largest share of tonnage went to Denver County, followed by Arapahoe County, El Paso County and Jefferson County. These counties are reflective of the population density.

Figure 3.28 Origination and Termination of Tonnage in Retail Healthcare Supply Chain, 2021



Source: S&P TRANSEARCH.

The supply chain for Orthopedic Appliances, Parts and Accessories is explored in further detail below. This supply chain was chosen because the products being transported have a more significant share of national volume than would otherwise be suggested by Colorado's population and economic activity. [18] Colorado is home to medical device companies and startups that are developing innovative orthopedic technologies, implants, and devices. Examples include Jabil's facility established in Monument, Colorado, in 1979, with 1,000 employees and contractors manufacturing orthopedic products for joint reconstruction, trauma, spine, sports medicine, and other uses.

[18] Colorado has a relatively large share of U.S total trade value and total trade value is above $120 million for years 2017 through 2023 Q2 for this commodity group. Commodities are defined by standard Harmonized System codes. State trade data is reported by the U.S. Census Bureau.

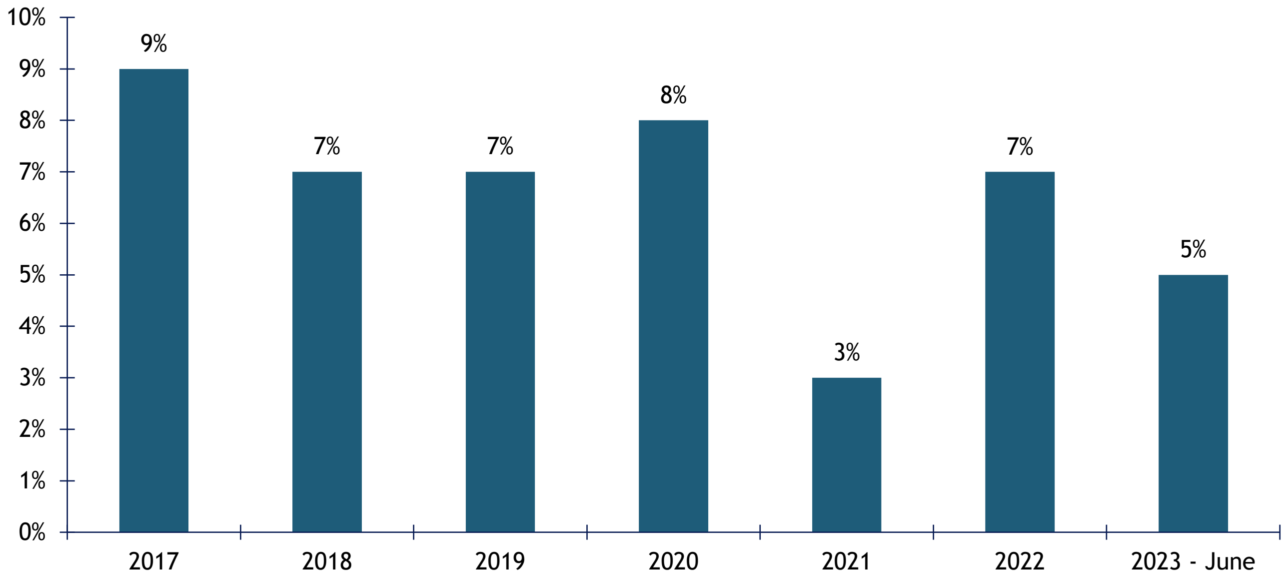
Orthopedic Appliances, Parts and Accessories (Imports and Exports)

Orthopedic appliances, parts, and accessories play a significant role in the treatment, rehabilitation, and support of individuals with musculoskeletal conditions or injuries. These devices are often prescribed or recommended by orthopedic specialists to provide stability, alignment, and relief for individuals suffering from bone, joint, muscle, or connective tissue problems. Orthopedic appliances, parts, and accessories can encompass the following:

- Braces and Supports: Common types include knee braces, ankle supports, wrist splints, and back braces.
- Prosthetic Limbs: Artificial legs, arms, and hands, for individuals who have lost a limb due to injury, disease, or congenital conditions.
- Orthotic Insoles and Shoes: These are custom or off-the-shelf shoe inserts designed to provide support, cushioning, and alignment for the feet, or specialized shoes with features such as arch support, extra cushioning, and proper alignment for individuals with foot, ankle, or lower limb problems.
- Casts and Splints: Plaster casts or synthetic splints are used to immobilize and protect fractured or injured bones, allowing them to heal properly.
- Wheelchairs and Mobility Aids: These assistive devices include wheelchairs, crutches, canes, and walkers, which help individuals with mobility impairments move around more easily.
- Prosthetic and Orthotic Components: These can include sockets, joints, connectors, and alignment systems used in the fabrication of prosthetic limbs and orthotic devices.
- Spinal Braces and Supports: Back braces, cervical collars, and spinal orthoses are used to provide support and stability for the spine, often prescribed for conditions like scoliosis or after spinal surgery.
- Orthopedic Implants: These are surgical devices like screws, plates, and rods used to stabilize and support fractured or damaged bones during surgical procedures.
- Compression Garments: These tight-fitting garments apply pressure to specific body areas and are commonly used to improve circulation, reduce swelling, and manage conditions like lymphedema.
- Traction Devices: Traction devices are used to gently stretch and realign bones and joints. They are often employed in the treatment of spinal or limb fractures.
- Rehabilitation Equipment: Devices such as exercise machines, resistance bands, and range-of-motion devices are used in physical therapy and rehabilitation programs to strengthen muscles and improve joint mobility.

Colorado's imports of Orthopedic Appliances, Parts and Accessories totaled $1.1 billion for 2017 through 2023 Q2. Figure 3.29 shows the share of all US Orthopedic imports that are imported to Colorado.

Figure 3.29 Colorado's Share of Total U.S. Imports for Orthopedic Appliances (Parts and Accessories),2017 to 2023

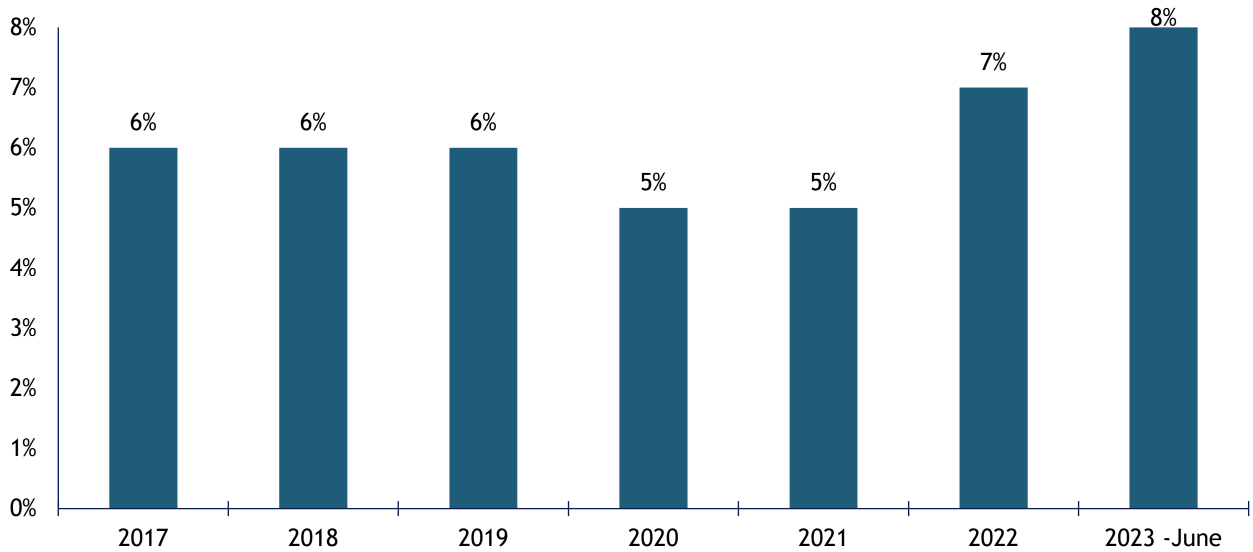


Source: Analysis from WSP based on data from U.S. Census Bureau.

Potential reasons for the large share of U.S. imports include Colorado's extensive network of orthopedic schools, clinics, and medical establishments, with a significant concentration in Denver and Colorado Springs. Colorado is home to several hospitals and medical centers with dedicated orthopedic departments. The University of Colorado School of Medicine, for example, has a renowned orthopedic surgery residency program. Additionally, the outdoor lifestyle and emphasis on physical activity may contribute to a higher demand for orthopedic services in the state. Sports such as mountain climbing, snowboarding, and skiing may result in physical strain or injury, requiring orthopedic treatment.

The production of orthopedic products in state might explain why Colorado's exports of orthopedic appliances totaled $1.0 billion in 2017 through 2022 Q2, representing 6 percent of U.S exports in this category over that period. Figure 3.30 shows the share of all US Orthopedic exports that are exported from Colorado.

Figure 3.30 Colorado's Share of Total U.S. Exports for Orthopedic Appliances (Parts and Accessories),2017 to 2023



Source: Analysis from WSP based on data from U.S. Census Bureau.

While Colorado's share of U.S. imports for these parts declined from 9 percent in 2017 to 3 percent in 2021, the state's share of U.S. exports increased from 6 percent to 8 percent over the same period. It is possible that some of the imports were supplanted by domestic manufacturing, with excess inventory being exported.

E-commerce

Definition of E-commerce

E-commerce is broadly defined as any commercial transaction involving the internet. This study narrows the focus to goods sold and bought online, as in the case where a consumer makes a "touchless" retail purchase using the internet. A wider definition, as used by the U.S. Census Bureau, would also include online manufacturing orders, services, and wholesale business conducted online. As previously discussed, this report focuses on the retail sector.

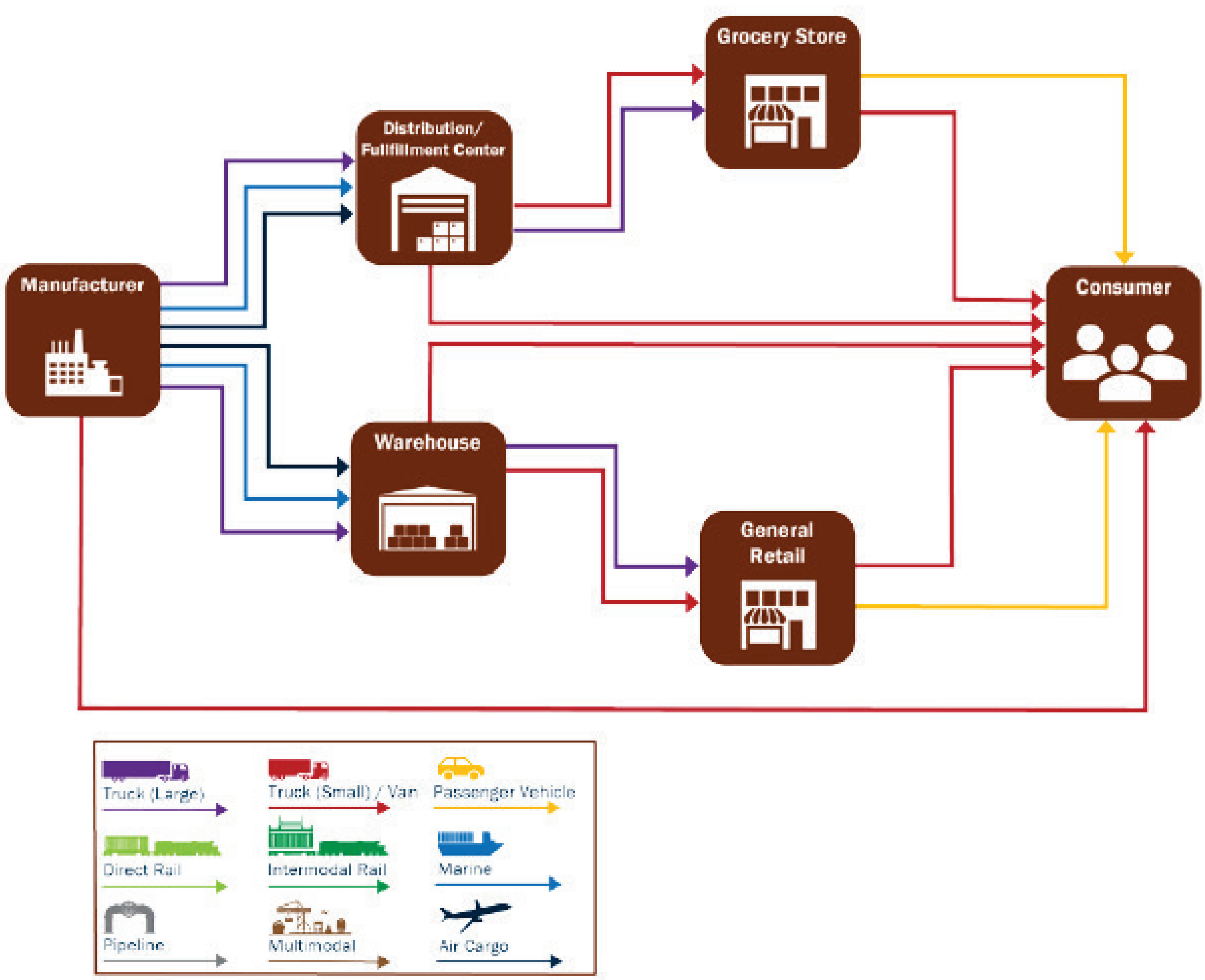
E-commerce has similarities and differences to traditional retail. The main differences involve how the product is ordered and delivered. For e-commerce, the transaction occurs over the internet and the product is delivered to the customer at their residence, business, a retail location, or another location of their choice. For traditional retail, the product is chosen, purchased, and taken by the customer at the retailer's location.

E-commerce companies use a variety of operational models in order to connect their inventory supply with customer demand. Some e-commerce companies sell their own products directly, while others pass orders on to a supplier. E-commerce sellers may be "pure players" operating entirely online, or "brick and click" businesses that sell online while also maintaining physical stores.

E-commerce has had a significant impact on the transportation sector. It has brought new retailers into the market while traditional retailers have expanded into providing online shopping options for their customers. These retailers have invested in additional warehousing capacity, as well as new and additional transportation assets in order to meet the growing demand for their products.

Figure 3.31 presents the typical supply chain for e-commerce. Products are sent from the manufacturer to a distribution center, fulfillment center, or a general warehouse via air, ocean, and/or truck transportation. Products are stored at distribution centers and warehouse facilities until an order is placed for the item, at which time they are either sent directly to the consumer (typically to their residence or business location) or to a grocery store or general retail store where they can be picked up.

Figure 3.31 E-commerce Supply Chain



Source: WSP, TxDOT Freight Plan 2022.

Size and Growth of the E-commerce Industry

Before the COVID-19 pandemic in 2019 e-commerce accounted for 11.2 percent of retail sales. [19] By the third quarter of 2020, after many stores had closed and people were isolating from the pandemic, this share jumped to 14.9 percent. Since then, the e-commerce share of retail has remained relative constant, at 14.6 percent during the third quarter of 2021, 14.8 percent during the third quarter of 2022, and 15.3 percent during the second quarter of 2023. The pandemic initially accelerated the growth in e-commerce, but it has since plateaued, with a moderate increase seen in 2023, comparable to pre-pandemic years. However, the pandemic introduced people to a wide range of online retail services, including grocery delivery and on-demand deliveries. These experiences are likely to contribute to the long-term growth of this sector.

One of the fastest growing segments within e-commerce is online grocery, which tends to be same-day/next-day delivery and involves perishables. Online grocery shopping offers several options for consumers, including curbside pickup or at-home delivery. Companies such as Kroger are currently improving their last-mile network throughout the country, including in Colorado, as they see this market continue to grow. [20]

Several key players in the e-commerce industry operate in Colorado, ranging from established giants to smaller startups. These include the following:

- Amazon: The world's largest e-commerce company, Amazon has a significant presence in Colorado, with fulfillment centers and distribution facilities across the state. These locations help the company meet its delivery commitments to customers in the state. See the land use impacts section below for a more detail description of Amazon's network in Colorado.
- Walmart: The world's largest retailer and also a major player in e-commerce, Walmart operates distribution centers and stores throughout Colorado, facilitating both online and in-store shopping.
- Etsy: Etsy is an online marketplace for handmade and unique products. Many Colorado-based artisans and sellers use Etsy to reach a global audience. Colorado has a vibrant startup ecosystem, and many local companies are involved in e-commerce, including those specializing in niche markets like outdoor gear, craft products, and more.

Distribution centers for e-commerce companies are typically strategically located to serve the state efficiently. They are often situated near major population centers to facilitate quick deliveries. Some distribution centers in Colorado are in Denver, Aurora, and Colorado Springs.

Currently, there is one Walmart fulfillment center in the state of Colorado. Target operates one e-commerce fulfillment center in Colorado, near downtown Denver. Fulfillment centers in neighboring states, including Wyoming, New Mexico, and Nebraska, may provide additional services.

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[19] U.S. Census, "Quarterly Retail E-Commerce Sales," published August 17, 2023 at https://www.census.gov/retail/ecommerce.html.

[20] https://chainstoreage.com/kroger-brings-fast-delivery-northern-colorado.

Impacts on Transportation

E-commerce is having significant impacts on the “middle-mile,” as goods supplied to distribution facilities, and on the “last-mile,” as deliveries are made to people’s homes. The e-commerce middle-mile is dominated by trucking. However, e-commerce’s emphasis on delivery speed and reliability is leading to a boom in air cargo, with airports that focus on packages seeing the most growth. This includes Memphis (FedEx World Hub), Louisville (UPS Worldport), and Cincinnati (Amazon Air Hub). Amazon has tended to favor smaller airports for its aircraft, leading to substantial activity to such locations as Allentown, Pennsylvania; Stockton, California; and Austin, Texas. Amazon recently located near the Northern Colorado Regional Airport in Loveland. [21] Rail intermodal is also being used to position e-commerce goods that are less time sensitive.

The impacts of e-commerce on the last mile have been more visible, with sharp increases of delivery trucks in urban areas and residential communities. In Colorado, as in the rest of the United States, most packages are delivered by either UPS, FedEx, the United States Postal Service (USPS), or Amazon Logistics. As of 2022, USPS had a 32 percent market share, followed by UPS at 24 percent, Amazon Logistics at 23 percent, FedEx at 19 percent, and the remaining 2 percent delivered by a wide range of smaller carriers. [22] The operations of these delivery vehicles concentrate in residential areas, where environmental, safety, and equity impacts are heightened. These delivery vehicles cause safety risks, particularly with cyclists and pedestrians, often because the delivery vehicles do not have dedicated places to park, causing disruptions. In dense urban areas of Colorado this can be a major challenge, as delivery vehicles have to compete for curb-space with many more uses. Because delivery vehicles frequent stops, they often block travel lanes, degrading the operations of the roadway network, and causing congestion.

Emerging technologies and modes have the potential to improve the efficiency and sustainability of last-mile logistics, mitigating some of the challenges mentioned above. The electrification of delivery trucks could reduce emissions and noise pollution, while other modes such as cargo bikes and delivery robots could improve the efficiency of making deliveries in high-density urban environments. Campuses around the country, including the University of Denver, have pilots testing robots to deliver meals. [23] Convenience and speed is driving many of the developments in last-mile logistics, which is generally leading to less consolidation of packages and orders and more vehicle miles. Crowd-sourced delivery services, such as Instacart, UberRush, and Amazon Flex, allow for faster localized delivery. However, crowd-sourced delivery increases the quantity and types of vehicles operating in residential areas, often without proper training or certification, which can generate safety risks and less efficiency. Regulations of these services can play a role in ensuring that last-mile delivery becomes more sustainable, and more compatible with residential environments.

[21] https://www.coloradoan.com/story/news/2022/03/17/amazon-buys-152-acres-land-near-airport-loveland-colorado/7073771001/.

[22] Pitney Bowes, Parcel Shipping Index, 2022. https://www.pitneybowes.com/content/dam/pitneybowes/us/en/shipping-index/23-mktc-03596-2023_global_parcel_shipping_index_ebook-web.pdf.

[23] https://www.cbsnews.com/colorado/news/university-denver-deploys-robots-deliver-food/.

Impacts on Land Use

E-commerce is having a transformative impact on land use, both because e-commerce redefines where retail activities take place, and because it requires a sprawling distribution network of warehouses. Nationwide, indicators point to there being an oversupply of retail space, which has led to significant store closures during the past decade, and particularly through the COVID-19 pandemic. [24, 25] This trend is also present in Colorado, with malls and large stores closing, including Bed Bath & Beyond, Tuesday Morning, Big Lots, and Macy's. [26, 27] Some malls are being reimagined to offer other services and activities to attract patrons, including adding dwellings, and other malls are transforming into warehousing space for urban distribution or even being torn-down for redevelopment. [28, 29]

At the same time, e-commerce is also drastically increasing the demand for warehousing. Prologis has estimated that e-commerce requires three times as much warehousing space as traditional retail because goods are not sitting in store racks anymore, and the emphasis on delivery speed requires products to be located close to e-commerce consumers. Colorado is no exception to this trend, with strong demand for warehousing space being observed through 2022, particularly in the northern parts of the state. [30]

Amazon accounts for almost half of all e-commerce nationwide, leading their network to have a large impact in every region. Figure 3.32 shows the location of major facilities that Amazon uses to serve e-commerce in Colorado. Amazon relies on a network of large fulfillment centers that collect goods from the middle-mile and help manage regional inventories, supported by a wide range of smaller fulfillment facilities that supply high-volume goods and allow same-day delivery. The Denver region is served primarily by three large fulfillment centers in Aurora and one facility in Thornton. These have the ability to sort and also process bulky goods (those weighing over 70 pounds). The Fort Collins area is served by a new facility in Loveland, located next to the regional airport. Colorado Springs is served by one large fulfillment center in the southeast of the city next to the Colorado Springs Airport. As can be seen in Figure 3.32, these large facilities are supported by a network of smaller middle-mile and last-mile distribution facilities that tend to be clustered in certain parts of the city. There are two Amazon Prime Now hubs in Colorado, one in downtown Denver and one in downtown Boulder.

The emphasis placed by Amazon on delivery speed and reliability requires e-commerce inventories to be located closer to consumers. This translates into growing demand for warehousing in denser, more urbanized areas. This trend has been enabled by multi-story warehousing and automation technologies that increase the density and efficiency of these facilities. The decentralization of warehousing can have a complex impact on transportation needs. On one hand, smaller facilities closer to households enables the use of a wider range of smaller and less impactful delivery vehicles, which are better designed to navigate residential streets with fewer impacts. However, this could translate into more vehicles making more trips

[24] Wigglesworth, R. 2017. "Will the Death of U.S. Retail be the Next Big Short?" Financial Times, July 16, 2017.

[25] Thompson, D. 2020. "The Pandemic Will Change American Retail Forever," The Atlantic, April 27, 2020.

[26] https://www.denverpost.com/2023/01/09/big-lots-macys-closing-colorado-stores/.

[27] https://www.denverpost.com/2023/02/24/tuesday-morning-to-close-16-of-its-discount-stores-in-colorado/.

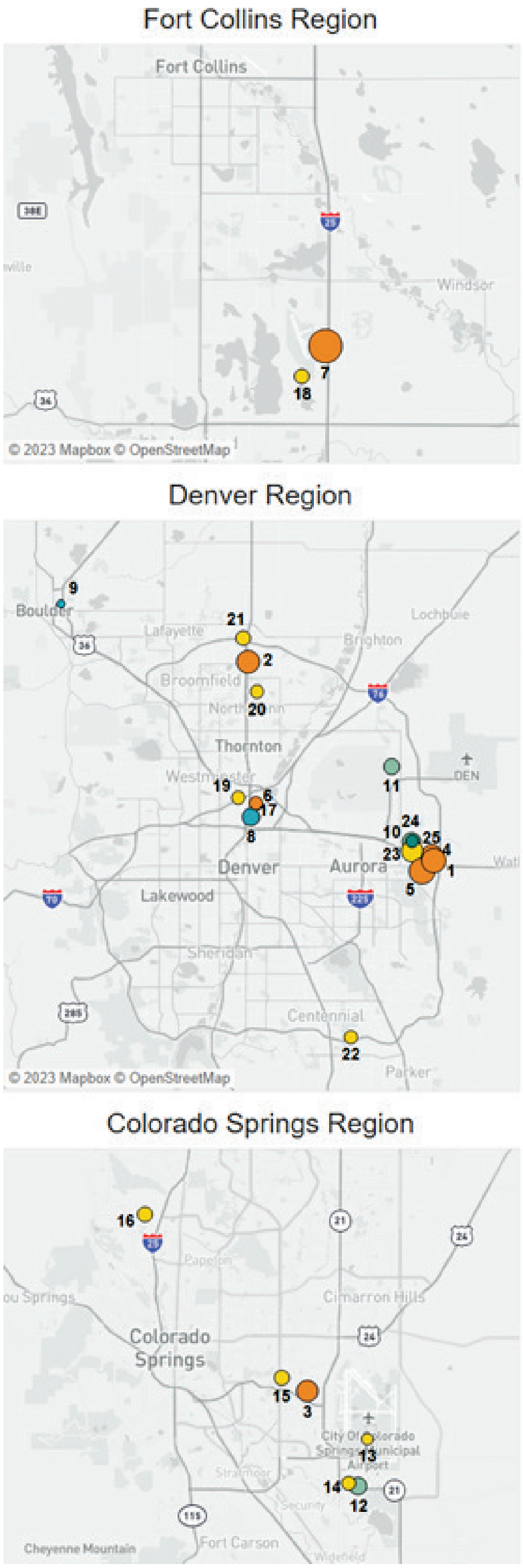
[28] https://www.nytimes.com/2023/02/16/business/shopping-malls-residences.html.

[29] https://www.forbes.com/sites/zengernews/2021/08/14/new-leases-on-life-malls-converting-to-fulfillment-centers-other-non-retail-uses/?sh=98ae05b42fad.

[30] https://affinityrepartners.com/news-insights/article/warehouse-distribution-in-northern-colorado-forges-on/#:~:text=Warehouse%2Fdistribution%20space%20is%20in,lease%20rates%20will%20follow%20suit.

to serve the same households, compared to fulfillment by larger trucks from a larger centralized fulfillment facility. Whether warehousing decentralization ends up becoming a positive trend depends on land use and transportation regulations involving these facilities.

Figure 3.32 Amazon Network in Colorado



Type of Amazon Facility
- Fulfilment Center
- Heavy/Bulky Delivery Station
- Last-Mile Delivery Station
- Middle-Mile Sortation Center
- Prime Now

Main Amazon Facilities in Colorado

ID	Type	Address	Opened	SQFT (est.)
1	Fulfilment Center	22205 E 19th Av, Aurora CO, 80019	2017	1,000,000
2	Fulfilment Center	14601 Grant Street, Thornton, CO, 80023	2018	855,000
3	Fulfilment Center	4222 Integration Loop, Colorado Springs, CO, 80916	2021	640,000
4	Fulfilment Center	22300 E 26th Av, Aurora, CO, 80019	2021	555,000
5	Fulfilment Center	21000 E 13th Av, Aurora, CO, 80018	2022	1,200,000
6	Fulfilment Center	6050 Washington Street, Denver, CO 80216	2021	159,300
7	Fulfilment Center	4625 Byrd Av, Loveland, CO, 80528	2023	640,000
8	Prime Now	480 E 55th Av, Denver, CO, 80216	2017	376,000
9	Prime Now	3550 Frontier Av, Boulder, CO 80301	2017	19,000
10	Middle-Mile Sortation Center	19799 E. 36th Av, Aurora, CO, 80011	2016	452,400
11	Middle-Mile Sortation Center	8350 Quintero St. Commerce City, CO, 80022	2021	278,500
12	Middle-Mile Sortation Center	4333 Integration Loop, Colorado Springs, CO, 80916	2021	278,300
13	Last-Mile Delivery Station	7704 Milton E. Proby Prkway, Colorado Springs, CO, 80916	2018	17,000
14	Last-Mile Delivery Station	4303 Grinnell Blvd, Colorado Springs, CO, 80911	2019	66,800
15	Last-Mile Delivery Station	715 S. Academy Blvd, Colorado Springs, CO, 80910	2022	135,000
16	Last-Mile Delivery Station	4607 Forge Rd. Colorado Springs, CO 80907	2023	105,000
17	Last-Mile Delivery Station	6050 Downing St., Denver, CO 80216	2019	79,800
18	Last-Mile Delivery Station	4555 E. 37th St. Centerra, Loveland, CO, 80538	2020	122,800
19	Last-Mile Delivery Station	875 West 64th Av, Denver, CO, 80221	2021	147,000
20	Last-Mile Delivery Station	900 E. 128th Av, Thornton, CO, 80241	2020	151,700
21	Last-Mile Delivery Station	400 W. 160th Av, Broomfield, CO, 80023	2021	200,900
22	Last-Mile Delivery Station	12675 Liberty Blvd, Englewood, CO 80112	2021	140,000
23	Last-Mile Delivery Station	2889 Himalaya Drive, Aurora, CO, 80011	2020	701,900
24	Heavy/Bulky Delivery Station	19799 E. 36th Av, Aurora, CO, 80011	2020	100,000
25	Heavy/Bulky Delivery Station	22300 E. 26th Av, Aurora, CO, 80019	2021	100,000

Source: MWPVL International.

3.3.4 Electronics + Supply Chain

Overview

Several products from various economic sectors were selected for further analysis in relation to their supply chain within Colorado, as well as nationally and globally. These critical supply chains include all aspects of a product's lifecycle, encompassing raw materials, production facilities, warehousing, local distribution, retail outlets, recycling/waste, and receipt or distribution of various contributing inputs and outputs. As materials move through the supply chain, they often rely on multiple modes. A disruption to any one process or movement can have a dramatic impact on the overall supply chain. Analyzing the transportation operations associated with these supply chain activities and movements supports the efficient movement of freight throughout Colorado.

This document focuses on the Electronics sector of Colorado's economy. The Electronics industry includes a wide range of commodities that are used in a range of products, including computers, communications, audio and video, and navigational instruments. The Electronics industry is defined in this document by NAICS codes (Table 3.27). At the top level the industry Electronics includes one three-digit NAICS code, 334 Computer & Electronic Products, with six commodity components, each with their own four-digit NAICS code.

Table 3.27 Definition of Electronics Industry and Subsectors (4-digit NAICS)

Industry	Subsector
Electronics	3341 Computer and peripheral equipment manufacturing
Electronics	3342 Communications equipment manufacturing
Electronics	3343 Audio and video equipment manufacturing
Electronics	3344 Semiconductor and other electronic component manufacturing
Electronics	3345 Navigational, measuring, electromedical, and control instruments manufacturing
Electronics	3346 Manufacturing and reproducing magnetic and optical media

The following analysis provides an overview of the Electronics sector and commodities, including their importance to the Colorado and global economies. Due to their importance in international trade, there is a drill down into the supply chain for semiconductors and other electronic component manufacturing. The term "semiconductor" is broadly defined in this analysis to include commodities such as solid-state electronic devices, integrated circuits, diodes, computer logic modules, and transistors. Therefore, all discussion of "semiconductors" in this analysis also refers to integrated circuits. However, for clarity, semiconductors are excluded when referring solely to "integrated circuits" in this analysis, as some data points are specific to integrated circuits. Also discussed is the industry contribution to Colorado's economy, and general and specific opportunities and constraints affecting the Electronics industry and semiconductor subsector. Overall, the Electronics industry in Colorado represents 23,532 employees, nearly 400 establishments, and annual wages of over $3 billion (Table 3.28). Semiconductor and other electronic component manufacturing is an important subsector in Colorado, comprising 20 percent of employment, 28 percent of the establishments, and 15 percent of the wages. Table 3.29 provides these same metrics for Colorado overall. The Electronics industry represents 15.3 percent of Manufacturing-related employment in Colorado (amounting to about 0.4 percent of overall employment in Colorado).

Table 3.28 Employment, Establishments, and Wages for Electronics Industry, 2022

	Employment		Establishments		Annual Wages	
Subsector	Total	% of Industry	Total	% of Industry	Total ($M)	% of Industry
Semiconductors	4,759	20%	111	28%	464	15%
Other Electronics	18,773	80%	288	72%	2,550	85%
Total	**23,532**	**100%**	**399**	**100%**	**3,014**	**100%**

Source: Quarterly Census of Employment and Wages, Bureau of Labor Statistics.

Table 3.29 Employment, Establishments, and Wages for Colorado Industries, 2022

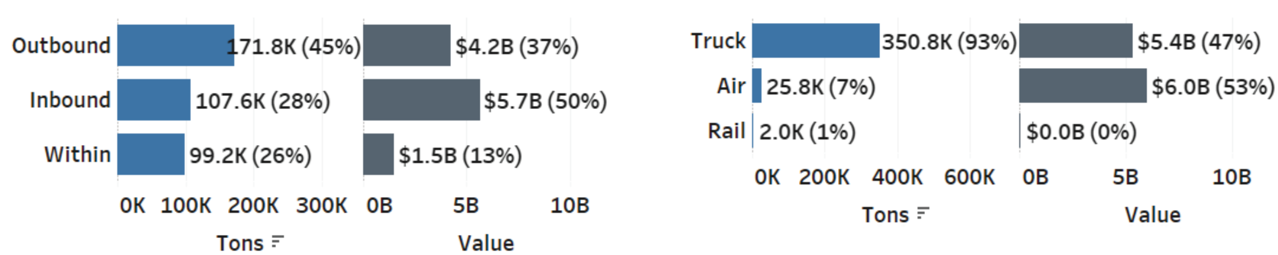
State	Employment	Establishments	Total Annual Wage ($M)
Colorado—Overall	2,814,732	245,461	$209,435
Colorado—Manufacturing	153,372	6,051	$12,671

Source: Quarterly Census of Employment and Wages, Bureau of Labor Statistics.

Commodities and Forecast

Figure 3.33 shows the split of Colorado commodity flows between outbound, inbound, and internal movements in the Electronics industry for tons and value, as well as by mode. As the data shows, by tonnage, a plurality of Electronics goods flows outbound. By value, half are moved inbound. The highest value goods are moved by air (53 percent of value) while the vast majority of tonnage (93 percent) is moved by truck. Due to the high value of electronics products, very little is moved by rail.

Figure 3.33 Electronics Industry Commodity Flows, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.30 shows projected changes in tonnage and value for the Electronics industry. Tonnage is expected to grow 2.9 percent per year between 2021 and 2050, and value is expected to grow 2.8 percent annually over the same timeframe. Both are expected to increase more than 50 percent between 2021 and 2050.

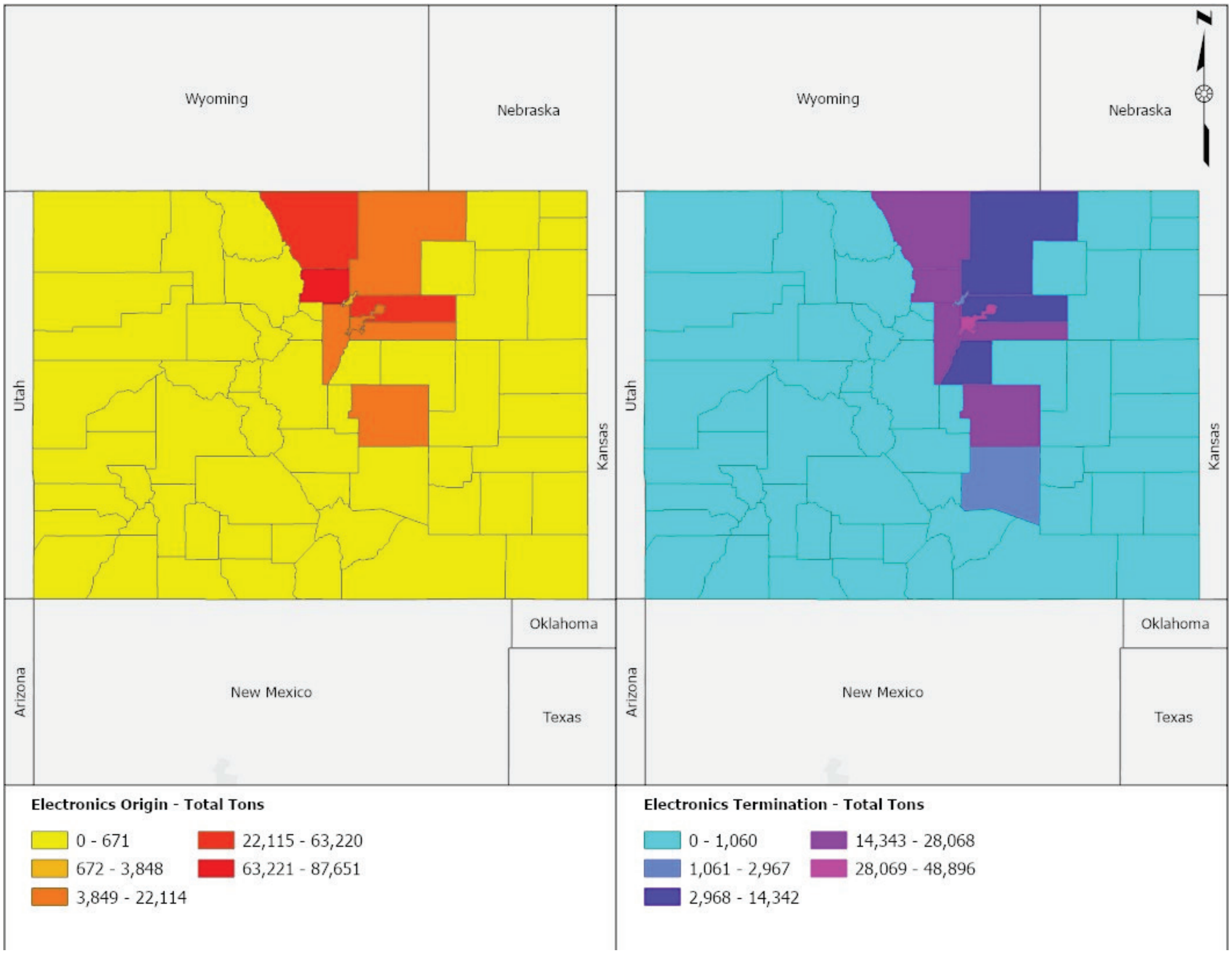
Table 3.30 Electronics Industry Commodity Flows, 2021 and 2050 Forecast

	Tons			Value		
Subsector	M 2021	% Change to 2050	Forecasted CAGR	% Change to 2050	%	Forecasted CAGR
Electronics	0.379	54.7%	2.9%	11.392	50.6%	2.8%

Source: S&P TRANSEARCH.

Figure 3.34 shows the origin and destination of tonnage for electronics in Colorado. The primary origin counties by tonnage are Larimer County (home of Fort Collins), Boulder County (home of Boulder), and Adams County. Each of these counties is the origin of at least 20,000 annual tons of electronics commodities. The primary destination counties by tonnage are the city of Denver, Larimer County, Boulder County, Jefferson County, Adams County, and El Paso County (home of Colorado Springs). Denver is the destination of more than 28,000 annual tons of electronics commodities, and the other listed counties are the destination of more than 14,000 annual tons of electronics commodities.

Figure 3.34 Origination and Termination of Electronics Industry Tonnage by Colorado County, 2021



Source: S&P TRANSEARCH.

International Trade

Computer and Electronic Products represented the state's top import commodity by value, accounting for $4 billion in 2021 (25 percent of all Colorado imports). Within this commodity, just over half of the state's import value was for Semiconductors and Other Electronic Components. Computer and Electronic Products represented the state's second-highest export commodity by value, accounting for $2 billion in 2021 (22 percent of all Colorado exports).

As shown in Table 3.31 and Table 3.32, the values and shares of component commodities differ between imports and exports. While the top U.S. Electronics import commodity was Computer Equipment, the top import commodity for Colorado was Semiconductors & Other Electronic Components. For exports Semiconductors was the top commodity for both the United States and Colorado. Because of its importance in international trade, the Semiconductors & Other Electronic Equipment subsector is the focus of a more detailed supply chain analysis later in this section.

Table 3.31 U.S. and Colorado Electronics Imports

Commodity by NAICS	2021 Import Value ($ Millions)		
	All States	Colorado	Share
334 Computer & Electronic Products	464,515	3,990	0.9%
3341 Computer Equipment	130,464	600	0.5%
3342 Communications Equipment	118,053	390	0.3%
3343 Audio & Video Equipment	41,030	59	0.1%
3344 Semiconductors & Other Electronic Components	98,051	2,041	2.1%
3345 Navigational/measuring/medical/ control Instruments	60,739	851	1.4%
3346 Magnetic & Optical Media	16,177	48	0.3%

Source: U.S. Census Trade Data, 2021.

Table 3.32 U.S. and Colorado Electronics Exports

Commodity by NAICS	2021 Import Value ($ Millions)		
	All States	Colorado	Share
334 Computer & Electronic Products	223,106	1,956	0.9%
3341 Computer Equipment	46,993	137	0.3%
3342 Communications Equipment	36,329	135	0.4%
3343 Audio & Video Equipment	6,736	12	0.2%
3344 Semiconductors & Other Electronic Components	74,649	840	1.1%
3345 Navigational/measuring/medical/ control Instruments	51,218	798	1.6%
3346 Magnetic & Optical Media	7,182	34	0.5%

Source: U.S. Census Trade Data, 2021.

Trends, Opportunities, and Constraints

Due to a variety of social and economic changes during the COVID-19 pandemic, the United States and the world experienced a semiconductor shortage beginning in mid-2020. The shortage of semiconductors severely impacted the output of integrated circuits. A supply chain model described in the *Harvard Business Review* revealed that a 10-day disruption of a fabrication facility would result in a 300-day delay to replenish the semiconductor supply. Several conflicting trends occurred during the COVID-19 pandemic that exacerbated typical supply fluctuations. These trends included the following:

- **People were less likely to commute to work by automobile—**The reduced demand for automobiles also led partially to a reduced demand for semiconductors. A conflicting outcome of the COVID-19 pandemic was that people felt less comfortable taking public transit and flying, leading to more purchases of automobiles. Semiconductor manufacturers slowed production early in the pandemic, in anticipation of decreased demand for automobiles, despite actual increases in demand for other devices using semiconductors.

- **People were spending far more time at home—**More people working from home led to the need for more laptops, video conferencing equipment, cloud services, information technology (IT) equipment, and other office equipment in people's homes. More time at home also led to people purchasing non-work electronic devices, such as 5G cell phones, video games, tablets, and exercise equipment (all requiring semiconductors).

According to an August 2022 article from S&P, experts predict that supply chain challenges across the semiconductor industry will extend to late 2023–early 2024. Additionally, delays are exacerbated by the use of just-in-time delivery, a practice that typically improves supply chain efficiency, but has resulted in significant delays when demand unexpectedly increases.

Supply chain delays can occur at any time, under positive or negative economic conditions. The seismic shift of society during the COVID-19 pandemic increased the frequency of supply chain delays. The United States' interconnectedness with the world's economy led to numerous events that contributed to a domino effect of delays for various industries, including semiconductors. These delays included an obstruction of the Suez Canal in March 2021; where $9.6 billion worth of goods pass daily. One analysis added that "it's the semiconductor industry that is most vulnerable to disruptions from shipping delays…any delay in supply could have devastating effects on semiconductor production." [31] Additional delays were experienced at the Ports of Los Angeles and Long Beach where a backlog began in October 2020 and lasted 25 months.

Federal Legislation

As part of the of the National Defense Authorization Act of 2021 (NDAA), Congress included TITLE XCIX, better known as the Creating Helpful Incentives to Produce Semiconductors for America (CHIPS) Act. [32] The aim of the CHIPS portion of the NDAA is to strengthen domestic production of semiconductors. Section 99902 of the NDAA created a financial assistance program to "incentivize investment in facilities and equipment in the United States for semiconductor fabrication, assembly, testing, advanced packaging, or research and development." The program is expected to provide billions of dollars in incentives to the industry.

The CHIPS Act provided $280 billion in new funding for domestic research and manufacturing of semiconductors, including $39 billion for chip manufacturing. The Semiconductor Industry Association maintains a list of semiconductor supply chain manufacturing investments since May 2020. Two of these investments are in Colorado:

- Integris, a leading supplier of advanced materials and process solutions for the semiconductor industry in Colorado Springs
- Microchip, a leading provider of smart, connected, and secure embedded control solutions in Colorado Springs

[31] https://area51esg.com/suez-canal-blockage-and-chip-shortages-another-dent-to-the-supply-industry/.

[32] https://www.congress.gov/116/plaws/publ283/PLAW-116publ283.pdf.

Supply Chain Highlight: Semiconductor Manufacturing

Semiconductors are used in many devices and appliances we use every day. An integrated circuit (colloquially known as a "microchip") consists of thousands or millions of miniaturized electronic components. Semiconductors are incorporated in nearly every electronic device we use, including computers, cell phones, automobiles, airplanes, appliances, and lighting devices. The small physical size of semiconductors allows for these devices to be available to consumers without taking up an enormous amount of space or requiring additional wiring. Semiconductors comprise a broad set of intermediate products, including diodes, computer logic modules, and transistors, which are essential components of electronic circuits. Advancements in various other industries (e.g., automobiles, energy production, Internet of Things, etc.) are fueled by semiconductors.

Semiconductor foundries are high-tech plants that are a vital part of the chip manufacturing process. These plants are large facilities that use a tremendous amount of electricity at rates higher than automotive plants and oil refineries. Additionally, the amount of water used by these plants is very substantial. Further, the manufacturing of semiconductors is a complex process that includes hundreds of inputs, a large portion of which are raw materials such as chemicals and gases. Raw materials and intermediate materials are sourced both domestically and internationally. However, while there are domestic sources of some of these materials (such as gases and wet chemicals), a large portion of materials, including intermediate products (such as silicon wafers, photomasks, and photoresists) are largely imported from abroad, especially Asia. [33] For these reasons, as well as the cost of labor, the majority of semiconductors are currently produced in Asia. However, Colorado has a growing number of semiconductor facilities. The complex supply chains, however, require special attention in order for this sub-industry to thrive in Colorado.

Colorado

Colorado's semiconductor industry includes companies engaged in chip design as well as two manufacturing facilities. Broadcom Inc. operates a wafer-manufacturing facility in Fort Collins. In 2019, nearly 1,750 people were employed at the facility. Additionally, Microchip Technology, Inc., based in Chandler, Arizona, employs 700 people at its semiconductor manufacturing plant in Colorado Springs. The company announced a $40 million retooling project for the plant in 2023. Northern Colorado and the Boulder area also host many research and design centers for semiconductors. Additionally, as a result of the 2021 CHIPS Act, two companies in Colorado have made recent significant investments in their facilities.

Semiconductors are important pieces of Colorado's economy. The subsector of Electronic Integrated Circuits, Not Elsewhere Specified or Identified, was Colorado's top import industry by value from 2017 through quarter 2 of 2023, accounting for $5.5 billion of imports. [34] According to Accenture, the various inputs of a typical integrated circuit chip must cross more than 70 international borders before the final product can be delivered to consumers.

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[33] Wafers are thin slices of semiconductors used to fabricate integrated circuits.

[34] U.S. Census Trade Data, 2021.

In early September 2023, the Semiconductor Industry Association announced that global semiconductor industry sales totaled $43.2 billion during July 2023. [35] Month-to-month sales increased the most in the Americas, increasing by 6.3 percent. The Asia Pacific region and China experienced the most significant sales decreases at -16.2 percent and -18.7 percent, respectively.

Supply Chain Flows

The manufacturing of semiconductors is a complex process that includes hundreds of inputs, a large portion of which are raw materials such as chemicals and gases. Raw materials and intermediate materials are sourced domestically and internationally. A general overview of the supply chain for semiconductors is shown in Figure 3.35.

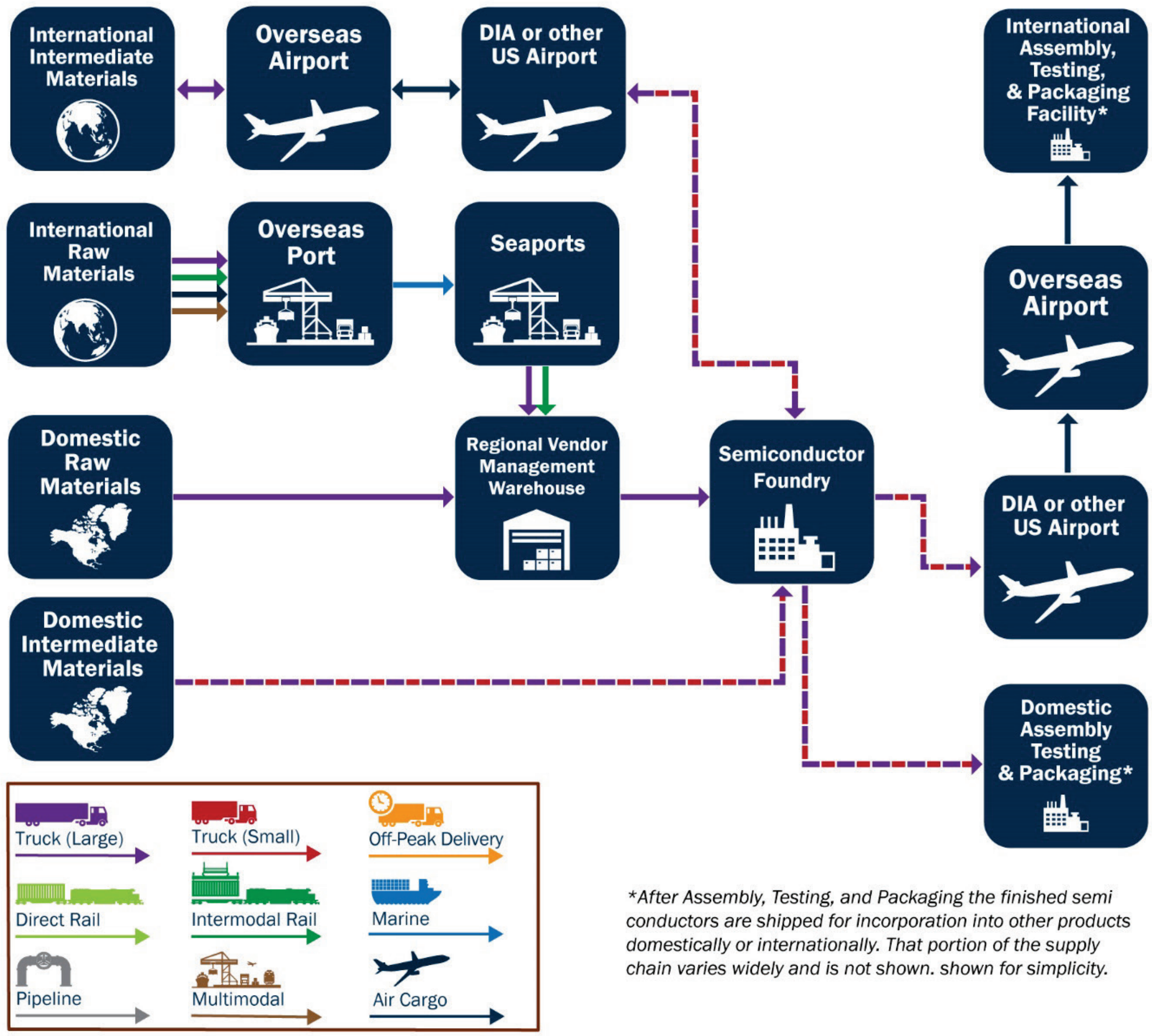
A large portion of the raw materials and intermediate components are brought in internationally from Asia by air cargo and marine shipments The international raw materials are imported via West Coast and East Coast ports and then moved by truck or rail to the regional vendor management warehouse, which stores the materials until they are needed by the foundry. Domestic raw materials are also trucked directly to the regional vendor management warehouse. The regional vendor management warehouse stores the materials until they are needed by the foundry, at which point they are then trucked to the foundry. Raw materials are often in bulk and hazardous in nature, necessitating international shipment via water. International intermediate components are imported via air and then are trucked to the semiconductor foundry. Additionally, some intermediate components are sourced domestically and arrive at the foundry via truck.

Once at these foundries, the manufacturing process begins. When complete, semiconductors are shipped to domestic and international Assembly, Testing, and Packaging (ATP) facilities. Eighty-one percent of ATP facilities are often located in China and East Asia, and due to the time sensitivity of the product, must be exported via air. [36] After assembly, testing, and packaging, finished semiconductors are shipped for incorporation into other products domestically and internationally. Denver International Airport is a major hub for intermediate inputs and semiconductor outputs from Colorado though limited-service options there sometimes require air cargo shipment through West Coast airports.

[35] https://www.semiconductors.org/global-semiconductor-sales-increase-2-3-month-to-month-in-july/.

[36] https://www.semiconductors.org/wp-content/uploads/2021/05/BCG-x-SIA-Strengthening-the-Global-Semiconductor-Value-Chain-April-2021_1.pdf.

Figure 3.35 Semiconductor Supply Chain Diagram



Source: WSP 2023.

The following tables and figures present data concerning the semiconductor supply chain in Colorado. Most solid-state semiconductors moving domestically to Colorado are from California or Oregon, with a significant portion from Arizona as well (Table 3.33). Domestic outbound solid-state semiconductors go to a more diverse set of states. Texas and California are the top two domestic destinations, accounting for 16 percent and 12 percent of tons, respectively.

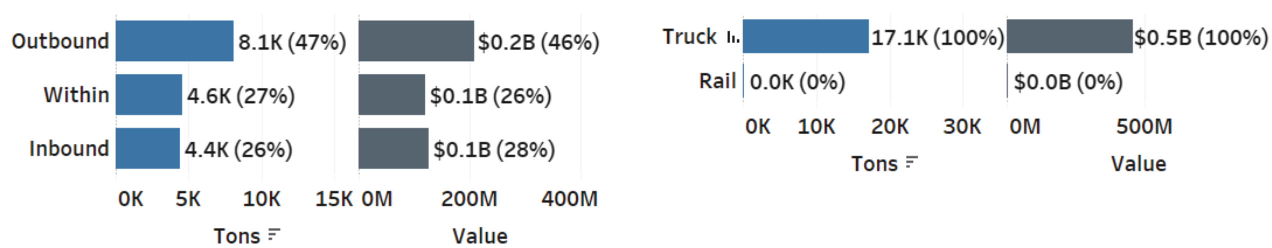
Table 3.33 Top Domestic Trading Partners for Solid State Semiconductors Supply Chain, 2021

	Inbound			Outbound		
Rank	State	Tons	%	State	Tons	%
1	California	1,607	36%	Texas	1,259	16%
2	Oregon	746	17%	California	943	12%
3	Arizona	702	16%	Illinois	706	9%
4	Idaho	374	8%	Missouri	522	7%
5	Texas	298	7%	Michigan	439	6%
6	New Mexico	170	4%	Ohio	419	5%
7	Washington	154	4%	Florida	347	4%
8	Utah	125	3%	Virginia	238	3%
9	Missouri	122	3%	New York	231	3%
10	North Carolina	51	1%	Georgia	207	3%
	Other	63	1%	Other	2,629	33%
	Total	**4,412**	**100%**	**Total**	**7,939**	**100%**

Source: S&P TRANSEARCH.

Figure 3.36 shows tonnage and value for solid-state semiconductors by direction and mode in Colorado. As the data shows, a plurality of tonnage and value are moved outbound. Note that the detailed commodity data in TRANSEARCH does not fully capture air cargo, so it indicates that all solid-state semiconductors in 2021 were moved into and out of Colorado by truck, whereas we know that air cargo is important to high value goods and carries 53 percent of all electronics goods by value into and out of Colorado (see Figure 3.33).

Figure 3.36 Flows of Solid-State Semiconductors Supply Chain, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.34 provides the import and export value of the Semiconductors and Other Electronic Components subsector in Colorado and the United States. Since Colorado's share of the U.S. population is about 1.7 percent, the data shows that Colorado's share of imports is greater than its share of the population.

Table 3.34 Semiconductors & Other Electronic Components Value

Trade	U.S. Total ($M)	Colorado ($M)	State Share
Imports	98,051	2,040	2.1%
Exports	74,649	839	1.1%

Source: U.S. Census Trade Data, 2021.

Relevant six-digit Harmonized System codes were examined, and Table 3.35 and Table 3.36 show commodity flow data for integrated circuits imports and exports, respectively. Colorado has a higher proportion of imports and exports of integrated circuits than the rest of the United States. Electronic Integrated Circuits (Nesoi) account for 11.9 percent of national imports and 4.4 percent of national exports. Other integrated circuit commodities represent smaller but still significant shares.

Table 3.35 Integrated Circuit Commodity Flow Data—Imports

Type	ID	Commodity	Colorado Value ($M)	National Value ($M)	CO Percent of National
Import	854232	Memories, Electronic Integrated Circuits	91	2,195	4.1%
Import	854233	Amplifiers, Electronic Integrated Circuits	32	644	4.9%
Import	854239	Electronic Integrated Circuits, Nesoi	1,240	10,415	11.9%
Import	854290	Electronic Integrated Circuits and Microassemblies Parts	5	310	1.7%

Source: U.S. Census Trade Data, 2021.

Table 3.36 Integrated Circuit Commodity Flow Data—Exports

Type	ID	Commodity	Colorado Value ($M)	National Value ($M)	CO Percent of National
Export	854232	Memories, Electronic Integrated Circuits	21	2,806	0.8%
Export	854233	Amplifiers, Electronic Integrated Circuits	4	2,123	0.2%
Export	854239	Electronic Integrated Circuits, Nesoi	618	14,023	4.4%
Export	854290	Electronic Integrated Circuits and Microassemblies Parts	8	1,208	0.7%

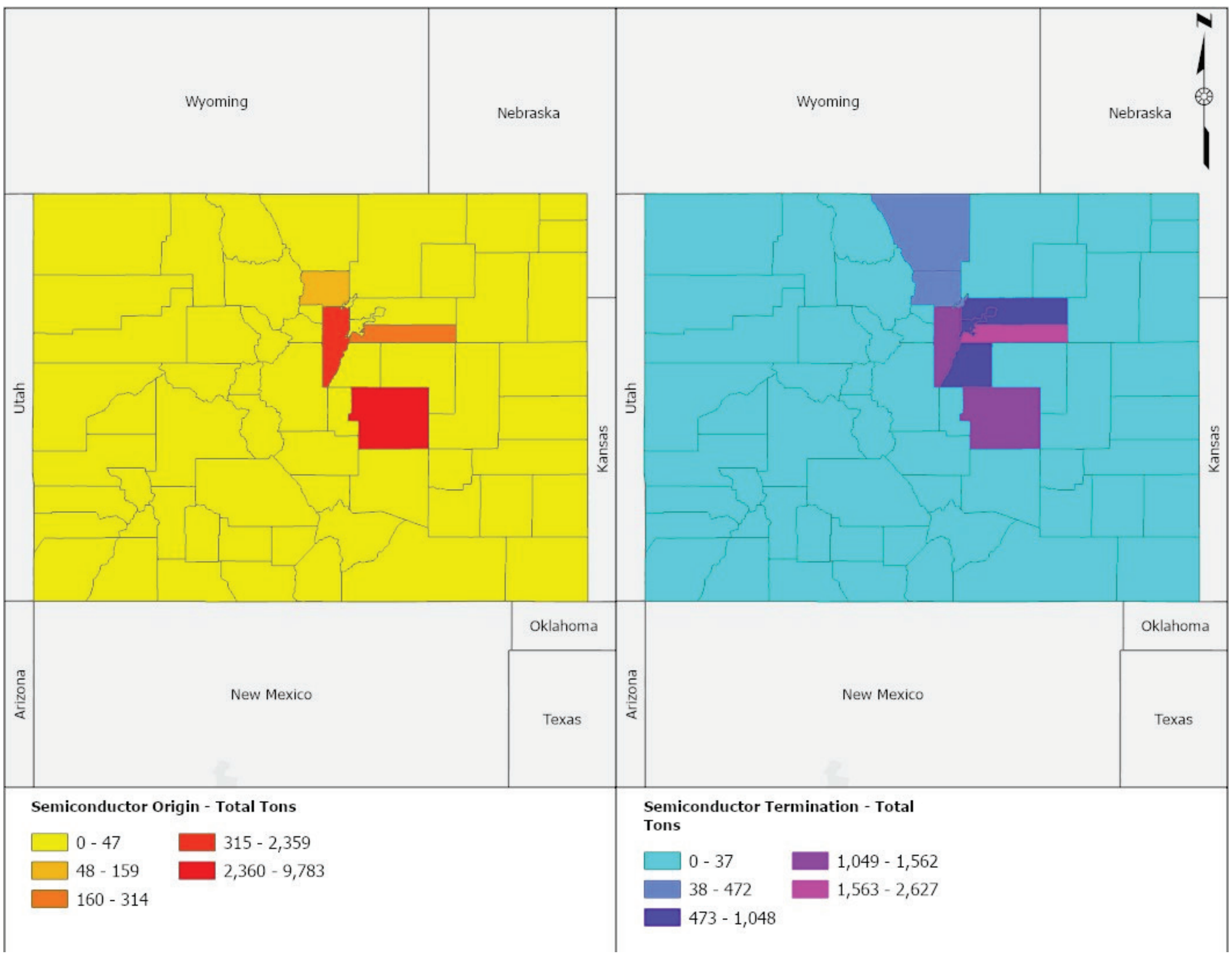
Source: U.S. Census Trade Data, 2021.

Imports of Electronic Integrated Circuits originate almost entirely from East Asia, including Taiwan, Malaysia, South Korea, Thailand, Philippines, and China, with nearly all value transported by air. Across the United States, China was the top origin for semiconductors.

Colorado's exports of Electronic Integrated Circuits totaled $3.2 billion from 2017 through quarter 2 of 2022, with a relatively steady 4 percent of total U.S. export value over that period. Malaysia is the top destination country, followed by Taiwan, Philippines, and China, with the highest percentage of volume exported by air. China was the top destination for semiconductors from the United States.

Figure 3.37 shows the origin and destination of tonnage for semiconductors in Colorado. The primary origin counties by tonnage are El Paso County, Jefferson County, Arapahoe County, and Boulder County. Each county is the origin of more than 160 annual tons of semiconductors, with El Paso and Jefferson counties the origin of more than 2,000 annual tons. The primary destination counties by semiconductor tonnage are Arapahoe County, Jefferson County, and El Paso County. Arapahoe County is the destination of more than 1,500 annual tons and Jefferson and El Paso Counties are the destination of more than 1,000 annual tons. This data reflects a high percentage of the traffic moving among these counties and therefore dependent on the efficiency of the regional infrastructure.

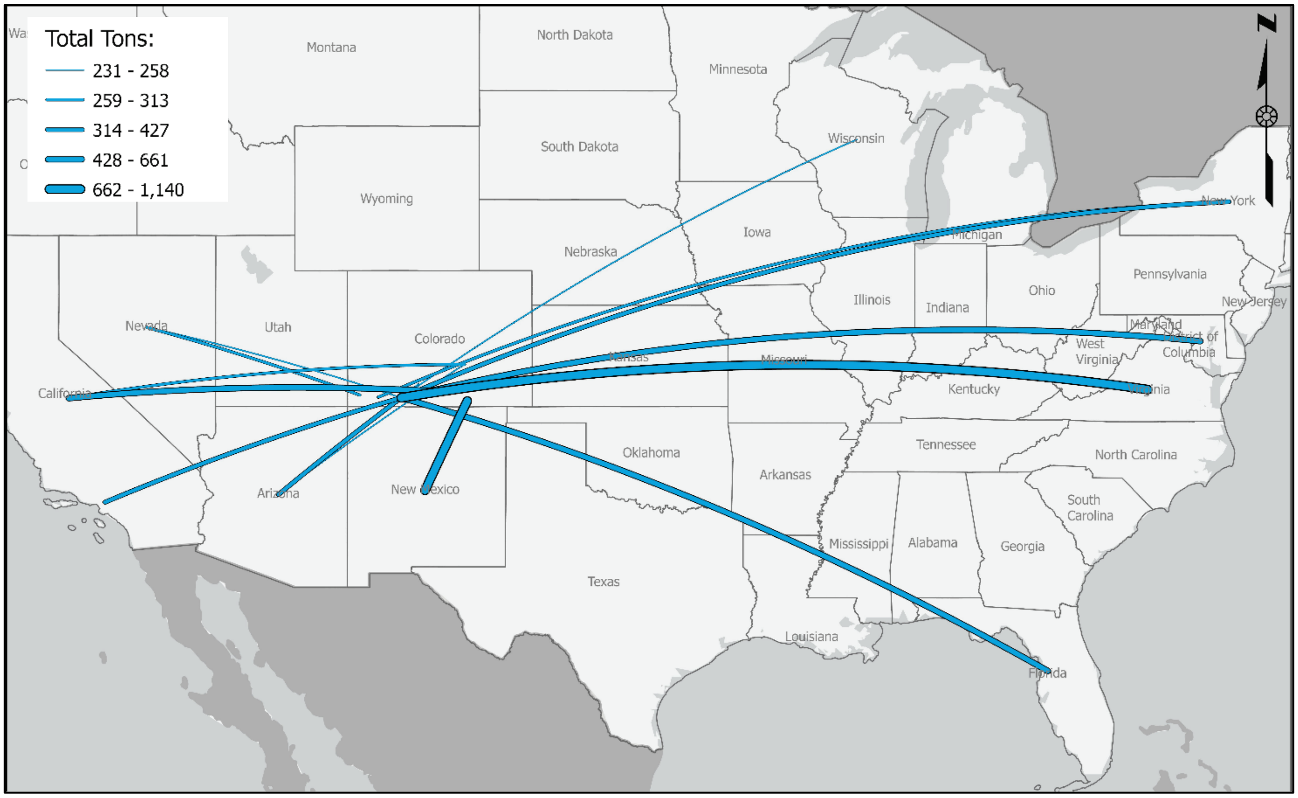
Figure 3.37 Origination and Termination of Semiconductor Tonnage by Colorado County, 2021



Source: S&P TRANSEARCH.

Figure 3.38 shows the domestic tonnage flows for semiconductors to and from Colorado counties. As shown in the figure, the highest outbound tonnages flow from Colorado to Virginia (1,140 tons), New Mexico (869 tons), and Florida (607 tons), and the highest inbound tonnages flow from California (569 tons). Other significant trading partners include New York, Florida, Nevada, and Wisconsin.

Figure 3.38 Semiconductor Supply Chain –Tonnage Flows



Source: WSP analysis of S&P TRANSEARCH.

3.3.5 Food and Agriculture + Supply Chain

Overview

Several products from various economic sectors were selected for further analysis in relation to their supply chain within Colorado, as well as nationally and globally. These critical supply chains include all aspects of a product's lifecycle, including raw materials, production facilities, warehousing, local distribution, retail outlets, recycling/waste, and receipt or distribution of various contributing inputs and outputs. As materials move through the supply chain, they often rely on multiple modes. A disruption to any one process or movement can dramatically impact the overall supply chain. Analyzing the transportation operations associated with these supply chain activities and movements supports the efficient movement of freight throughout Colorado.

This document focuses on the Food and Agriculture sector of Colorado's economy. This industry includes a wide range of commodities used in a variety of products, encompassing crop and animal farming, ranching, food manufacturing, and brewing. The Food and Agriculture industry is defined in this document by NAICS codes (Table 3.37). The Food and Agriculture sector includes NAICS codes related to initial production of plant and animal products through farming and ranching, as well as NAICS codes related to manufacturing and refinement of products. Additionally, the Food and Agriculture sector involves and benefits from other industries not listed, such as fertilizer and pesticide manufacturing, equipment manufacturing, and transportation and distribution services.

Table 3.37 Definition of Food and Agriculture Subsectors and Industries (4-digit NAICS)

Industry	Subsector
Crop Farming	1111 Oilseed and grain farming
Crop Farming	1112 Vegetable and melon farming
Crop Farming	1113 Fruit and tree nut farming
Crop Farming	1119 Other crop farming
Beef and Cattle Ranching	1121 Cattle ranching and farming
Other Animal Farming	1122 Hog and pig farming
Other Animal Farming	1123 Poultry and egg production
Other Animal Farming	1124 Sheep and goat farming
Other Animal Farming	1125 Aquaculture
Other Animal Farming	1129 Other animal production
Crop Farming	1151 Support activities for crop production
Food Manufacturing	3111 Animal food manufacturing
Food Manufacturing	3112 Grain and oilseed milling
Food Manufacturing	3113 Sugar and confectionery product manufacturing
Food Manufacturing	3114 Fruit and vegetable preserving and specialty food manufacturing
Food Manufacturing	3115 Dairy product manufacturing
Food Manufacturing	3116 Animal slaughtering and processing
Food Manufacturing	3117 Seafood product preparation and packaging
Food Manufacturing	3118 Bakeries and tortilla manufacturing
Food Manufacturing	3119 Other food manufacturing
Beer and Breweries	3121 Beverage manufacturing
Food Manufacturing	3122 Tobacco manufacturing

The following analysis provides an overview of the Food and Agriculture sector and commodities, including their importance to Colorado and global economies. The analysis also drills down into the supply chain for the Brewing subsector that falls under the Food and Agriculture category. Also discussed is the industry contribution to Colorado's economy and general and specific opportunities and constraints affecting the Food and Agriculture industry and brewing subsector. Overall, the Food and Agriculture industry in Colorado represents almost 50,000 employees, over 2,600 establishments, and annual wages of more than

$2.7 billion (Table 3.38). [37] Brewing is an important subsector in Colorado both culturally and economically, comprising 18 percent of employment, 18 percent of establishments, and 20 percent of wages in the Food and Agriculture industry

Table 3.38 Employment, Establishments, and Wages for Food and Agriculture Industry, 2022

	Employment		Establishments		Total Annual Wage ($M)	
Subsector	Total	Percent	Total	Percent	Total	Percent
Food Manufacturing	25,066	50%	729	28%	$1,508	54%
Beer and Breweries	9,093	18%	469	18%	$545	20%
Crop Farming	6,540	13%	722	27%	$290	10%
Beef and Cattle Ranching	5,546	11%	438	17%	$273	10%
Food & Agriculture	1,990	4%	165	6%	$88	3%
Other Animal Farming	1,481	3%	120	5%	$69	2%
Total Food and Agriculture	49,716	100%	2,643	100%	$2,773	100%

Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2022 data).

Table 3.39 provides employment, establishment, and wage metrics for Colorado as a whole. The Food and Agriculture industry represents 1.8 percent of total employment, 1.1 percent of total establishments and 1.3 percent of total wages in Colorado.

Table 3.39 Employment, Establishments, and Wages for Colorado Industries, 2022

State	Employment	Establishments	Total Annual Wage ($M)
Colorado Total (All Industries)	2,814,732	245,461	$209,435
Food and Agriculture Total	49,716	2,643	$2,773
Food and Agriculture Share of Statewide Total	1.77%	1.08%	1.32%

Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2022 data).

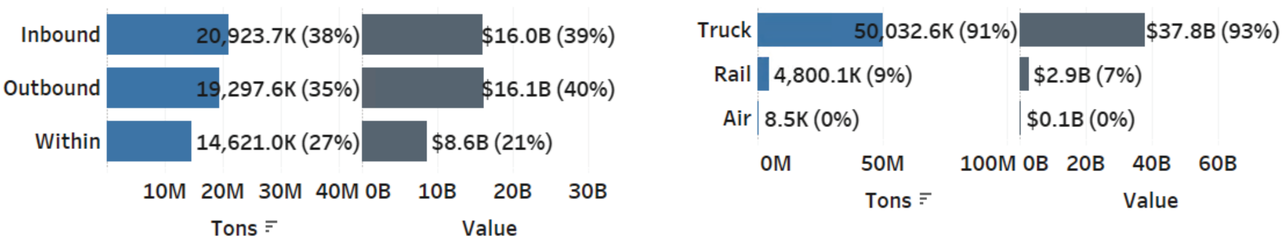
Commodities and Forecast

Figure 3.39 shows the split of Colorado commodity flows between outbound, inbound, and internal movements in the Food and Agriculture industry for tons and value, as well as by mode. Inbound and outbound flows of Food and Agriculture products are fairly balanced, with no direction comprising more than 40 percent of the total tonnage or value. Trucking is the dominant mode of the Food and Agriculture

[37] Quarterly Census of Employment and Wages data capture employment and wages covered by unemployment insurance. Some small farms are not covered, and informal labor participation may also result in underrepresentation.

sector, carrying more than 90 percent of related freight by tons and value. Trucking is significant for reaching farms and ranches that are dispersed across large geographic areas, as well as for distribution of finished food and beverage products. Rail plays a critical role in moving agricultural goods, particularly grain and fertilizers. Air freight comprises a very small contribution (less than 1 percent share) to the Food and Agriculture industry.

Figure 3.39 Commodity Flows of Food and Agriculture Industry, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.40 shows projected changes in tonnage and value for the Food and Agriculture industry. Tonnage is forecast to grow 1.1 percent annually, while value is forecast to grow slightly more quickly at 1.5 percent annually between 2021 and 2050. In 2021, the highest volume commodity by weight was Crop Farming (48 percent of industry total). The highest volume commodity by value was Food Products and Manufacturing (55 percent of industry total), reflecting the additional value added by the manufacturing process and the higher value of consumer goods than raw or intermediate products. Food Products and Manufacturing is also forecast to grow faster than any other subsector in the Food and Agriculture industry at 2.2 percent annually between 2021 and 2050. Two commodity subsectors are forecast to shrink over the 30-year period: animal farming and tobacco.

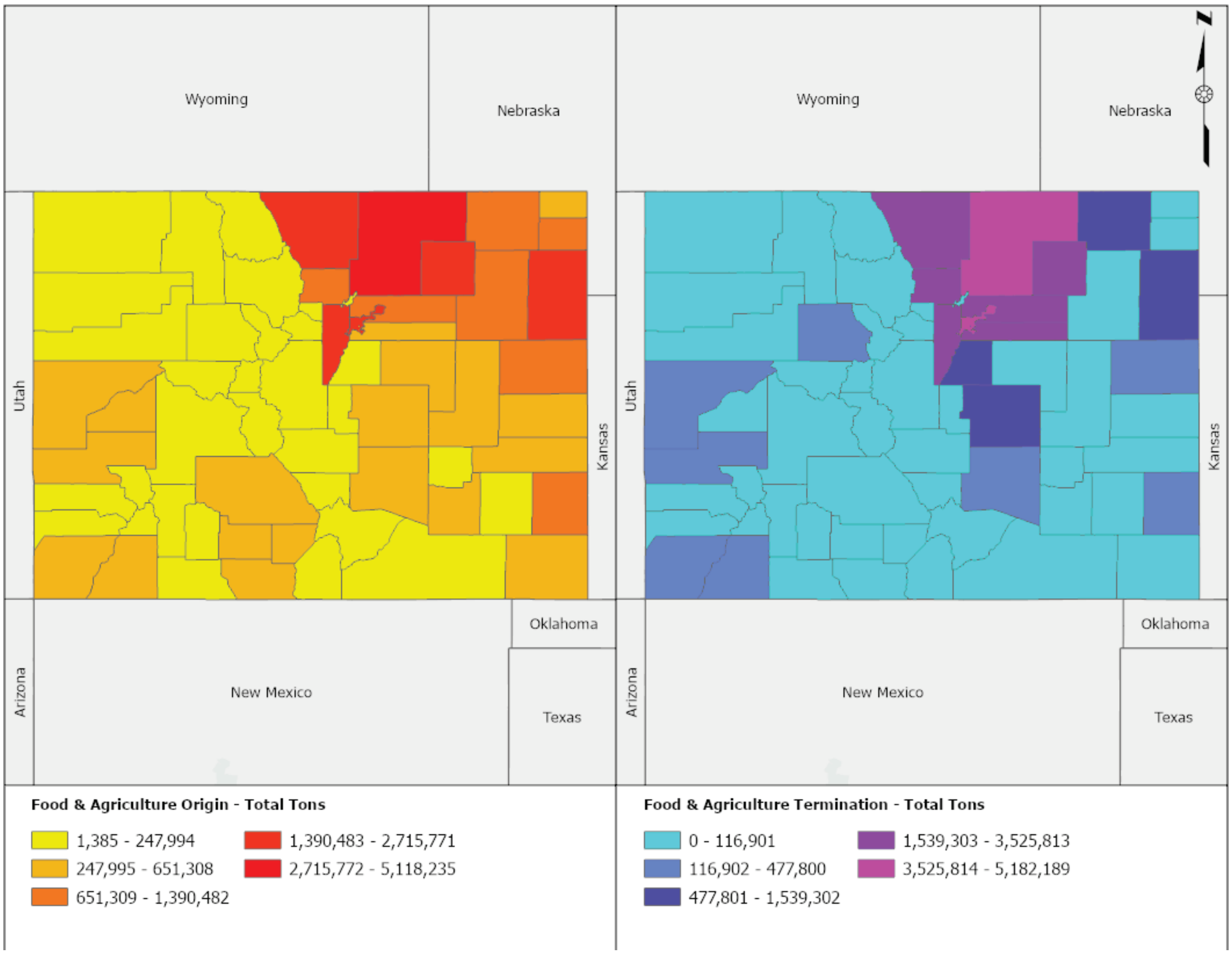
Table 3.40 Commodity Flows by Subsector in Food and Agriculture Industry, 2021 and Forecasted CAGR out to 2050

	Tons			Value		
Subsector	M 2021	%	Forecasted CAGR	$B 2021	%	Forecasted CAGR
Crop Farming	26.13	47.6%	0.6%	5.40	13.2%	0.8%
Food Products and Manufacturing	14.51	26.5%	2.2%	22.51	55.2%	2.2%
Beverage Manufacturing	6.49	11.8%	1.5%	5.83	14.3%	1.5%
Animal Farming	5.66	10.3%	-0.3%	5.72	14.0%	-0.5%
Food & Ag—Other	2.02	3.7%	1.0%	0.60	1.5%	1.5%
Tobacco	0.03	0.1%	-5.9%	0.72	1.8%	-4.5%
Total	**54.84**	**100.0%**	**1.1%**	**40.78**	**100.0%**	**1.5%**

Source: S&P TRANSEARCH.

Figure 3.40 shows the origin and destination of tonnage for Food and Agriculture in Colorado. The northeastern quadrant of the state holds the greatest concentration of agricultural and food production by weight with Weld, Morgan, Denver, and Yuma Counties each originating more than 2 million tons of freight in 2021. Destination counties are more geographically concentrated, with only 13 counties comprising 90 percent of destination tonnage. Weld and Denver Counties received over 5 million tons of food and agricultural products in 2021, while Adams and Morgan Counties received over 3 million tons. The top receiving counties include the greater Denver area and counties north of the greater Denver area.

Figure 3.40 Origination and Termination of Tonnage (k) in Food and Agriculture Industry, 2021



Source: S&P TRANSEARCH.

International Trade

As shown in Table 3.41 and Table 3.42 below, Colorado exports of food and agricultural products exceed imports at a ratio of approximately 3.6:1 exports to imports, while the nation as a whole is nearly balanced in Food and Agriculture exports and imports. Similar to the nation as a whole, Food & Kindred Products lead imports with nearly half of the Food and Agriculture import total. Nationally, exports of Agricultural Products and Food & Kindred Products each comprise slightly less than half of the total agricultural export value. In Colorado, Food & Kindred Products is the dominant export commodity with 96 percent of agricultural export value comprised almost entirely by meat products.

Table 3.41 U.S. and Colorado Food and Agriculture Imports

	2021 Import Value ($ Millions)			
Commodity by NAICS	All States	Colorado	Share of US	Percent of CO Food and Ag
Food and Agriculture	190,968	644	0.3%	100%
111 Agricultural Products	44,175	118	0.3%	18%
112 Livestock & Livestock Products	11,192	60	0.5%	9%
114 Fish, Fresh/chilled/frozen & Other Marine Products	17,641	12	0.1%	2%
311 Food & Kindred Products	86,898	307	0.4%	48%
312 Beverages & Tobacco Products	31,063	146	0.5%	23%

Source: U.S. Census Trade Data, 2021.

Table 3.42 U.S. and Colorado Food and Agriculture Exports

	2021 Export Value ($ Millions)			
Commodity by NAICS	All States	Colorado	Share of US	Percent of CO Food and Ag
Agriculture & Food	180,832	2,325	1.3%	100%
111 Agricultural Products	86,611	83	0.1%	4%
112 Livestock & Livestock Products	2,416	8	0.3%	<1%
114 Fish, Fresh/chilled/frozen & Other Marine Products	5,252	1	<0.1%	<1%
311 Food & Kindred Products	77,856	2,222	2.9%	96%
312 Beverages & Tobacco Products	8,698	12	0.1%	<1%

Source: U.S. Census Trade Data, 2021.

Trends, Opportunities, and Constraints

Agriculture and food production is unique in its strong dependence on environmental factors and its large geographic footprint. Inputs, products, and equipment are distributed by rail and truck, often using rural highways over a widespread network not designed for heavy machinery. The industry also faces many of the same labor challenges as other freight-generating industries, exacerbated by geographic dispersion and seasonal demands. The industry requires a high level of transparency and traceability to monitor health and public safety as well as to respond to recalls and public concerns. There are several key challenges to the agricultural supply chain's competitiveness and resilience in Colorado:

- Transportation and operation of equipment—Large agricultural equipment is transported to farms and ranches on rural roadways not designed for wide or heavy movements (e.g., two-lane highways, absent or narrow shoulders, and pavement depth). Even when equipment is transported by rail, the roadway system is used for final delivery. Once in operation, some equipment is driven on rural roadways alongside passenger and freight traffic. Farm equipment vehicles are typically slower and wider than general traffic, resulting in safety or mobility challenges related to passing and visibility.
- Agricultural land loss—Agricultural land is lost to development for a number of reasons, including challenges in profitability and division of land following transfer to heirs. Between 2001 and 2016, Colorado lost 124,000 acres of agricultural land to urban high density uses. [38] The American Farmland Trust estimates that between 2016 and 2040, an additional 417,000 acres in Colorado will be converted to high- or low-density development if current patterns continue (53 percent of land suited to agricultural uses). [39]
- Climate change—A warming climate has many impacts on agriculture in Colorado, including both positive and negative pressures on productivity estimated by the U.S. Environmental Protection Agency. [40] Reduced snowpack impacts natural biomes and water availability, potentially impacting species and disrupting ecosystems. The High Plains Aquifer supplies water for crop and livestock activities in eastern Colorado, and it is becoming depleted. Additional watering demands will accelerate aquifer depletion, potentially threatening agriculture in Colorado. Heat waves may negatively impact cattle and corn yield, and shorter winters may negatively impact yield of winter wheat but result in longer growing seasons for other crops. A warmer climate is also likely to increase threats to agriculture such as wildfires and pests.
- Consolidation of farmland—Since the 1930s, consolidation of farmland has resulted in the number of farms in the United States declining while increasing the average farm size. [41] In May 2023, the University of Colorado Boulder estimated that the number of farms globally will shrink to half the size

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[38] American Farmland Trust. Farms under Threat: State of the States. Updated 2020. https://farmlandinfo.org/wp-content/uploads/sites/2/2020/09/AFT_FUT_StateoftheStates_rev.pdf.

[39] American Farmland Trust. Development 2040. https://development2040.farmland.org/.

[40] U.S. Environmental Protection Agency. 2017. What does climate change mean for Colorado? https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-co.pdf.

[41] U.S. Department of Agriculture. Farming and Farm Income. 2023. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/.

by the end of the century, positing that this consolidation introduces risk to global food supply chains due to reduced biodiversity and versatility. [42]

- Consumer preferences and organics—The U.S. Department of Agriculture 2021 Organic Survey found that sales of organic products totaled $11.2 billion, a 13 percent increase from the 2019 survey. The top sector for sale of organic products was livestock and poultry products, especially dairy milk. [43] Colorado ranks 9th in the nation in certified organic acreage, with 191,000 acres reported in the 2021 U.S. Department of Agriculture survey and ranks 10th in the nation in certified organic sales with $253 million. [44]
- Labor and automation—A 2020 survey of agricultural employers conducted by Colorado State University found that more than 20 percent of employers were unable to find the workers they needed within the prior five years, and nearly 90 percent expected their labor requirements to remain the same or increase over the following five years. [45] Advances in automation have potential to either reduce labor requirements or increase yield (and by extension, profitability). Automated machinery, improved supply chain tracking, use of drones, and automated greenhouse farming are all in various stages of testing or deployment in agricultural contexts. [46]

Supply Chain Highlight: Brewing

The brewing industry provides an example of how the state's multimodal freight systems are essential to a growing and significant industry cluster in Colorado. The state's beer industry, including brewers, importers, distributors, and retailers, supports nearly 64,000 jobs and produces $12.7 billion in economic activity in Colorado each year, according to a study on the U.S. beer industry. [47] Colorado is home to both large international companies and the fifth highest concentration of craft brewers in the United States. [48] In 2022, the craft beer industry in Colorado employed over 6,685 workers at approximately 440 breweries, with a combined economic impact of $2.4 billion. [49] Over 834,006 barrels of craft beer were produced in

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[42] University of Colorado. 2023. https://www.colorado.edu/today/2023/05/11/number-farms-world-declining-heres-why-it-matters-you.

[43] USDA. 2022. USDA releases 2021 Organics data. https://www.nass.usda.gov/Newsroom/2022/12-15-2022b.php.

[44] USDA. 2022. NASS Highlights. https://www.nass.usda.gov/Publications/Highlights/2022/2022_Organic_Highlights.pdf.

[45] Colorado State University Extension. 2020. https://foodsystems.colostate.edu/wp-content/uploads/2020/06/Preliminary-Findings.Colo-Ag-Labor-Survey-for-Employers.March-2021-1.pdf.

[46] Association for Advancing Automation. 2022. The AgTech Revolution: How Technology is Boosting the Agriculture Industry. https://www.automate.org/industry-insights/agtech-automation-of-agriculture.

[47] Beer Serves America, Economic Impact of the Beer Industry, for Beer Institute and National Beer Wholesales Association (NBWA), 2022. https://beerservesamerica.org/wp-content/uploads/2023/05/BSA2023_CO.pdf.

[48] The Growth in the Number of Breweries and the Implications for Compliance with State Excise and Retail Taxes, by KPMG, 2018.

[49] O-I Facility in Winsor Profile, https://www.packaging-gateway.com/projects/owens/?cf-view.

Colorado in 2022, according to the Brewers Association. [50] The Molson Coors brewery in Golden is the largest single-site brewery in the world, with a production capacity of 9.7 million barrels of beer a year. [51]

Figure 3.41 presents a generalized description of the main supply chain steps for the brewing subsector's production in Colorado. Inputs to the brewing industry include agricultural products such as hops, wheat, barley, and other grains, as well as yeast. Hops and grains are grown in Colorado and also imported from Canada, New Zealand, England, and midwestern states. Hops are typically trucked from domestic producers and flown from international producers, while grain movement relies on rail and trucking. Flavorings and special ingredients for craft beers such as coffee or fruits are flown or trucked in from across the country and overseas. Aluminum, glass, cardboard, and other packaging materials are essential inbound supplies in the brewing process, and packaging suppliers use all modes to first bring products into the state and/or country. These materials are often recycled in plants across the country and in Asia and manufactured into cans, kegs, and bottles in Colorado. The Rocky Mountain Metal Container facility, located on a million square foot facility in Golden, is the nation's largest aluminum can plant, and produces over 4.5 billion cans per year to supply Molson Coors breweries. Colorado is also home to one of the largest glass-manufacturing factories in the United States, the Owens-Illinois plant in Windsor, Colorado, which produces more than 3 million beer bottles a day. [52]

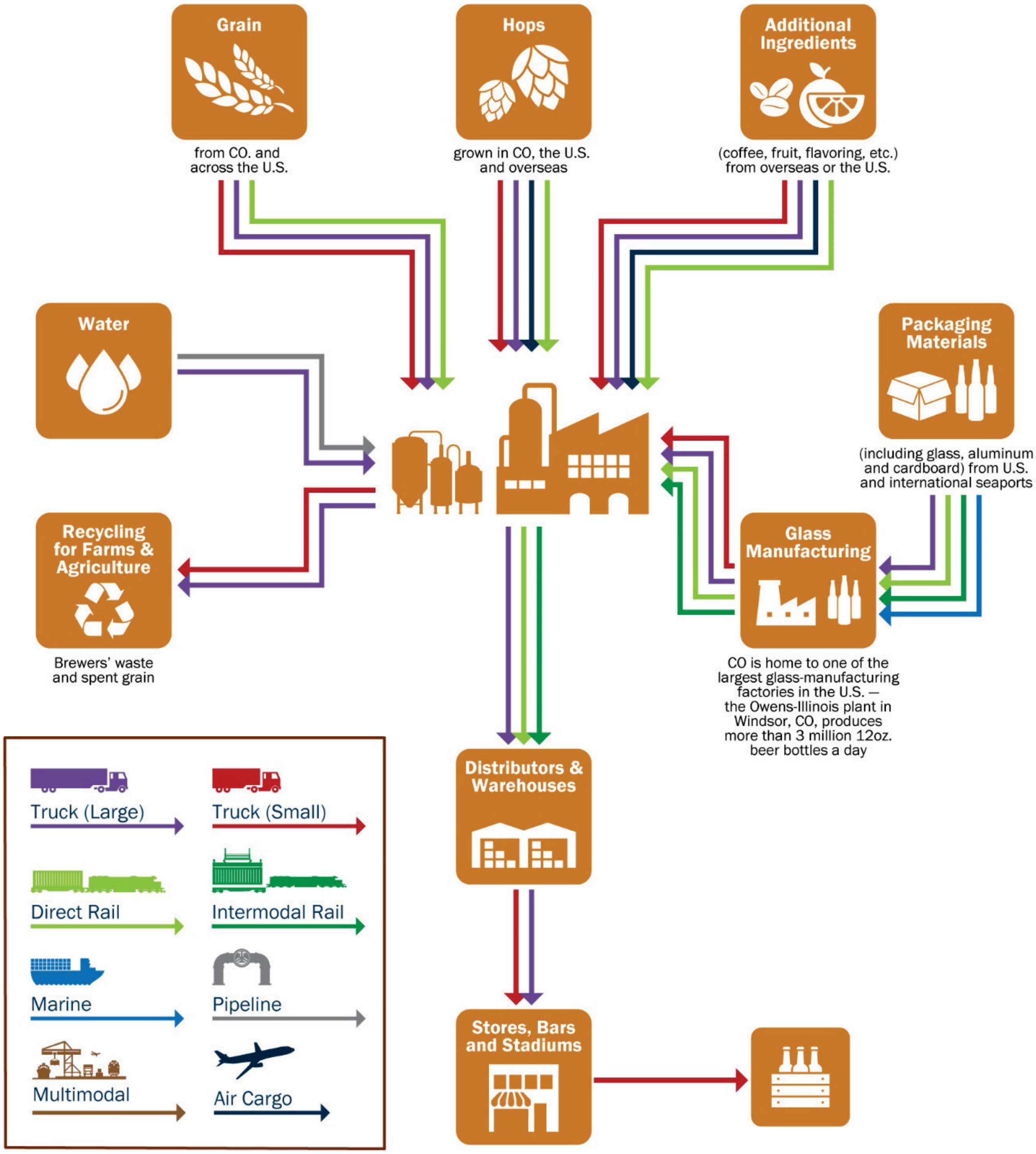
Once brewed, beers are distributed throughout the state and across the world through a network of warehouses, distributors, and exporters. The typical truck can carry about 18 pallets, each pallet containing 80 cases or 20 kegs of beer. A large brewer like Molson Coors ships out more than 1,500 truckloads and approximately 100 rail carloads of final product each week. Spent grain and other byproducts from the brewing process are shipped to farms for use in feed, compost, and other products.

[50] Colorado's Craft Beer Sales & Production Statistics, 2022, Brewer Association. https://www.brewersassociation.org/statistics-and-data/state-craft-beer-stats/?state=CO.

[51] Molson Coors Brewery Profile, CHP Technical Assistance Partnership, 2022. MolsonCoors-Profile.pdf (ornl.gov).

[52] The Growth in the Number of Breweries and the Implications for Compliance with State Excise and Retail Taxes, by KPMG, 2018.

Figure 3.41 Brewing Supply Chain Diagram



Source: WSP 2023.

The following tables and figures present data concerning the domestic flows of goods in the brewing supply chain to and from Colorado, defined as the "Malt Liquors (Beer)" commodity group in the S&P TRANSEARCH commodity database. As shown in Table 3.43, Texas is the top origin of inbound tonnage, accounting for 82 percent of inbound tonnage. The top destinations for outbound tonnage are California (11 percent), Texas (8 percent), Oregon (6 percent), Arizona (5 percent), and Michigan (5 percent). While inbound flows are heavily concentrated from one state (Texas), outbound flows are spread throughout the western and midwestern United States.

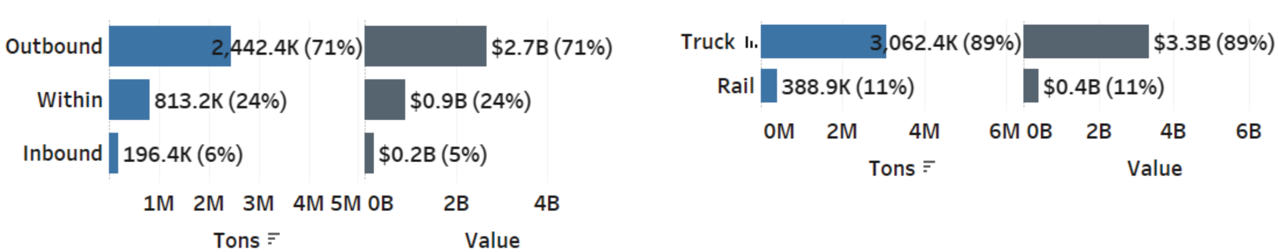
Table 3.43 Top Domestic Trading Partners for Malt Liquors (Beer) Supply Chain, 2021

	Inbound			Outbound		
Rank	State	Tons	%	State	Tons	%
1	Texas	115,407	82%	California	267,237	11%
2	Arizona	9,666	7%	Texas	201,038	8%
3	New Mexico	5,472	4%	Oregon	144,880	6%
4	California	4,715	3%	Arizona	130,227	5%
5	Missouri	1,983	1%	Michigan	112,263	5%
6	Ohio	630	<1%	Utah	91,018	4%
7	Oregon	582	<1%	Kansas	75,095	3%
8	Montana	567	<1%	Minnesota	72,464	3%
9	Utah	473	<1%	Nebraska	66,457	3%
10	Wyoming	354	<1%	Nevada	65,282	3%
-	Other	785	1%	Other	1,216,316	50%
N/A	**Total**	**140,633**	**100%**	**Total**	**2,442,277**	**100%**

Source: S&P TRANSEARCH.

Figure 3.42 shows tonnage and value for the Brewing subsector by direction and mode in Colorado. Most tonnage and value (more than 70 percent) is outbound due to the significant production of brewed beverages in Colorado. Nearly 90 percent of tonnage and value of beer in Colorado is moved by truck, while the remaining share is moved by rail. The reliance on trucks for domestic movements reflects the retail-like patterns of beer distribution in which many geographically dispersed destinations receive truckload, or less-than-truckload, deliveries of beverages.

Figure 3.42 Flows of Malt Liquors (Beer) Supply Chain, by Direction (left) and Mode (right), 2021



Source: S&P TRANSEARCH.

Table 3.44 provides the import and export value of the Brewing subsector in Colorado and the United States, defined here as the "Beverages" NAICS commodity code, which includes both alcoholic and nonalcoholic beverages. Since Colorado's share of the U.S. population is about 1.7 percent, the data shows that Colorado's shares of imports and exports are underrepresented compared to its population. This finding reflects the significant domestic consumption of product from Colorado-based breweries and beverage manufacturers, both in relation to large-scale producers such as Coors and the state's myriad craft breweries.

Table 3.44 Beverages (NAICS 3121) Export Value

Trade	U.S. Total ($M)	Colorado ($M)	State Share
Imports	$29,105	$146	0.5%
Exports	$8,375	$12	0.1%

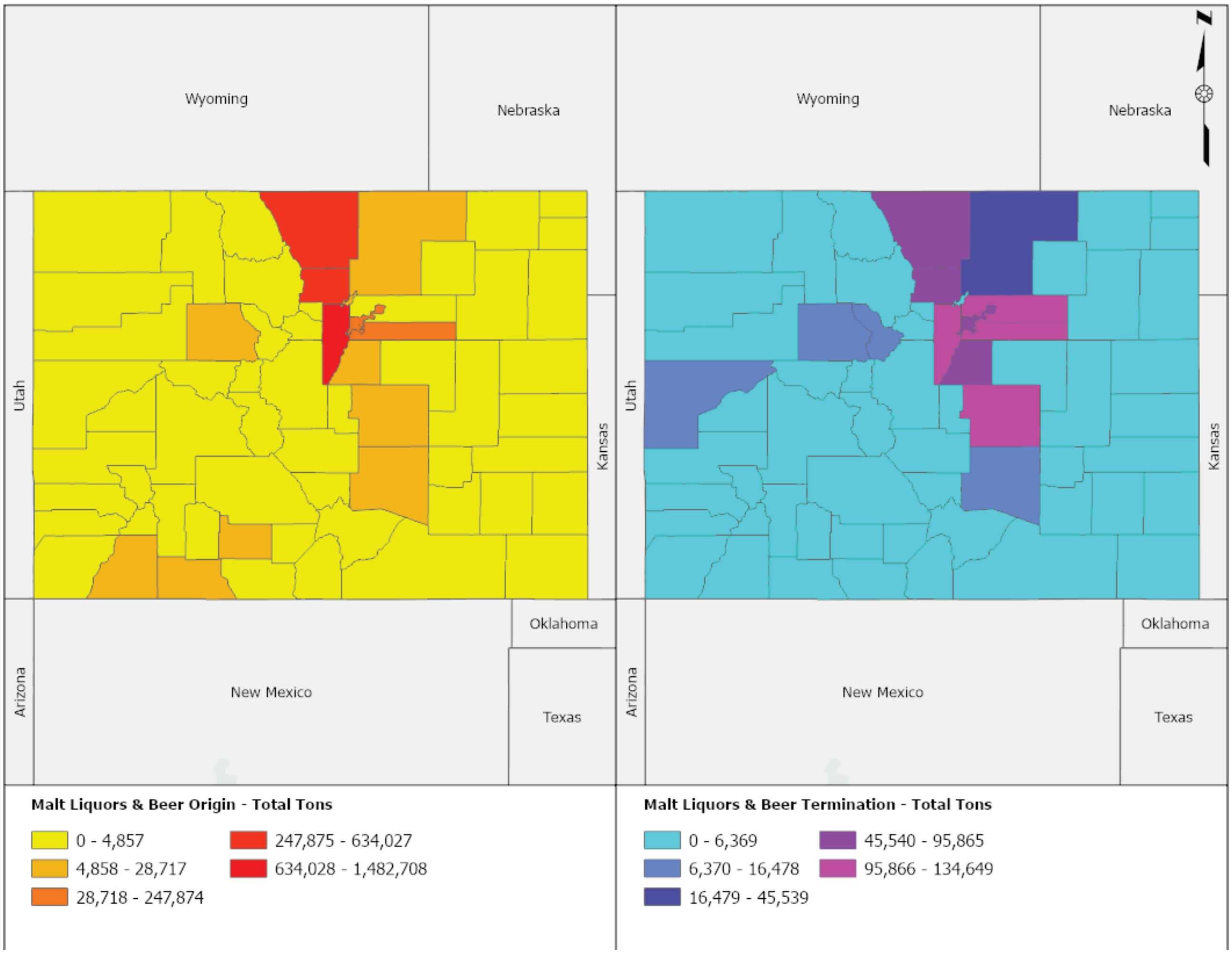
Source: U.S. Census Trade Data, 2021.

France and Italy each comprised approximately one-fifth of import value of beverages to Colorado in 2021. Mexico, the United Kingdom, Canada, and New Zealand follow with 8 to 12 percent each. The United States shares the same top three importing countries (Mexico, France, and Italy), and Mexico makes up almost one-third of U.S. beverage imports.

Three countries received a cumulative 73 percent of Colorado beverage exports in 2021: Canada (33 percent), South Korea (23 percent), and Japan (17 percent). The nation as a whole shares the same leading receiver of beverage exports (Canada, 21 percent). U.S. beverage exports are much less concentrated than Colorado's: the top 17 countries comprised 75 percent of U.S. beverage exports.

Figure 3.43 shows the origin and destination, respectively, of tonnage in the brewing industry in Colorado. The primary origin counties by tonnage are Jefferson, Boulder, and Larimer Counties which each generated over 500,000 tons in 2021. The primary destination counites by tonnage are Adams, Arapahoe, Jefferson, and El Paso Counties, which each attracted over 100,000 tons in 2021.

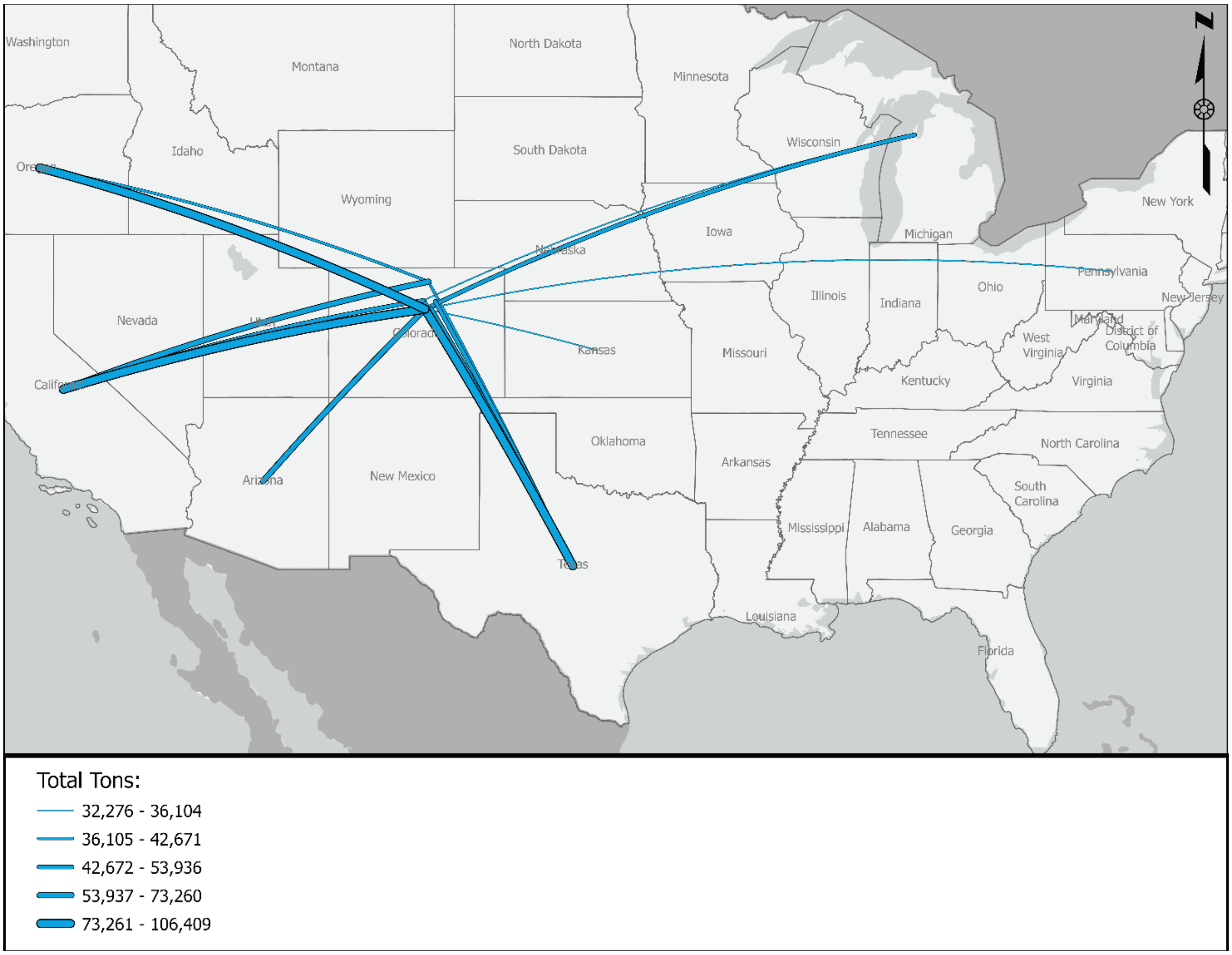
Figure 3.43 Origin and Destination of Tonnage in Brewing Supply Chain, 2021



Source: S&P TRANSEARCH.

Figure 3.44 shows the domestic tonnage flows for the brewing industry to and from Colorado counties. As shown in the map, the top domestic trading partners are the states of Texas, California, Oregon, Arizona, and Michigan. Each of these states had combined flows to and from Colorado exceeding 100,000 tons per year. Texas and California each accounted for more than 10 percent of the total domestic trade to and from Colorado.

Figure 3.44 Brewing Supply Chain (Tonnage Flows), 2021



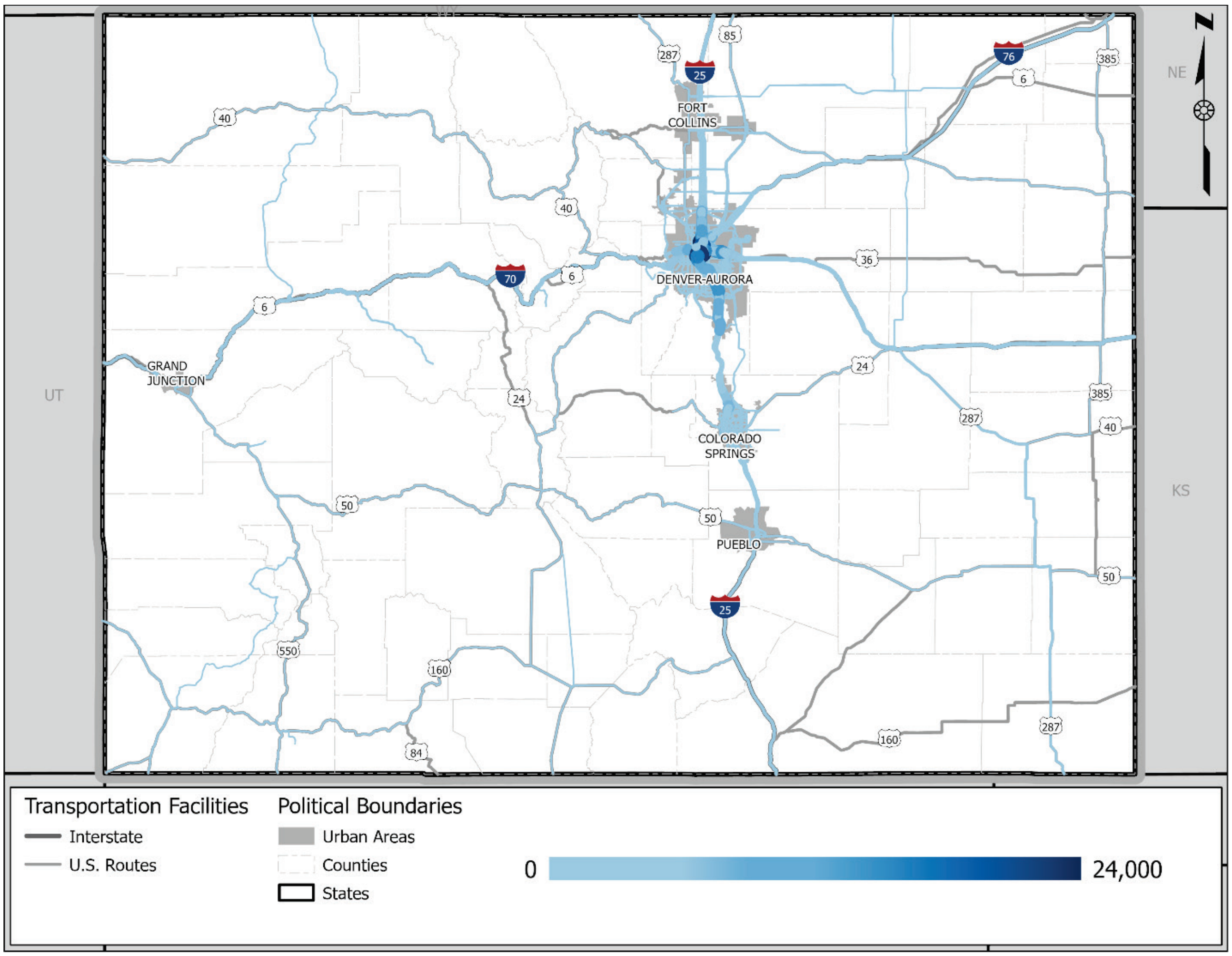
Source: WSP analysis of S&P TRANSEARCH data.

3.4 Economic Connectivity

Colorado's key industry clusters and top trading partners represent current markets that are critical to producers, manufacturers, and consumers in the state. Businesses rely on the entire state multimodal freight network, including highway, rail, air cargo, and intermodal connections to move goods. Each transport mode is vital to specific industries. However, highway and rail connections are most important to Colorado, as trucks and trains continue to move the majority of domestic and international freight. Colorado's top domestic inbound and outbound trading partners are typically neighboring states and top international trading partners are accessed through overland border ports of entry. From a statewide economic competitiveness perspective, Colorado's highway and rail systems are most vital to economic connectivity.

Improving intermodal connectivity, ensuring efficient connections, enhancing safety, addressing road and bridge conditions, and eliminating capacity constraints on highway and rail systems is critical. CDOT recognizes the importance of economic connectivity and the linkages between transportation investments and economic competitiveness by ensuring that key trade routes receive priority through state and federal designations and by evaluating the potential economic connectivity benefits of specific improvements through established project prioritization processes. CDOT is currently exploring freight data analytics to better understand specific origin and destination patterns for key commodity and industry-based movements. Even without specific data, national data on truck volumes and routes can help CDOT understand what routes within the state are most important to interstate goods movement. Figure 3.45 shows the magnitude of highway freight flows on the National Highway System.

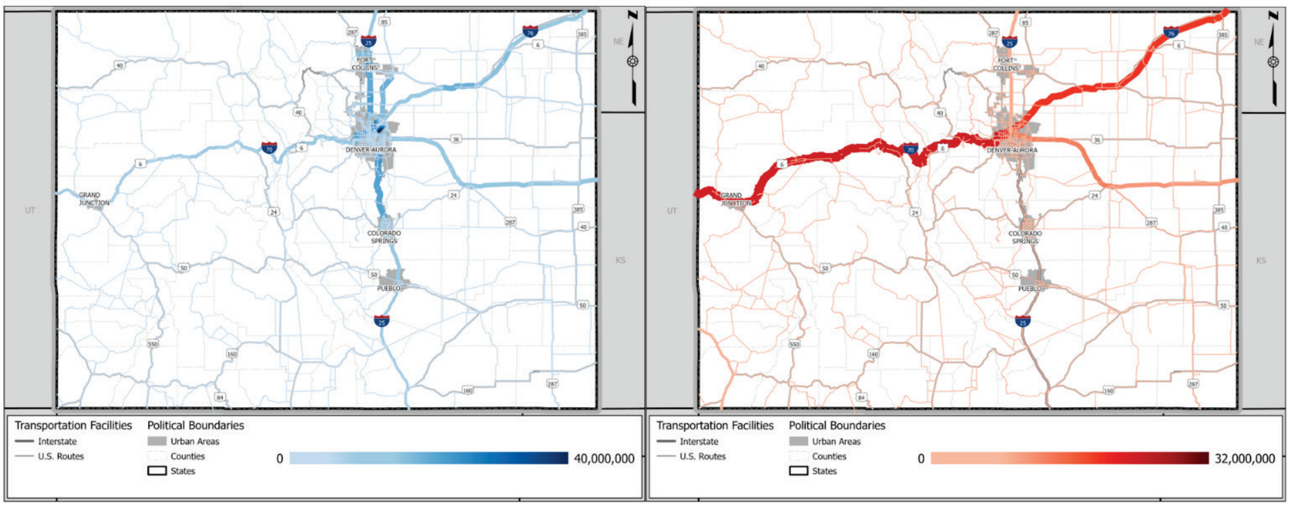
Figure 3.45 Truck Average Annual Daily Traffic (AADT) on Colorado National Highway System



Source: National Performance Management Research Data Set (NPMRDS), USDOT, 2022.

Truck volumes on the National Highway System suggest that Interstate routes in Colorado, including I-25, I-70, and I-76, are utilized to connect Colorado to national markets. However, the National Highway System also accounts for other key routes in Colorado, including U.S. 287, U.S. 385, U.S. 34, U.S 50, U.S. 40, and other critical linkages. These key freight corridors are used by Colorado industries and passthrough traffic alike. Commodity flow routing and origin-destination data provided by IHS TRANSEARCH illustrates the variation in freight corridors utilized by Colorado-based industries and passthrough traffic (Figure 3.46). Trucks carrying Colorado-based commodities move along I-25, I-76, I-70, and a variety of other U.S. and state routes connecting Colorado freight-generating and attracting industries to their origins and destinations. Trucks passing through Colorado, on the other hand, primarily travel along I-76 and I-70 in an east-west orientation, with flows also occurring on I-25 to the north of Denver and flows along U.S. 491 and U.S. 287.

Figure 3.46 Freight Corridors Utilized by Commodity Flow Origin/Destination (by Tonnage)—Non-Passthrough (Left) and Passthrough (Right)

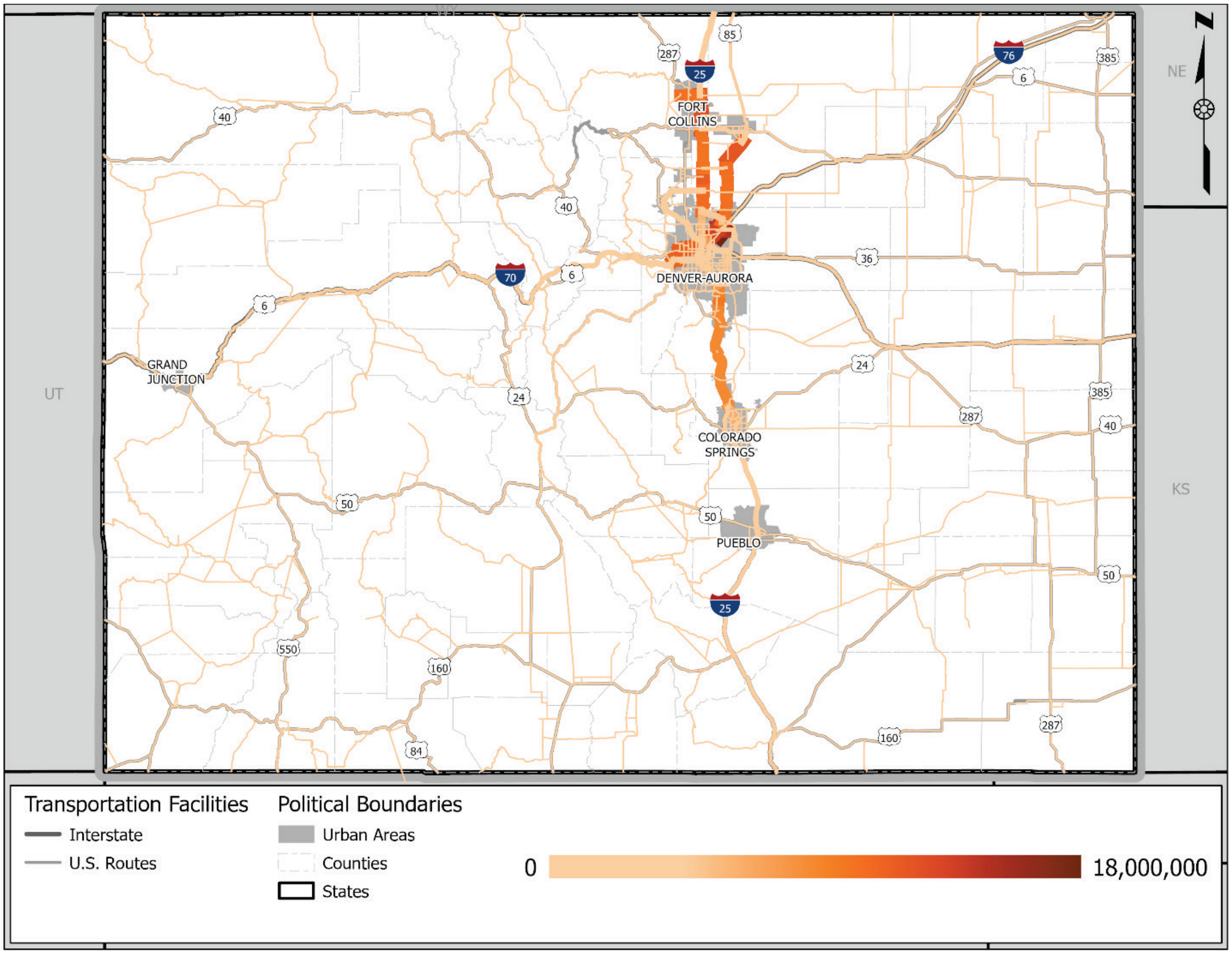


Source: IHS TRANSEARCH, 2021.

The most critical highway routes linking Colorado to domestic and international markets are further explored in the rest of this section. While all industries use all corridors, some industries are particularly reliant on certain corridors and those relationships are also described below:

I-25 North/South—This corridor extends from Denver north with connections to I-80 in Wyoming and continuing to I-90 with links to Canadian ports of entry and markets in the Pacific Northwest. U.S. 287 and U.S. 85 north of Denver provide redundant and reliever routes for truck traffic along this corridor. The I-25 corridor south of Denver continues to connect Colorado to El Paso, Texas, via New Mexico. Truck traffic crossing the international port of entry at El Paso utilizes this route to connect international trade flows to markets in Colorado and the Mountain West. Within Colorado, I-25 is part of the national Camino Real Corridor priority freight corridor, and I-25 North/South is the largest freight corridor in Colorado by tonnage flows related to the construction industry (Figure 3.47).Urban areas along this corridor, including Denver, Colorado Springs, Fort Collins, and Pueblo, as well as the industries serving these markets, generate the most construction activity in the state. This activity is most concentrated in the Denver urban area, with significant construction-related flows on I-25 (to the north and south), US-85 (to the north), and I-70 and I-76.

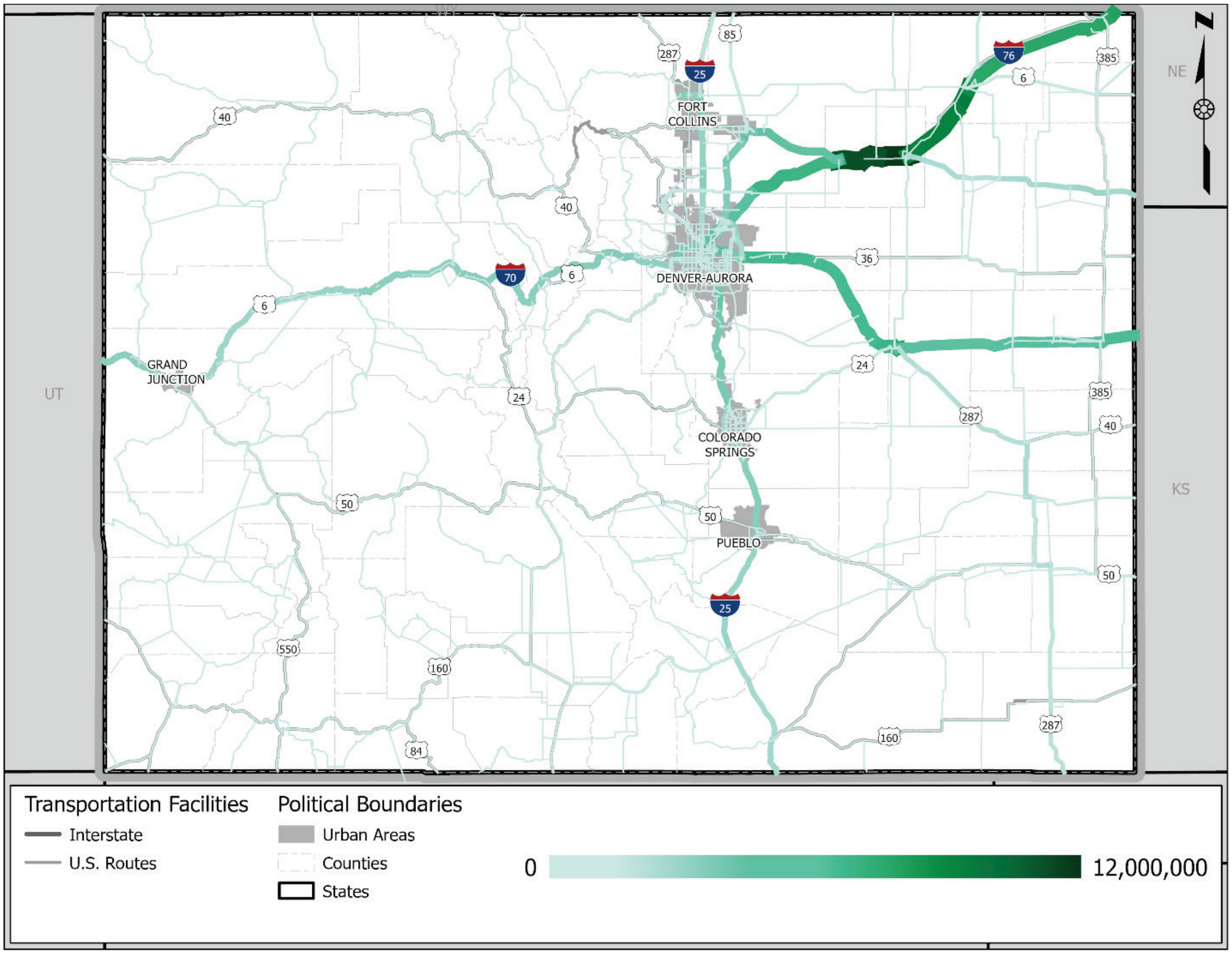
Figure 3.47 Construction Tonnage Flows on Colorado's Roadway Network



Source: I TRANSEARCH, 2021.

I-76 and SH 71 North—This corridor extends from Denver with connections northbound to I-80 in Wyoming and continuing on I-76 with access to major markets in the Midwest and longer connections to the East Coast. U.S. 34 is the key redundant route for these movements. Within Colorado, I-76 and SH 71 are part of the national Heartland Expressway priority freight corridor. I-76 in particular is the key freight corridor for movements of food and agriculture commodities to and from Colorado, connecting Denver to Nebraska and beyond (Figure 3.48). Food and agriculture flows are also concentrated along other corridors such as I-70, I-25, US-34, and US-287.

Figure 3.48 Food & Agriculture Tonnage Flows on Colorado's Roadway Network



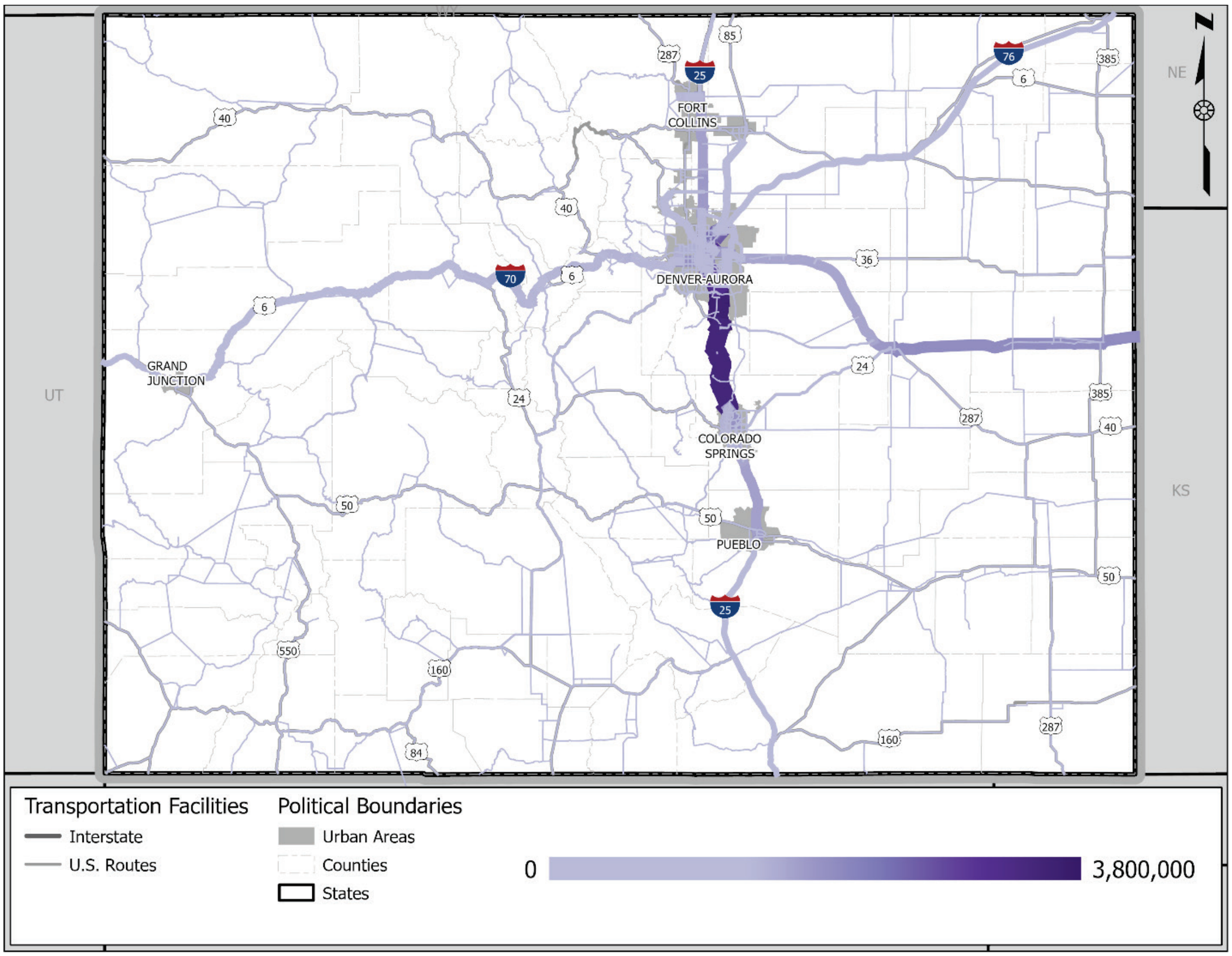
Source: IHS TRANSEARCH, 2021.

U.S. 287 South—This corridor includes segments of I-70 East and U.S. 287 and connects the Denver metro area and agricultural producers in Colorado to markets and international ports in Texas. U.S. 287 is important for truck traffic traveling to and from major Gulf Coast seaports and consumer markets in Texas. Supporting and redundant routes include segments of U.S. 24 and U.S. 385. Within Colorado, I-70 from Denver to Limon and U.S. 287 between Limon and the Oklahoma border are part of the national Ports-to-Plains priority freight corridor.

I-70 to the west of Denver—This corridor includes all of I-70 from Denver to Grand Junction and provides interstate connectivity to I-15 in Utah. Goods moving to and from major markets in Salt Lake City, Utah, and Las Vegas, Nevada, and intermodal traffic from seaports in Los Angeles and Long Beach, California, utilize I-15 and I-70 to serve Colorado markets. I-70 also provides critical intrastate connections to communities in Western Colorado. U.S. 40 from Idaho Springs to the Utah border is an important redundant route for access to and from Salt Lake City and I-80. Within Colorado, I-70 is part of the national I-70 priority freight corridor.

I-70 to the east of Denver—This corridor includes I-70 east of Denver and provides connectivity to Denver International Airport, distribution centers in the eastern metro area, and critical link to the U.S. 287 north-south corridor. Within Colorado, I-70 from Denver to Limon is part of the national Ports-to-Plains priority freight corridor. This connectivity to the airport and distribution centers in the metro area as well as to ports further away in other states (e.g., Los Angeles/Long Beach) is best reflected in the presence of large warehousing and distribution traffic flows along the I-70 corridor (Figure 3.49). This distribution traffic also follows some of the same routing patterns as construction-related traffic, with significant concentration in the Denver metro area and high utilization of the I-25 north/south corridor, however, an even higher proportion of its flows move on the segment south of Denver, between Denver and Colorado Springs.

Figure 3.49 Distribution Tonnage Flows on Colorado's Roadway Network



Source: IHS TRANSEARCH, 2021.

U.S. 50 East—This corridor connects Pueblo to U.S. 287 and U.S 385 as well as interstate connectivity for goods moving to and from Colorado and major consumer markets in the Midwest and Texas and international ports along the Gulf Coast via I-35 in Kansas and Oklahoma. Within Colorado, U.S. 50 is part of the national High Plains priority freight corridor.

These key highway routes, in addition to other important intrastate routes, are incorporated into the Colorado Freight Corridor network and are represented in nationally designated systems, such as the National Highway Freight Network. These designations recognize the importance of key routes to regional and state economic competitiveness and are described in more detail in Chapter 4. Beginning with the Intermodal Surface Transportation Efficiency Act of 1991, certain corridors have been designated in federal transportation legislation as high-priority corridors. Colorado's five Congressionally-designated high priority corridors—the Heartland Expressway (I-76 and SH 71), the Ports-to-Plains (U.S. 287), the Camino Real (I-25), the High Plains (U.S. 50), and I-70 (Denver to Salt Lake City)—link Colorado to top domestic and foreign trading partners and are incorporated in the Colorado Freight Corridor highway network.

Evaluating and improving rail and highway connections to neighboring states and major trading partners (such as Wyoming, Utah, and Kansas) and multistate freight corridors linking Colorado to national trade corridors, international ports, and major consumer markets (such as California and Texas) is a priority for CDOT.

CDOT works with private industry, economic development organizations, and regional planning partners to identify projects with potential economic connectivity and competitiveness benefits. For example, investments that relieve congestion or address freight bottlenecks provide travel time savings and reduce the costs of congestion to freight shippers and carriers. Projects that expand access and connectivity to intermodal facilities, including terminals, air cargo hubs, rail yards or distribution centers, provide efficiency benefits to freight-reliant benefits and can reduce transportation costs for businesses and consumers. New facilities can expand the economic development potential of industrial sites, free trade zones, or other designated economic development areas.

CDOT considers the economic connectivity benefits of projects eligible for freight-specific funding through the project prioritization and investment approach described in Chapter 8. This investment approach and the priority strategies identified in this plan reinforce CDOT's commitment to improving the mobility of freight within, into, and out of the state. A key finding of this plan is the need for transportation planning partners to better coordinate with economic development organizations and private industry to identify projects that offer connectivity benefits to key industry clusters and or improve intra- and interstate rail, highway, air cargo, or intermodal access for Colorado businesses.

4

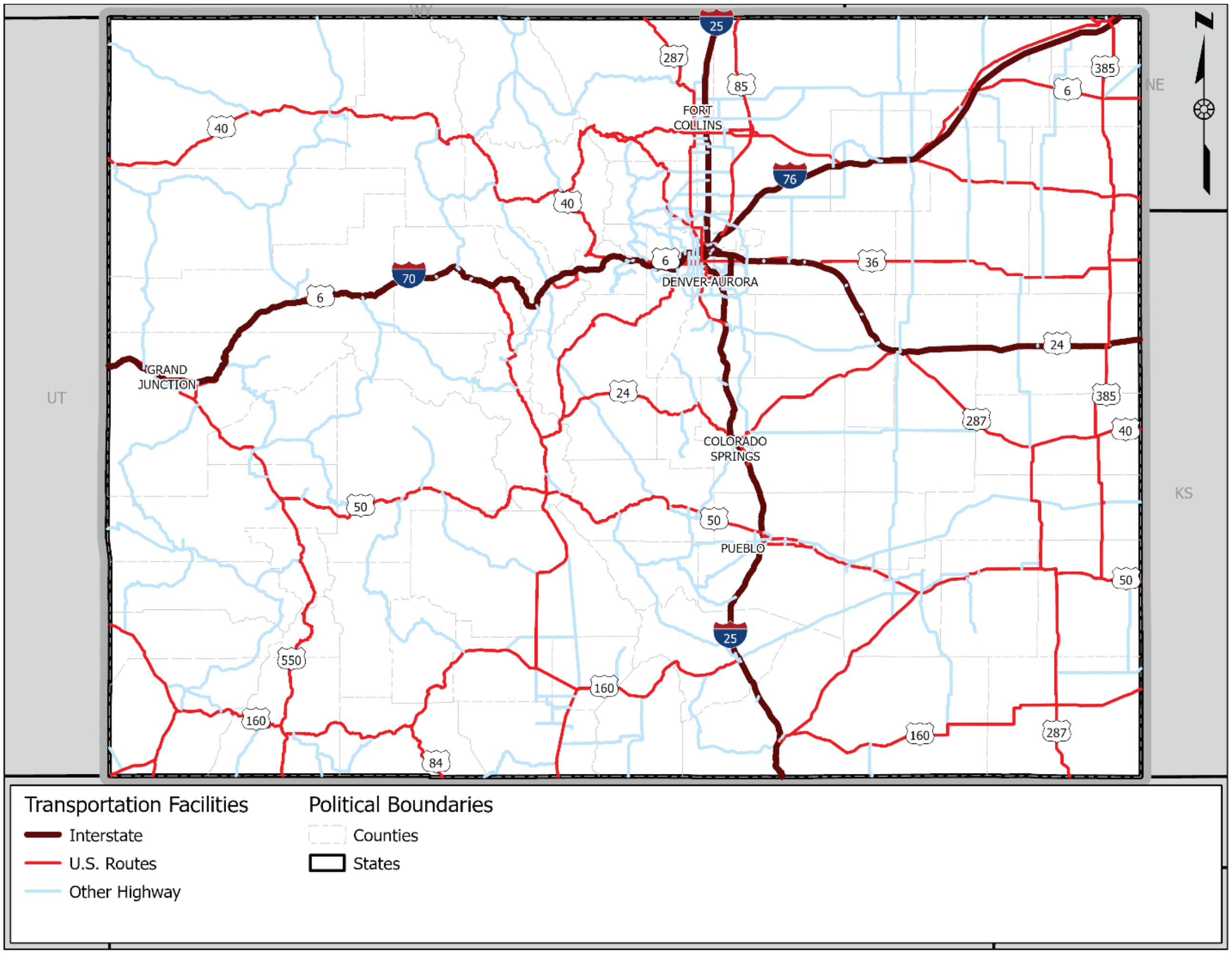
Assessing Safety, Mobility, and Asset Condition on Colorado's Highway Freight Network

4.1 Colorado's Highway System

As an inland state, Colorado relies heavily on its air, rail, and highway infrastructure to support freight industries. Colorado lacks any navigable waterways as an alternate mode for freight transportation. Highways, in particular, provide nearly all of the access component of to-market good delivery in the Centennial State, and the vast majority of middle mile freight transportation. This chapter discusses the state's freight highway inventory, utilization, and operations.

In the United States generally, highways are consistently the most important freight and passenger transport network. This is true for Colorado as well, which moves over 83 percent of its freight by weight and nearly 73 percent of its freight by value across highways. The interstates, consisting of I-70 , I-25, I-76, I-225, and I-270, carry the majority of truck traffic, with some strategic US routes (including U.S. 6, U.S. 287, U.S. 285, U.S. 50, and U.S. 85) playing roles as critical connectors and ports of entry. Figure 4.1 shows the extent of the state's interstate and US highway network.

Figure 4.1 Colorado Highway System Overview

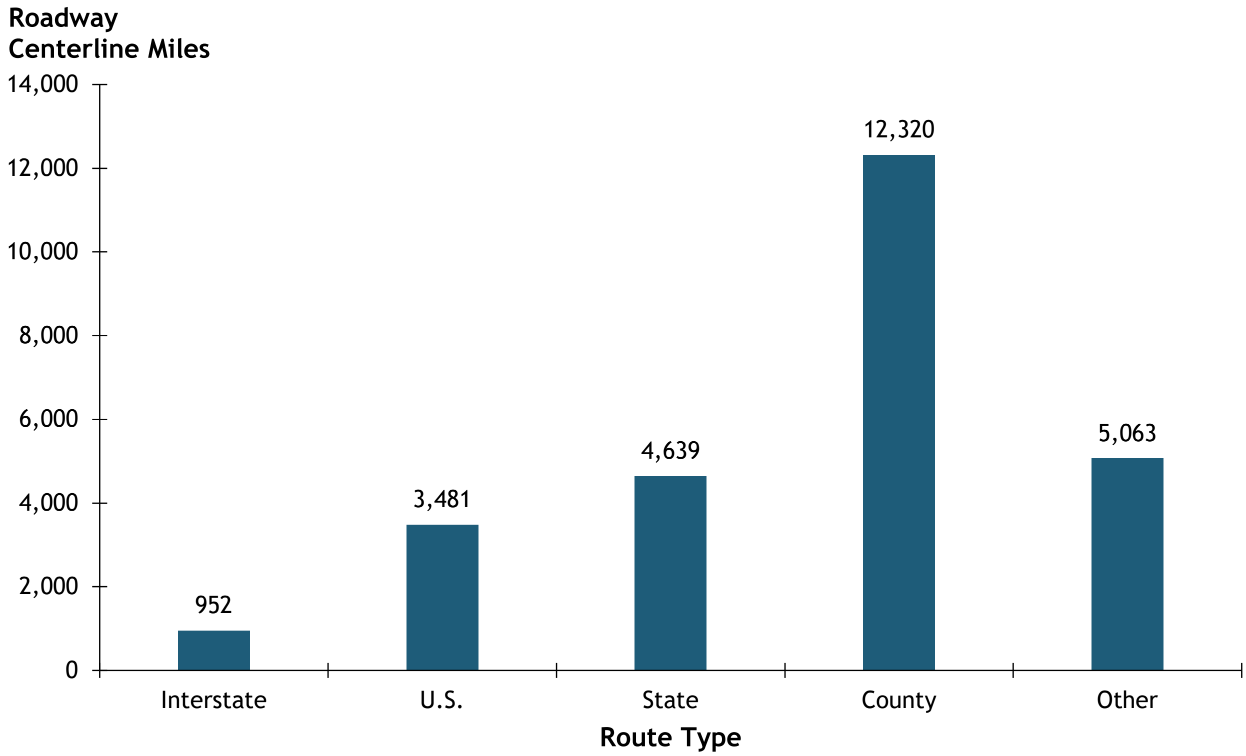


Source: CDOT Online Transportation Information System.

The interstate system consists of 952 miles between the five routes. The longest and most geographically hazardous of the interstates is I-70 stretching approximately 450 miles west to east across the state. I-70 has a number of vehicle constraints west of the front range, and runs parallel to U.S. 6 to support trailers, hazardous materials, oversize-overweight, and other freight routing that connects Colorado to the west and international ports of entry. When considering non-local routes in the state, county routes represent the largest single share of roadway centerline miles in the state, with over 12,300 miles. Figure 4.2 details the centerline miles of roadway in the state by route type, excluding local routes.

Different route types are the responsibility of different agencies and the type of roadway may impact potential funding sources. CDOT is responsible for the state highway system while counties and municipalities maintain their own network of roadways within their jurisdiction. As an example, counties may levy taxes and receive loans to build and repair county roads and bridges but any loans must be approved by county voters

Figure 4.2 Roadway Centerline Miles by Route (Non-Local Routes)



Source: CDOT Online Transportation Information System.

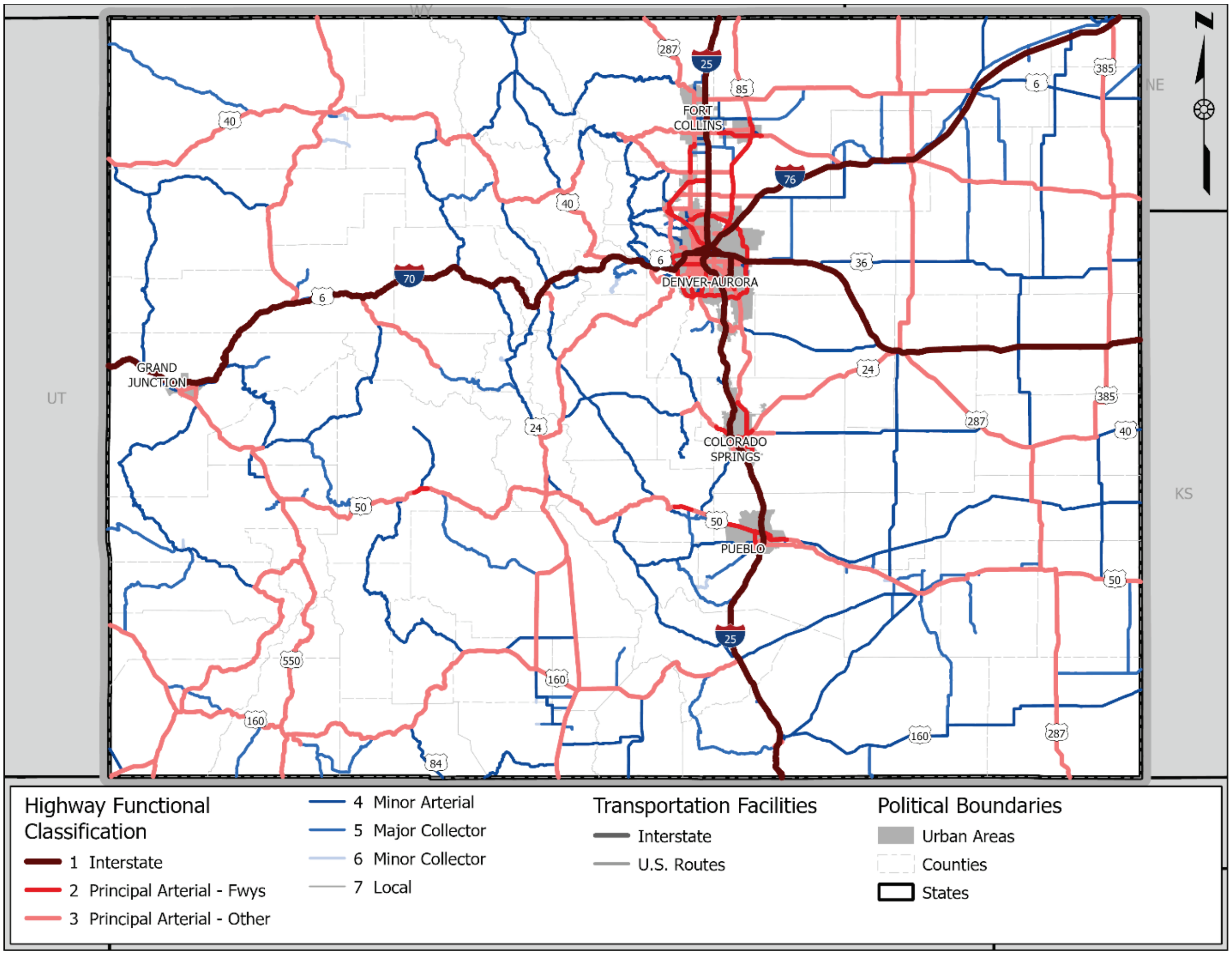
From the functional classification perspective, the highway system mileage is largely either non-freeway principal arterial or minor arterial. This is consistent with other states. Most of the system is made up of middle tier functional classification routes that provide access to freeways and collectors. Combined, both non-freeway principal arterial and minor arterial make up nearly 6,300 centerline miles of the almost 9,100 miles of highway in the state, or 69 percent. Notably, Figure 4.3 shows that much of the US route system is principal arterial, both freeway and non-freeway. This is a generally standard correlation between functional classification and route type, but worth noting considering the state's population is heavily located in metropolitan-areas (due in large part to the state's topography) so net roadway usage is much lower outside metropolitan areas and interstates. In addition to Figure 4.3, Figure 4.4 shows the centerline miles by functional classification for the highway system.

Arterials are roadways that provide a high level of mobility. Interstates are the highest classification of arterials and allow for the efficient movement of long distance freight deliveries by road.

Collectors provide a balance of mobility and access by gathering traffic from Local Roads and funneling them to the Arterial Roads.

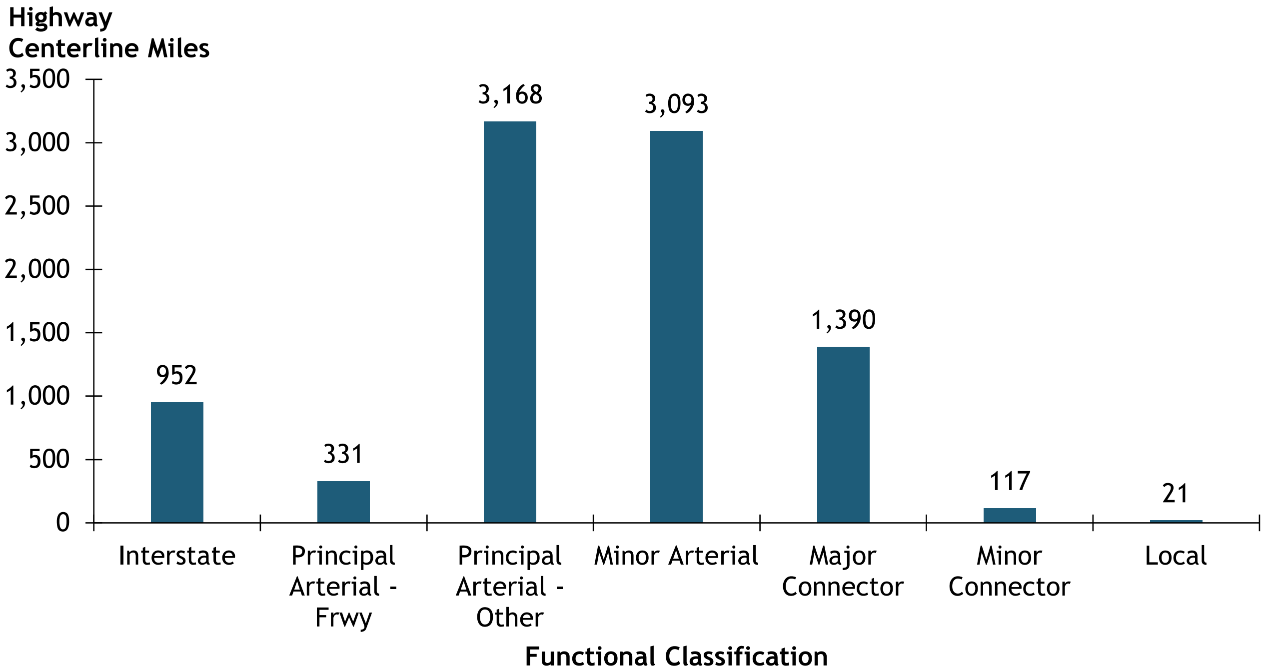
Locals provide a high level of land accessibility and are not intended for long-distance travel. These roads help to provide the final-mile connection to warehouse and distribution centers.

Figure 4.3 Colorado Highway System Functional Classification



Source: CDOT Online Transportation Information System.

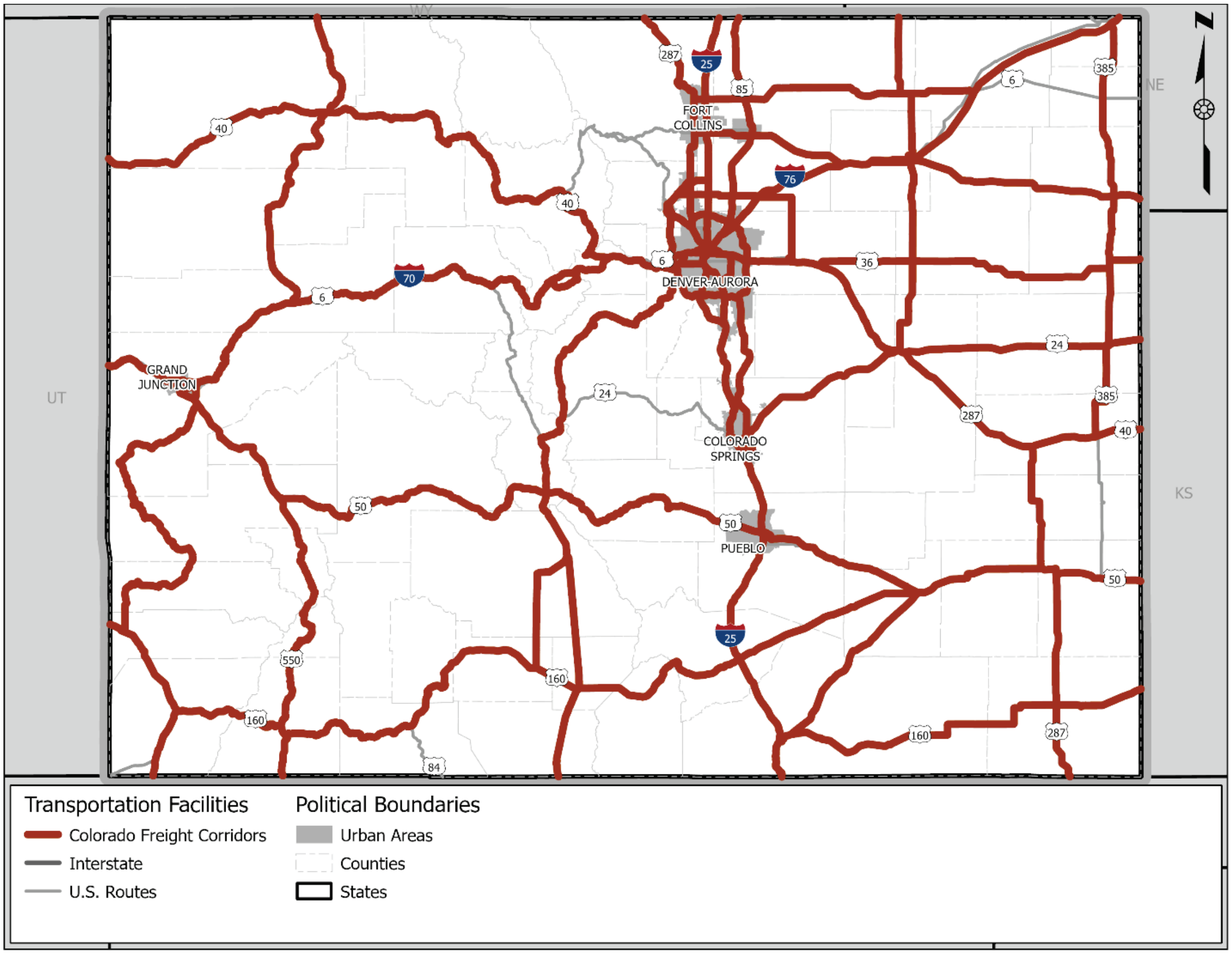
Figure 4.4 Highway Centerline Miles by Functional Classification



Source: CDOT Online Transportation Information System.

Additionally, Colorado designates it's own distinct freight network, weighing the truck utilization, industries, federal designations, and overall criticality to the movement of freight throughout the state. This network is largely consistent with the higher order corridors of the National Highway System, presented in the following section, but identifies additional corridors primarily in the western and south-eastern portion of the state. Routes such as U.S. 160 and SH 141 provide regionally significant connections to main thoroughfares that are notable for statewide freight planning. Figure 4.5 shows the Colorado freight network.

Figure 4.5 Colorado's Priority Freight Network

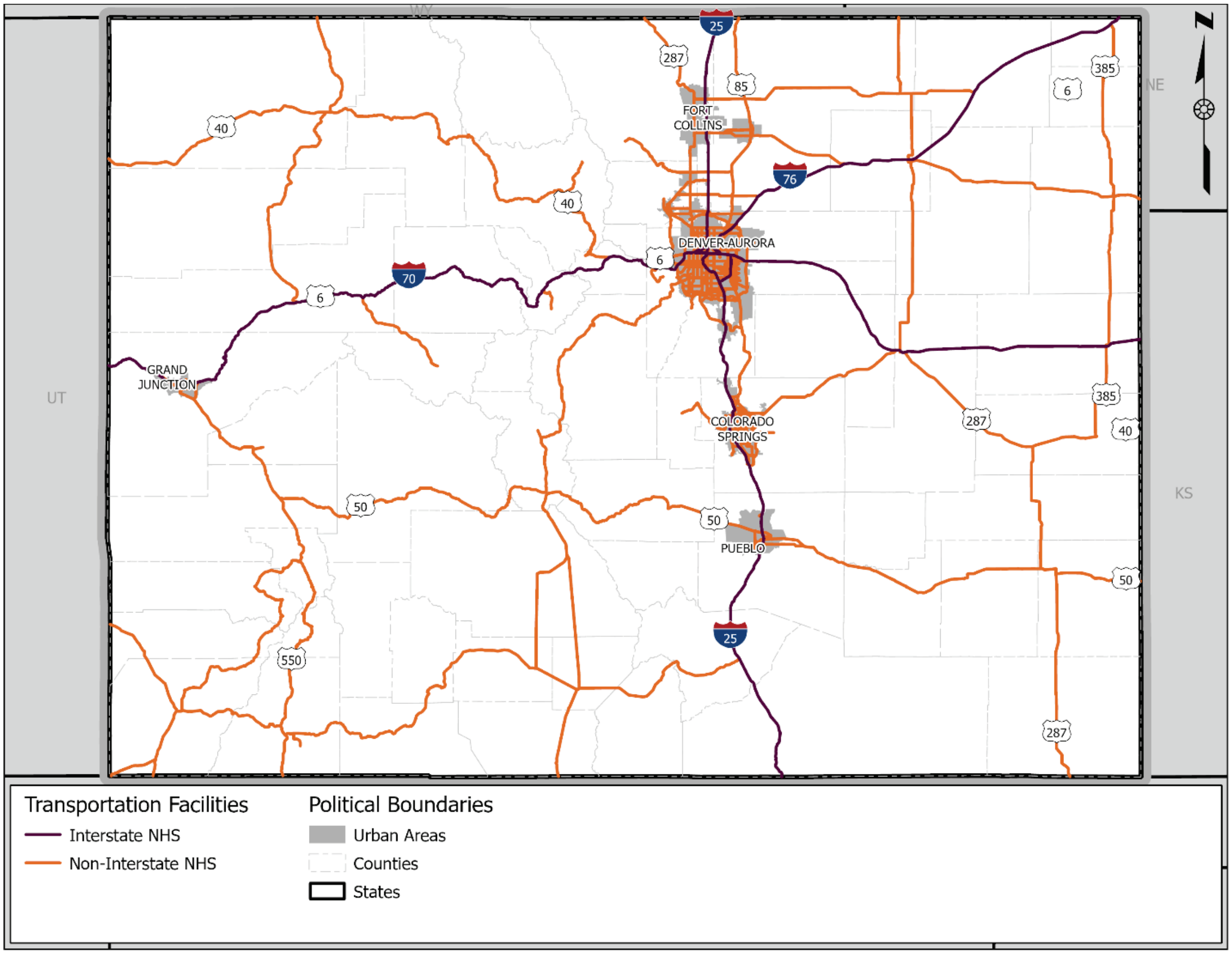


Source: Colorado Department of Transportation, 2022.

4.1.1 National Highway System

The Federal Highway Administration (FHWA) defines the National Highway System (NHS) as "roadways important to the nation's economy, defense, and mobility." The NHS includes interstates, principal arterials, the military's Strategic Highway Network (STRAHNET) and associated connectors, and intermodal connectors. There are 4,413 NHS miles in Colorado, consisting of 3,439 non-interstate mainline miles and 952 interstate mainline miles, with an additional 22 non-interstate intermodal connector miles. Figure 4.6 shows the extent of the NHS across Colorado, and Figure 4.7 breaks down the NHS in the state by type.

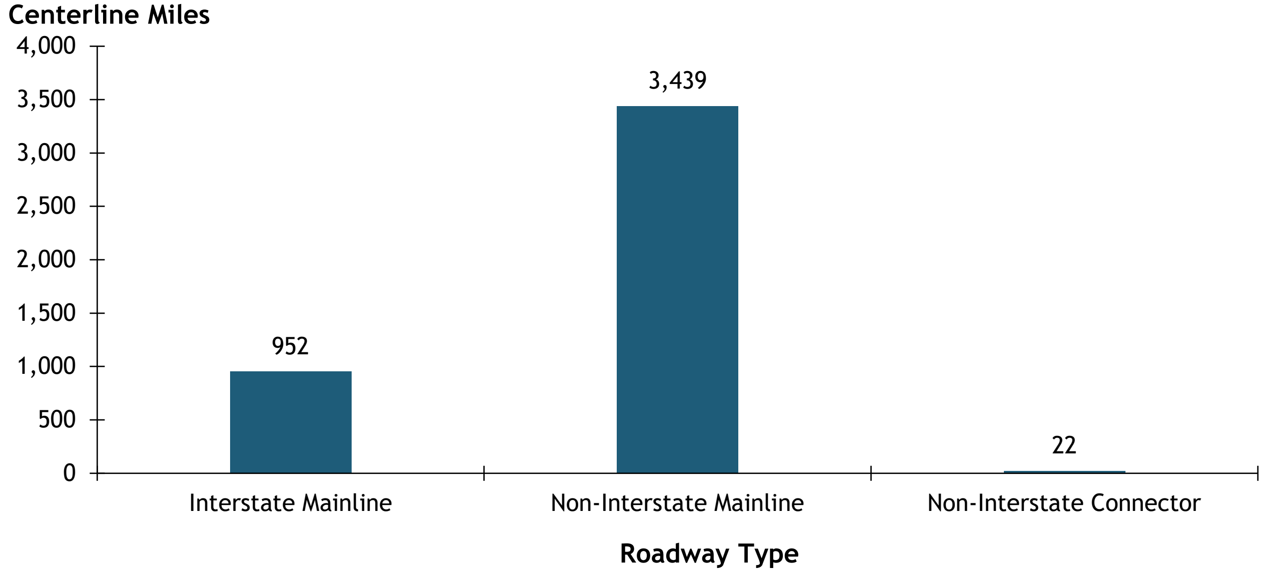
Figure 4.6 Colorado National Highway System (NHS)



Source: USDOT, FHWA, National Highway System.

Intermodal connectors link the NHS with Colorado's major intermodal facilities. There are six of these major intermodal types in the state: Airports, Public Transit Stations, Truck/Rail Facilities, Truck/Pipeline Terminals, Intercity Bus Terminals, and AMTRAK Stations. Additionally, there are 26 unique intermodal facilities within the context of the NHS connectors, of which 14 deal in freight and freight activities. There are more details provided in the intermodal sections of the plan, but the highway component supports the identification of critical facilities dependent on truck movements in the state, and can help prioritize roadway enhancements and rehabilitation.

Figure 4.7 National Highway System Centerline Miles by Type



Source: USDOT, FHWA, National Highway System.

4.1.2 National Highway Freight Network

The National Highway Freight Network (NHFN) is an FHWA designation that replaced the Primary Freight Network and National Freight Network designations to more strategically direct federal resources toward performance improvement on freight intensive highways. This designation is a critical component of allocating federal resources to Colorado's roadways. With the passage of the Infrastructure Investment and Jobs Act (IIJA), $350 billion is allocated towards Federal highway programs. The National Highway Freight Program is specifically allocated $7.15 billion over the next five years, or an average of $1.43 billion per year. Additional freight funding is available through competitive grant programs such as the National Infrastructure Project Assistance Program (MEGA) and Rebuilding American Infrastructure with Sustainability and Equity (RAISE).

The NHFN consists of the Primary Highway Freight System (PHFS), Other Interstates Portions Not on the PHFS (non-PHFS), Critical Urban Freight Corridors (CUFC), and Critical Rural Freight Corridors (CRFC). This section describes these four categories and details their significance to freight movement in Colorado.

PHFS and Non-PHFS Interstate

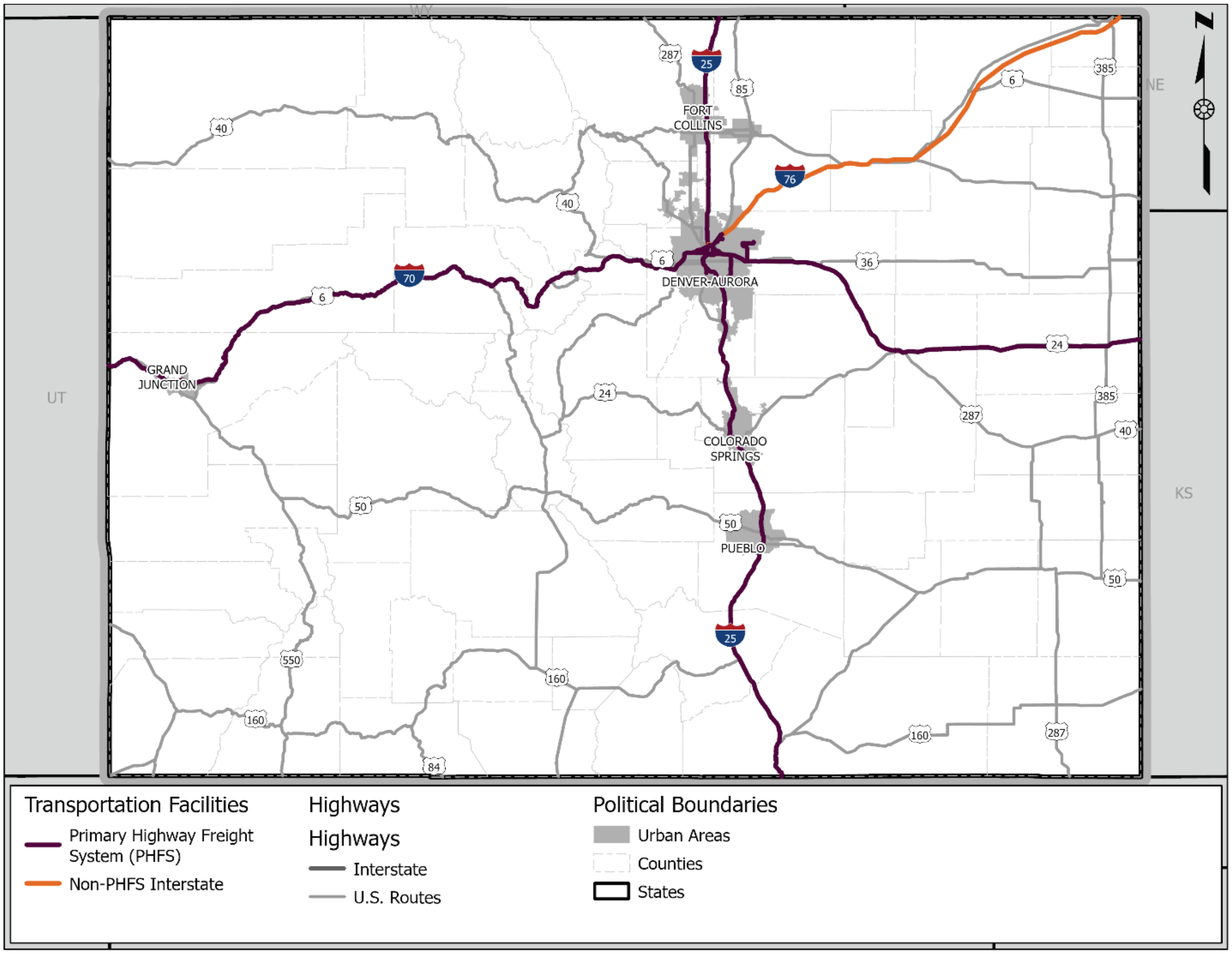
The Primary Highway Freight System (PHFS) is a subset of the NHFN, and represents "the network of highways identified as the most critical highway portions of the U.S. freight transportation system determined by measurable and objective national data."[53] The PHFS network is managed by the Office of Freight Management and Operations and consists of nearly 41,800 centerline miles, 38,000 of which are interstate and the remaining 3,800 miles are part of the non-interstate highway system. The FHWA Administrator is required to re-designate the PHFS every five years to reflect changes in freight flows and

[53] National Highway Freight Network—FHWA Freight Management and Operations (dot.gov).

was last redesignated in 2022. In Colorado, the PHFS is 802 centerline miles in length and consists primarily of interstate miles, but also includes several hundred miles of U.S. routes.

The non-PHFS interstate represents important connectors of the PHFS interstates and the lower functional classification routes. There are 10,265 centerline miles of non-PHFS interstate across the country, 173 miles of which are within Colorado. These miles are exclusively located along I-76, connecting I-25 and I-70 to I-80 in Nebraska. In total, PHFS and non-PHFS interstate mileage represents 975 miles of Colorado roadway. Figure 4.8 shows the extent of the PHFS and non-PHFS interstate miles in Colorado.

Figure 4.8 Colorado PHFS and Non-PHFS Interstate



Source: USDOT, FHWA, National Highway Freight Network.

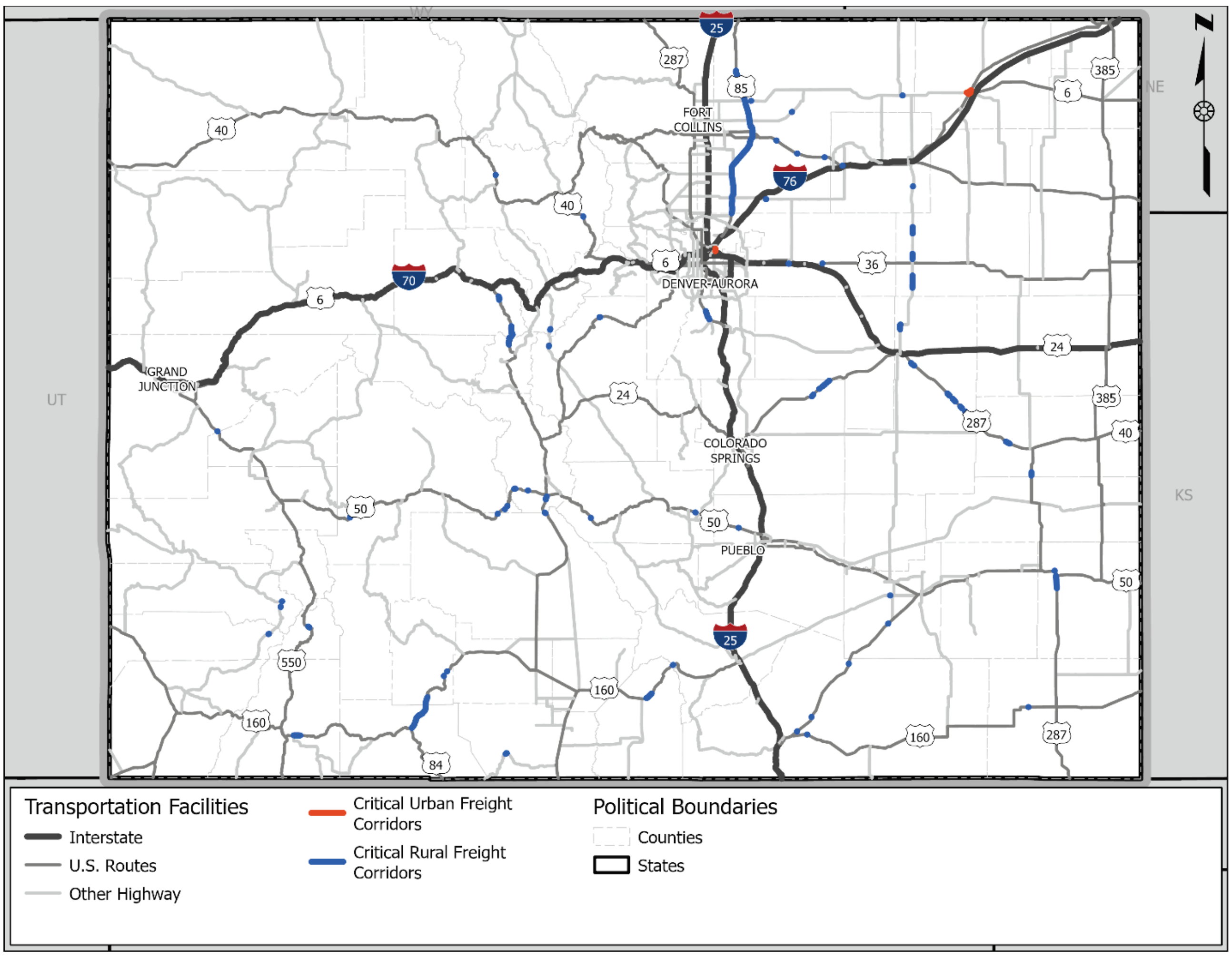
Critical Urban and Critical Rural Freight Corridors (CUFC and CRFCs)

Critical Urban and Critical Rural freight corridors provide essential connectivity to the NHFN. States, and in some cases Metropolitan Planning Organizations (MPO) may strategically direct resources toward system improvements through such designation.

CUFCs are public roads in urbanized areas which provide access and connection to the PHFS and the interstate system with other ports and intermodal facilities. State and MPO designation of CUFCs is limited to the maximum of 150 miles of highway or 10 percent of the PHFS mileage in the state, whichever is greater. There are 2,656 centerline miles designated as CUFCs. As of December 2023, Colorado has 5.02 miles of CUFCs.

CRFCs are public roads not in an urbanized area which provide access and connection to the PHFS and the interstate system with other ports and intermodal facilities. State designation of CRFCs is limited to the maximum of 600 miles of highway or 20 percent of the PHFS mileage in the state, whichever is greater. There are 5,390 centerline miles designated as CRFCs. As of December 2023, Colorado has 127.99 miles of CRFCs. [54] Figure 4.9 shows the designated CUFCs and CRFCs in Colorado.

Figure 4.9 Colorado CUFCs and CRFCs, 2023



Source: CDOT Freight Mobility and Safety Branch.

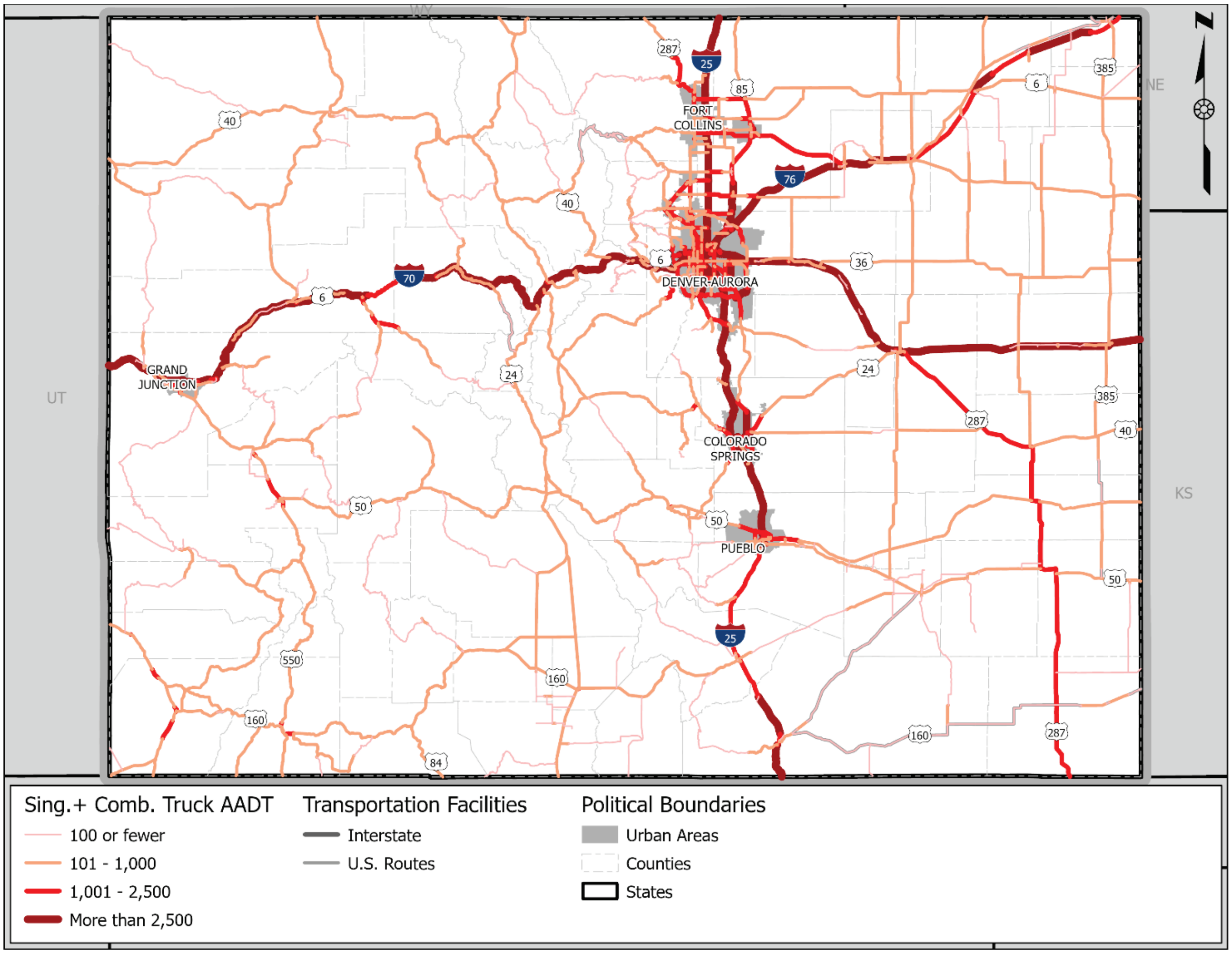
[54] Federal Highway Administration. Freight Management and Operations. *National Highway Freight Network*. https://ops.fhwa.dot.gov/Freight/infrastructure/nfn/index.htm.

4.1.3 Truck Volumes

Truck volumes are a key measure to identify where highway freight is most concentrated, determine which routes play the most critical role in freight movement, and estimate which routes may see increased pressure from trucks throughout the state. Truck percent of traffic is used in conjunction with raw volumes to determine which routes are important for freight industries, and not just a function of high population density. These two metrics together provide a high-level picture of truck demand in the state and identifies the key corridors in the state.

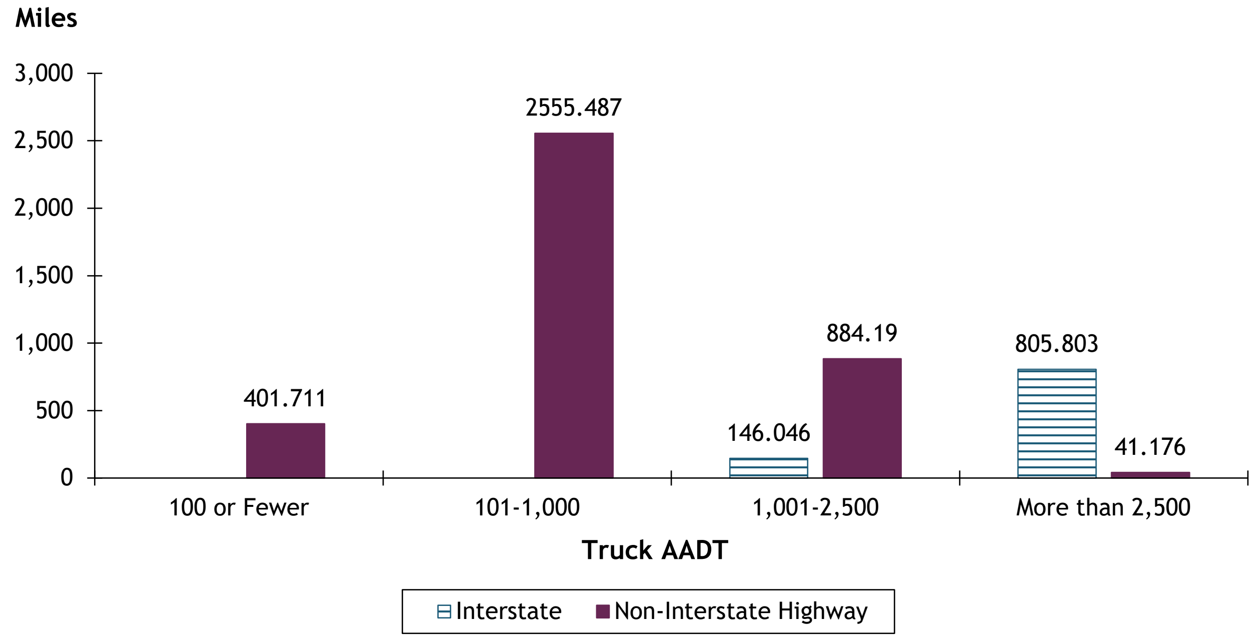
In Colorado, as in all other states, uninterrupted flow facilities see the highest volume of trucks, namely interstates. Interstates 25, 70, and 76 are the key truck routes in the state, supporting the majority of truck movements and serving as the primary routes for through traffic. The state's urban areas constitute the highest volume of truck traffic; specifically around the cities of Denver, Fort Collins, Colorado Springs, and to a lesser extent Pueblo and Grand Junction. Figure 4.10 shows the Annual Average Daily Truck Traffic (AADTT) in Colorado. Notably, there are very few non-interstate routes with an AADTT exceeding 2,500 in 2021. Primarily this includes U.S. 85 and U.S. 36 in Denver along with U.S. 24 and Powers Blvd in Colorado Springs. Significant portions of these routes have high AADTT. Other routes have shorter segments of high AADTT throughout some of the Front Range urban areas. Figure 4.11 shows the distribution of truck traffic across the interstate and non-interstate corridors. Notably, all of Colorado's interstates handle at least 1,000 trucks daily, with the vast majority supporting well over 2,500 trucks daily. Non-interstate routes usually handle between 100 and 1,000 trucks.

Figure 4.10 Annual Average Daily Truck Traffic Volumes, 2021



Source: Traffic Count Records, CDOT, 2021.

Figure 4.11 Truck AADT Mileage by Route Type, 2021

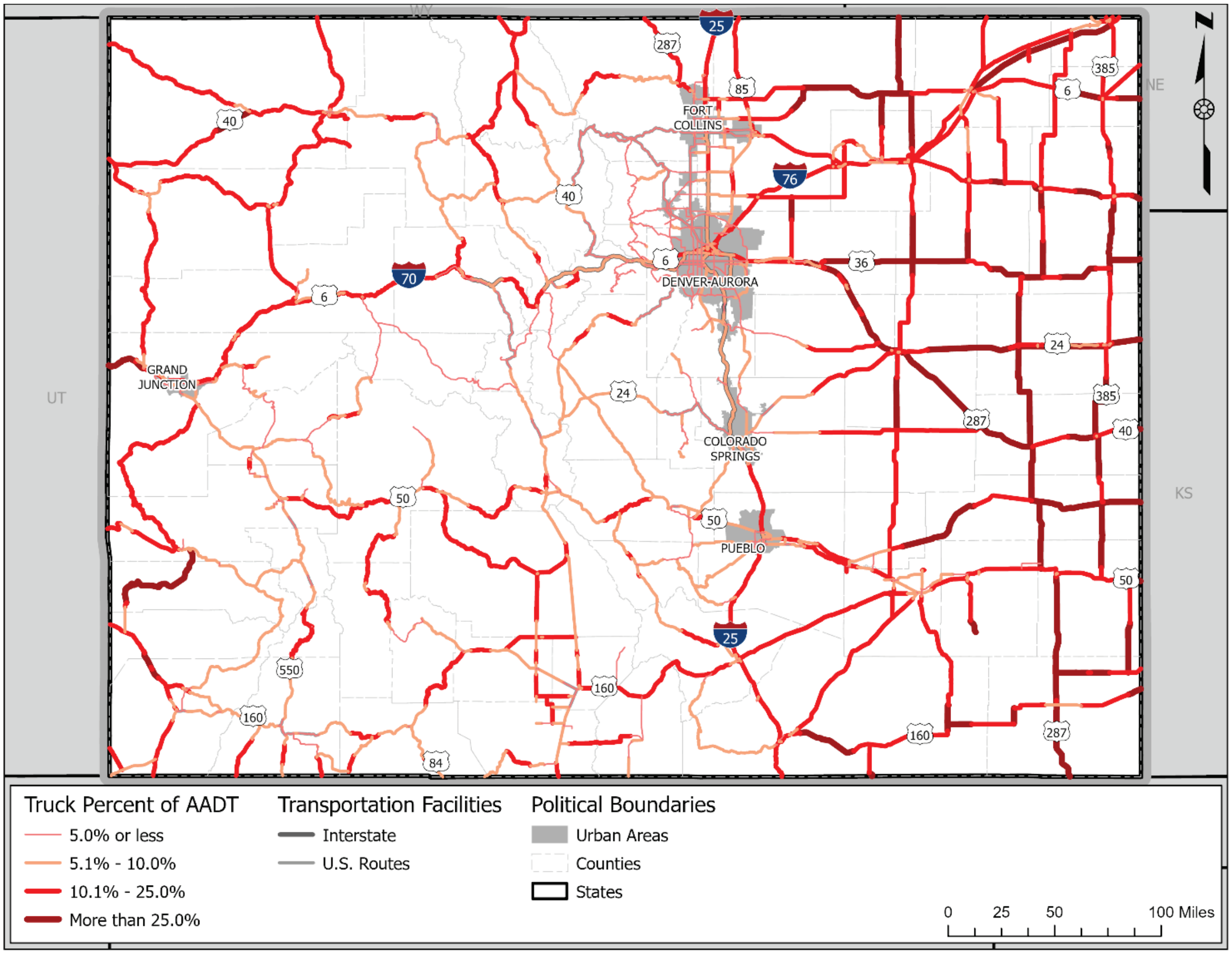


Source: Traffic Count Records, CDOT, 2021.

> **Western Slope:** Those counties west of the continental divide to the Utah border.
>
> **Front Range:** Those counties on the eastern base of Colorado Rockies foothills.
>
> **Eastern Plains:** Those counties east of the Colorado Rockies foothills to the Kansas border.

Truck percent is often shown alongside the raw volume because volume is driven largely by population density, whereas the truck share of traffic is typically dictated by industry needs and the locate of freight facilities. For this reason it is common to see an urban and rural distinction between truck AADT and truck percent. This is also the case in Colorado, where the majority of high truck percent roadways are the US and State routes across the front range. These correlate to large footprint freight industries, like agriculture, or large warehouses/manufacturing facilities. Two major themes appear with the truck percent in Figure 4.12. First, despite the Western Slope being largely rural, the percent of traffic that are trucks is not in excess of 25 percent as it is on the Front Range and Eastern Plains. Second, I-76 and I-70 both have substantial segments where truck traffic exceeds 25 percent of total traffic. These indicate that the west does not have and extensive quantity freight producing facilities, and that a substantial portion of travel in the eastern portion of the state dedicated to the movement of goods rather than passenger traffic.

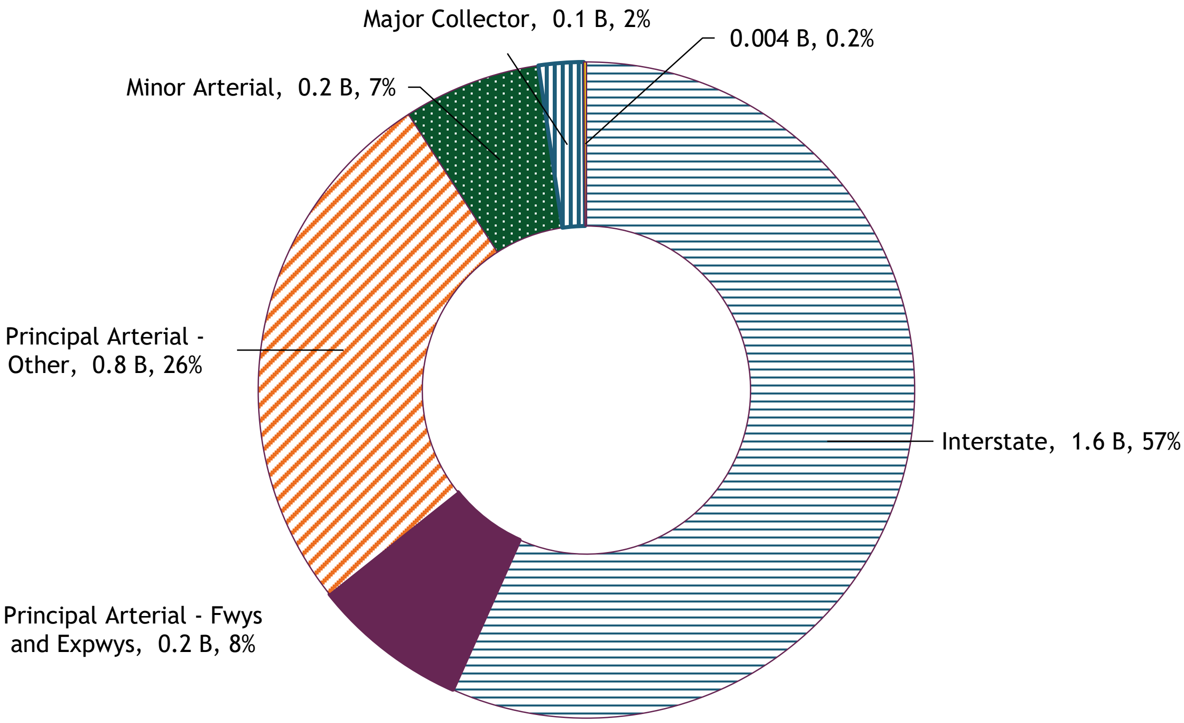
Figure 4.12 Truck Percent of AADT, 2021



Source: Traffic Count Records, CDOT, 2021.

Interstates serve as the backbone of the roadway network, and connect Colorado internally and with other states. There are five major interstate corridors in the state: I-25, I-70, I-76, I-225, and I-270. The 952 miles of interstates carried approximately 1.6 billion truck miles (VMT), accounting for 57 percent of truck VMT in the state in 2021. Following interstates, the other principal arterials carried the second highest VMT, representing 26 percent of all truck VMT on the highway system as shown in Figure 4.13. The concentration of VMT on these highway classes highlights the prioritize the preservation, maintenance, or rehabilitation needs of these classes.

Figure 4.13 Vehicle-Mile-Traveled by Functional Classification, 2021



Source: Traffic Count Records, CDOT, 2021.

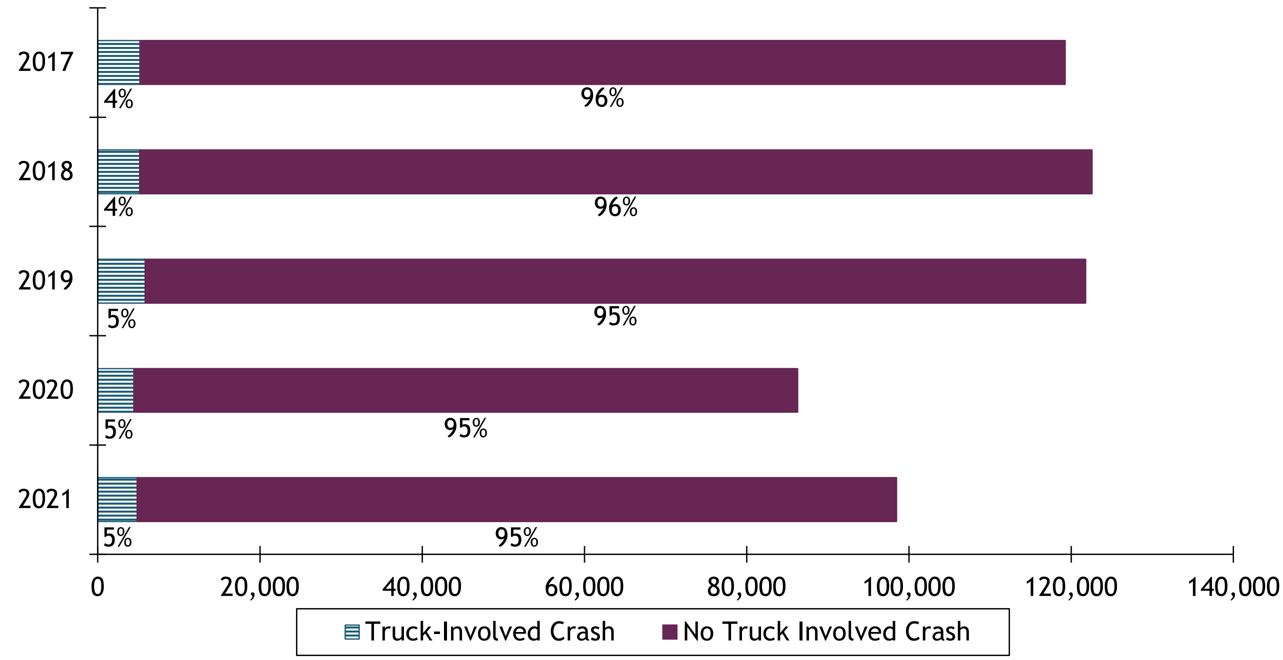
4.2 Truck Safety

Highway safety is of utmost importance to ensure the health and wellbeing of users as well as support the efficient operation of the freight network in the state. During 2017–2021, the number of truck-involved crashes experienced fluctuations, with a significant reduction in 2020 likely due to the pandemic and quarantine measures that reduced the number of cars on the road. During this time, trucks were deemed essential and continued to operate. As restrictions eased, the number of cars on the road increased as did the number of crashes involving cars and trucks. Crash data indicates that the driver of the car may be at fault in approximately 63 percent of crashes involving cars and trucks in Colorado. [55]

In general, 17 percent fewer vehicle crashes happened in 2021 compared to 2017. As Figure 4.14 shows that between 2017 and 2019, the number of crashes steadily increased, with a peak of 122,597 crashes seen in 2018. Pandemic travel restrictions resulted in a sharp decline in crashes in 2020. As restriction began to ease, the number of crashes started to rise again in 2021. In 2017, 4 percent (5,218 crashes) of the total crashes involved trucks, and by 2021, this figure had increased to 5 percent (4,852 crashes) of the total crashes.

[55] Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data. Note: The assumption used in this analysis is that a crash is identified as truck-caused if there is a violation code associated with a truck-type vehicle. In this approach, 66,691 unique crashes were caused by trucks, accounting for approximately 37 percent of all truck-involved crashes.

Figure 4.14 Total Crashes and Truck-Involved Crash in Colorado, 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

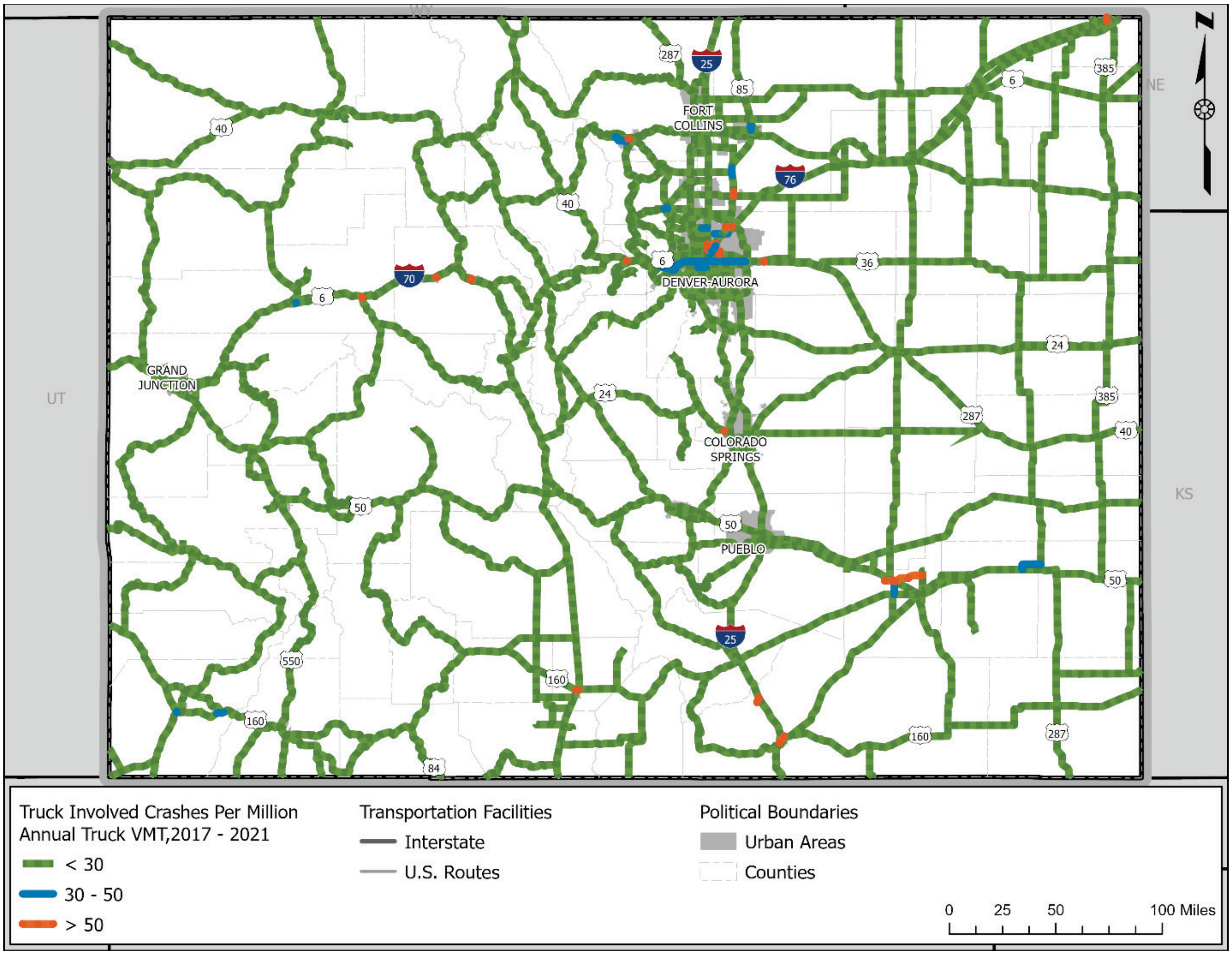
Truck-involved crashes tend to occur more frequently on major highway corridors. As shown in Figure 4.14, approximately 63 percent of truck-involved crashes took place on interstates and state highways. To identify hot spots for truck-involved crashes, a crash density analysis was conducted using the dataset from 2017 to 2021. Figure 4.15 illustrates the results, indicating that the highway segments in Denver-Aurora have higher truck-involved crash concentrations. Figure 4.16 lists the top 10 segments with the highest truck-involved crash rates for both urban and rural locations.

Table 4.1 Truck-Involved Crashes by Road Functional Classification, 2017-2021

Road Type	Truck-involved Crash	Percent
Interstate	7,405	29%
State Highway	8,602	34%
Other Roadways	9,559	37%
Total Crashes	**25,566**	**100%**

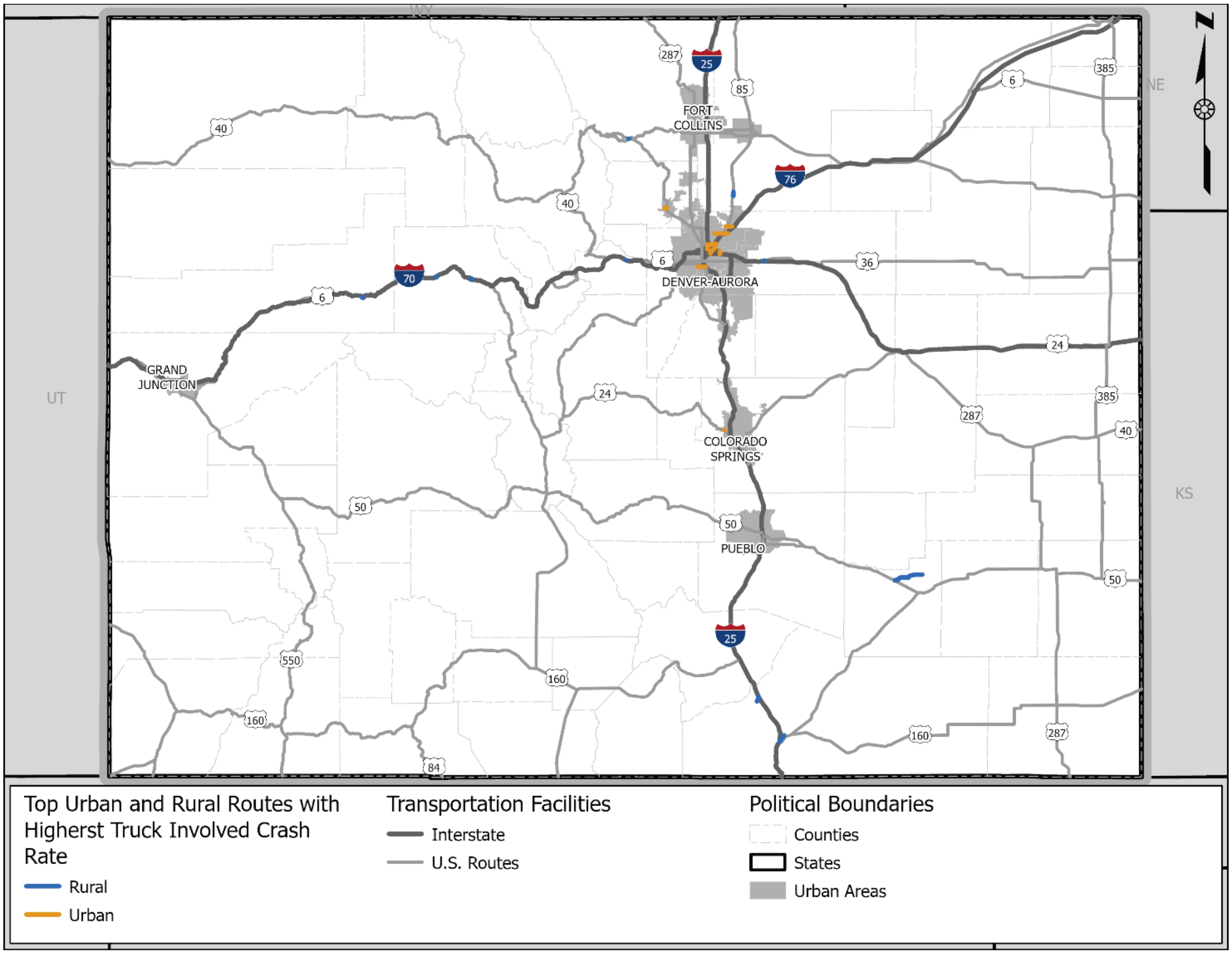
Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Figure 4.15 Truck-Involved Crashes Per Million VMT, 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Figure 4.16 Top 10 Urban and Rural Segments by Highest Truck Involved Crash Rate



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Colorado has a total of 64 counties however approximately 74 percent of all truck-involved crashes occurred in 10 specific counties, as detailed in Table 4.2. Denver, Adams, and Weld counties have the highest frequency of truck-involved crashes. The majority of these top-10 counties are located in the central and northern regions of the state.

Table 4.2 Truck-Involved Crashes by Counties, 2017-2021

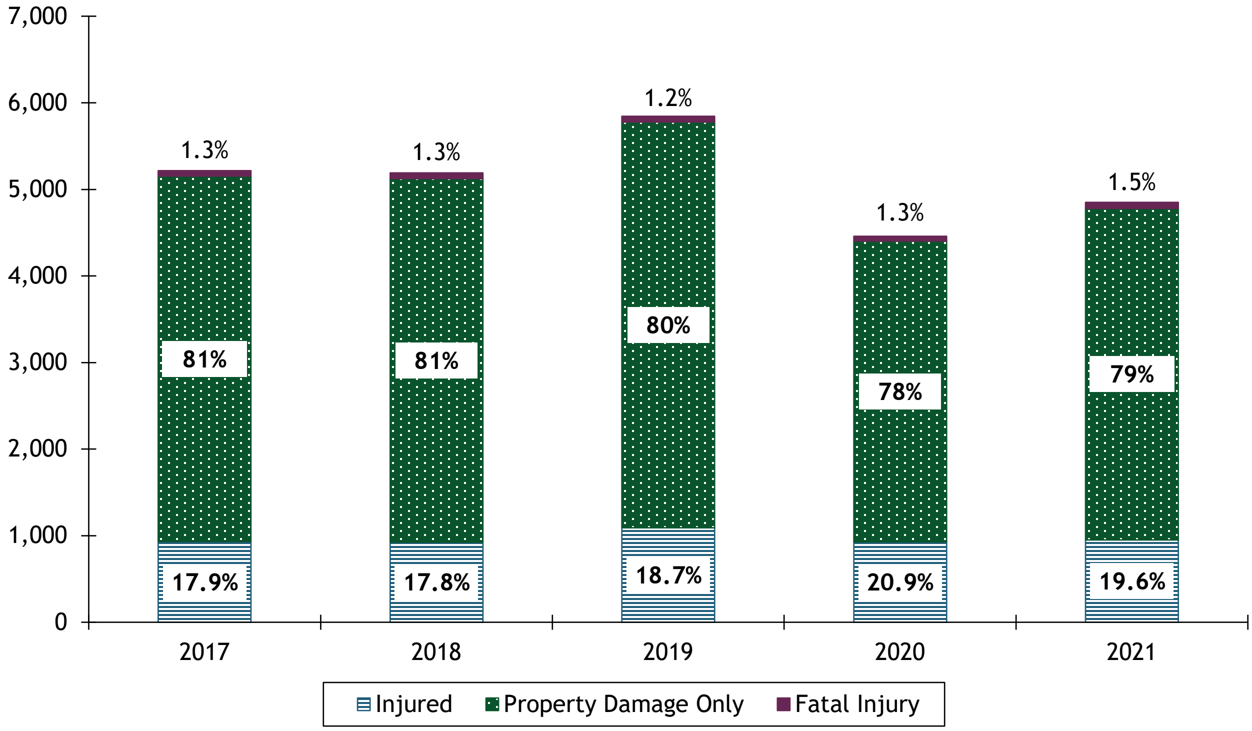
County Name	Truck-involved Crashes	Percent of Total
Denver County	4,483	18%
Adams County	3,159	12%
Weld County	2,226	9%
El Paso County	1,859	7%
Arapahoe County	1,691	7%
Jefferson County	1,536	6%
Larimer County	1,385	5%
Douglas County	1,163	5%
Boulder County	791	3%
Eagle County	632	2%
Other Counties	6,641	26%
Total	**25,566**	**100%**

Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Vehicle crashes often lead to varying degrees of injury and property damage. Figure 4.17 summarizes crash severity for truck-involved crashes. Between 2017 and 2021, over three-quarters of truck-involved crashes did not result in injury or fatality. During this period, 329 truck-involved crashes resulted in fatal injuries, accounting for 1 percent of the total number of truck-involved crashes. Additionally, 4,833 crashes caused injuries, representing 19 percent of truck-involved crashes.

When considering the annual perspective, in 2020, 21 percent of truck-involved crashes resulted in injuries, which is 2 percent higher than the five-year average injury rate and shows a trend of increasing injury rate from 2017–2020, while the rate of fatal injuries remained relatively stable over the years.

Figure 4.17 Truck-Involved Crashes by Injury Severity, 2017–2021

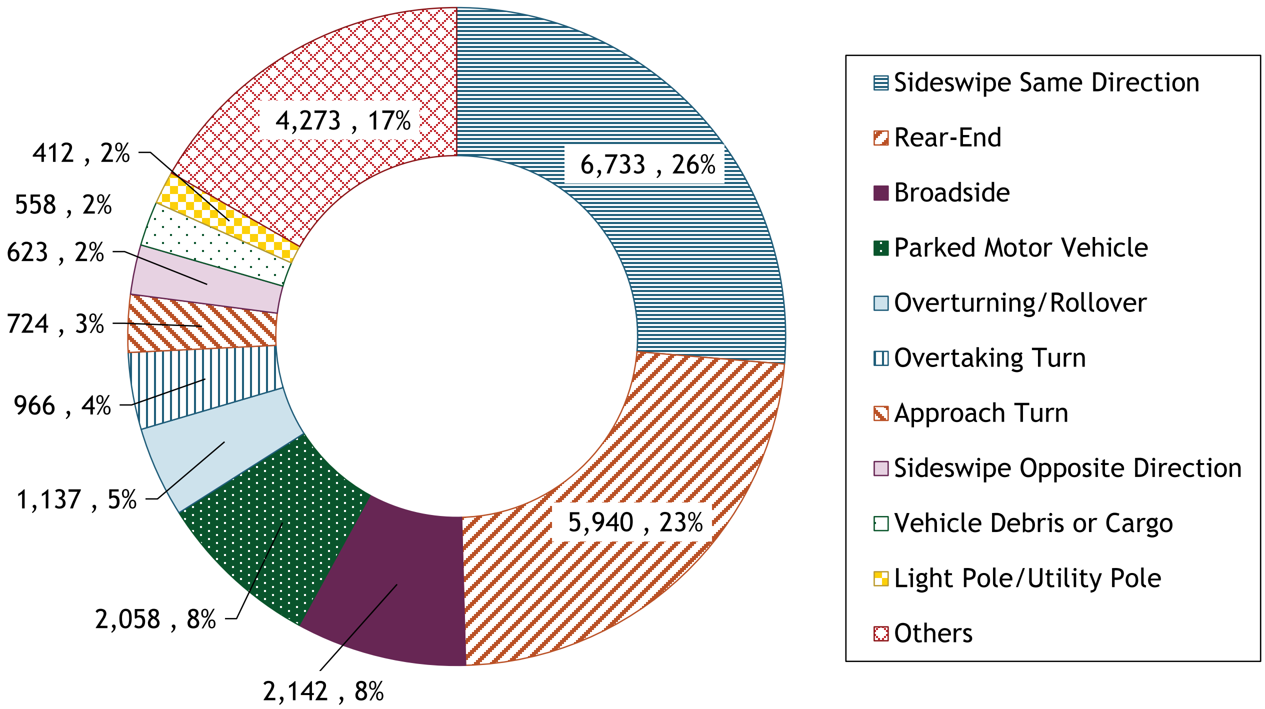


Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Highway safety is crucial for maintaining the efficient and secure operation of the freight system. To gain a deeper understanding of the causes of truck-involved crashes and provide guidance for future highway improvements, an analysis was conducted to address the safety needs of the freight industry. This analysis aimed to identify the underlying causes of truck-involved crashes, including factors such as crash type, road conditions, and time factor. By understanding the causes and patterns of truck-involved crashes, appropriate measures can be implemented to minimize risks, improve safety regulations, and enhance the overall efficiency and security of the freight transportation

In Colorado, as shown in Figure 4.18, sideswipe in the same direction collisions are the most common type of crash. Between 2017 and 2021, this type of crashes accounted for 11 percent of all vehicle crashes statewide. Within the freight system, sideswipe in the same direction were more common, with 6,733 truck-involved crashes during the same period, representing 26 percent of all truck-involved crashes.

Figure 4.18 Truck-Involved Crashes by Major Crash Type, 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Based on data from the Federal Highway Administration (FHWA), human factors are responsible for over 95 percent of all crashes, either entirely or partially. [56] Table 4.3 shows the human factors that contributed to crashes involving trucks in Colorado, but does not distinguish whether they were the fault of the car or truck driver. Inexperienced drivers caused eight percent of crashes. Other prominent causes include driver preoccupied, unfamiliarity with the area, distracted,, and fatigue.

Table 4.3 Human Causes of Truck-involved Crashes, 2017-2021

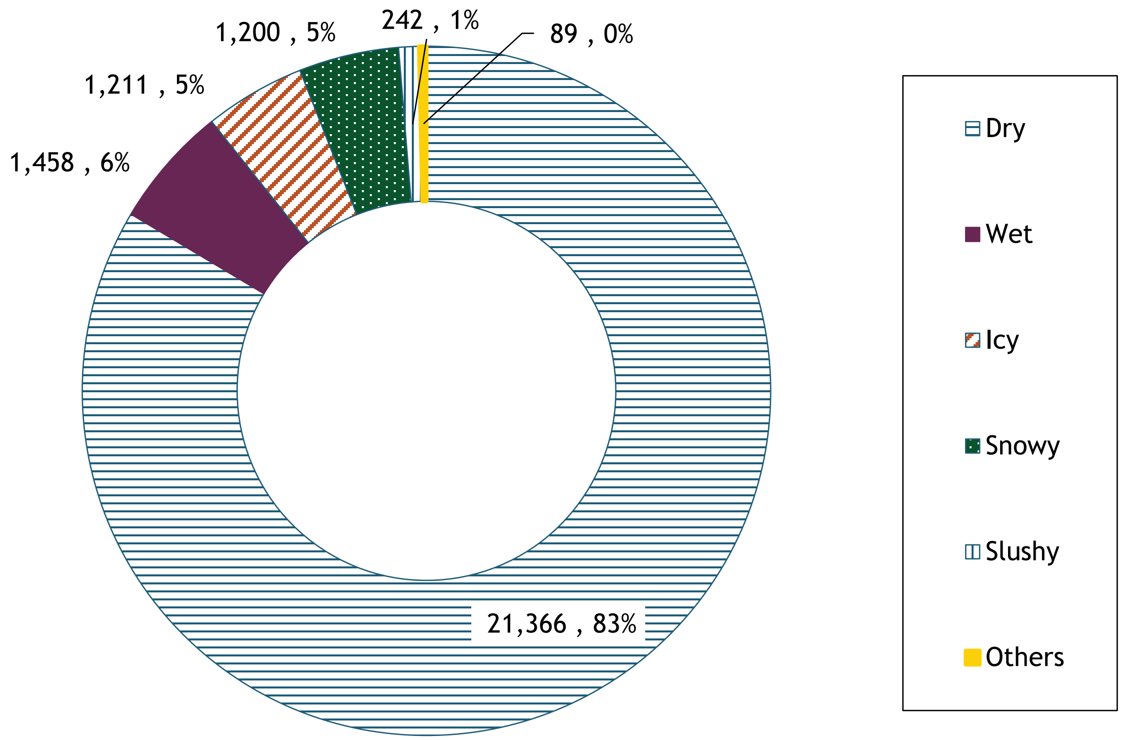
Cause	Count of Crash	Percent
Driver Inexperience	1,949	8%
Driver Preoccupied	1,789	7%
Driver Unfamiliar With Area	1,664	7%
Distracted	521	2%
Asleep or Fatigued	398	2%
Other or Unknown	19,245	75%
Total Crash	**25,566**	**100%**

Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

[56] https://highways.dot.gov/public-roads/januaryfebruary-2017/studying-human-behavior-improve-roadway-safety.

Apart from human factors, environmental factors have a significant impact on road surface conditions, and they can also be responsible for causing crashes. As shown in Figure 4.19, between 2017 and 2021, over 93 percent of truck-involved crashes occurred on dry surfaces, while 6 percent and 5 percent of crashes took place on wet and icy surfaces, respectively. Wet and icy surfaces decrease the friction between tires and the road, potentially resulting in a loss of vehicle control. Similarly, rainy or sunny conditions can lead to obstructed visibility or sun glare, further increasing the likelihood of accidents.

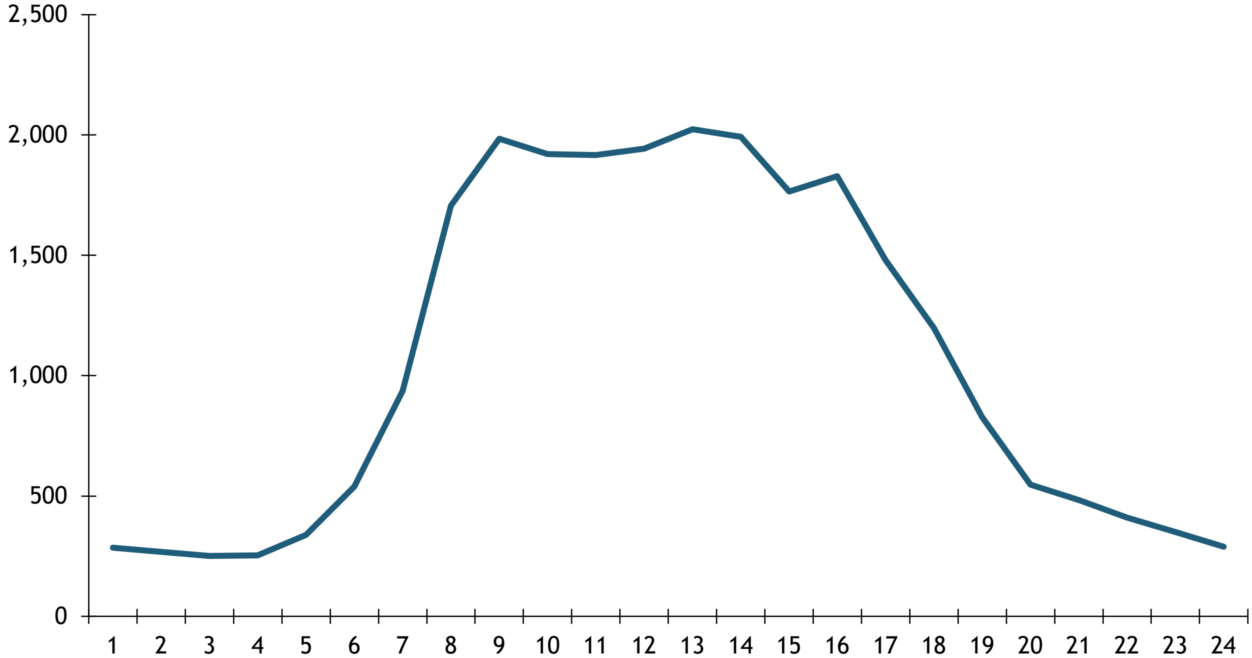
Figure 4.19 Truck Involved Crashes by Major Surface Condition, 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

In terms of time distribution (Figure 4.20), the majority of truck-involved crashes occurred between 8 am and 6 pm, accounting for approximately 77 percent of all truck-involved crashes. The peak period for truck-involved crashes was between 12:00 p.m.–12:59 p.m., during which 7.9 percent of the total crashes took place.

Figure 4.20 Truck-involved Crash by Hour of Day, 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

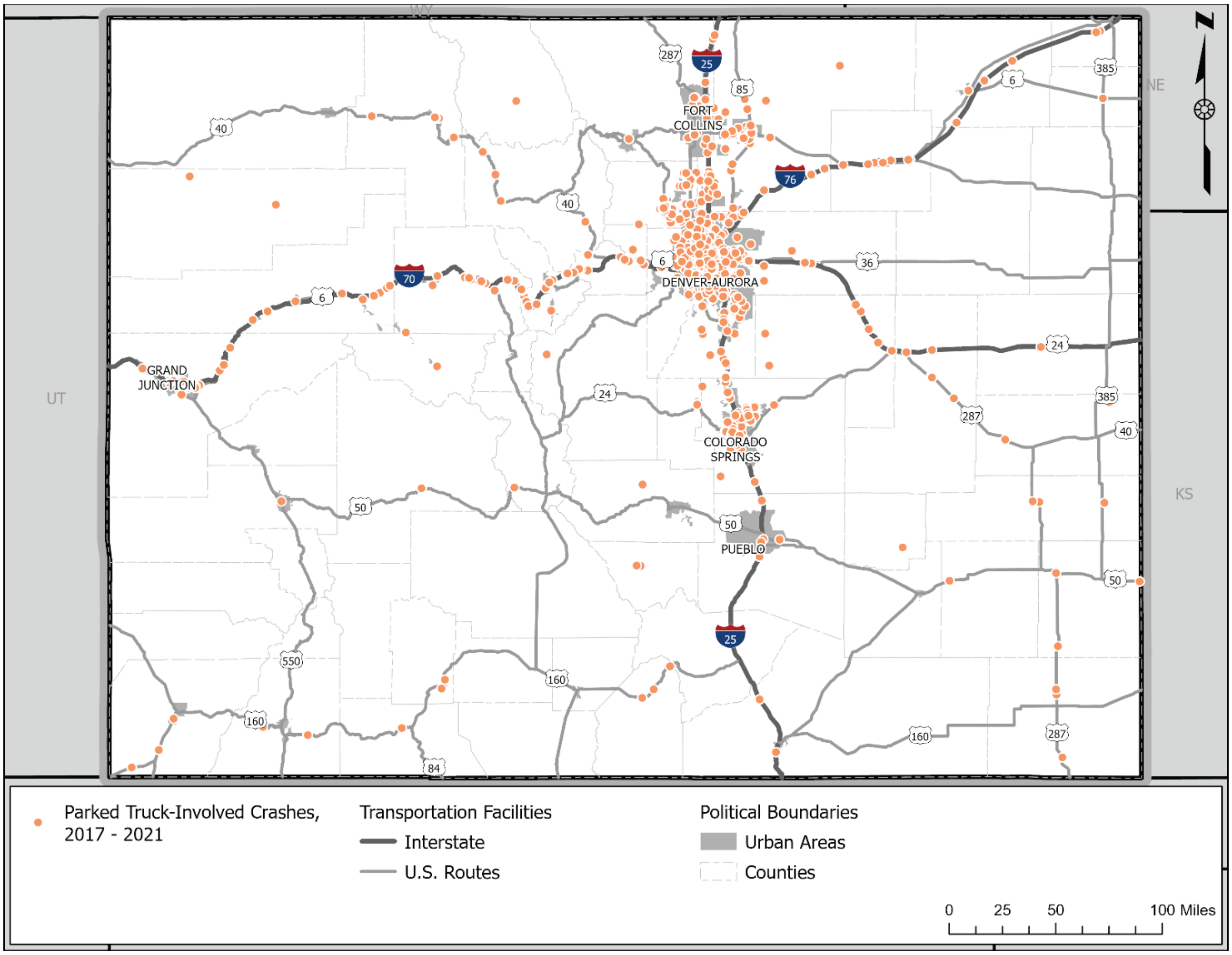
Adequate truck parking is of utmost importance for highway safety. It enables drivers to safely pull away from the road, finding suitable spots to rest or check their vehicles as needed. Table 4.4 shows the trend for parked-truck-related crashes and all truck-involved crashes. From 2017 to 2021, there were 1,143 recorded crashes in Colorado involving parked trucks, constituting approximately 4.5 percent of all truck-related accidents in the state. The proportion of parked truck-involved crashes showed a gradual increase before the pandemic. As shown in Figure 4.21, parked truck involved crashes were more likely in the urbanized regions including the Fort Collins, Denver-Aurora, and Colorado Springs regions. In 2021, the rate of such incidents continued to rise, emphasizing the critical need for sufficient and safe truck parking areas, as well as safety training for drivers to mitigate these collisions.

Table 4.4 Parked Truck Involved Crashes Trend, 2017-2021

Crash Type	2017	2018	2019	2020	2021	Total
Parked Truck-involved Crash	228	245	287	154	229	1,143
All Truck-involved Crash	5,218	5,190	5,846	4,460	4,852	25,566
Percent of parked truck-involved crash	4.4%	4.7%	4.9%	3.5%	4.7%	4.5%

Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Figure 4.21 Parked Truck Involved Crash Distribution, 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

4.3 Highway Freight Infrastructure Needs and Issues

Highway infrastructure play a critical role in enabling the good's movements within, coming to, or leaving the state. The predominant highway infrastructure impacting freight movement includes pavement, bridges, and tunnels. The condition, restriction, and capacity of these infrastructures determine the connectivity and mobility of the highway network. This section discusses the potential importance of each infrastructure and highlights the highway freight infrastructure needs.

4.3.1 Congested Bottlenecks

The main truck bottlenecks in Colorado were identified through an economic analysis of truck Global Positioning System (GPS) data. The analysis used findings from *National Cooperative Highway Research*

Program (NCHRP) Research Report 925 Estimating the Value of Truck Travel Time Reliability to estimate the costs that congestion causes to trucking companies and businesses that use trucking services. [57]

In this analysis, the National Performance Management Research Data Set (NPMRDS) published by the FHWA is used in identifying and quantifying congestion costs. This dataset provides truck-specific travel-time data for each of the roadways segments constituting the National Highway System (NHS) in Colorado, for every 15-minute period throughout the year 2022. This travel-time data is used to calculate two congestion metrics recommended by *NCHRP Research Report 925: Vehicle Hours of Excess Travel (VHET) and Vehicle Hours of Unreliability (VHU)*. The first metric quantified the impact of recurring congestion by comparing the average travel time experienced by trucks on each segment to the free-flow travel time for that segment. The latter metric quantified non-recurring congestion (or unreliability in travel time) by comparing the 95th percentile travel time for each segment to the average travel time for that segment. This latter measure provides an insight into the unplanned congested traffic scenarios experienced by trucks on their trips.

These two measures of congestion were then converted into estimated costs of congestion incurred by trucks as they face recurring and non-recurring congestion using the monetization parameters recommended by *NCHRP 925*. [58] These composite user costs represent real costs borne by trucking companies and businesses across the supply chain due to congestion on Colorado roadways. For example, the top ranked bottleneck in the Denver Metro area, a 5-mile segment near the I-25 and I-70 interchange, costs Colorado industries almost $75 million annually in congestion costs. Absent congestion costs across the state, businesses throughout the supply chain would accrue value associated with improved travel times, more efficient operations, and higher throughput in goods transportation.

This represents an improvement over analyses that only estimate costs to trucking companies and ignore broader supply chain impacts. This approach identifies bottlenecks through a more complete estimation of congestion costs to industries and the broader economy, which is critical for prioritizing and right-sizing solutions.

The remainder of this section summarizes key findings of this analysis. The complete analysis is included in Appendix A: Truck Congestion & Bottlenecks.

Identification and Clustering of Bottlenecks

The thresholds used to identify bottlenecks were set at the top 5 percent of user costs per mile in each bottleneck type (Urban Denver Metro, Urban Other, and Rural). Different thresholds for the user cost metric were used to identify bottlenecks in rural areas versus urban areas. Bottlenecks in urban areas typically have different magnitude and characteristics than bottlenecks in rural areas. If the same threshold was used throughout the state, the highly congested roads in metropolitan areas would dominate the results. Table 3.1 shows these thresholds. Roads were classified as being Urban Other or

[57] Guerrero, S. E., Hirschman, I., Bryan, J., Noland, R., Hsieh, S., Schrank, D., and Guo, S. 2019. *NCHRP Research Report 925: Estimating the Value of Truck Travel Time Reliability*, Transportation Research Board, National Academies of Science, Engineering and Medicine.

[58] Per NCHRP 925, VHET (i.e. recurring congestion) is valued at $66/hr. while VHU (i.e. non-recurring congestion) is valued at $160/hr. These figures were developed through a survey of shippers, 3P operators and other participants across the supply chain.

Rural based on the distinction made in NPMRDS (originally coming from the U.S. Census Bureau). Urban Denver Metro was defined as urban roads in the counties of Denver, Adams, Arapahoe, Douglas, Jefferson, Boulder, Gilpin, Broomfield, Clear Creek, and generally follow the boundaries governed by the Denver Regional Council of Governments (DRCOG).

Table 4.5 Truck Bottleneck Thresholds and Totals

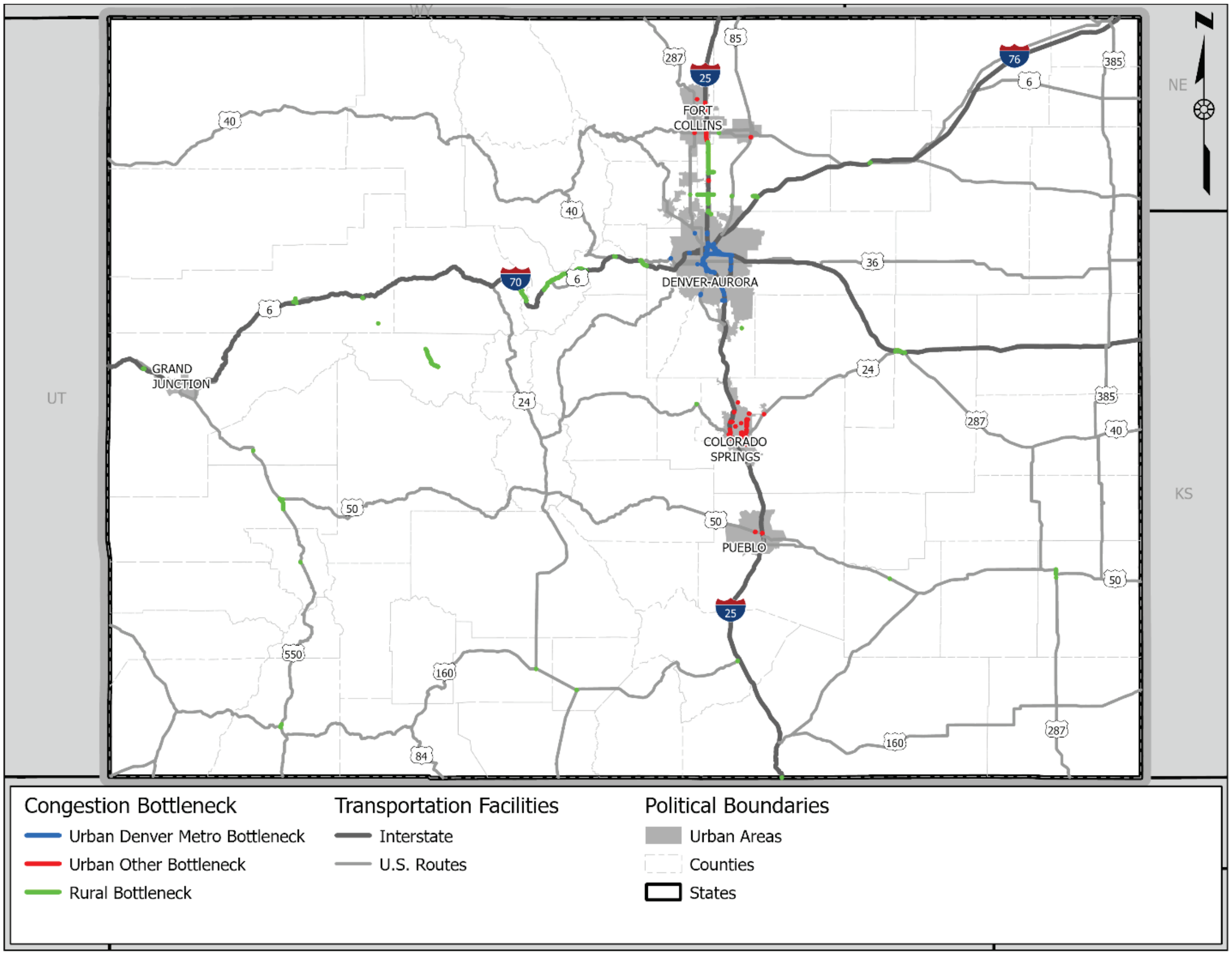
Bottleneck Type	User Cost Threshold ($/mile-day)	Bottleneck Centerline Roadway Miles	Number of Bottleneck Segments (TMCs)
Urban Denver Metro	23,318	50	155
Urban Other	11,487	21	69
Rural	5,531	99	91
	Total	**170**	**315**

Source: WSP analysis of NPMRDS data.

Bottlenecks that were judged to be caused by roadway construction work zones were excluded from further consideration. Work zones cause significant slowdowns to traffic; however, they represent temporary restrictions that will be resolved once construction activities end. Therefore, these do not represent bottlenecks that need addressing.

There were 155 roadway segments in Urban Denver Metro with user costs higher than the threshold (in NPMRDS each segment is defined by a unique Traffic Message Channel [TMC]), totaling 50 centerline miles of roadway. In Urban Other, 69 roadway segments were above the threshold, combining for 21 centerline miles of roadway; in Rural, 91 roadway segments were above the threshold, combining for 99 miles of roadway. In total, roughly 42 percent of the bottleneck distance was identified in urban areas and sixty percent in rural areas. Figure 4.22 displays a map of the bottlenecks, showing thorough coverage throughout Colorado, but concentrated in urban regions across the state (as highlighted in Figure 4.25 through Figure 4.27).

Figure 4.22 Truck Bottleneck Locations—Statewide



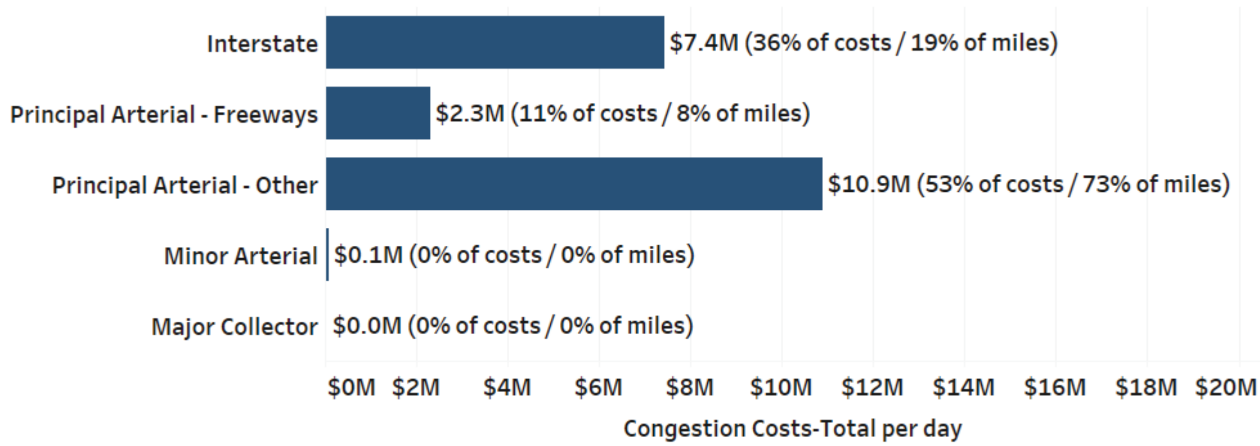
Source: WSP analysis of NPMRDS data.

A manual process was conducted to combine consecutive bottlenecks into bottleneck clusters. Especially in urban areas, where the network is segmented more finely, numerous consecutive segments were designated as bottlenecks. For simplicity, and ease of interpreting the results, consecutive and near consecutive segments were combined into bottleneck clusters. In some cases, nearby roads that are not consecutive were combined into the same cluster if the underlying cause of the bottleneck was judged to be the same. This resulted in 64 Rural bottleneck clusters, 48 Urban Denver Metro bottlenecks, and 45 Urban Other bottlenecks.

Costs and Impacts of Congestion

On a typical weekday, congestion is estimated to cause $20.7 million in costs to trucking companies and shippers (throughout the NHS in Colorado). Interstates contribute almost 36 percent of all congestion costs, even though they account for approximately 19 percent of NHS mileage. Other freeways and principal arterials (excluding interstates) account for 81 percent of total mileage and 64 percent of the total congestion costs, see Figure 4.23. Congestion accruing on minor arterials and major collectors account for insignificantly small congestion costs to freight.

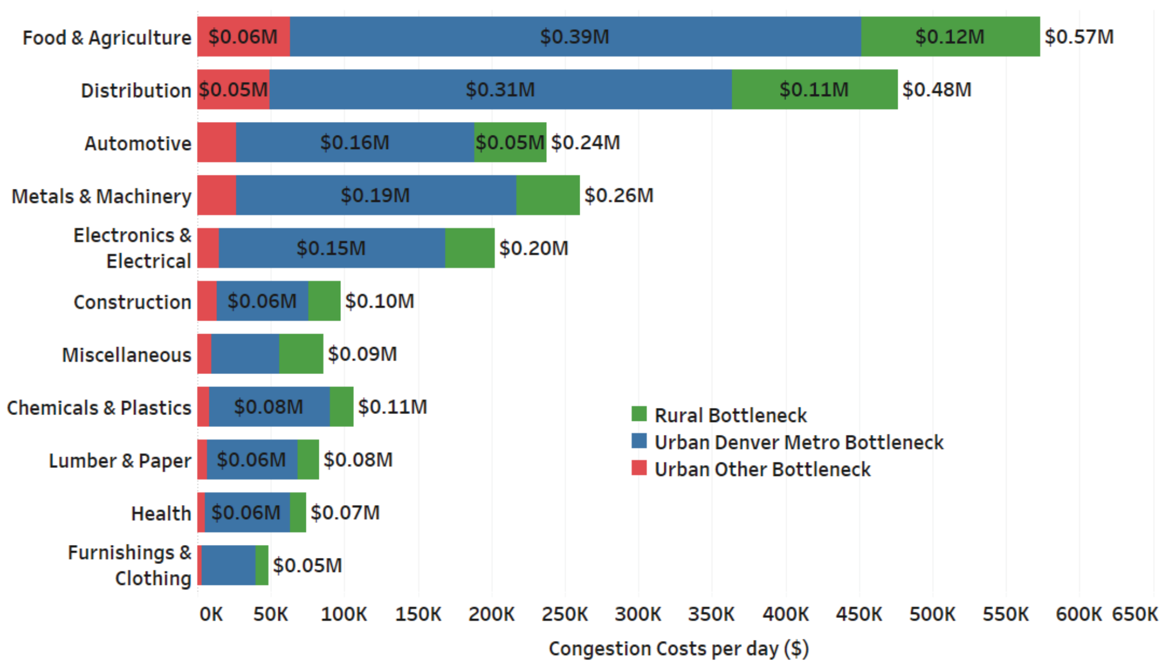
Figure 4.23 Congestion Costs per day ($) by Roadway Functional Class



Source: WSP analysis of NPMRDS data.

Of the $20.7 million in daily statewide congestion costs referenced above, about $3.7 million (or 18 percent) occur at specific bottlenecks identified in this analysis. Using commodity flow data from Transearch that detailed the distribution of truck traffic serving each supply chain at each roadway segment in the state, these daily congestion costs were further broken out by the supply chains impacted by congestion. Looking at the impact of congestion at these bottleneck hotspots only (Figure 4.24**)**, the food and agriculture industry is most impacted (congestion costs of over $570k per day), followed by distribution, automotive, metals and machinery, and electronics and electrical goods. Bottlenecks in the Denver Metro region account for over two-thirds of statewide bottleneck costs accrued by each of the supply chains analyzed.

Figure 4.24 Bottleneck Congestion Costs per day ($) by Supply Chain Groups



Source: WSP analysis of NPMRDS and Transearch data.

Top Bottlenecks

This section describes the top 20 bottleneck clusters in Colorado for each of the bottleneck types (Urban Denver Metro, Urban Other, Rural) and the estimated costs they generate.

Urban Denver Metro Region

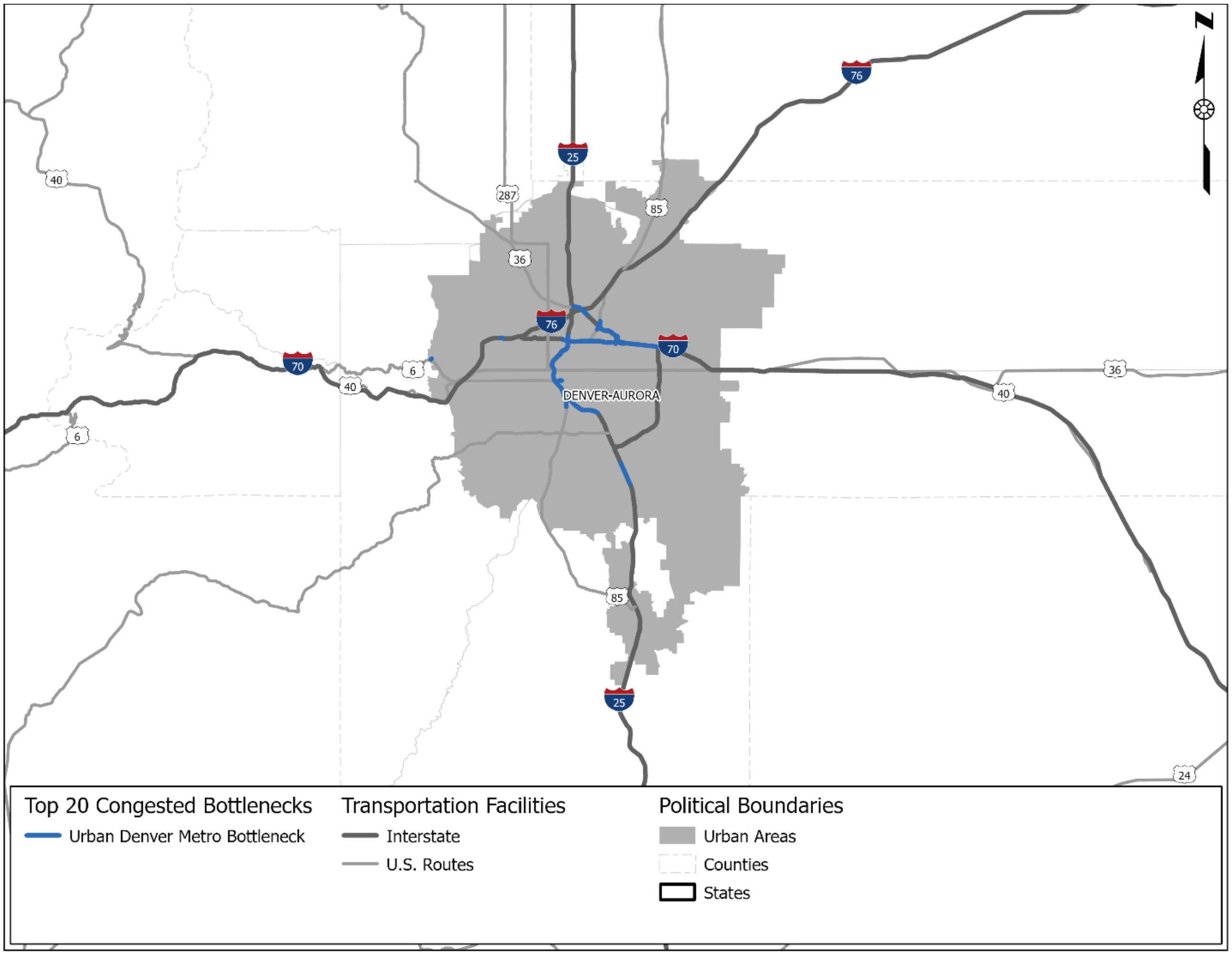
The top 20 bottleneck clusters in the Denver Metro region are listed in Table 4.6 and mapped in Figure 4.25. In total, these bottlenecks represent 42 centerline miles of roadway that generate $1.83 million of congestion costs to trucks and supply chains each day. As indicated by the northbound and eastbound notations in the bottleneck names, the mileage and user costs listed in this table are for specific direction of travel.

Table 4.6 Top 20 Bottlenecks in Urban Denver Metro Region

Rank	ID	Bottleneck Name	Total Miles	Average Daily Truck Volume	Congestion Costs ($/day)
1	108	SB I-25 from I-70 Exit 214 to W 23rd Ave	5.19	7,256	$247,396
2	68	NB I-25 from S Downing St to 15th St	5.79	6,786	$227,321
3	152	WB I-270 from Central Park Blvd to U.S. 85	3.12	5,189	$175,273
4	26	EB I-70 FR from Brighton Blvd to CO-2	2.16	7,225	$151,609
5	158	WB I-70 from Quebec St to Filmore St	2.80	4,650	$140,858
6	24	EB I-25 from S Santa Fe Dr to Evans Ave/Exit 203	3.49	5,924	$118,765
7	30	EB I-70 from I-270 to I-225	4.05	6,996	$114,048
8	29	EB I-70 from I-25/Exit 274 to 1175 Ft east of Brighton Blvd	1.92	6,490	$111,408
9	37	EB I-76 from Washington St to York St/I-76 on ramp	1.57	5,235	$110,803
10	70	NB I-25 from W Florida Ave to W Alameda Ave	1.56	3,415	$62,372
11	61	NB I-25 FR from Park Ave W/Exit 213 to I-70	1.36	11,566	$61,634
12	67	NB I-25 from on ramp at E Dry Creek Rd to on ramp at E Orchard Rd	2.14	6,898	$56,133
13	74	NB I-76 FR from 64th Ave to I-270	1.41	4,663	$43,607
14	93	SB CO-35 from E 49th Ave to I-70	0.89	1,961	$41,041
15	23	EB I-25 FR from Exit 205/S Downing St to on ramp at S University Blvd	0.56	5,924	$35,187
16	64	NB I-25 from CO-224/Exit217A to I-25 NB on ramp	1.01	9,472	$30,155
17	81	NB U.S. 85 from E 56th Ave to E 62nd Ave	0.77	2,480	$28,305
18	138	WB CO-36 from I-25 NBFR to Ridgegate Pkwy	0.98	1,299	$25,752
19	105	SB I-25 from E 55th Ave to E 52nd Ave	0.88	8,007	$24,613
20	36	EB I-76 from E 64th Ave to Washington St	0.95	4,674	$23,967
		Totals:	**42.60**	-	**$1,830,247**

Source: WSP analysis of NPMRDS data.

Figure 4.25 Top 20 Bottlenecks in Urban Denver Metro Region



Source: WSP analysis of NPMRDS data.

Urban Other

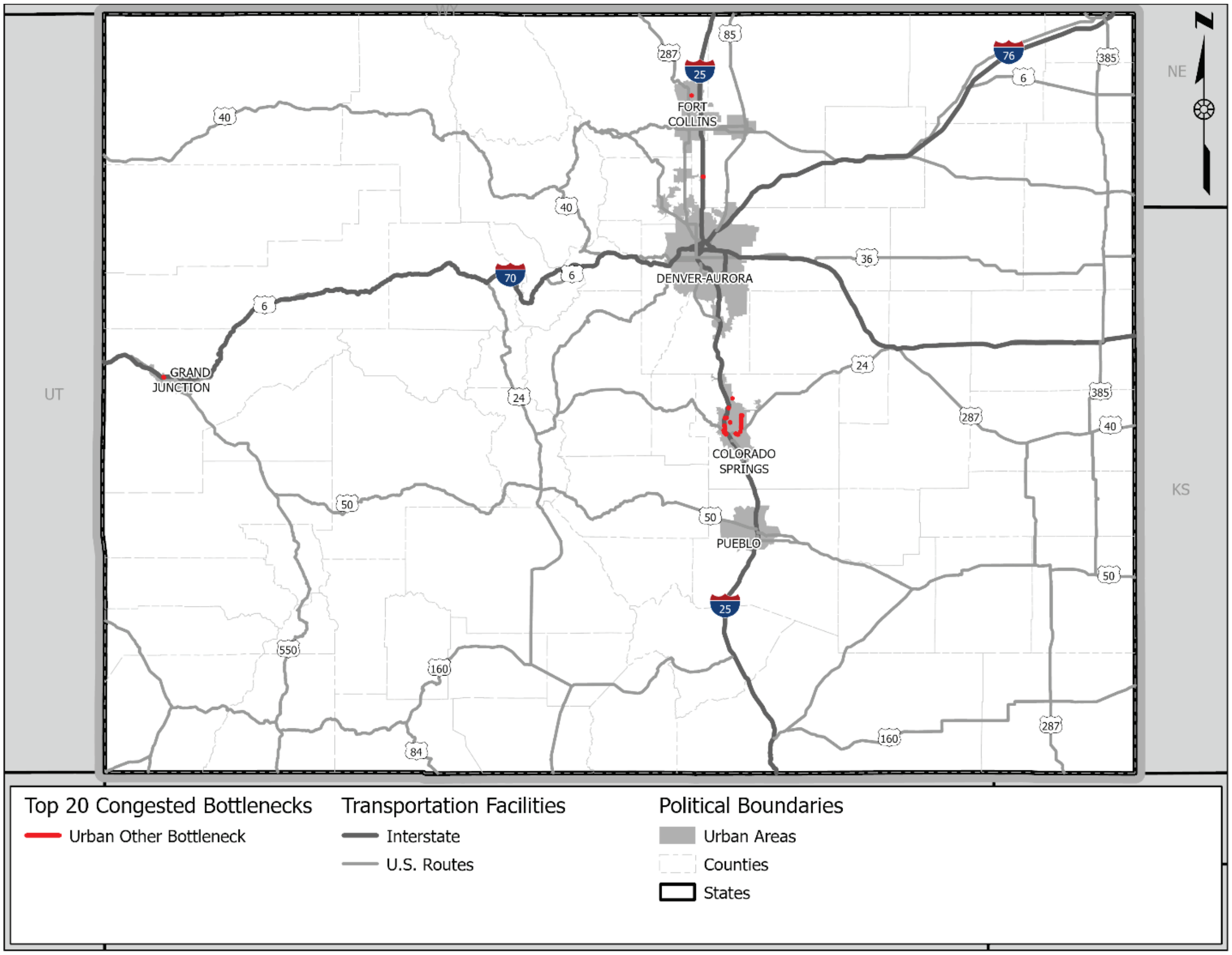
The top 20 bottleneck clusters in the other urban regions of the state are listed in Table 4.7 and mapped in Figure 4.26. In total, these bottlenecks constitute 18.5 centerline miles of roadway in the urban regions around the state (excluding Denver Metro), generating $287 thousand of user costs to trucks each day.

Table 4.7 Top 20 Urban Other Bottlenecks

Rank	ID	Bottleneck Name	Total Miles	Average Daily Truck Volume	Congestion Costs ($/day)
1	69	NB I-25 from S Tejon St to W Fontanero St/Exit 144	3.35	4,484	$57,253
2	48	NB CO-21 from Constitution Ave to Stetson Hills Blvd	2.78	1,745	$49,951
3	109	SB I-25 from U.S. 34 to CO-66	2.48	3,827	$35,580
4	103	SB I-25 from CO-34 to Harmony Rd	2.61	3,071	$32,862
5	49	NB CO-21 from U.S. 24 to Palmer Park Blvd	1.07	1,640	$14,517
6	163	WB Jet Wing Dr to CO-83	0.97	1,250	$13,267
7	149	WB E Garden of the Gods Rd from U.S. 85 to I-25	0.71	680	$11,759
8	54	NB CO-83 from U.S. 24 to Airport Rd	0.81	917	$9,760
9	18	EB E Garden of the Gods Rd from I-25 to U.S. 85	0.69	681	$9,656
10	2	EB CO-24 from W I-25 FR to E I-25 FR	0.23	965	$8,298
11	164	WB Stetson Hills Pkwy from Charlotte Pkwy to CO-21	0.50	814	$7,827
12	136	WB CO-24 from E I-25 FR to W I-25 FR	0.24	963	$7,104
13	127	SB U.S. 85 from I-25 EBFR to E Ramona Ave	0.40	609	$5,158
14	38	EB Stetson Hills Pkwy from CO-21 to Charlotte Pkwy	0.43	860	$5,019
15	77	NB U.S. 50 at IH-70	0.21	668	$3,829
16	84	NB W Cimarron St at I-25	0.30	676	$3,792
17	121	SB U.S. 50 at IH-70	0.24	691	$3,517
18	21	EB E Woodmen Rd from 2025 ft east of Tuft Blvd to Black Forest Rd	0.15	755	$2,727
19	3	EB CO-47 from N Elizabeth St to Pueblo Mall Blvd	0.16	769	$2,710
20	98	SB E Union Blvd at E Fillmore St	0.12	937	$2,702
		Totals:	**18.5**	-	**$287,288**

Source: WSP analysis of NPMRDS data.

Figure 4.26 Top 20 Urban Other Bottleneck Clusters



Source: WSP analysis of NPMRDS data.

The supply chains most impacted by these top 20 other urban bottlenecks include food and agriculture, construction, and distribution. Through trucks and empty units contribute significantly to congestion at these bottlenecks, with share of total congestion costs ranging from 22 percent to 88 percent.

Rural

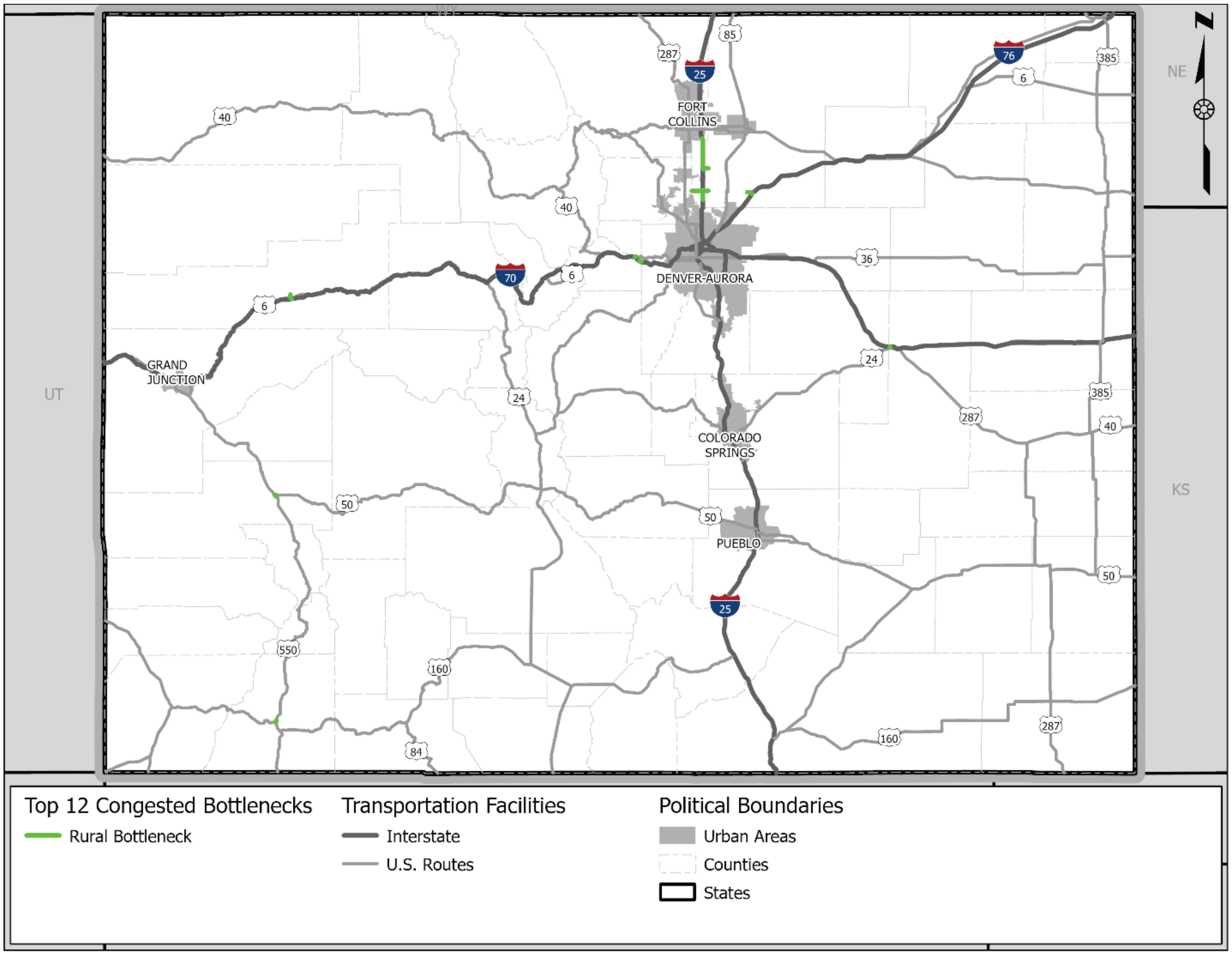
The top 20 bottleneck clusters in the rural regions in the state are listed in Table 4.8 and mapped in Figure 4.27. In total, these bottlenecks constitute 87.3 centerline miles of roadway in rural regions around the state, generating $593 thousand of user costs to trucks each day.

Table 4.8 Top 20 Rural Bottlenecks

Rank	ID	Bottleneck Name	Total Miles	Average Daily Truck Volume	Congestion Costs ($/day)
1	65	NB I-25 from CO-66 to U.S. 34	10.78	3,675	$81,461
2	32	EB I-70 from U.S. 6 to Eisenhower Memorial Tunnel	7.87	1,505	$66,916
3	111	SB I-70 from Pitkin Creek to Shrine Pass Rd	10.02	1,400	$55,792
4	95	SB CO-82 from Lake Wildcat to Cooper	8.79	369	$53,672
5	161	WB I-70 from U.S. 6 to Straight Creek	7.88	1,539	$48,761
6	109	SB I-25 from U.S. 34 to CO-66	6.66	3,715	$42,904
7	140	WB CO-52 from Colorado Blvd to County Line	5.99	451	$36,042
8	104	SB I-25 from CO-52 to CO-8	3.54	4,420	$25,502
9	34	EB I-70 from U.S. 6/Exit 216 to Stevens Gulch Rd/Exit 221	3.61	1,459	$24,116
10	73	NB I-70 from Homestead Rd to	2.02	1,502	$22,220
11	143	WB CO-66 from I-25 to CO-13	2.11	659	$21,741
12	72	NB I-70 from CO-9 to U.S. 6	2.99	1,958	$17,722
13	162	WB I-70 from U.S. 6/Exit 216 to Stevens Gulch Rd/Exit 221	2.58	1,502	$16,424
14	78	NB U.S. 550 from Chipeta Rd to E Niagara Rd	2.25	503	$13,400
15	5	EB CO-52 from CO-41 to I-76 NBFR	1.88	620	$13,191
16	88	SB CO-13 from 20th St to IH-70	1.81	441	$11,655
17	76	NB U.S. 287 from U.S. 50 to CO-196	1.76	907	$10,967
18	120	SB U.S. 287 from U.S. 50 to CO-196	1.85	860	$10,695
19	160	WB I-70 from U.S. 287 to Williams Ave	1.80	1,375	$10,246
20	154	WB I-70 from Eisenhower Johnson Tunnel East to Loveland Valley Lodge	1.11	1,502	$9,816
		Totals:	**87.3**	**-**	**$593,243**

Source: WSP analysis of NPMRDS data.

Figure 4.27 Top 20 Rural Bottlenecks



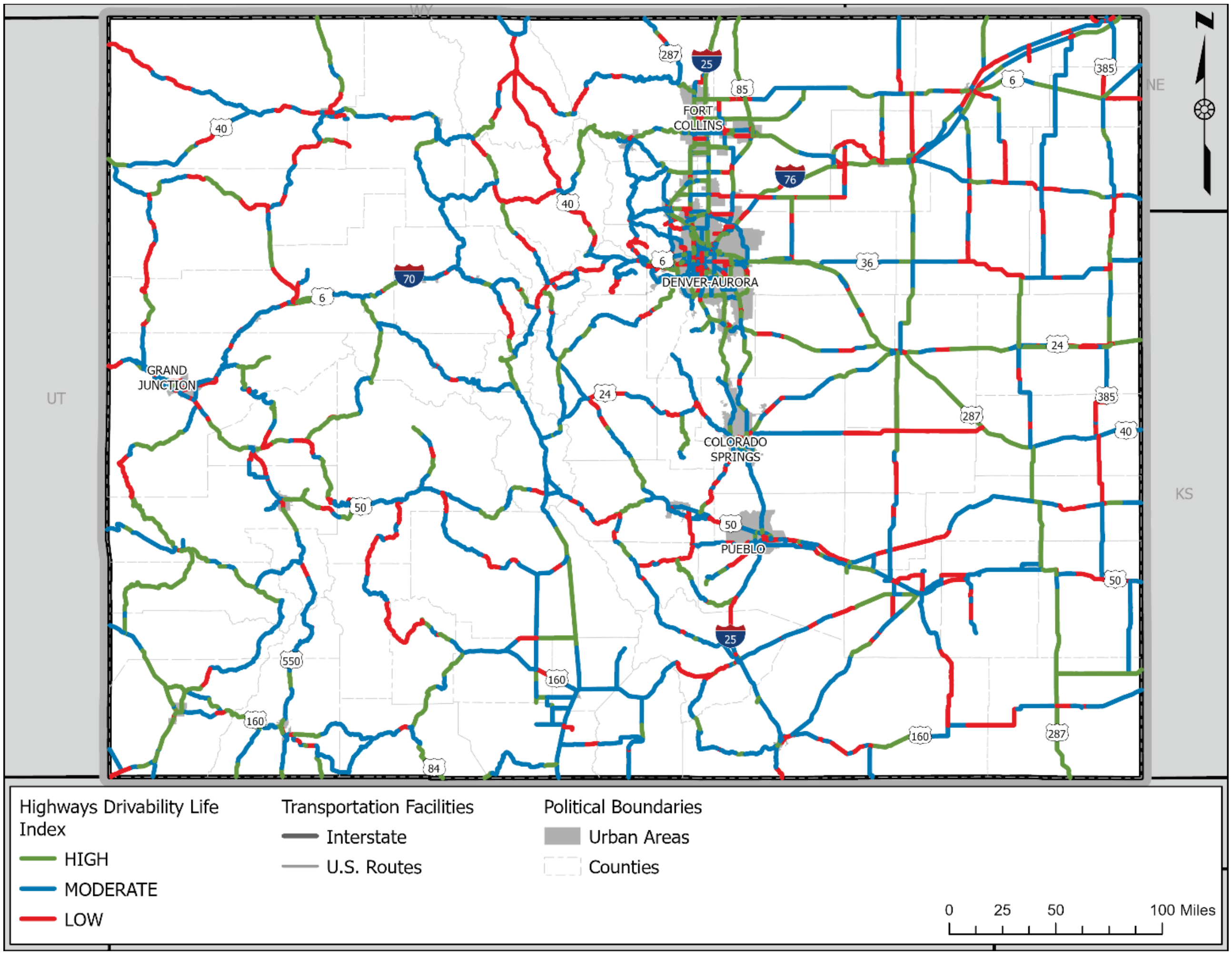
Source: WSP analysis of NPMRDS data.

The supply chains most impacted by these top 20 rural bottlenecks include food and agriculture, construction, and distribution.

4.3.2 Pavement Condition

The condition of the roadway system significantly impacts truck movement. To assess the pavement's usable lifespan across the entire highway system in the state, CDOT developed the Drivability Life Index in 2013, similar to the conventional Pavement Management System. The Drivability Life index classifies highway pavement conditions into three categories: low, moderate, and high, representing remaining lifespans of 0-3 years, 4-10 years, and more than 10 years, respectively, as shown on Figure 4.28.

Figure 4.28 Remaining Drivability Life on Colorado Highway

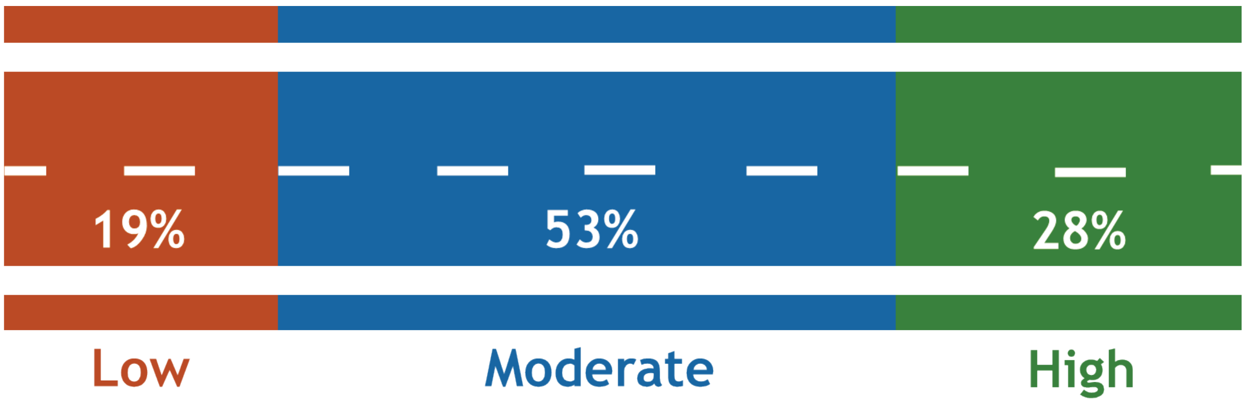


Source: CDOT, Highways: Drivability Life, 2022 https://data-cdot.opendata.arcgis.com/datasets/cdot::highways-drivability-life-1/about.

Based on CDOT's 2022 Transportation Asset Management Plan (TAMP), the goal is to have 79 percent of the state highway system rated as having high or moderate Drivability Life by 2036. As of 2022, without considering ongoing maintenance, over 78.4 percent of the state highway system in terms of centerline mile falls within the moderate or high Drivability Life category (Figure 4.29). With CDOT's ongoing commitment to pavement preservation and maintenance, the state will likely achieve the targeted 79 percent rating by 2036. [59] The continued efforts will lead to further improvements in the drivability and condition of the state's highways to maintain an effective and safe freight network.

[59] https://www.codot.gov/programs/tam/cdot-2022-transportation-asset-management-plan-remediated.pdf.

Figure 4.29 Drivability Life Percent of Highway System



Notably, throughout stakeholder engagement there was considerable concern for maintenance and upkeep of infrastructure. Stakeholder concerns largely derive from the alternate route component of roadway failure. Depending on the severity of the pavement deterioration, poor quality pavement may damage goods in transport or potentially cause an accident. Poor pavement surrounding a warehouse or distribution facility may discourage users from utilizing the facility in spite of other positive factors.

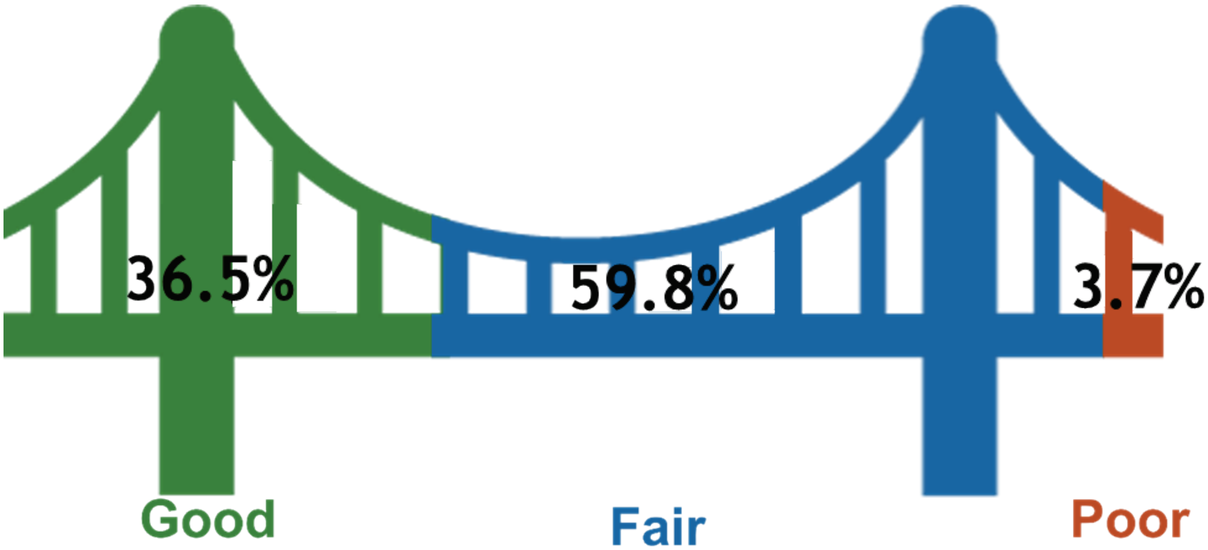
4.3.3 Bridge Condition

Bridge conditions and clearance restrictions put limits on freight mobility. Bridges with lower clearance allowance may limit load and route choices for trucks. Colorado, as of 2022, has 2,763 bridges situated on and maintained by the National Highway System (NHS). Federal agencies are obligated to periodically assess the condition of these bridges, with major evaluation metrics of deck, superstructure, substructure, and culverts. Colorado follows the National Bridge Inventory (NBI) bridge condition rating system of good, fair, and poor.

There were 109 bridges on the NHS in Colorado rated as having poor conditions, accounting for 3.7 percent of the total NHS bridges in the state, well within Colorado's poor-condition bridge target of 4 percent. There were also 36.5 percent of bridges in good condition, already exceeding the 36 percent by 2025 goal, as shown on Figure 4.30. The state has worked to preserve and maintain structures in fair and good conditions, and the good-condition bridge proportion exceeds the expectation. These treatments in general have relatively lower costs and higher rates of return. To maintain the 4 percent poor-rated NHS bridge target, continued efforts should focus on the rehabilitation or reconstruction of inadequate structures. [60]

[60] https://www.codot.gov/programs/tam/cdot-2022-transportation-asset-management-plan-remediated.pdf.

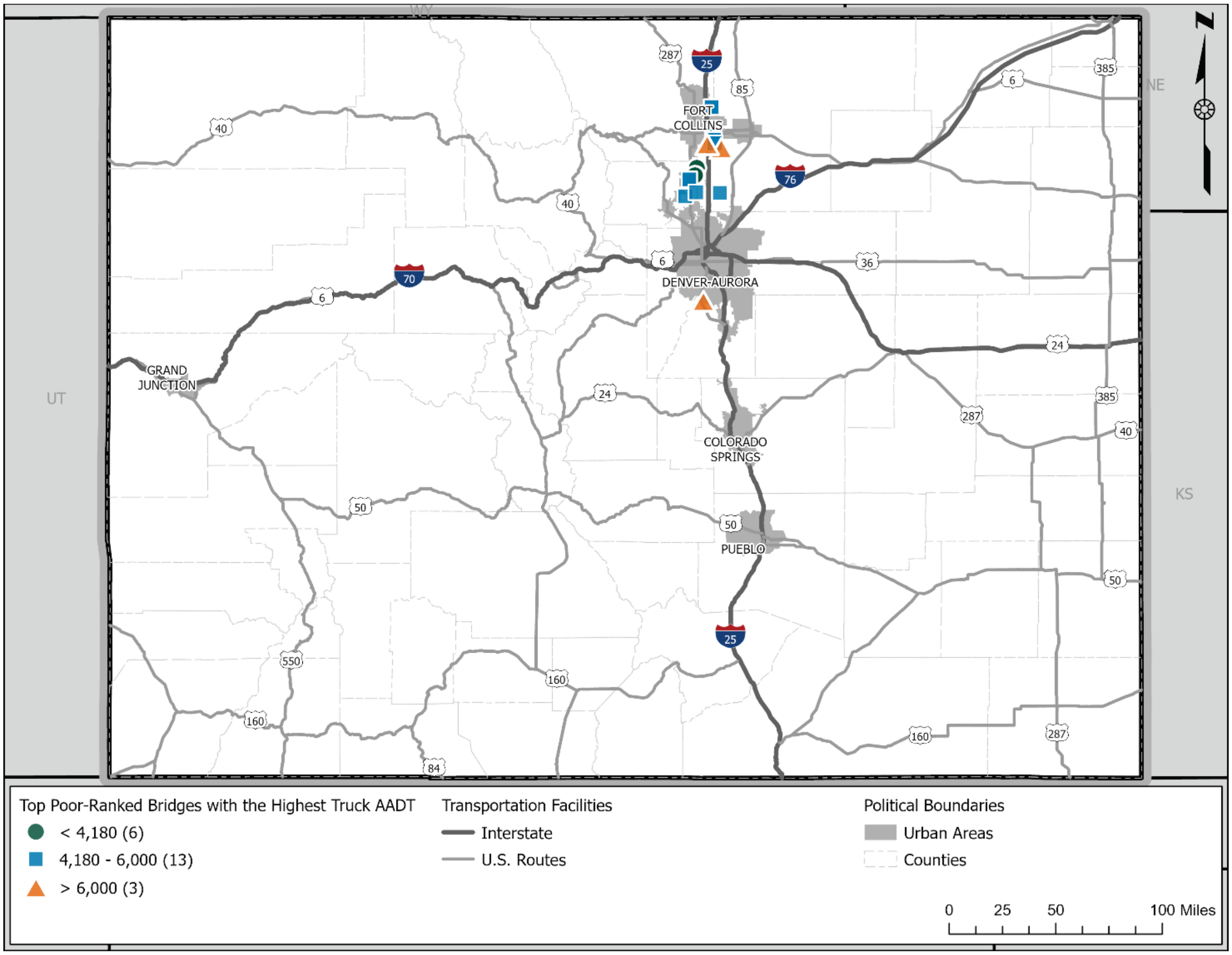
Figure 4.30 NHS Bridge Condition



Source: Structures, CDOT, 2022, [Structures (all types) | Structures (all types) | C-Plan : CDOT Open Data (arcgis.com)].

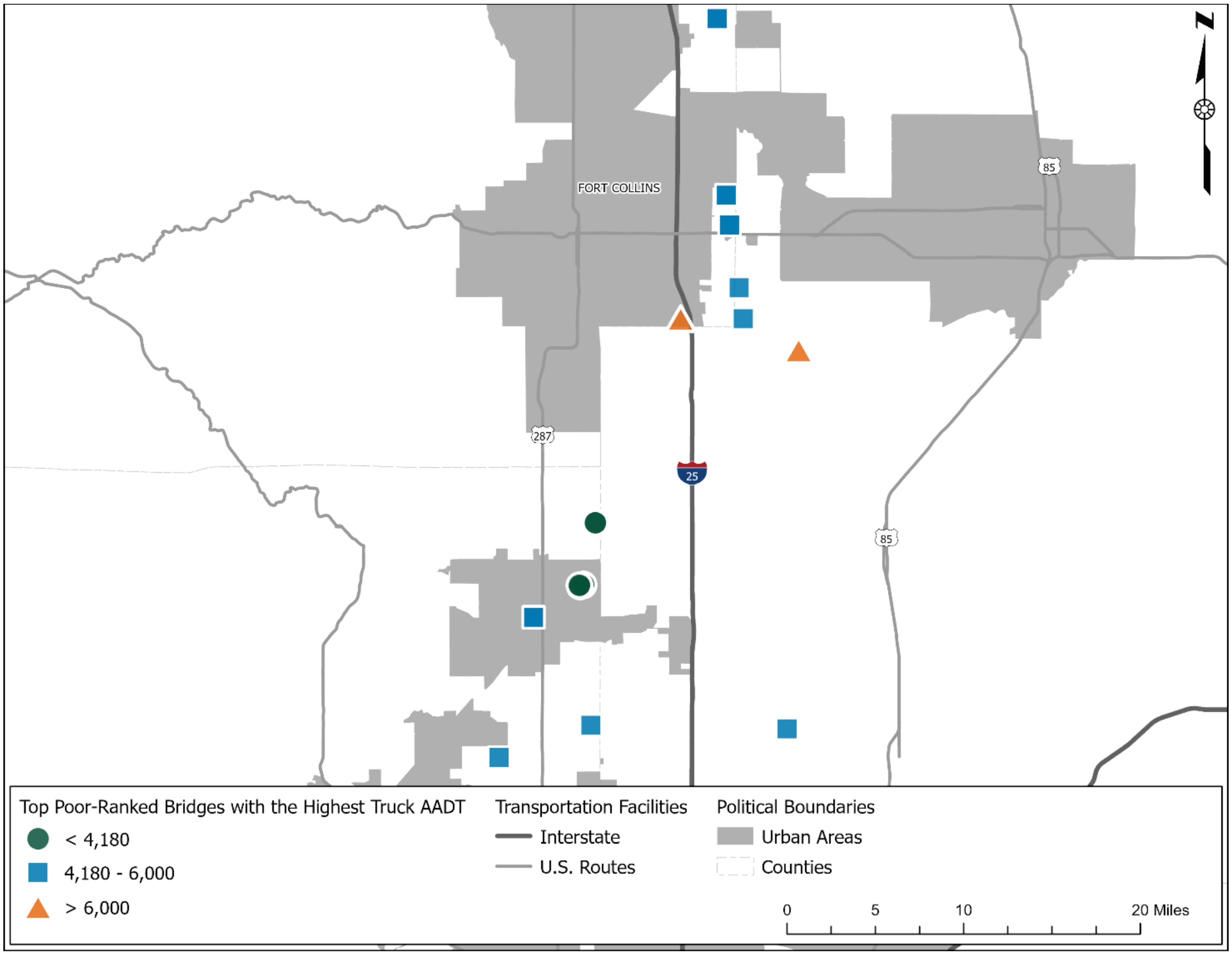
Roadway surface and bridge deterioration are highly correlated with vehicle movement, especially trucks that carry heavy loads. To maintain and improve truck freight movement, it is necessary to prioritize the maintenance of poor-condition bridges, especially the ones with high truck volume. Figure 4.31 and Figure 4.32 highlight 22 poor-condition bridges with the highest truck AADTT in 2022 in the state and in Fort Collins. The AADTT on the shown bridges varies between 4,180 to 7,700, and most of these identified poor-condition bridges are situated along principal arterials, such as I-25, I-70, I-76, and SH-35, primarily in the Denver-Aurora and Fort Collins regions.

Figure 4.31 Poor Condition Bridges with Highest Truck AADT



Source: National Bridge Inventory, 2022, https://www.fhwa.dot.gov/bridge/nbi/ascii2022.cfm.

Figure 4.32 Poor Condition Bridges with Highest Truck AADT (in/near Fort Collins)



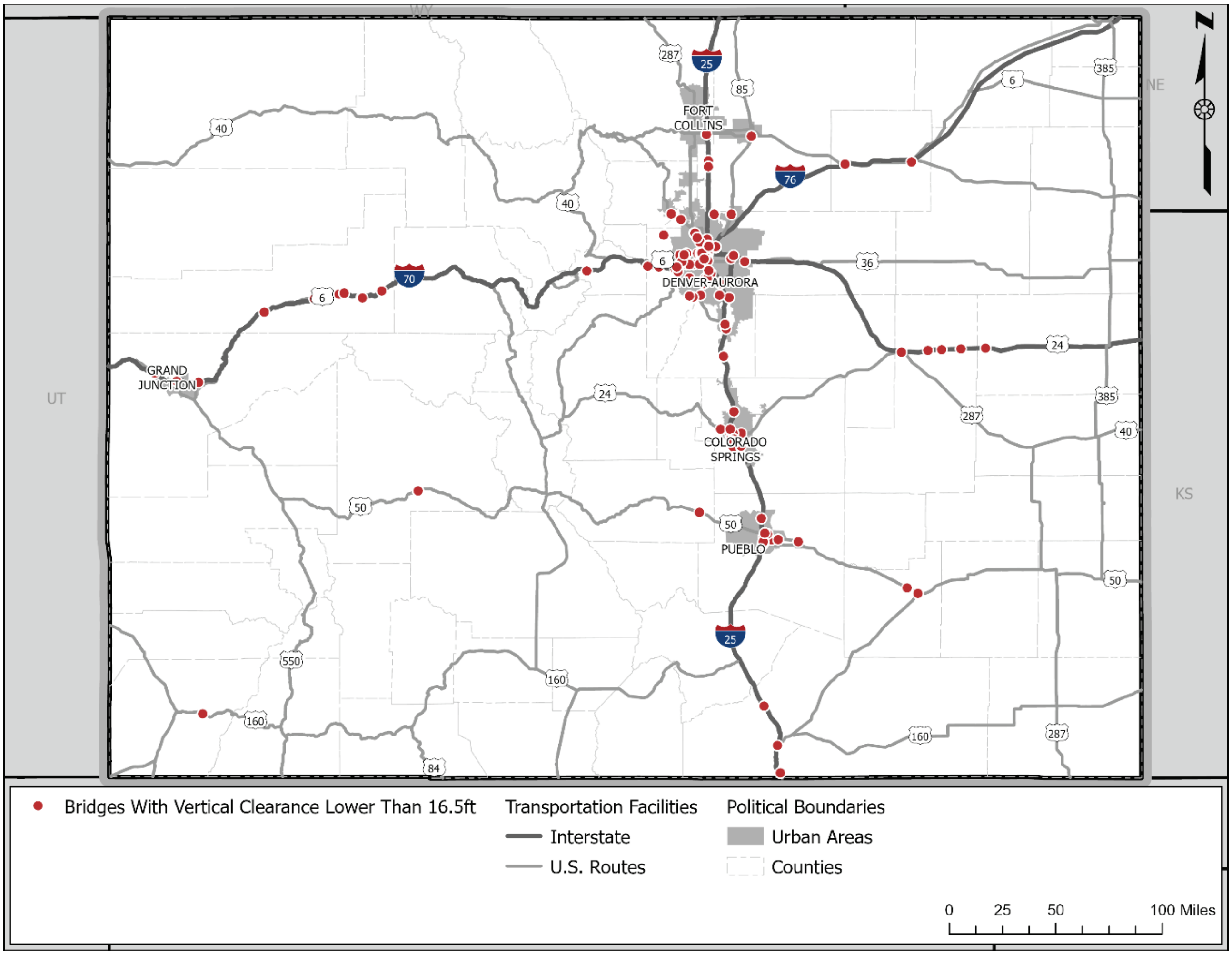
Source: National Bridge Inventory, 2022, https://www.fhwa.dot.gov/bridge/nbi/ascii2022.cfm.

4.3.4 Bridge Restrictions and Clearances

Truck transportation faces certain constraints from vertical clearance and weight restrictions imposed on bridges, especially for oversized or overweight vehicles. In Colorado, the minimum vertical clearance standard for vehicular bridges is 16.5 feet. [61] The majority of bridges comply with the minimum vertical clearance standard. As shown in Figure 4.33 and Figure 4.34, 143 bridges, representing 5.1 percent of all NHS bridges have a vertical clearance lower than the minimum standard, potentially posing restrictions and challenges for oversized trucks traveling under these bridges. And geographically speaking, more than half of these bridges are within or near the Denver-Auroa area.

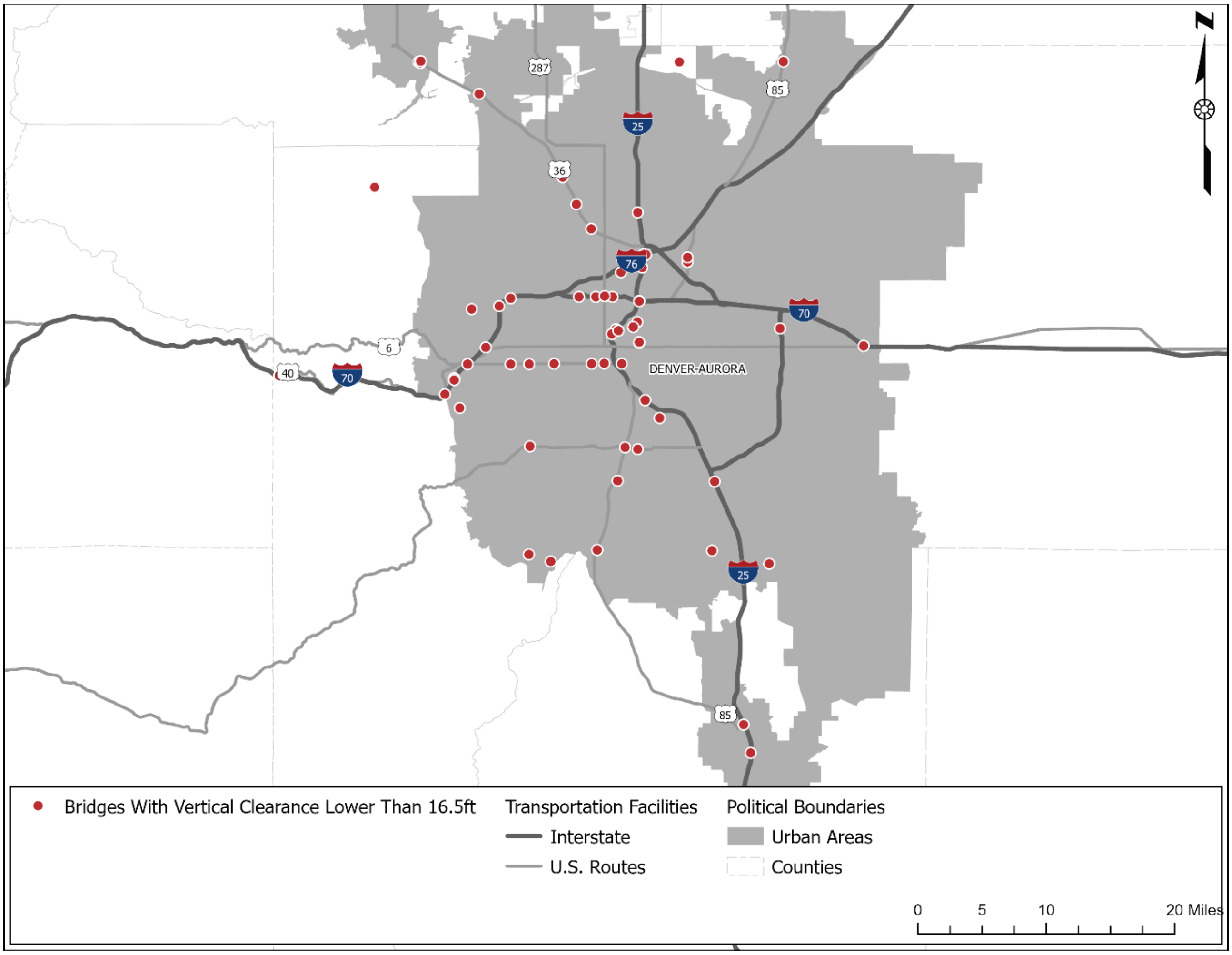
[61] https://www.codot.gov/programs/bridge/bridge-manuals/design_manual/bdm_section_2_2022.pdf.

Figure 4.33 Bridges with Vertical Clearance Lower Than 16.5 feet



Source: Structures, CDOT, 2022, [Structures (all types) | Structures (all types) | C-Plan : CDOT Open Data (arcgis.com)].

Figure 4.34 Bridges with Vertical Clearance Lower Than 16.5 feet (in/near Denver-Aurora)



Source: Structures, CDOT, 2022 , [Structures (all types) | Structures (all types) | C-Plan : CDOT Open Data (arcgis.com)](#).

Bridge weight restriction provides an insight into bridge operational status and is based on the bridge operating stress level. In Colorado, there are four bridges located on the National Highway System (NHS) that are currently posted for load restrictions. CDOT's goal is to have no bridges with weight restrictions.

CDOT is in the process of evaluating all bridges and major culverts located on freight corridors or freight support corridors, to determine treatments and estimated costs to ensure the efficient and resilient use of these routes for the trucking network. Using a data-driven approach, structures and treatments will be prioritized and preliminary project bundles will be developed to aid in planning and programming structures for improvements. This project provides the foundational steps to help ensure that the bridges on Colorado's freight routes can continue to support these routes, while working toward Policy Directive 14 (PD14) metrics of reducing load and height restricted bridges in the state. [62]

[62] Policy Directive 14: "Policy Guiding Statewide Plan Goals and Objectives". Colorado Department of Transportation. https://www.codot.gov/programs/tam/pd-14-performance-targets.

4.3.5 Tunnels

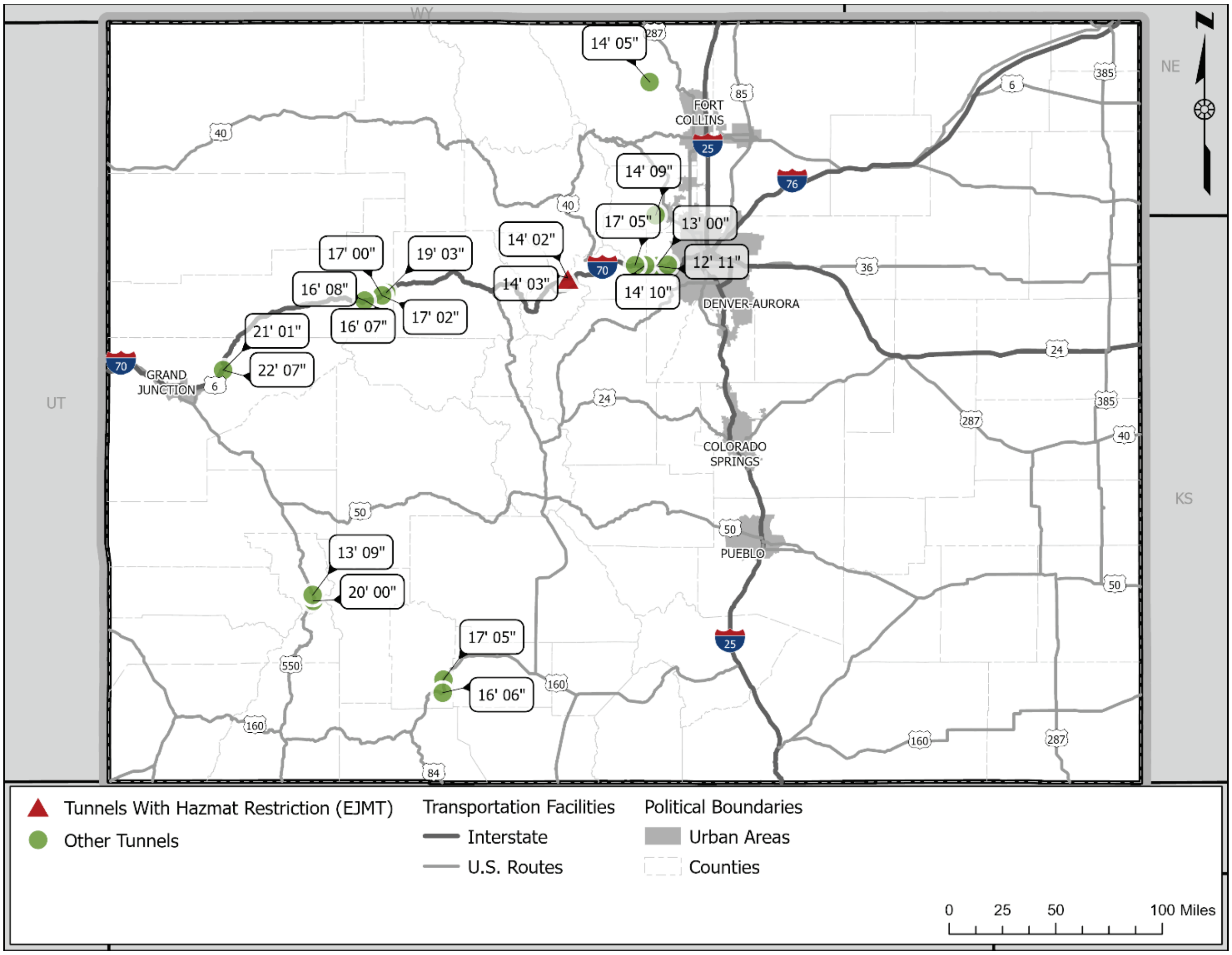
Similar to bridges, tunnels on roadways impose limitations on the size and weight of vehicles. There are a total of 22 tunnels in Colorado, with a significant concentration of 11 tunnels located along I-70 in the mountainous region (Figure 4.35). Fifty percent of these tunnels have a minimum clearance that is less than 16.5 feet, requiring some oversized trucks to find alternative routes.

The Eisenhower-Johnson Memorial (EJMT) is an important connection to safely move goods from the eastern slope of the Rocky Mountains to the western slope. A report CDOT published in 2020 states: "In current practice, hazardous materials (hazmat) trucks, such as gasoline tankers, are not allowed to pass through EJMT and are routed over Loveland Pass via US Highway 6 (US 6). Loveland Pass is a difficult route, with tight switchbacks and steep grades; it is a route that often must be closed due to snow, which creates even more hazardous driving conditions and avalanche danger. When US 6 must be closed, portal attendants close EJMT to normal traffic and allow hazmat vehicles to enter EJMT once per hour." Both options pose risks to the environment, infrastructure, goods movement, and the traveling public. [63]

Source: CDOT.

[63] CDOT. 2020. Transportation of Hazardous Materials through Eisenhower-Edwin C Johnson Memorial Tunnel—Study. https://www.codot.gov/programs/research/pdfs/2020-research-reports/cdot-transportation-of-hazardous-materials-through-eisenhower.pdf.

Figure 4.35 Tunnels with Vertical Clearance and Hazmat Restriction



Source: Tunnels, Colorado Department of Transportation, 2022, https://data-cdot.opendata.arcgis.com/datasets/cdot::tunnels/explore?location=38.146153%2C-107.126112%2C7.97.

The Eisenhower-Johnson Memorial Tunnels Hazardous Materials Route Study

The EJMTs are located about 70 miles west of Denver, Colorado on I-70. Each tunnel consists of two lanes and carries one-way traffic. The tunnels are approximately 9,000 feet long at an elevation of 11,000 feet above sea level. At present, hazardous materials (Hazmat) trucks, such as gas tankers, are not allowed passage through the EJMT and are routed over Loveland Pass via U.S. 6. The latter is a mountain pass with tight switchbacks and steep grades. Hazmat vehicles are currently only allowed through EJMT when U.S. 6 is closed and then only allowed once an hour and the tunnels are closed to normal traffic.

In 2020 CDOT conducted a study, mandated by Senate Bill 19-032, to study whether and under what circumstances hazmat should be allowed in EJMT. The study also compared to the risk of these vehicles traveling over Loveland Pass, The study concluded as follows:

- **Implementation Statement:** If hazmat routing is shifted from U.S. 6/Loveland Pass to I-70 through EJMT, risk is essentially transferred between the two corridors. Two hazmat routing rule change options show promise:
    1. **Allowing some classes of hazmat through the tunnel during times of lower traffic (quiet hours)** decreases risk by lowering the frequency of crashes and by reducing the exposed population. This would allow selective hazmat (2 CCR 601-8 Tunnel Rules Green Table) to travel through EJMT only during quiet hours (11:00 PM to 6:00 AM seven days a week). This would require regulatory change to implement.
    2. **Allowing some empty (placarded) hazmat vehicles to use EJMT** offers a slight reduction in overall risk. This would require organizational and regulatory change. Empty (but not purged) vehicles must still display hazmat placards, so it is recommended that a process be established for tunnel operators to identify which placarded hazmat cargo tanks are empty. Multiple tunnel, roadway, and operational safety mitigation options have been identified that will further reduce risk of hazmat incidents on public safety, infrastructure, local economies, and the environment.

CDOT would need to identify funding to implement tunnel or roadway options while operational safety mitigation may be implemented though a collaborative approach between CDOT, Colorado State Patrol (CSP), the trucking industry, and emergency responders. If decision makers elect to implement changes, it is recommended that a combination of options be carried forward for further evaluation; these combinations will have a greater cumulative benefit and risk reduction. Any options pursued will require time, stakeholder engagement, collaboration, and funding commitments from decision makers along the corridor.

The results of the risk comparison – comparing U.S. 6 with its current rate of Hazmat truck transport to I-70 through EJMT with a changed policy to allow unrestricted Hazmat truck transport are summarized as follows:

- **Casualty Risk:** On an annual expected value basis, the number of casualties on I-70 is higher than on U.S. 6 for all scenarios together. Tunnels are usually designed for 20MW fires as per National Fire Protection Association (NFPA) Guidelines. A significantly higher fire, such as 100MW, is possible with gasoline trucks. The 20MW and 100MW fires dominate the results for both routes. If one of the non-fire scenarios were to occur in the tunnel causing an explosion during a peak travel time, the consequences could be catastrophic in terms of loss of life.
- **Environmental Impact:** U.S. 6 and I-70 have a similar significant potential for environmental impact from a Hazmat incident. Sensitive wildlife habitat, forest and vegetation, and water supply sources could all be adversely affected by a Hazmat spill, explosion, or fire. For U.S. 6, the Snake River and Dillon Reservoirs are at risk, and for the I-70 route, the Clear Creek and Straight Creek are at risk.
- **Infrastructure Damage:** A Hazmat incident on each route (outside of the EJMT on the I-70 route) would result in similar damage to the roadway on both routes, with a replacement cost of

approximately $5.5 million/mile. Along U.S. 6, there is also the possibility that adjacent buildings and other infrastructure in Keystone, the A-Basin ski area, and Dillon could be damaged in an explosion or spreading fire caused by a Hazmat incident. The greatest risk to infrastructure is the EJMT on I-70. The Quantitative Risk Assessment Model (QRAM) model results show that the worst Hazmat incident would cause damages with a repair cost of 12.5 percent of the replacement value of the tunnel. It is highly unlikely that the tunnel structure would collapse; however, there would be severe damage to the tunnel ceiling, as well as the electrical and mechanical systems.

- **Local Economic Impact:** The local economy of the region is highly dependent on tourism, not only skiing in the winter months, but also other outdoor recreation in the summer months. For U.S. 6, the local economies of Keystone, Dillon, and the A-Basin ski area are all dependent on the proper function of U.S. 6, and would be severely impacted if a Hazmat incident was to occur on U.S. 6 and cause a soil or water contamination problem in these locations. In a comparable manner, the local economies of Silverthorne and Dillon depends on the proper function of I-70 and would be similarly impacted by a nearby Hazmat incident on I-70 . The criticality of I-70 extends beyond the local economy in the area. This route serves as a major east-west corridor for the state, as well as for the United States. Closure of the EJMT for a significant period of time, even one tube with the other operating with bi-directional traffic, would significantly disrupt traffic flow between the Denver metropolitan area and the western slope of the Rocky Mountains causing a severe economic impact to areas such as Vail and Aspen.

Based on these results and the information gathered in the study, the following recommendations were made:

- The current procedures for convoying Hazmat trucks through the EJMT should be revised to limit the speed of the trucks through the tunnel to 30 mph, using CCTV at tunnel exits and Colorado State Patrol personnel to help enforce this speed limit. In addition, the dangerous traffic condition related to the mixing of passenger cars and Hazmat truck traffic (cars at high-speed attempting to overtake the trucks on the stretch of I-70 following the exit of the tunnel after the Hazmat truck convoy has ended) should be examined.
- Improvements should be made to U.S. 6 at Loveland Pass to accommodate the parking and pedestrian demands associated with the increased recreational use, especially during the nighttime hours when Hazmat truck travel through the area is common.
- U.S. 6 should undergo evaluation to determine if mitigations to the route geometry and roadway conditions could be done to help reduce the problems faced by Hazmat truck drivers with side-to-side sloshing of liquid cargo in bulk containers while traveling over Loveland Pass.
- A truck runaway ramp should be installed in the westbound direction on U.S. 6 near Milepost 220, and it should be designed to contain a possible Hazmat spill. In addition, the current truck runaway ramps on I-70 outside of the EJMT should be modified to contain a possible Hazmat spill, and the regular use of these ramps should be evaluated to determine if additional ramps are needed for exit from the left side of the road.
- CDOT should evaluate the Colorado Motor Carriers Association (CMCA) “Proposal for Pilot Program for Movement of Hazardous Materials through the Eisenhower Tunnel”.

Later in 2020, and pursuant to the mandate of Senate Bill (SB) 19-032, CDOT formed four committees consisting of major stakeholders (CDOT, CSP, CMCA, local governments, Emergency Services, et.al.) to discuss, evaluate and recommend the next steps related to the above studies pertaining to Hazmat transport through the EJMT. In 2022, the CDOT risk assessment team initialized a quantitative investigation to study whether and under what circumstances hazardous materials transports should be allowed in the EJMT. In the scope of this project CDOT sought to estimate the risk associated with the transport of hazardous materials on U.S. 6, including Loveland Pass, and compare this risk estimate to the risk for I-70, including the EJMT, in a quantitative manner.

This included the following tasks:

- Empties—Verify assumptions on “empties” in alignment with the Federal Codes. Later further defined and analyzed as less than 499 Gallons per non-regulated /non—routed hazmat regulation.
- Foam—Research on the pass/fail feasibility of adding foam concentrate to the existing fixed fire suppression system (FFSS) in EJMT.
- Electric Vehicles (EV)—Research the differences in EV to tanker fire.

One of the major issues CDOT is facing with respect to the transport of hazardous materials, either over Loveland Pass or through EJMT, is to balance the low probabilities but potentially large consequences of events involving hazardous materials with the daily need for the safe transport of people, energy, and chemicals that facilitate Colorado’s economy. As the risk for residents and road users is one of CDOTs major concerns, the methodology selected for the quantitative comparison had to be capable of assessing personal risk in open road as well as tunnel sections.

The analysis utilized two of the current leading international risk analysis software to quantitatively analyze hazmat transport through the EJMT. First, the Dangerous Good Quantitative Risk Assessment Model (DG-QRAM), an industry standard for quantified risk assessment of hazmat transport through tunnels, particularly for comparing tunnel routes to alternative open road routes became a natural choice. Comparing the general risk of open road sections and sections including tunnels is one of the core features of DG-QRAM. However, it often falls short on the detailed assessment of specific tunnel characteristics like complex tunnel ventilation systems or fixed fire suppression systems.

To compliment the limited capabilities of DG-QRAM, another tunnel risk analysis model – Tunnel Risk Model (TuRisMo) was selected. This Austrian tunnel risk modelling software focuses solely on the personal risk for tunnel users while considering the various tunnel safety features (ventilation, fire suppression, et.al.) that DG-QRAM is unable to assess. Both tools were combined in a novel homogenized approach. DG-QRAM was used to estimate the general risk for both routes. TuRisMo was applied for the tunnel section to calculate risk reduction factors representing the effect of specific mitigation measures which cannot be accounted for by DG-QRAM directly. This combination allowed for the quantitative comparison of both routes also taking the characteristic safety design of EJMT into account. To date, the assessment is still ongoing, but the results obtained in the first phase suggest that overall risk can indeed be reduced with specific risk reduction measures.

4.3.6 Oversize and Overweight (OSOW) Vehicles

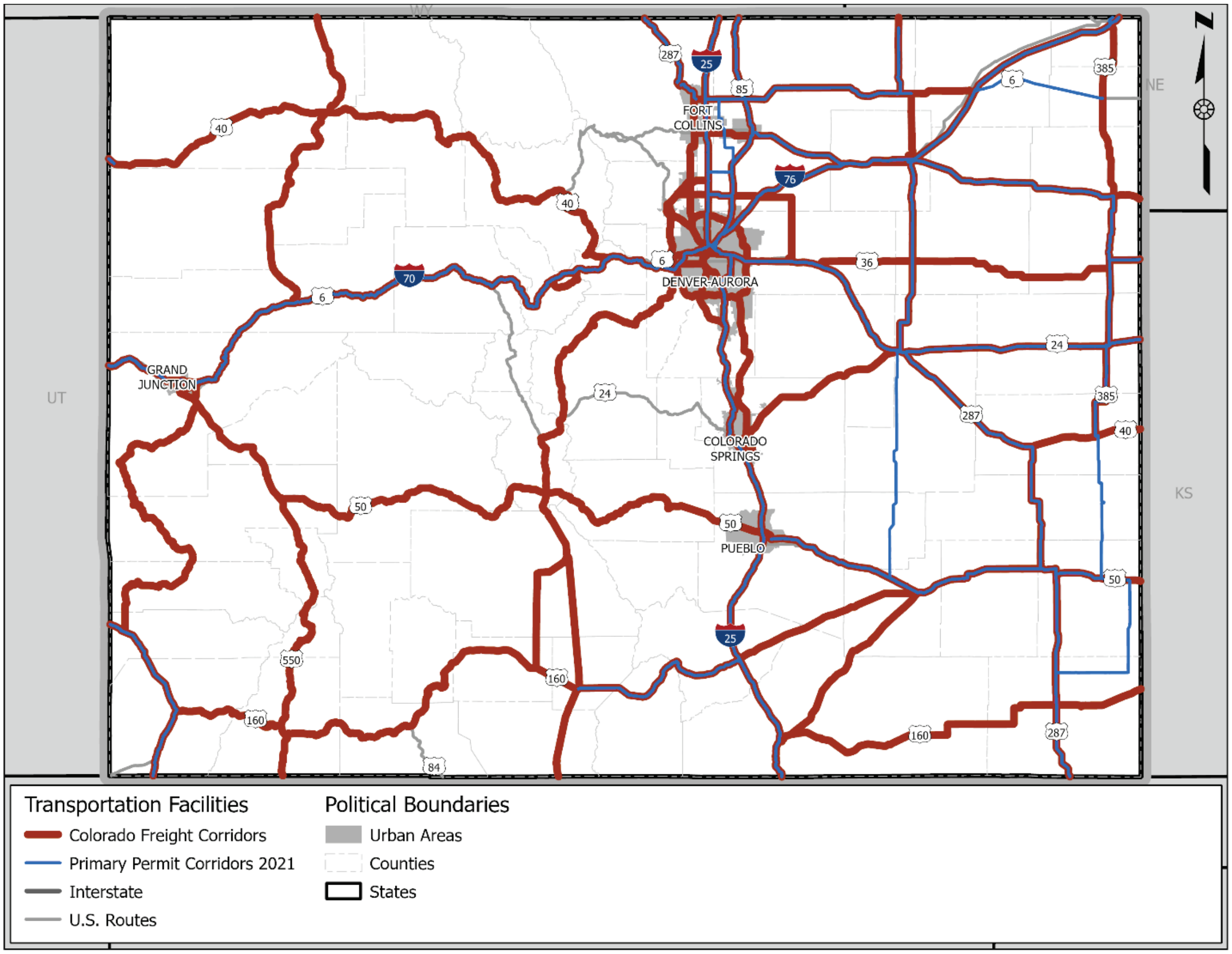
Transportation of oversize and overweight (OSOW) loads is an integral necessity of the freight highway system. Every state is responsible for issuing OSOW permits to ensure every loaded vehicle can traverse the roadways safely and quickly. Colorado, in particular, has a variety of treacherous terrain served by infrastructure where OSOW restrictions are in place. This section details the OSOW operations in the state, the ongoing CDOT driven activities, and OSOW infrastructure needs of the state.

Overview of Colorado's OSOW Infrastructure and Programs

Since 2009 the state has instituted the Colorado Bridge Enterprise program to finance, repair, reconstruct and replace designated bridges. One of the purposes of the enterprise program is to identify and rectify freight infrastructure needs. In 2021 the state added surface transportation projects for tunnels and renamed the program the Bridge and Tunnel Enterprise (BTE). The BTE operates as a government-owned business within CDOT, and the Colorado Transportation Commission serves as the Board of Directors.

The CDOT Freight Mobility & Safety Branch is responsible for issuing OSOW and hazardous materials permits. The state issues nearly 30 different OSOW permit types to ensure drivers are properly informed as to the routes they are able to safely traverse. In 2021, Colorado issued 58,129 OSOW permits, of which 39,212, or about two thirds, were external type permits which are designated to be used to transport OSOW loads across state lines. The remining third are internal, the majority of which are single-trip permits. Figure 4.36 shows the routes along which 80 percent of single-trip permits are issued, and their correlation with the Colorado Freight Corridors.

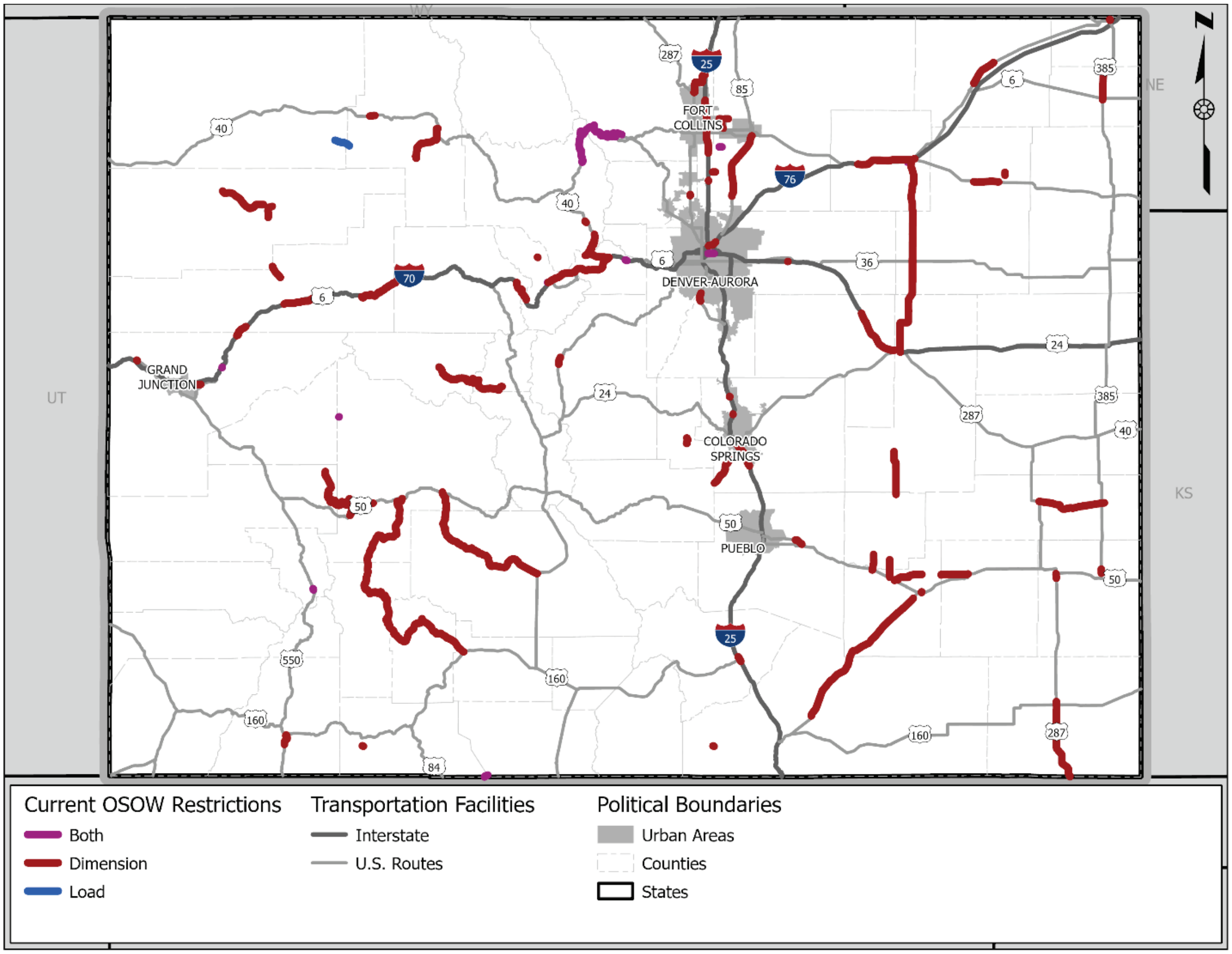
Figure 4.36 Primary Single-trip Permit Routes, 2021



Source: Colorado Department of Transportation, 2022.

CDOT also catalogs the specific route segments where special OSOW regulations exist. The state largely issues dimension type OSOW restrictions, with some load and mixed restriction routes, as shown in Figure 4.37. Of note, there are approximately 90 miles of I-70, 50 miles of I-25, and 25 miles of I-76 that have some form of OSOW restriction. These interstates represent some of the most trafficked freight corridors in the state, and provide direct access to the state's most populous urban areas. Additionally, U.S. 287 currently has 30 miles of OSOW dimension restriction beginning at the Oklahoma state border, which is worth consideration in the context of Ports to Plains corridors.

Figure 4.37 Active OSOW Restricted Routes, August 2023

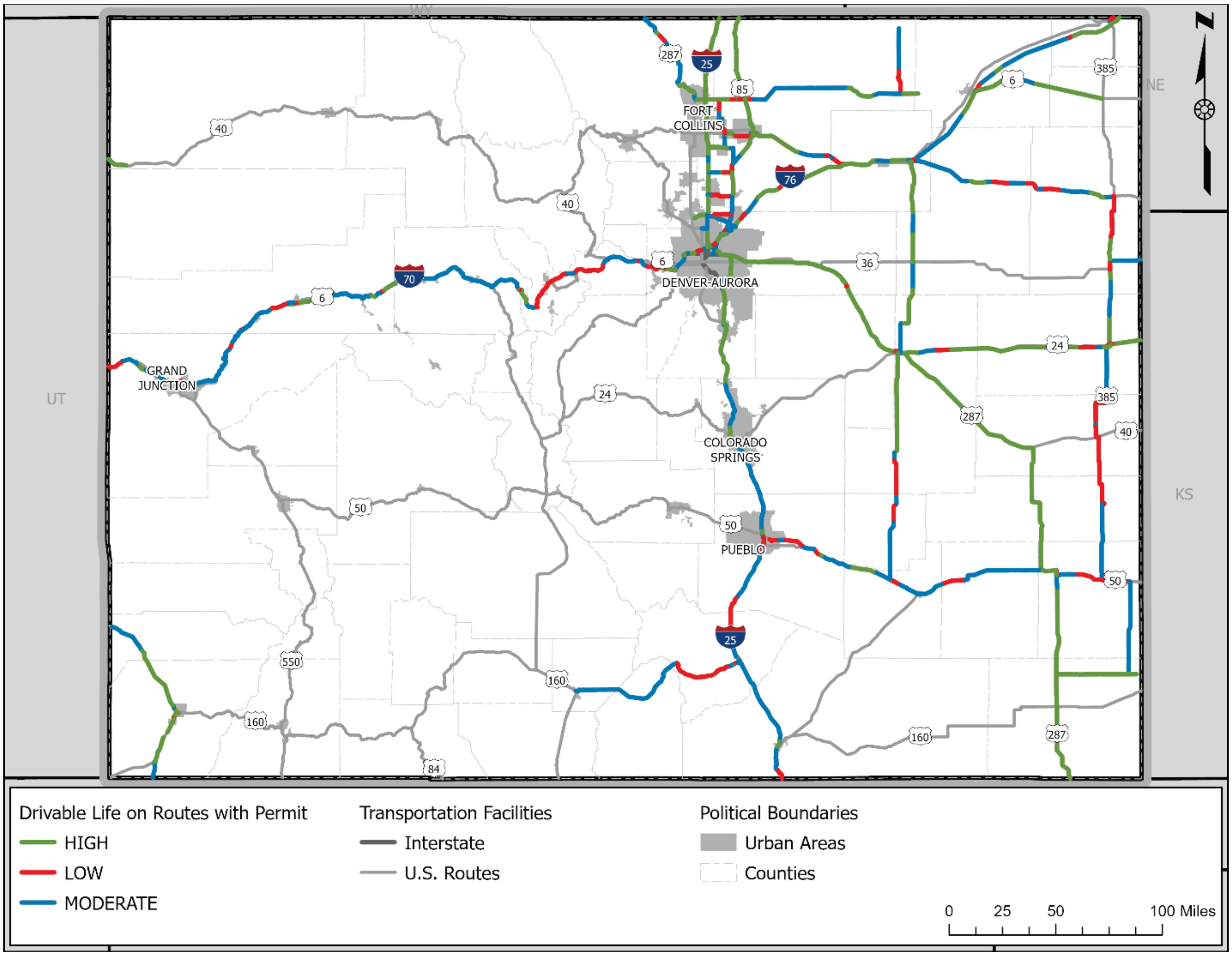


Source: CDOT Open Data Portal.

Improving OSOW Freight Infrastructure

The drivable life of pavement on the primary single-trip permit routes, shown in Figure 4.38, is broadly either high or moderate. Notably, routes in and around the Denver metro area, extending north to Fort Collins and south to Colorado Springs, are largely either high or moderate. The same trend can be seen on I-70 east of Denver, I-76 and U.S. 287; with U.S. 287 having almost exclusively high drivable life. All of these routes provide access from neighboring states to the Denver area, so the are high priority routes and expectedly have higher drivable life. The routes west of I-25, however, have a relatively higher share of roadway with low drivable life, including along I-70 immediately west and east of the Eisenhower-Johnson Memorial Tunnel. I-70 is also the only primary single-trip permit route extending from the I-25 corridor to the western border of the state. Figure 4.38 shows the drivable life for these primary permit routes.

Figure 4.38 Drivable Life on Primary Permit Routes, 2021



Source: CDOT Open Data Portal. CDOT, Highways: Drivability Life, 2022 https://data-cdot.opendata.arcgis.com/datasets/cdot::highways-drivability-life-1/about.

Colorado's bridge and tunnel infrastructure represent key weight, height, and hazmat restriction points across the Colorado highway system, and targeting them for improvements has been a priority for CDOT to allow for the full utilization of freight routes in the state. The CDOT Freight Mobility & Safety Branch has been working with Staff Bridge for more than three years to identify deliverable solutions to restrictive bridges on freight routes. The number one goal is to eliminate and prevent weight restricted structures on freight routes, and to minimize maintenance and improve safety over the extended life of these structures.

The Department has committed $6 million ($2 million each fiscal year (FY) from 21-23) with a programmatic approach to fixing the liabilities associated with 41 identified National Highway Freight Program (NHFP) timber structures. These funds are in addition to the $7.2 million funding for structures not on freight routes. The program requires regions to manage the design to construction process, thereby maintaining full cooperation throughout the CDOT levels of governance. This hand-in-glove approach ensures that statewide freight infrastructure goals are met with regional support and approval. Project P-18-BP Retrofit is an example of one such project where improvements to a mainline I-25 bridge resulted in increased load capacity thereby allowing for alternate route utilization and reducing freight pressure on other routes.

PROJECT: P-18-BP—RETROFIT

LOCATION: I-25 ML NB MP 5.596 (37.059982, -104.523098)

BUDGET: $1,200,000 (NHFP FUNDS)

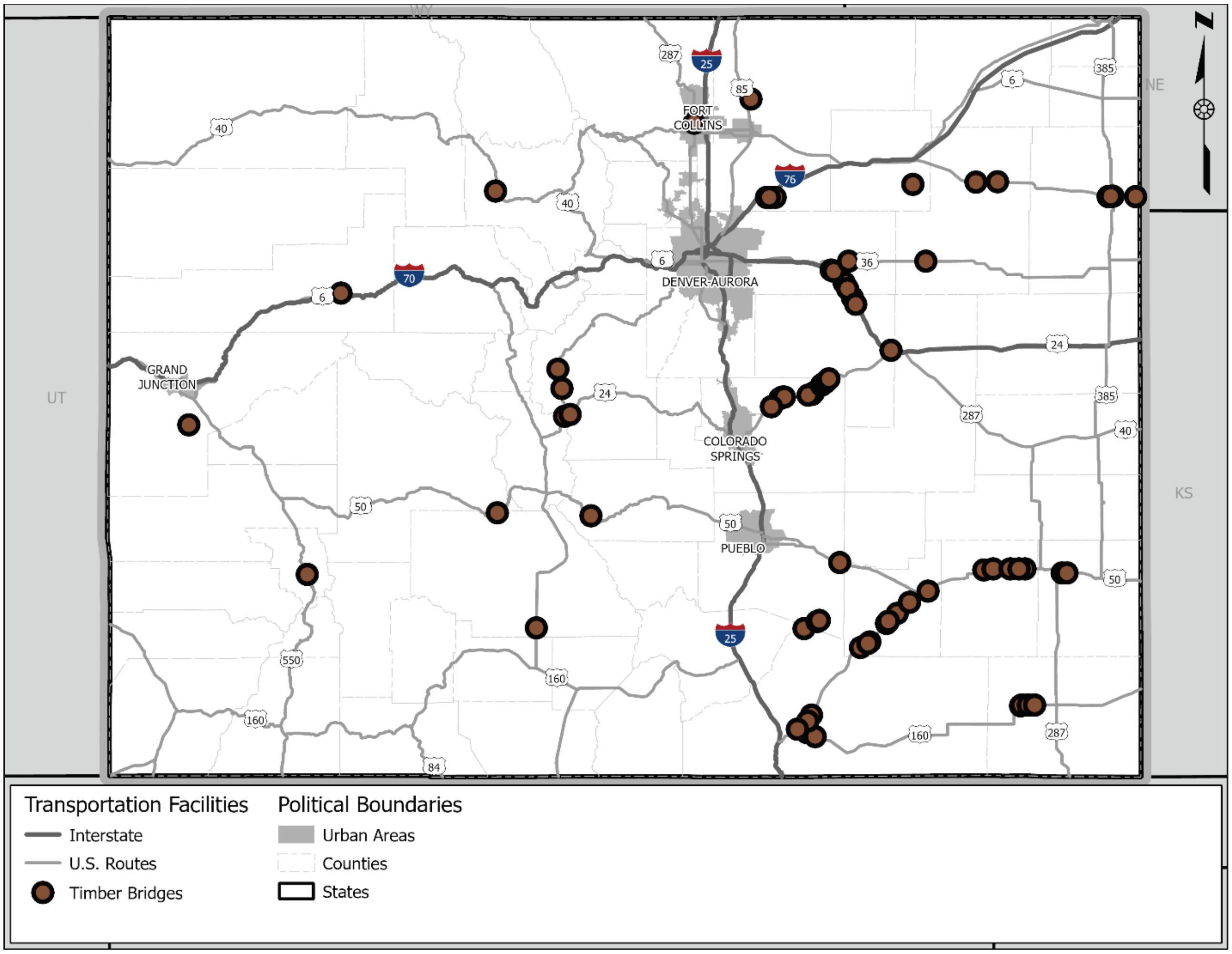
PROJECT OUTLINE: REPAIR STRUCTURE P-18-BP BY INJECTING EPOXY RESIN AND FIBER WRAPPING THE APPROPRIATE AREAS IN ORDER TO BRING THIS STRUCTURE'S WEIGHT RATING TO A WHITE RATING AND THEREFORE ALLOWING OVER WEIGHT (OW) LOADS TO UTILIZE THIS ROUTE ONCE AGAIN. THIS WILL SIGNIFICANTLY REDUCE MILES DRIVEN BY OSOW IN OUR STATE AS WELL AS EASE STRESSES THAT OVER-SIZE/OVER-WEIGHT (OSOW) LOADS ARE CAUSING ON US 287/ US 385.

PROJECT DESCRIPTION: THIS TWO-STEP FEDERAL AID PROJECT WAS DESIGNED TO REHABILITATE THE NORTHBOUND GALLINAS BRIDGE (P-18-BP) TO MEET CURRENT FEDERAL HIGHWAY ADMINISTRATION (FHWA) LOAD AND SAFETY STANDARDS. THE BRIDGE SPANS THE FRONTAGE ROAD (EXIT ROAD 6) AT EXIT 6 (GALLINAS) ON INTERSTATE I-25 NEAR RATON PASS. IT ALSO MARKS THE ACCESS POINT TO THE SANTA FE TRAIL RANCH SUBDIVISION. THE FIRST STEP IN THE REHABILITATION PROCESS INVOLVED PRESSURE-INJECTING EPOXY INTO CRACKS TO SHORE UP THE SURFACE STRUCTURE. THE SECOND STEP CONSISTED OF WRAPPING THE LONGITUDINAL GIRDERS WITH FIBER REINFORCED POLYMER (FRP) FOR SHEAR AND FLEXURE STRENGTHENING. THE PROJECT IMPROVES ROUTING RESILIENCY AND EFFICIENCY, RELIEVES STRESS ON THE US287 CORRIDOR NEAR THE OKLAHOMA BORDER, AND ALLOWS FOR SAFER ROUTING TO BE UTILIZED IN SOUTHERN COLORADO.

NEW WEIGHT ALLOWANCES: AFTER THE RETROFIT/REPAIR WAS COMPLETED THE ALLOWABLE WEIGHTS INCREASED BY ABOUT 20 PERCENT DEPENDING ON THE VEHICLE.

CDOT has made a substantive effort to ensure highway routes are both safe and accessible to provide the highest level of routing efficiency for truck freight. Figure 4.39 shows the timber bridges identified for NHFP funding in support of these goals. At the time of release of this plan at least 10 bridges have already been upgraded or are undergoing rehabilitation to support the state's freight needs. The completed timber bride upgrades represent a meaningful drive to improve freight routes in a manner sensitive to existing needs. This instills confidence in stakeholders that the remaining bridges, along with the recognition of existing OSOW restrictions, will be addressed and that the needs of freight industries will be met to enhance the economic competitiveness of Colorado in the context of a national marketplace.

Figure 4.39 NHFP Qualified Timber Bridge Structures



Source: CDOT Timber Bridge Inventory.

Colorado continues to advance weight, height, and commodity restriction needs by identifying assets that can enhance network utilization. The majority of the Freight Mobility & Safety Branch's goals and objectives remain unchanged from previous years, including efficient and accurate permitting of extra-legal vehicles or loads and LVCs, Hazardous Materials (HazMat) and nuclear permits, and working closely with industry representatives through the state's Freight Advisory Committee (Colorado FAC) on maximizing investments for freight safety and education.

4.4 Highway Operations Support Infrastructure

Highway support infrastructures are fundamental elements to maintaining an accommodating and safe freight network. Major support infrastructures include runaway ramps, and chain stations, which are crucial for Colorado, a state that has 830 mountains with elevations over 11,000 feet and relatively unpredictable weather. Truck parking facilities and inspection stations are also important support infrastructure to maintain an efficient operation of the highway network.

4.4.1 Runaway Truck Ramps

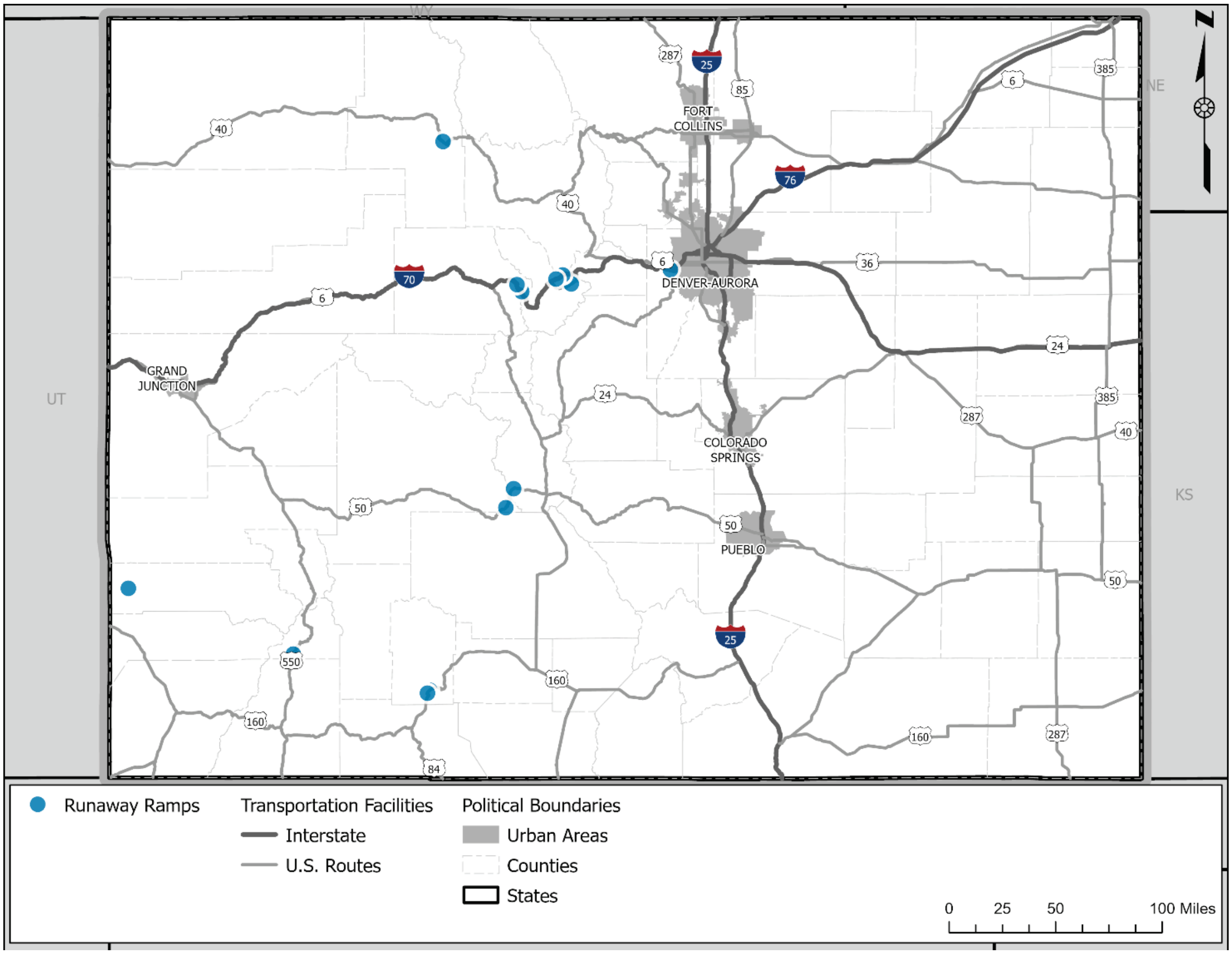
A runaway truck ramp is a crucial mitigation measure that offers a safe area for trucks to use in the event of mechanical issues, particularly brake failure. These ramps provide an emergency escape for trucks experiencing brake failure while descending steep grades, allowing them to come to a controlled stop and avoid potential safety issues. The location of these runaway ramps is determined based on factors such as the expected brake temperature and speed of trucks. Generally, these ramps are strategically placed at points along the roadway where the brake temperature is projected to reach 1000 degrees Fahrenheit, at which temperature the vehicle may run out of control, indicating the necessity for a safe descent grade. [64]

In Colorado, there are 14 truck runaway ramps, and six of these ramps are situated along the I-70 in the mountainous region (Figure 4.40). The ramp used most frequently is lower Straight Creek going westbound on I-70 coming out of the Eisenhower-Johnson Memorial Tunnel. It is used more than 50 times a year on average. This section of roadway is commonly referred to by truckers as the most challenging interstate section in the country as it has sections of 7 percent grade or more that can put a major strain on commercial motor vehicle (CMV) brakes if the driver is overusing them. Data indicate that 90 percent of these incidents occur with out of state CDL holders.

CDOT is looking at innovative ways to finance maintenance for runaway truck ramps, ensuring continued safety and accessibility for truckers to utilize them and decreasing fatalities on the freight network.

[64] https://www.dot.state.pa.us/public/Bureaus/design/PUB13M/Chapters/Chap17.pdf.

Figure 4.40 Runaway Truck Ramps



Source: Colorado Department of Transportation Online Transportation Information System (CDOT-OTIS).

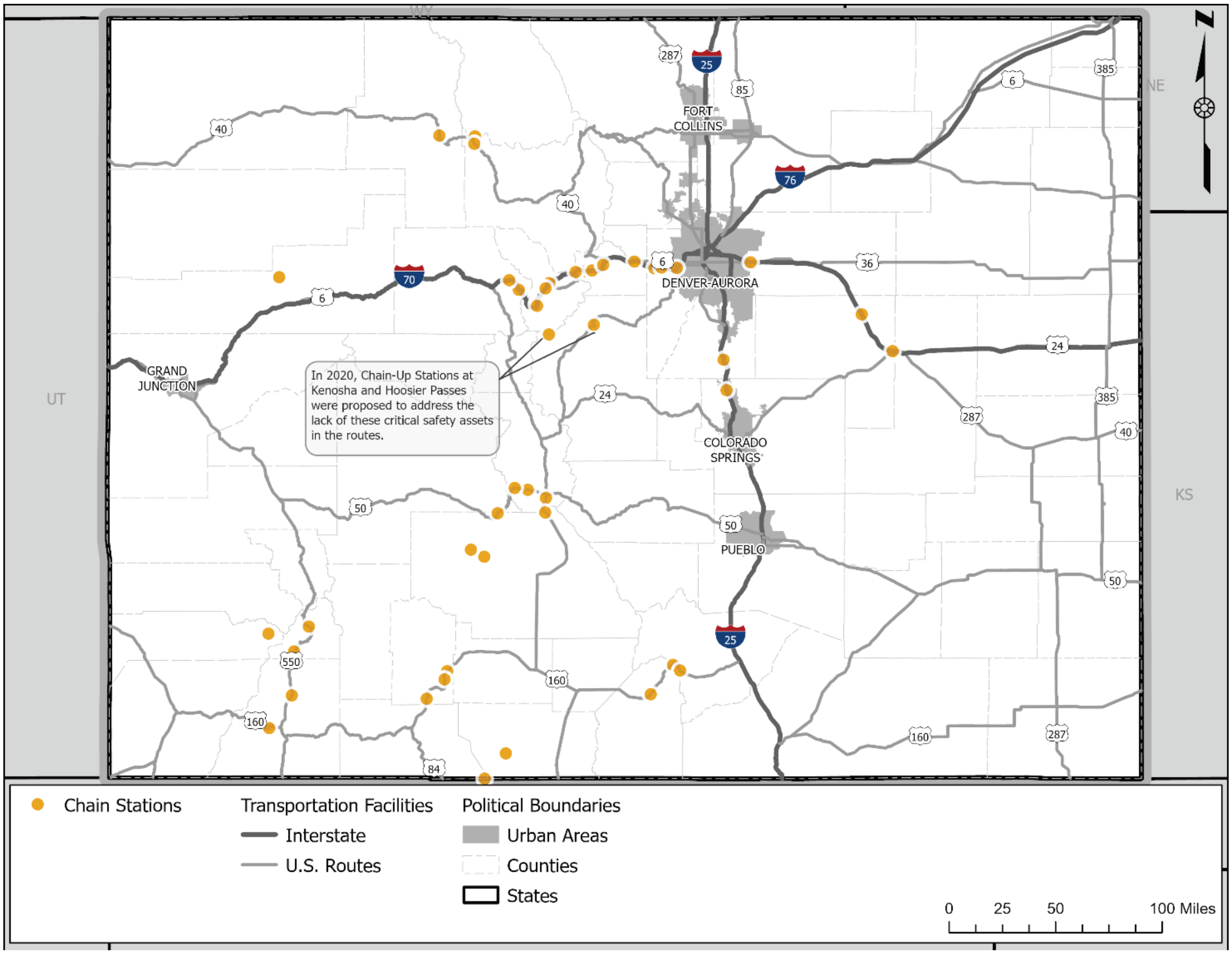
4.4.2 Truck Chain Stations

In 2011, CDOT initiated the chain law, which requires all commercial vehicles traveling on I-70 between Dotsero exit and Morrison exit to be equipped with sufficient chains from September 1st to May 31st.[65] The establishment of chain stations provides truck drivers a safety area to equip or remove chains from the vehicle, or check the mandatory chains to avoid potential vehicle failure and safety concerns during adverse weather conditions. Chain stations allow CDOT Maintenance to concentrate on snow removal operations instead of mobilizing equipment to move stranded vehicles that have lost traction out of the way of traffic.

[65] https://www.codot.gov/travel/colorado-chain-law.

As shown in Figure 4.41, there are 58 designated chain stations along Colorado's roadway network, and 19 of them sit on I-70's mountain corridor. These areas are essential along Colorado's interstates and mountain passes. Most of the chain stations are on I-70 is because the interstate passes through several mountain ranges and they are more likely to experience severe weather, leading to a greater need to ensure safety of trucks passing on. In addition, I-70 is a major east-west transportation corridor that has a high traffic volume of truck traffic, and having chain stations can ensure truck drivers can safely navigate the route.

Figure 4.41 Truck Chain Stations



Source: CDOT-OTIS, 2021.

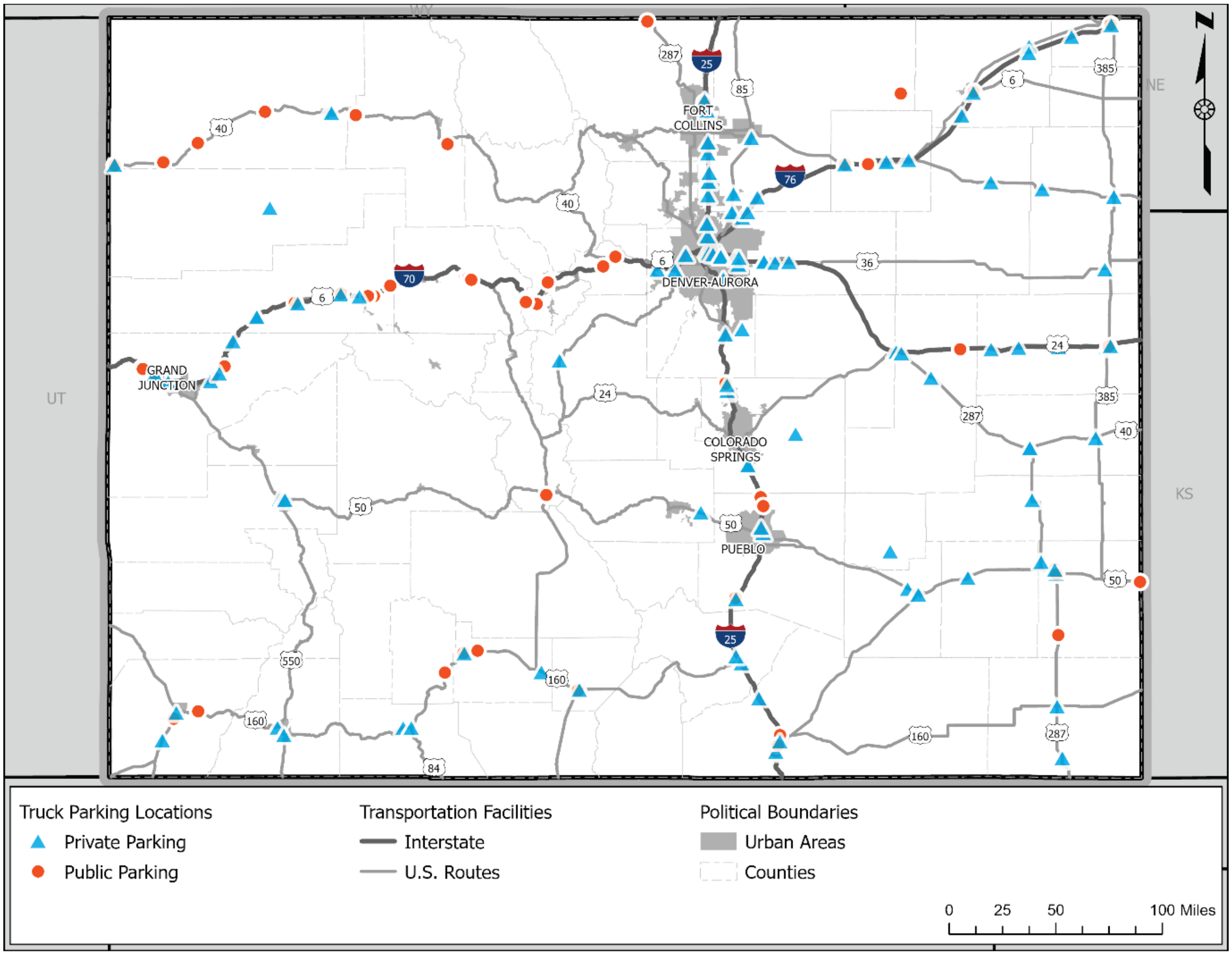
Often during snow events when visibility is low, truck drivers pull over on the shoulder just before the chain station because they are unable to see around the trucks in front of them to know if there is a place to pull over farther ahead within the chain station. Subsequent trucks approaching, seeing trucks pulled over on the shoulder, make the same assumptions and follow suit. Soon there is an increasing number of trucks pulled over on the shoulder. CDOT is developing a system for detecting open spaces within the chain stations and communicating it to truck drivers via dynamic message signs, which will improve both operations and safety.

4.4.3 Truck Parking

Truck parking remains a challenge across the nation and Colorado is no exception. A nationwide survey conducted by the American Transportation Research Institute in 2022 found that truck parking is the top concern for truck drivers. The lack of available parking has been linked to driver recruitment and retention issues. Lack of real-time information, growing congestion, especially in urban areas, and stricter monitoring of hours-of-service laws under new electronic logging device requirements continue to add to the challenge of providing sufficient and safe truck parking in areas where drivers need it. Lack of parking or information about available parking can result in trucks parking on highway shoulders, ramps, and interchanges, or in other areas that create safety hazards for both the truck driver and other road users. Parking issues can also create inefficiencies and delays in supply chains. Trucks may stop well before their allotted driving time runs out to ensure access to a parking spot or detour out of their way to find parking, losing valuable road time and delaying shipments.

Moving Ahead for Progress in the 21st Century (MAP-21) legislation instituted a national priority to address the shortage of parking for commercial motor vehicles to improve safety for drivers and travelers. Within MAP-21, a provision commonly known as Jason's Law required the USDOT to conduct a survey and assessment of truck parking needs across each state. Colorado has 147 commercial truck parking facilities with a total of 4,860 spaces, and 68 public truck parking facilities, such as rest areas, weigh stations, and welcome centers, with a total of 544 spaces (Figure 4.42).

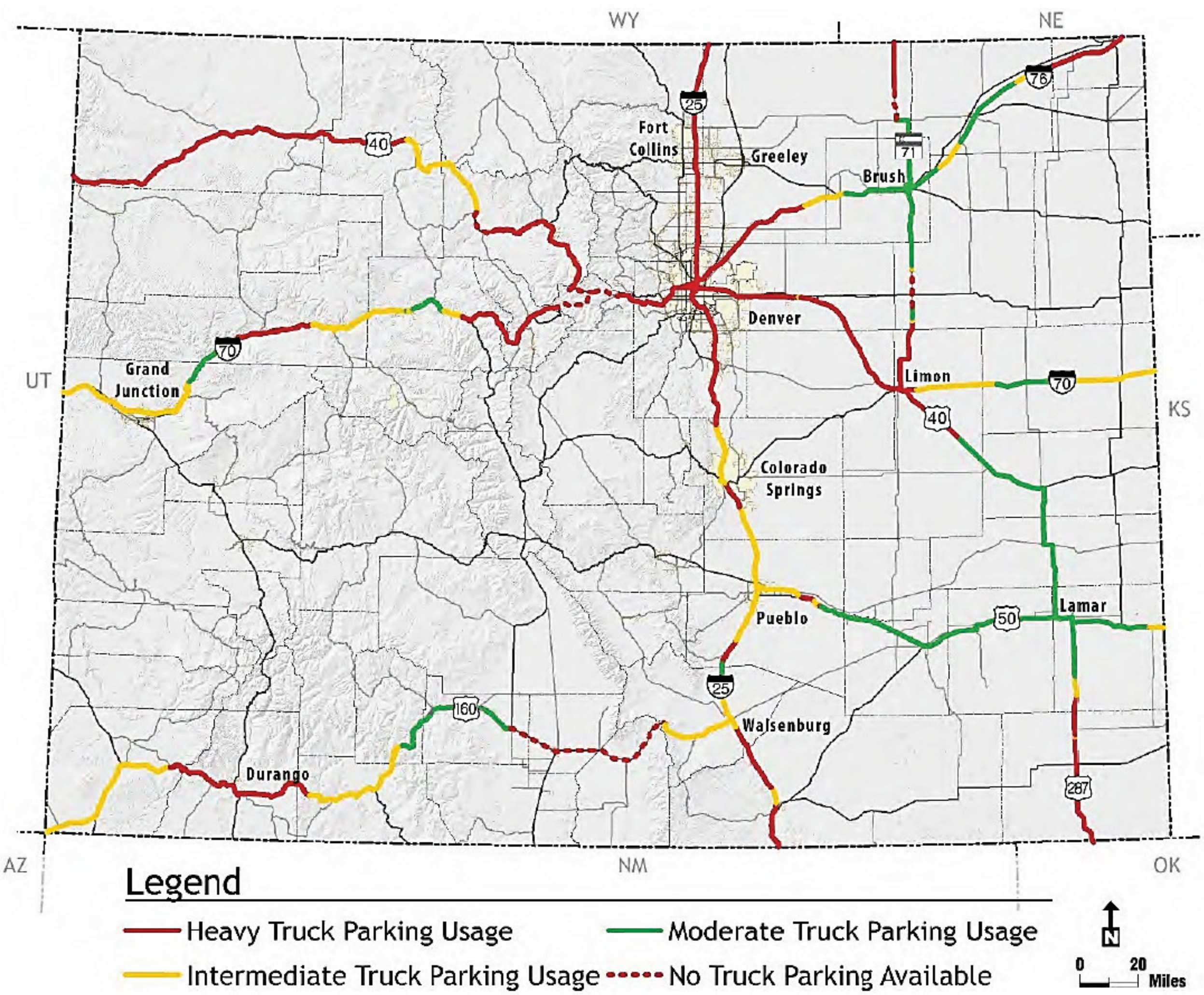
Figure 4.42 Colorado Truck Parking Facilities



Source: CDOT COTrip [I-70 - Golden Gate Petroleum | COtrip Traveler Information] ; Truck Parking Assessment [TPA 2019_Report_FINAL_reduced (1).pdf (colorado.gov)].

In 2019, CDOT conducted a Truck Parking Assessment (TPA) to identify statewide truck parking needs and network gaps on major freight corridors. This mirrors findings where most acute shortages are in major freight corridors and large metro areas. Figure 4.43 shows the study corridors and provides a summary of current usage ratings along those corridors—all of which demonstrate a need for additional truck parking spaces at some point. Notably, sections of I-70 and US 40 in Clear Creek County, US 160 in Costilla and Alamosa counties, and SH 71 in Washington County were identified as lacking available truck parking. Besides, most highway segments in the Fort Collins and Denver-Aurora regions exhibited heavy truck parking usage.

Figure 4.43 2017 Truck Parking Assessment Corridor Usage Levels



Source: CDOT, 2019, Colorado Truck Parking Assessment, https://freight.colorado.gov/sites/freight/files/documents/TPA%202019_Report_FINAL_reduced%20%281%29.pdf.

CDOT is currently working to implement truck parking solutions across the state with emphasis on the Heavy Truck Parking Usage corridor segments. For instance, in 2020, CDOT expanded truck parking at two rest areas—Sleeping Ute and Shaw Creek—along US Route 160, an important corridor for truckers delivering goods to southern Colorado and further southwestern United States. [66] Long-term maintenance costs, right of way, and land use issues were identified as the main challenges to expanding capacity.

Truck Parking Partnerships

Recognizing the need for innovative solutions to address the growing demand for safe truck parking, CDOT recently completed a "Truck Parking Public-Private Partnership Project Development Playbook", and is

[66] https://www.ttnews.com/articles/colorado-dot-expand-truck-parking-two-rest-areas.

exploring P3 solutions in high need areas, such as the Town of Bennett where the need for parking is high (see the case study on page 4-62). [67, 68]

Impacts of Climate Related Road Closures

Extreme weather conditions, wildfires, and other unplanned events can close roads temporarily, creating a large demand for truck parking until the road re-opens.

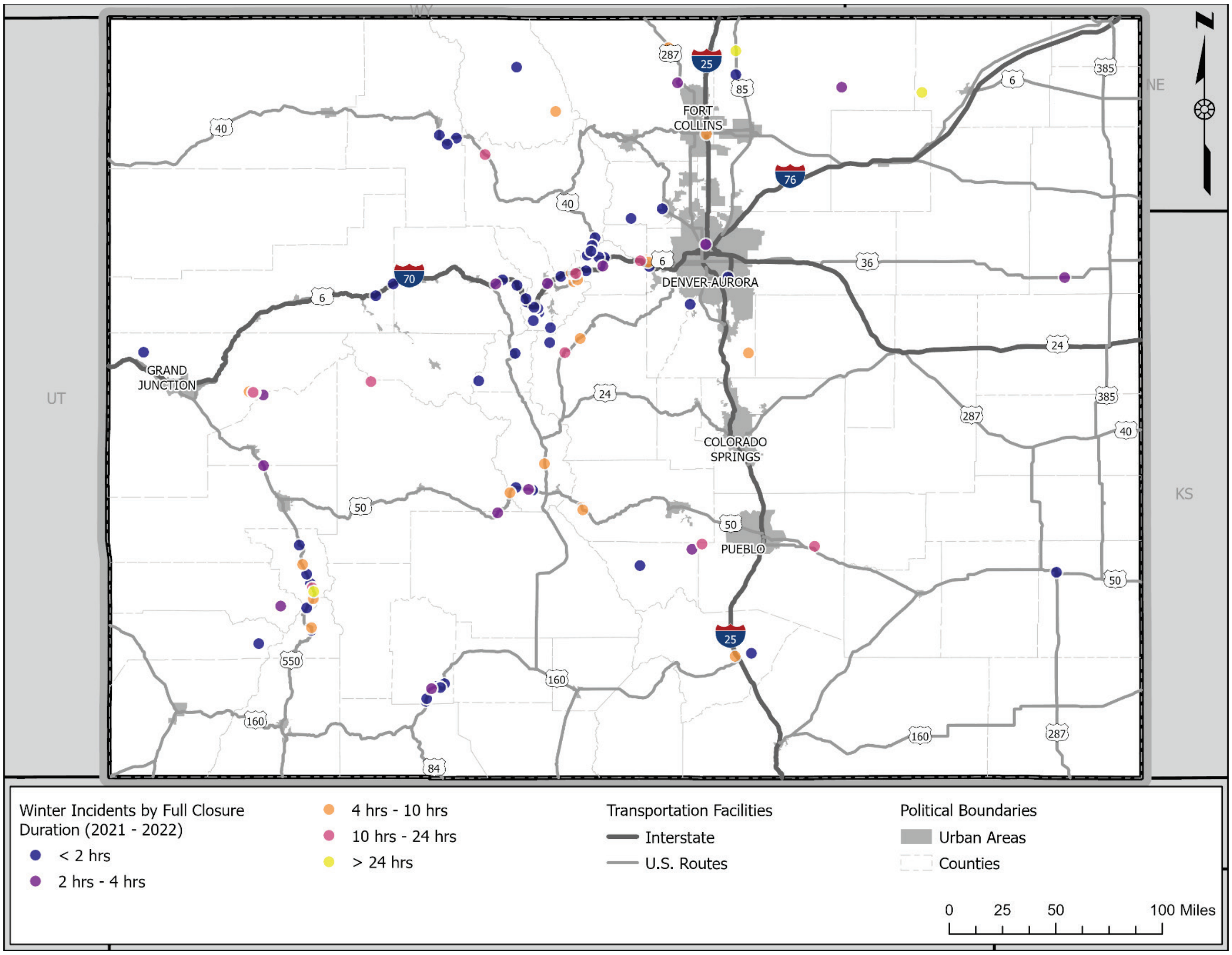
According to CDOT Open TMS Incident Summary, there were about 168 incidents caused by inclement weather that required full closure during 2021 – 2022. The related causes include adverse weather, avalanches, and icy roads, The 168 environmental-related incidents resulted in an average of 200 minutes of roadway full closure. Figure 4.44 shows the full closure duration for climate-related incidents happened since October 2021 to the end of 2022. There were several full closure that lasted longer than one day, which may resulted in truck detour. Geographically speaking, there is a higher concentration of climate-related incidents in the mountain region, especially along I-70.

32 out of the 168 full-closure incidents took place on I-70 in 2021 and 2022. Only six out of the full-closure implemented along I-70 were in 2021, and November and December are likely to be the peak period when full closures may take place. Along I-70, the segment to the east of Idaho Springs and Rifle to Destro Segment are the hot spots for climate-related full closures, at where 15 and 11 closures happened during 2021 to 2022, respectively,

[67] CDOT, 2022, https://freight.colorado.gov/sites/freight/files/documents/Truck%20Parking%20Playbook%202022.pdf.

[68] https://freight.colorado.gov/sites/freight/files/documents/NCTP%20-%202022%20presentation%20-%20Hurst%20-%20Colorado%20%282%29.pdf.

Figure 4.44 Climate-related Full Closure Incidents by Duration



Source: CDOT Open TMS Incident Summary Report.

Detention and Staging Parking

The TPA also highlighted the need for truck parking near industrial and warehousing land uses. Often times a truck will arrive to pick-up or deliver a load only to be turned away from the facility for a short period of time because the facility is not prepared for the truck (e.g., all the loading docks are occupied). The driver will typically attempt to remain nearby to respond immediately when the facility is ready, and in the absence of designated parking facilities or parking availability will park on the side of the road nearby. A 2014 FMCSA study and 2015 study conducted by J.B. Hunt showed an average lost time of one to two hours per pick-up and delivery. [69] The Town of Bennet, in a public private partnership with Love's and CDOT, were able to full a major truck parking need as demonstrated in the callout below.

[69] https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/mission/advisory-committees/mcsac/81096/mcsac-detention-times.pdf.

TRUCK PARKING P3 CASE STUDY: TOWN OF BENNETT

Opportunity: A Love's truck stop located in Bennett, a high need truck parking area, was willing to purchase adjacent land to expand their truck parking lot by 70 spaces.

Challenge: In order to accommodate the additional truck traffic forecasted by the expansion, improvements would be needed to a bridge on SH 79 over I-70 that provides access to the Love's. The cost of the bridge improvement, on top of the land purchase and parking lot expansion, rendered the project costs prohibitive for Love's.

Solution: CDOT signed a memorandum with the Town of Bennett, agreeing to pay for the bridge design with National Highway Freight Program dollars. The town made intersection improvements and will seek other funding and federal grant opportunities for construction of the bridge improvements. In 2013 CDOT completed a Planning and Environment Linkages (PEL) study that led to approval of bridge improvements. Love's commitment to build and maintain an additional 70 truck parking spaces, along with the needs identified in 2013 PEL, demonstrated a clear public benefit to move forward with the bridge improvements.

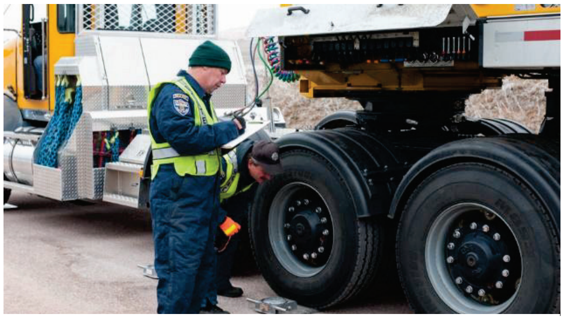
Outcomes: CDOT is facilitating the addition of 70 truck parking spaces in a high need area, at a lower capital investment than had they built it, and with no ongoing maintenance costs. The process will be documented to memorialize lessons learned; roles and responsibilities; and challenges and solutions; and to define a process that can be replicated to achieve additional truck parking successes across the state.

4.4.4 Enforcement Infrastructure Assets

Colorado State Patrol's Motor Carrier Safety Section is tasked with reducing commercial vehicle related crashes, hazardous materials incidents, and eliminating criminal interdiction activity in commercial motor vehicles. Highway infrastructure it uses to fulfill its mission include ports of entry, WIM stations, and mobile enforcement pullout sites described below.

Ports of Entry and Weigh-In-Motion Stations

There are ten stationary port of entry (POE) facilities located in key positions throughout the state on major highways that a motor carrier operator would use to either enter or exit Colorado. These are located at Cortez, Dumont, Fort Collins, Fort Morgan, Lamar, Limon, Loma, Monument, Trinidad, and Platteville (virtual station). Trucks are weighed and inspected to ensure they comply with size and weight requirements in place to protect infrastructure, and that the vehicle is in safe operating condition.

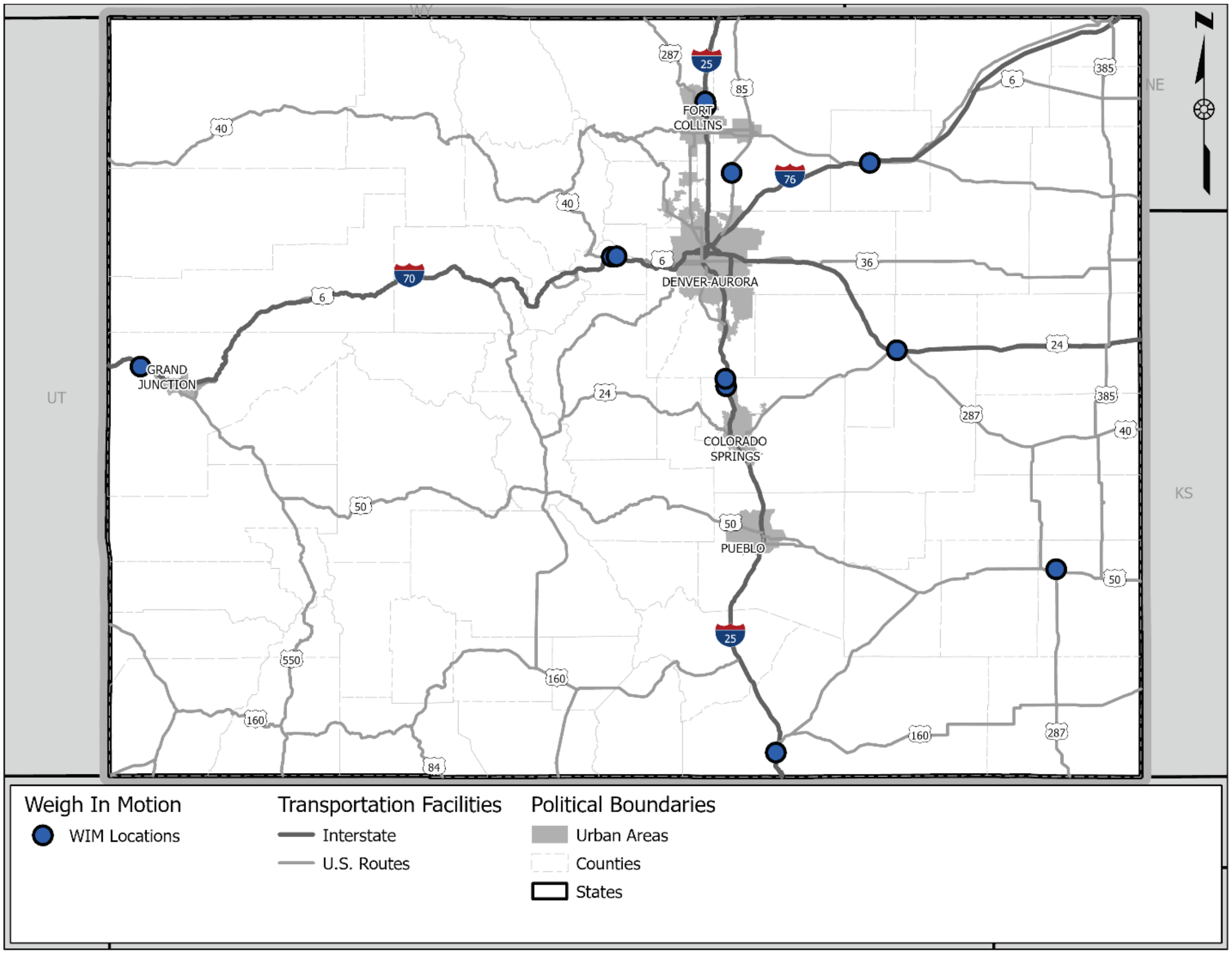


Source: CDOT.

Each POE includes a weigh-in-motion (WIM) system that collects each vehicle's axle and gross vehicle weights as they pass over the sensors or scales, and collect traffic data such as volume, vehicle classification, speed, and weight using pavement sensors. The WIM system weighs vehicles traveling at a reduced or average traffic speed without requiring the vehicle to stop. The WIM system for CDOT is operated by the Colorado State Patrol (CSP). The location of these WIM stations is determined by factors such as traffic volume and network locations. WIM stations are often installed on roads with significant traffic, such as interstate highways and major routes. High-traffic routes are more likely to have overweight vehicles, making monitoring vehicle weights on these routes important. Network location also plays a crucial role in deciding where to install WIM stations. WIM stations are mainly located within a road network, including entry and exit points to other states. In addition, WIM stations are also used to keep track of the data on axle loads, traffic patterns, and other relevant information.

In Colorado, there are 12 weigh-in-motion ramps, which primarily connect the freight network around Colorado (Figure 4.45). The installation of WIM stations support the Colorado Freight Plan Goals, which is to enhance safety and security for commercial carriers and improve mobility and efficiency of goods movement.

Figure 4.45 Weigh-In-Motion Stations



Source: CDOT Freight Mobility and Safety Office Inventory, 2023.

CDOT is using $2 million of NHFP on the Weigh-In-Motion Program and Safety Enhancement project to conduct a site inspection of each POE location and provide a full analysis of the current state of the WIM system. Upon completion of analysis, CDOT will prioritize the needs, fund the repair or replacement of WIM scales, and add safety enhancements such as lighting or barriers as needed.

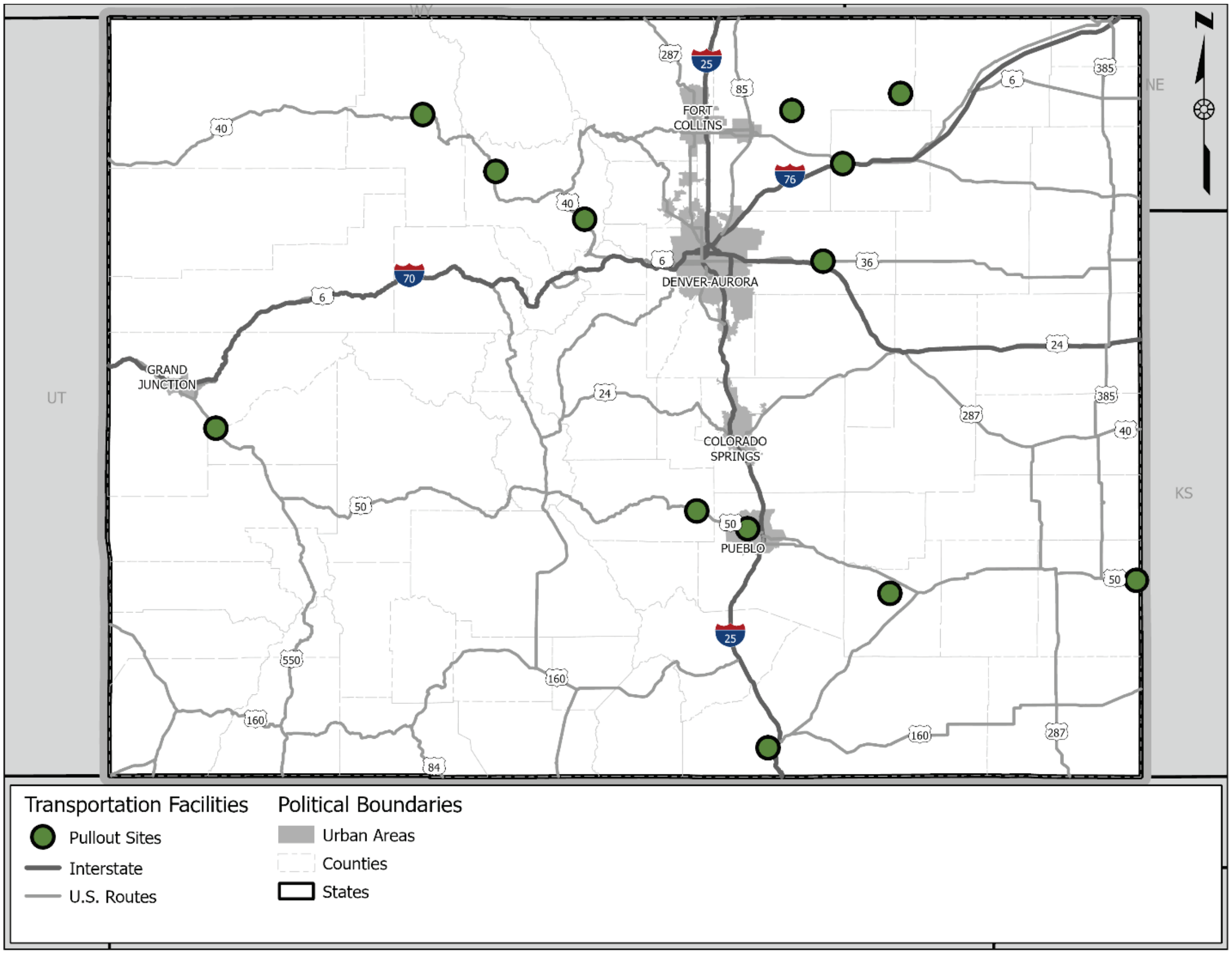
Mobile Enforcement Pullout Sites

CDOT constructed for Colorado State Patrol and Port of Entry 10 Mobile Enforcement Pullout Sites for performing mobile truck enforcement in needed areas around the state, shown in Figure 4.46. An 11th is under construction, scheduled to open early 2024. These pullouts may have other temporary uses but enforcement safety is the primary focus. Oversize loads may also get inspected or do temporary staging at these locations as well. CDOT owns the ROW for these sites which are typically 500 feet long

Source: CDOT.

with 100-foot tapers on each end, for 300 feet of operating area, and that are 14-20 feet wide. The locations were selected by a group from CSP, POE, and CDOT.

Figure 4.46 Mobile Enforcement Pullout Sites



Source: Colorado Department of Transportation, 2023.

4.4.5 The Mountain Rules Campaign

The leading edge communication program developed by CDOT is an important operational support asset. This program is a comprehensive, strategic and safety-focused effort to inform and educate in-state and inter-state trucking companies and drivers on the challenges of driving in Colorado's mountains. It includes information on preventing and avoiding hazards, resources to consider, and a consistent reminder to drive slowly and steadily to be safe for the long haul. CDOT's partners in this effort are the Colorado State Patrol, Colorado Motor Carriers Association, and in-cab driver alert providers, PrePass Safety Alliance and Drivewyze.

The Mountain Rules is an industry-informed effort. Using a focus group with the help of the Colorado Motor Carriers Association, CDOT was able to identify the best approach for providing alerts, including timing of advance notifications, locations and frequencies for reminders, and the type of alerts (audio and/or visual). Driver alerts are subscription-based and include in-cab driver alerts that notify drivers of steep grades, locations of runaway truck ramps, and areas for brake check and cooling.

The Mountain Rules website also includes instructional videos titled:

- The Mountain Rules
- Summer Driving and Avoiding Hot Brakes in Colorado
- Truck Safety and Winter Driving in Colorado
- Construction Zone Safety in Colorado

Source: https://freight.colorado.gov/mountain-rules/mountain-rules.

5

Assessing Safety, Mobility, and Asset Condition on Colorado's Non-Highway Freight Networks

Colorado's highway network serves the majority of freight within the state, including providing critical first- and last-mile movements. Additional freight services are provided by the rail and air transportation systems. These systems allow for multimodal options when transporting goods, offering shippers different shipping times, rates, and potentially minimizing risk to their supply chains while simultaneously removing additional truck trips from Colorado's highways. Chapter 5 details the freight rail operators in Colorado and major freight airports along with other non-highway freight infrastructure such as inland ports, intermodal terminals, and strategic military transportation facilities.

5.1 Colorado's Freight Rail System

Rail freight moves shipping containers and truck trailers by rail. Unlike trucks, freight railroads can ship larger and heavier volumes, removing several trucks off the road. Railroads are at least three times more fuel efficient compared to trucks and reduce greenhouse gas emissions by up to 75 percent on average. Freight rail also has the potential for intermodal, transloading between trains and container ships or transferring containers from trucks to trains.

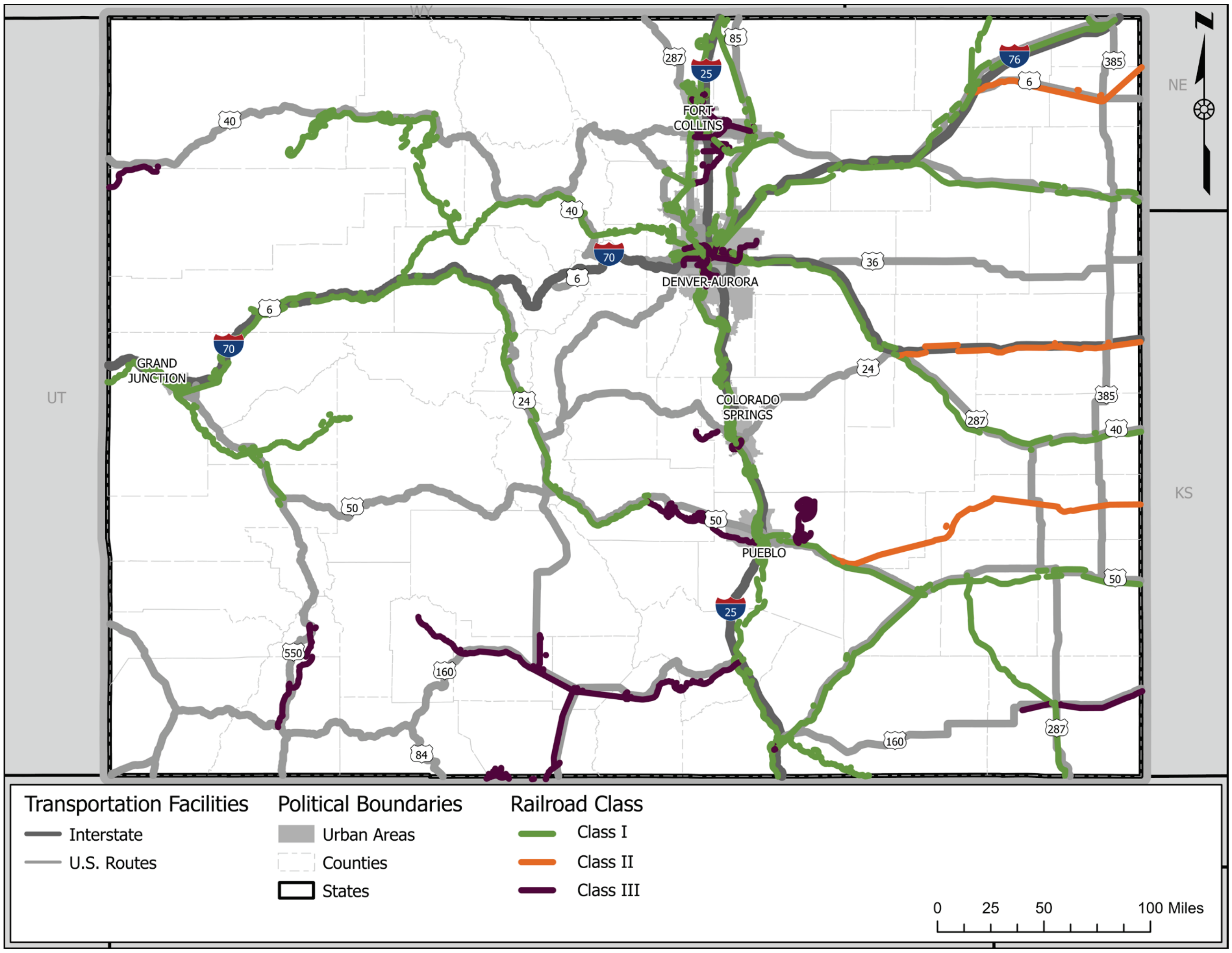
In Colorado, fourteen privately owned freight rail companies operate over 2,545 route miles of track. The STB categorizes railroads into classes determined by operating revenue. Colorado has two Class I railroads, three Class II or regional railroads, and nine Class III or short line railroads (Table 5.1 and Figure 5.1). Colorado's two Class I railroads are BNSF and UP. These rail systems are the primary arteries for rail cargo traveling to and from Colorado and provide important connections for rail traffic to the national rail networks and international markets. Compared to the national operations of BNSF or UP, Colorado's short line railroads focus on regional and local services and provide rail access to specific customers and regional industries, usually in connection with Class I carriers. Ten short line railroads operate line-haul services that connect multiple customers to the national rail network. Both Denver Rock Island and Colorado & Wyoming Railway operate switching or terminal railroads that serve a specific facility or rail yard.

Table 5.1 Short Line and Regional Railroads in Colorado

Railroads	Type	Miles Operated in Colorado in 2021
Kansas and Oklahoma Railroad	Regional	3
Kyle Railroad	Regional	84
Nebraska, Kansas, & Colorado Railway	Regional	68
Cimarron Valley Railroad	Short Line	28
Colorado & Wyoming Railway	Short Line	5
Colorado Pacific Railroad	Short Line	122
Colorado Pacific Rio Grande Railroad	Short Line	154
Denver Rock Island Railroad	Short Line	6
Deseret Power Railway	Short Line	22
Great Western Railway of Colorado	Short Line	80
Rock & Rail	Short Line	55
San Luis Central Railroad	Short Line	13
Utah Railway	Short Line	32

Source: Association of American Railroads (AAR).

Figure 5.1 Colorado's Freight Rail System



Source: Federal Railroad Administration.

5.2 Freight Rail Inventory and Needs

5.2.1 Freight Rail Movements

In 2021, Colorado's freight railroads moved more than 44.5 million tons of goods and products into, from, and within the state (excluding through movements). Railroads transport approximately 19 percent of all freight handled in Colorado. For key commodities such as coal, grain shipments, chemical products, and lumber, railroads handle a significant portion of all movements.

Over two-thirds of rail cargo volume in Colorado is generated by "through movements" or rail traffic that passes through the state enroute to other destinations. Rail flows including pass through reached 143.2 million tons, accounting for 37 percent of the total rail freight. Much of this through traffic is north-south movements of coal and other commodities.

Several states show up as key trading partners across multiple commodities in both inbound and outbound shipments. Wyoming, Texas, Illinois, and California are major trading partners for Colorado. Improving and expanding rail connections to these states is critical for Colorado's key industries and producers. Outbound rail movements and rail services are particularly important to Colorado-based producers, farmers, manufacturers, and transportation and logistics companies. Goods and products made in Colorado provide significant value-added to local economies and contribute to Colorado's gross economic output. Ensuring that these industries have access to efficient and cost-effective rail service is vital. For example, much of eastern Colorado's winter wheat harvest is shipped by rail to Texas for international export. Coal produced on the Western Slope fires power plants or is exported to international markets through California and Illinois. Bulk products such as chemicals, pulp paper, and waste and scrap are shipped by rail to processors and manufacturers in California and Illinois. Manufacturers across Colorado rely on rail service to move machinery and equipment to international seaports and distribution centers in Iowa, Texas, Illinois, and other gateways.

5.2.2 Freight Rail Needs and Capacity Constraints

The following section summarizes key issues and related opportunities for freight rail in Colorado. These issues will be monitored by CDOT staff, addressed through coordination with rail partners, acted on in implementation efforts, and integrated into future state and regional planning efforts.

Improvements and Planning for Rail-Served Industrial Developments—Rail-served industrial sites and future rail-related development zones present significant opportunities for economic development in Colorado. Regional economic development organizations in some parts of the state report challenges attracting and retaining industrial businesses in need of rail access. Agricultural producers rely on rail access at grain elevators and intermodal facilities. Many former or current grain elevators are underused and could be redeveloped to improve access for existing rail customers and to expand facilities and infrastructure to attract new businesses.

Redeveloping these sites, while preserving rail access, presents a significant opportunity for communities on the Eastern Plains and San Luis Valley. Pueblo and Colorado Springs are home to current and former military installations, defense contractors, and rail infrastructure that could be expanded to serve defense and homeland security industries and entirely new businesses. In particular, the former Pueblo Chemical Depot, or PuebloPlex, offers tremendous opportunity for industrial development with improved rail access. In northern Colorado, rail-served industrial sites have recently been developed, such as the Great Western Industrial Park, and other new sites are being planned such as a BNSF joint development opportunity in Hudson.

The Western Slope sits along the UP main line with access to BNSF and has significant railroad infrastructure and assets. Manufacturing activity is growing in Grand Junction, and potential industrial development sites could be planned and developed to facilitate future growth. With significant growth expected in the Front Range economy and continued growth in consumer spending, new intermodal facilities, distribution and logistics centers, and transload facilities in areas near population centers will be needed.

Private railroads offer economic development and real estate services and actively coordinate with local governments and businesses to identify, develop, and promote industrial properties. UP, BNSF, and short line railroads provide site selection information and resources that are available for Colorado businesses and economic development organizations. To support these efforts, economic development opportunities can be better integrated into transportation planning so that rail-related projects and sites are identified early in the planning and project development processes.

Additionally, providing public assistance or funding support, through a grant or a loan program, would enable local governments to capitalize on redevelopment opportunities and jointly fund needed improvements in partnership with railroads and businesses. States with active freight rail assistance programs offer subsidized loans or cost-sharing between state and local governments and private railroads to fund economic development related infrastructure or to track improvements. These programs are typically funded with state general fund revenues and, in some cases, through Federal funding, including the National Highway Freight Program.

Targeted Freight Intermodal Connectivity Improvements—The National Highway Freight Program, funded through the FAST Act, allows Federal funding for improvements within private intermodal facilities and rail yards, as well as highway access improvements to rail-served intermodal facilities. Intermodal facilities play a critical role in Colorado's transportation system, link modes to enable efficient freight handling, and generate value-added economic activity. Currently, CDOT's statewide and regional planning processes have not identified significant needs for access, connectivity, or improvements to intermodal facilities. By strengthening planning processes to engage economic development organizations and private industry, improvements may be identified in the near future and more readily considered for public funding. The CFP identifies future project areas, including rail-served intermodal facilities eligible for funding under dedicated Federal freight funds.

Addressing Rail Service Constraints—Private railroad operators own, operate, and maintain Colorado's freight rail system. Railroads invest significant resources into maintaining and improving the state's rail network without public funding support. To remain competitive with trucking and to meet modern track standards, short line railroads need public funding and assistance to upgrade track and infrastructure. The State of Colorado has a clear interest in supporting the continued operation of short lines because they are critical to regional industries and provide economic development opportunities and direct economic benefit to regional economies.

For Colorado to remain competitive and to serve rail customers more efficiently, capacity constraints on existing systems must be identified. Necessary improvements may be funded by private railroads or as possible through partnerships among CDOT, local or regional agencies, and private railroads. For example, vertical clearance of tunnels in Colorado limits the ability of rail to ship double-stacked shipping containers and to efficiently handle intermodal traffic. With a growing consumer market, intermodal rail will be critical to addressing future freight demand. Wyoming and Kansas are investing in major intermodal terminals and inland ports to serve intermodal shipments from West Coast seaports and distribute into Colorado markets. Colorado could capture the value-added economic activity and high-wage logistics jobs associated with terminal activity by mitigating rail capacity constraints, upgrading track conditions, and supporting industrial rail development.

Capacity constraints on Colorado's freight rail system include:

- **Vertical clearance** is the distance between the rail bed and the bottom of overhead structures. To allow unrestricted access for all standard rail car configurations, including double-stacked intermodal cars and tri-level auto carriers, 23 feet 6 inches is needed between the rail bed and the underside of any overhead structure. For lines handling intermodal traffic, AAR recommends vertical clearances of 22 feet 6 inches to accommodate double-stacked domestic containers. For intermodal shipments, double-stack clearance is rapidly becoming the national standard because it greatly improves capacity and thereby reduces the cost to ship goods by rail, making double-stack rail services more competitive with trucks for customers' shipments while taking long haul movements off highways. Most of Colorado's Class I network allows double-stack container configurations. However, the only continuous east-west rail corridor in the state is UP's Moffat Corridor between Denver and Salt Lake City, Utah. Several vertical clearance restrictions on this line prevent the movement of double-stacked cars.

- **Weight limit** is the gross weight of a rail car plus any cargo carried. The current standard is 286,000 pounds (286k lb.), with some portions of track on heavily used corridors now allowing 315k lb. Most of Colorado's Class I rail network can carry 286k lb. cars, with some sections of UP's network able to handle 315k lb. Some sidings and branch lines on both BNSF and UP rail networks are not currently 286k lb. capable. Short line railroads operate on track that is often older and not updated to modern weight capacity standards. A significant portion of Colorado's short line network cannot carry 286k lb. cars. This limits the ability of short lines to interface directly with Class I rail networks for many carload shipments and to serve customers safely, efficiently, and rapidly.
- **Track capacity** provides railroads with operating flexibility and allows a limited number of trains to be handled on a given line. Sidings or passing tracks that allow trains to either overtake or pass one another in an area with only a single main line typically can improve flexibility and capacity. In industrial areas alongside busy main lines, this category includes tracks that are needed to efficiently serve customers without delaying through traffic. Additional tracks or sidings on freight rail corridors may be needed to accommodate interoperability of future passenger rail service with existing freight service. Extended sidings may also be required to accommodate longer freight trains. Because sidings are nearly 2 miles long, these must be carefully located and designed so that something positive for rail does not create a problem for cars and trucks.
- **Terminal and yard capacity** addresses the number of cars that can be processed or stored at a facility. Operational strategies and efficiency at the terminal or yard facilities can have significant impacts on overall line capacity. Some short line railroads in Colorado provide car storage to act as relievers for Class I railroads or rail customers owning or leasing their own railcars. Should rail traffic increase across lines, this storage strategy may not be feasible in the future as the track capacity now used for car storage will be needed for additional train movements.
- **Rail line operating speed** dictates the average speed that trains move on a corridor with potential impacts on capacity and the ability to move higher-value, time-sensitive goods. Several factors influence operating speed, including train makeup, speed limits, track conditions, topography, and signaling. Due to curves, grades, and operations through metro areas, Colorado's major main line and some short line railroads are subject to safe operating speed limitations in some areas. Average operating speeds are a key metric for railroads in the quest to deliver goods on-time to customers.
- **Traffic control and signaling systems** help ensure safe operations and interoperability of passenger and freight train speeds. Traffic control systems efficiently improve capacity use. Federal law requires Positive Train Control (PTC) and other emerging technologies on some, but not all, subdivisions and lines of Colorado's Class I rail lines. Colorado and rail partners are committed to implementing and testing innovative safety technologies on other rail lines across the state.

- **Land use development and encroachment**—As areas surrounding current rail infrastructure are developed for residential, commercial, or other incompatible land uses, the ability of railroads to fully use or expand existing infrastructure and assets may be limited. Mixed-use development near existing rail assets may impose constraints on rail operations related to noise, safety, and hazardous materials. Improved zoning, regional freight land use planning, and continued coordination between local agencies and private railroads can mitigate incompatible development (such as schools, hospitals, dense residential developments, etc.) from occurring along or near rail lines.
- **Preservation of Freight Corridors and Assets**—When a rail line is no longer considered economically viable for a Class I railroad to operate, the result is often the sale or the lease of the line, usually from Class I railroads to short line or regional railroad companies. The only other alternative is to file a formal request for abandonment to the Federal STB. Rail corridor abandonments can have significant impacts on the statewide multimodal transportation system and on local and regional economies. With the loss of rail service, freight previously being moved by rail must be moved by truck, causing additional deterioration (i.e., pavement surface condition and/or traffic volumes) of local roadways and state highways. Many businesses, particularly in rural areas, cannot compete without rail access and could be at risk of failure or relocation within or out of the state. Once a railroad corridor is abandoned, it is often cost-prohibitive to return to service and is unlikely to be available for any motorized transportation purpose, particularly if rail tracks are salvaged or right-of way is sold.

  The ability to respond quickly to a potential abandonment is an important factor in ensuring corridor preservation. A railroad may file a Notice for Exemption or Petition for exemption with the STB if a track has not been used for two or more years or if the track has so little traffic on it that the carrier could not be making a profit. Following this administrative request, abandonment authorization from the STB can take place in as little as 90 days. The Colorado legislature created the State Rail Bank in 1998 as a vehicle to preserve rail corridors from abandonment. The State Rail Bank is currently unfunded, and the process of acquisition must be coordinated with CDOT, the Colorado Transportation Commission, and the legislature. Concepts and funding options that enable flexibility and rapid response to abandonment and acquisition should be considered.

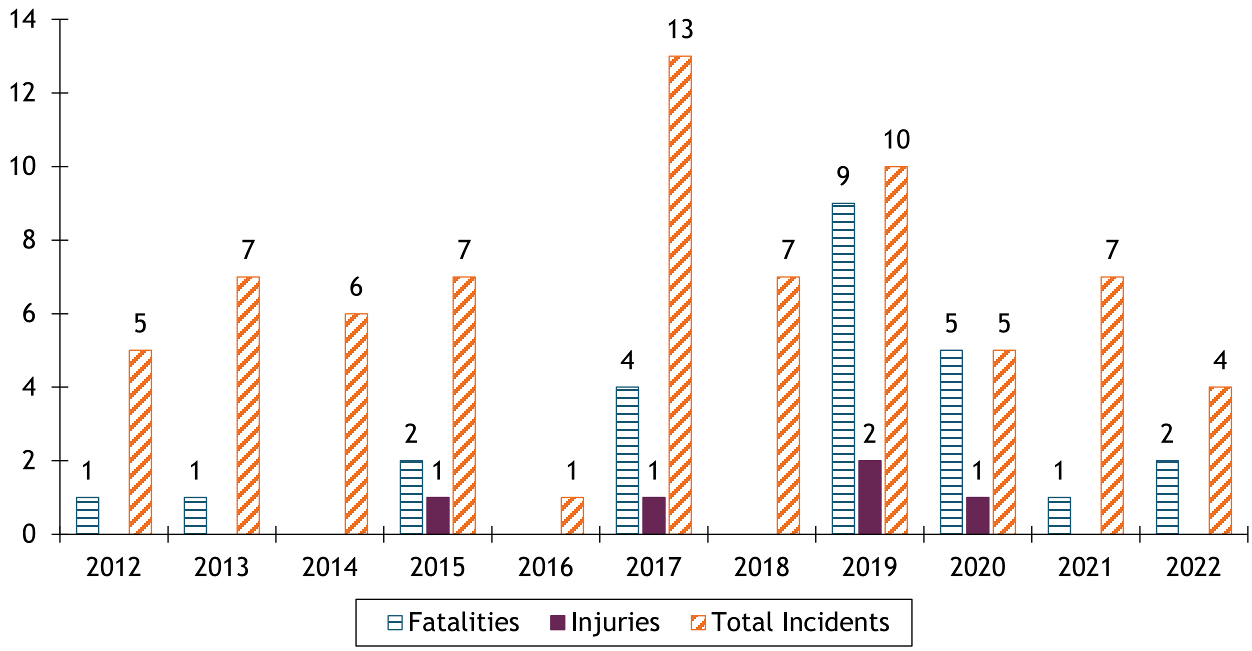
  Additional freight rail assets and infrastructure may also be identified for sale by railroads. These assets represent significant opportunities for the state and could be leveraged and repurposed for economic development, multimodal transportation centers, intermodal yards, or passenger rail stations. In 2015, UP closed the Burnham Yard repair facility in Denver, which is slated for sale in 2018 or soon thereafter. This 70-acre parcel is zoned for industrial development, has significant rail infrastructure, but is near rapidly urbanizing and expanding residential neighborhoods in Denver. Regional Transportation District (RTD) is pursuing plans to purchase a portion of the property to support future light rail, but the future of the remainder of the site is uncertain. The State of Colorado could consider identifying and monitoring freight rail assets and infrastructure of strategic value (in addition to rail corridors) and consider the purchase or reuse of these sites for public benefit.
- **Safety and Security**—Freight rail safety and security issues continue as fatalities and serious injuries at railroad-highway crossings and due to trespassing have not substantially declined over the past decade. The State of Colorado and CDOT can consider additional support, funding, or legislative action to promote safety initiatives. Current programs and initiatives where continued support and additional funding or resources are important include security task forces, trespassing legislation, additional funding for rail crossings, and expanded support for Operation Lifesaver and other educational

programs. With a rapidly growing and urbanizing population along the Front Range and in surrounding regions, the safety risks at railroad-highway crossings will grow. Major new planned developments along existing rail lines call for additional rail crossings, but financial support for grade separated crossings is underfunded. The State of Colorado recently funded the PUC's crossing program for the first time in over a decade, but available monies are well below anticipated local needs.

5.2.3 At-grade Rail Crossings

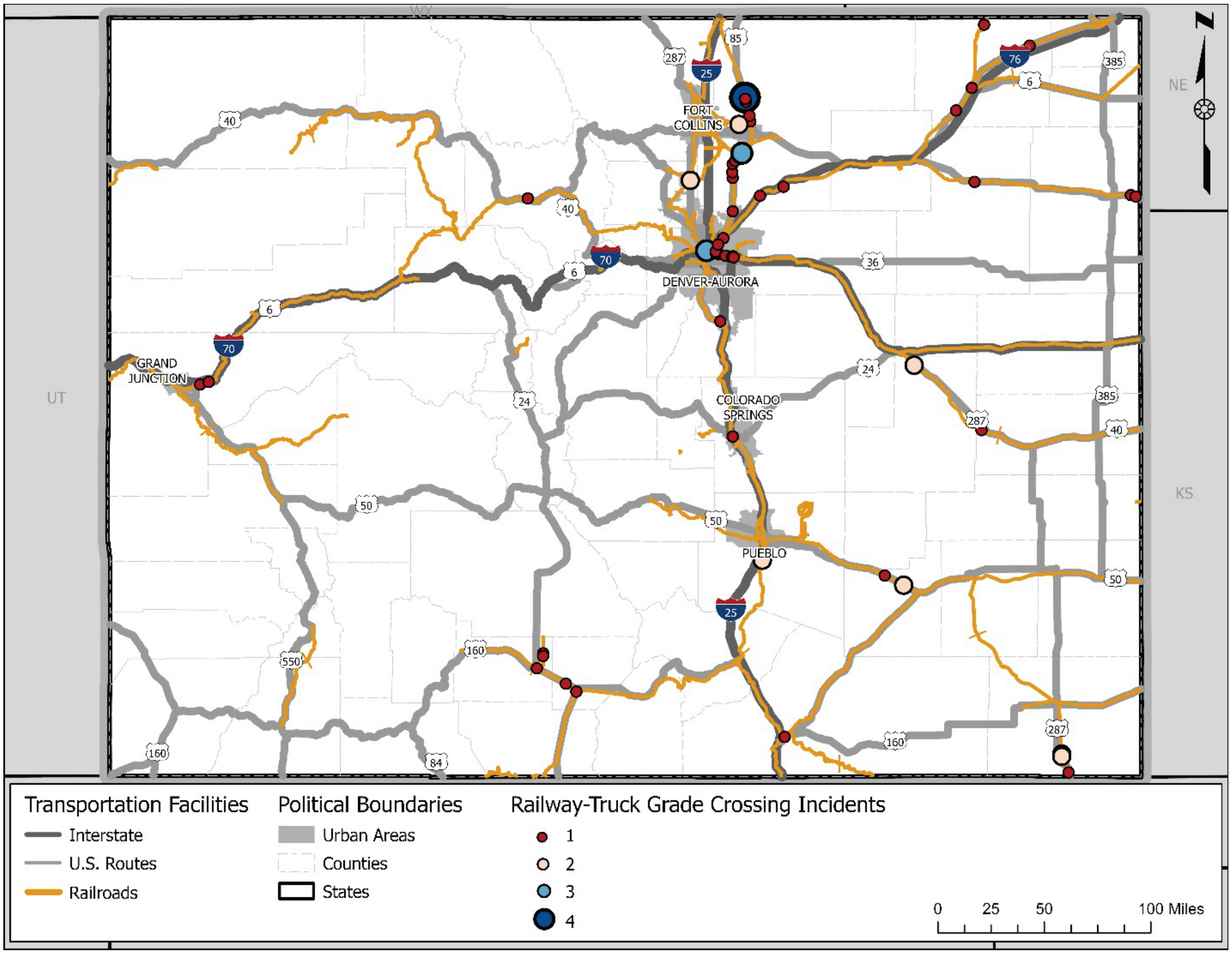
Railway-truck crossing safety incidents in Colorado peaked at 13 in 2017 before declining to 4 in 2022. Between 2012 and 2022, there were 58 incidents involving trucks and truck-trailers. These incidents generally occur at public at-grade rail crossings and involve accidental crashes when trucks attempt to circumvent safety devices, when trucks stall on tracks, or when truck drivers fail to yield at grade crossings. Other incidents may occur because of intentional behavior by a driver. Figure 5.2 shows that fatalities and injuries resulting from rail-truck incidents have fluctuated throughout the decade. A single incident can result in multiple injuries or fatalities. Figure 5.3 maps out the railway-truck incidents across Colorado, and indicates at-grade crossings where multiple incidents have occurred. Most incidents are concentrated in grade crossings near U.S.-85 and I-70 in Denver and north to Fort Collins. Grade crossings in Ault, Gilcrest, and Denver had the highest number of reported collisions.

Figure 5.2 Railway-Truck Total Incidents, Serious Injuries, and Fatalities in Colorado, 2012-2022



Source: Federal Railroad Administration.

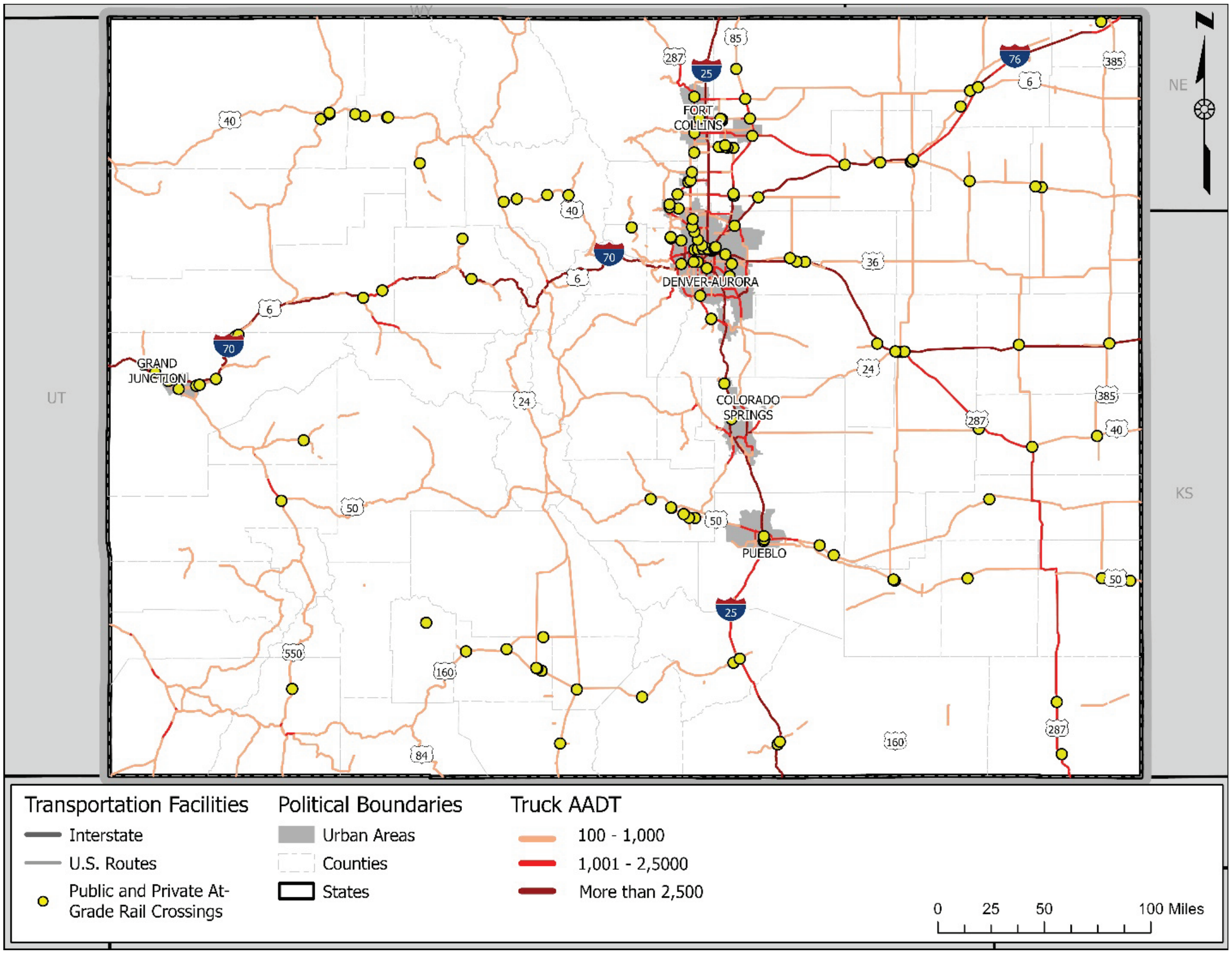
Figure 5.3 Railway-Truck At-grade Crossing Incidents, 2012 to 2022



Source: Federal Railroad Administration—Highway-Rail Grade Crossing Accident/Incident Report. https://data.transportation.gov/Railroads/Highway-Rail-Grade-Crossing-Accident-Data-Form-57-/7wn6-i5b9.

Commercial trucks may be at a greater risk at rail crossings. Trucks stall on railway-highway crossings or fail to completely clear a crossing on a congested roadway. Northeast Colorado has both a high number of public and private at-grade rail crossings and significant truck travel on rural roads due to oil and gas development (see Figure 5.4). Many at-grade crossings in rural areas have only passive warning signs. With a growing population and increased residential development along major travel corridors, the number of at-grade crossings and the risk of incidents at all crossings may increase. CDOT, through the FHWA Section 130 Program, seeks to improve crossing safety at high-hazard locations. Local governments and private railroads also improve crossings and maintain warning devices to improve roadway safety.

Figure 5.4 Public and Private At-Grade Railway-Highway Crossings at Major Truck Corridors, 2021



Source: Federal Railroad Administration.

In addition to safety hazards, at-grade crossings also result in truck delays that on some local roads can exceed one hour when trains are loading or unloading nearby. Several examples in Commerce City are shown in Figure 5.5 where the UP line crosses 96th Avenue, 104th Avenue, and 112th Avenue which are often blocked. CDOT is working with the local business community, municipality, freight industry, and railroad to identify low-cost solutions as alternatives to expensive grade separations. For instance, installing a low-cost culvert over the Burlington Ditch would connect Yosemite Street between 96th Avenue and 88th Avenue creating an alternate route for trucks to access I-76 entirely through industrial land uses. CDOT is also working with in-cab communication providers to develop push notifications to truck drivers on the status of trains at specific crossings to indicate whether a train will block the road for longer than 30 minutes, less than 30 minutes, or only a few minutes as it passes through. This information will enable drivers to plan their route before getting caught at a blocked railroad crossing.

Figure 5.5 At-grade Railway-Highway Crossings on Local Roads

5.2.4 Rail Safety

Railroads can pose risks to the traveling public, railroad workers, communities, and environment. Train accidents, including derailments, can be potentially serious. Safety accidents involving trains and in rail yards can cause serious injuries or fatalities to workers. Inattentive drivers and trespassers also create risks for railroad operators and can cause serious incidents to occur. Technologies to improve safety, including PTC, are increasingly being implemented. Federal, state, local, and private programs and initiatives bring partners and resources together to improve safety and security on Colorado's rail systems. Train incidents reported to the Federal Railroad Administration (FRA) include collisions, derailments, or other accidents. Between 2017 and 2021, approximately 54 percent of train incidents were due to human factors, while 27 percent were due to track issues. These incidents are primarily located within train yards (47 percent). The vast majority of train accidents involved a derailment (over 80 percent).

Rail transport of products such as crude oil, chemicals, waste, and other goods is generally safer than moving these hazardous materials by truck. Hazardous materials are transported in specifically designed and regulated tanker cars. Colorado freight rail operators must comply with Federal regulations within the FAST Act and rules developed by the Pipeline and Hazardous Materials Safety Administration (PHMSA). In

Colorado, a joint agency authority is responsible for receiving and tracking information about crude shipments. These joint agencies are the Colorado Department of Public Safety and the Colorado Department of Public Health and Environment. These agencies have developed procedures for emergency preparedness for various types of explosives or volatile liquids, such as chlorine, which have also been the subject of similar rail safety concerns in the past.

With growth in the oil and gas industry, Colorado is experiencing an increase in crude oil and petroleum products produced in the state and shipped by rail. With increased development in formerly industrial areas, some Denver neighborhoods have rail lines, residential development, and commercial properties all located in close proximity. Most hazmat loads are flammable liquids, including crude oil, ethanol, and oil- and gas-related liquids, that present risk when traveling on rail lines in densely populated areas.

Table 5.2 reports FRA data on hazardous material incidents in Colorado over the past decade. Colorado has not experienced serious derailments or accidents involving the release of hazardous materials. When accidents do occur, they can pose significant threats to communities and environmentally sensitive areas. Most incidents involving damaged or derailed cars occur in rail yards and terminals. Private railroads are investing to upgrade equipment to meet modern safety standards and implement safety protocols.

Table 5.2 Railroad Incidents Involving Hazardous Materials in Colorado, 2011-2021

Incident	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Hazmat Cars Damaged or Derailed	11	4	4	10	5	4	17	6	1	9	0	71
Cars Releasing Hazmat	0	0	0	1	0	0	0	0	0	1	0	2

Source: Federal Railroad Administration.

5.2.5 Freight Rail Trends

The production and consumption of commodities shipped by rail in Colorado depend on broad macroeconomic conditions. Changes in energy prices can result in significant shifts in demand for crude petroleum, natural gas, and coal. Weather and global food prices can result in large year-to-year changes in Colorado's agricultural crop and livestock production. National and state economic conditions can directly affect the quantities of consumer goods such as automobiles and household products, as well as construction materials and equipment shipped by rail. Long-term forecasts of freight movements are highly uncertain and available data is based largely on historic trends, rather than on forecasted changes in Colorado's industry composition or global and state economic conditions.

Private railroads produce independent estimates of future freight rail demand, which are used when making capital investments and strategic business decisions. By 2040, through rail movements are expected to decline to 137.9 million tons from $143.2 million in 2021. Much of the decline in freight rail tonnage is attributable to continued declines in coal production from Colorado and the long-term decrease in coal as a fuel for electricity generation. This reflects the significance of coal traffic in total tonnage carried by freight rail. Additional growth in non-coal traffic could come from increased use of short line railroads to move key agricultural and natural resource commodities and to facilitate movements to and from new industrial customers to Class I railroads. Intermodal rail traffic, including shipping containers from international ports, accounts for a relatively small proportion of Colorado rail traffic. With a growing consumer market and millions of new residents by 2040, Class I intermodal service to and from Denver may expand, resulting in additional rail movements not accounted for in current projections.

5.3 Colorado's Air Cargo System

5.3.1 Air Cargo Movements

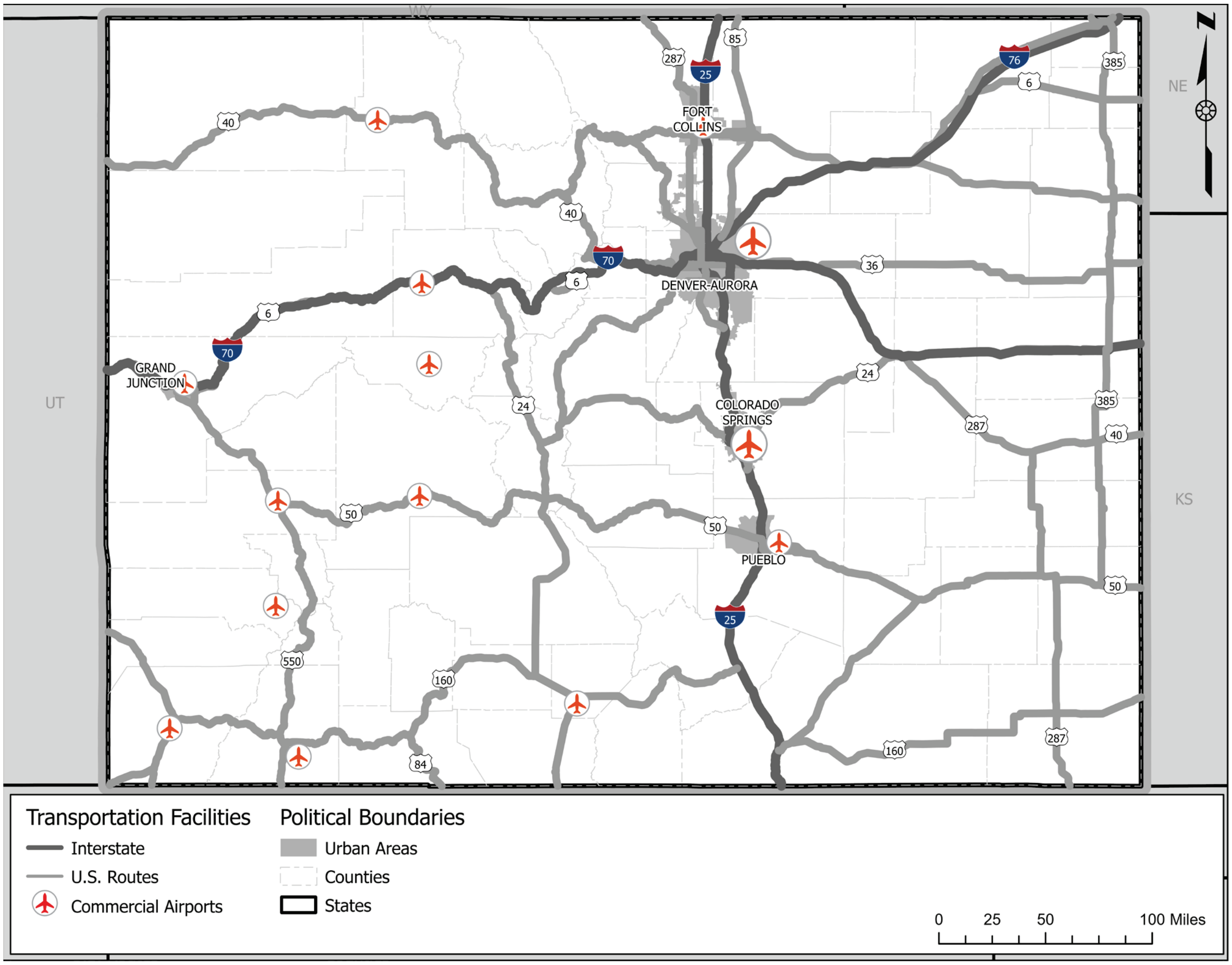
Airports play a key role in Colorado's economy. According to the *Colorado Aviation Economic Impact Study*, air cargo movements generate $4.4 billion in business revenues to the state. Air cargo provides a fast and reliable supply chain option to businesses shipping low weight, high value products such as electronics, semiconductors, pharmaceuticals and small merchandise.

Air cargo service is executed with different operational patterns depending on the company, business model and airline. Air cargo is generally classified into different subset categories. Integrators, the dominant carriers in the domestic market, use air cargo as one piece of a broader network of freight service that includes multiple modes and segments of freight movement. Examples include United Parcel Service and Federal Express. Belly Cargo Carriers move air cargo in the bottom of the fuselage of a passenger-carrying aircraft. Commercial airlines that carry passengers frequently provide belly cargo service as an extra revenue source and a means to maximize asset utilization. Nationally, the majority of belly cargo is international because the wide body aircraft flown internationally offer more cargo carrying capacity than the narrow body aircraft flown domestically. [70] All cargo airlines move cargo either as charters or on regularly scheduled routes. All cargo airlines do not move people and are not involved with the movement of freight outside of the aviation mode. Combination Airlines offer any combination of passenger, belly cargo and pure air freight services. Aircraft, Crew, Maintenance, Insurance (ACMI) are cargo aircraft leasing services that provide capacity for air cargo operators through contracts that provide an aircraft, qualified crew, certified maintenance of the aircraft and requisite insurance. ACMI serves a mechanism for capacity to be added and moved to different locations across the world depending on demand. Amazon Air is unique in that it is not only an Integrator but by extension is the beneficial cargo owner and retailer.

Colorado is home to 14 commercial service airports (see Figure 5.6) with 28 runways. Air cargo is handled by dedicated private freight carriers and carried on passenger flights as belly cargo. In 2020, more than 253,000 metric tons of freight moved through Denver International Airport (DEN), the leading air freight hub, accounting for approximately 95 percent of all air freight moved in and out of Colorado. The remaining top-five airports—Colorado Springs Municipal (COS), Grand Junction Regional (GJT), Durango-La Plata County (DRO), and Yampa Valley Regional (HDN) close to Hayden—account for nearly all other air cargo moved.

[70] OST_R | BTS | Transtats.

Figure 5.6 Commercial Airports in Colorado



Source: CDOT Open Data Portal.

Denver International Airport

The Denver International Airport covers an area of 53 square miles, making it one of the largest airports in the world by land area. [71] In 2022, 723,890,450 pounds of cargo moved through DEN. Air cargo operations occur 24 hours a day at DEN and many cargo flights arrive overnight. Several cargo movers and support facilities such as World Port Cargo Support, DHL, UPS, FedEx and United Airlines operate out of DEN. Freight is transferred from on-site cargo facilities to trucks for delivery to FedEx and UPS distribution centers in the Denver metro area, around the state, and in neighboring states. FedEx and UPS account for 54 percent of the total freight tons that originated from DEN in 2022. Southwest Airlines and United Airlines both carry belly cargo, or air freight carried on passenger flights. DEN is expanding logistics-based development on or near the airport. The pending completion of an Amazon Fulfillment Center south of DEN is one example. DEN is host to several world-class integrators and cargo airlines: ABX Air, Inc. and Air Transport International, Inc. (both of whom contract with Amazon Air), Alpine Air Express, Inc., Amerijet

[71] https://www.flydenver.com/about/administration/air_service.

International Inc./DHL, Bemidji Aviation Services, Inc., Federal Express Corporation, Kalitta Air, LLC, Mesa/DHL and United Parcel Service Co. In addition, the U.S. Postal Service facility is located nearby, providing a wide array of competitive shipping and receiving options. The airport also has a joint-use cargo facility that currently serves nine airline operations anchored to a 39-acre cargo ramp.

For air cargo, the ability to sort, organize, and repackage goods on site or near airport terminals and outside of urban area congestion is critical. While DEN has capacity and infrastructure to support expanded air cargo operations, national economic factors and relatively low truck transportation prices have resulted in air cargo movements at DEN that are far fewer than initial forecasts suggested. Limited on-site air cargo process and customs handling may continue to make air cargo uncompetitive in the short-term. For example, inbound FedEx shipments from foreign countries cannot easily clear customs in Denver due to a lack of secure areas and customs facilities, as well as the operational routing and efficiency decisions of carriers. Instead, cargo destined for Colorado is often routed to Memphis or other national air hubs to clear customs before being returned to DEN for distribution and delivery. Landed weight from 2016 to 2022 is shown in Table 5.3.

Table 5.3 Landed Weight (million lbs.)

Incident	2016	2017	2018	2019	2020	2021	2022
Denver International Airport	1,425.4	1,392.0	1,491.6	1,645.0	1,827.5	1,832.7	1,806.5
City of Colorado Springs Municipal	107.4	89.4	87.0	105.8	103.7	102.5	101.6
Total	**1,532.8**	**1,481.4**	**1,578.6**	**1,750.8**	**1,931.2**	**1,935.2**	**1,908.1**

Source: Federal Aviation Administration. [72]

Regional Airports Handing Air Cargo

The Bureau of Transportation Statistics reports the volume of air cargo moved by airport. Table 5.4 shows the top five Colorado airports that move air cargo. Smaller regional airports in Colorado Springs, Grand Junction, Durango and Hayden serve niche air cargo markets that would otherwise be unreachable via air transport.

[72] https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/cy22_cargo_airports.

Table 5.4 Top Five Colorado Air Cargo Airports by Volume (tons)

	2016		2017		2018		2019		2020		2021	
Destination	Belly	Freighter	Belly	Freighter	Belly	Freighter	Belly	Freighter	Belly	Freighter	Belly	Freighter
Denver	37,515	132,996	50,497	130,955	51,773	135,070	57,131	142,395	34,826	165,151	46,871	156,819
Colorado Springs	29	6,622	30	5,656	27	5,169	60	7,995	6	5,842	1	6,044
Grand Junction	2	3,028	5	3,330	4	2,893	3	3,410	2	2,647	2	2,778
Durango	1	636	3	630	1	589	2	777	0	717	0	713
Hayden	0	181	0	191	0	189	0	199	0	182	0	192

Source: Bureau of Transportation Statistics.

Colorado Springs, CO Airport offers direct flights to Chicago, Atlanta, Dallas-Ft. Worth, Salt Lake City, Denver, Phoenix, Las Vegas, Los Angeles, and Long Beach. Seasonal direct flights to Minneapolis / St. Paul, San Antonio and San Diego are also offered by various airlines. The majority of air cargo moves in air freighters.

Grand Junction, CO Airport had 228,782 enplanements and 231,260 deplanements in 2022 shared across Allegiant, American, Delta, Frontier and United Airlines. American served 49% of enplanements and 47% of deplanements. The majority of air cargo moves in air freighters.

Durango, CO Airport, also known as Durango La Plata County Airport, services southwest Colorado as well as northwest New Mexico. 367,000 passengers were enplaned / deplaned in Durango in 2022. American and United offer year-round daily non-stop service to Dallas-Ft. Worth, Denver and Phoenix, with seasonal nonstop service to Houston. The majority of air cargo through Durango moves via air freighters.

Hayden, CO Airport, also known as the Yampa Valley Regional Airport, serves as the air gateway to northwest Colorado and is a 30 minute drive from Steamboat Springs, Hayden, and Craig, CO. Alaska, United, JetBlue, Southwest, Delta, and American serve Hayden, CO with year-round and seasonal flight schedules. Air cargo volume is limited and moves exclusively in air freighters.

Shipping freight domestically or internationally by air is expensive, with a cost per ton that is often significantly higher than moving goods by truck. As a result, much of the freight that could be shipped by air into or out of Colorado is instead transported by truck from major air cargo hubs such as Memphis, Houston, Louisville, or Chicago. Recent estimates by DEN suggest that as much as 80 percent of freight that could be shipped by air is instead trucked out of Colorado. Air freight makes economic sense for businesses shipping high value products such as electronics or pharmaceuticals or goods that are time-sensitive, for example replacement parts or perishable items. This time versus cost analysis becomes even more critical when considering shipments beyond North America where the only alternative to air cargo is ocean freight. An ocean trip between ports in China and Long Beach, CA can take two weeks or more, not including time at both ports to load and unload the cargo and truck or rail transit time to the final destination. A similar shipment from Asia to Colorado by air might take three to five days, depending on the destination airport. Colorado airports handle more goods inbound by weight (57 percent) than they do outbound (41 percent), with only two percent of cargo moving within the state. Most origins and destinations in the state can be reached by truck at a far lower cost.

For air cargo moving into and out of Colorado, Tennessee is the top origin and destination, due to FedEx's hub at Memphis International Airport. The UPS hub at Louisville International Airport in Kentucky also generates significant air cargo activity in Colorado. Consolidated carriers such as UPS and FedEx play an important role in the Colorado air cargo market. These two companies carried 78 percent of the total weight of all air shipments bound to and from Colorado in 2019. Although both companies connect to other airports in Colorado (FedEx for example has an air presence in Grand Junction and Colorado Springs), both rely on DEN as the key node in the air cargo distribution network. Both of these firms also operate long-haul trucking and last-mile delivery services in conjunction with air cargo movements.

Beyond these consolidated carriers, California, Utah, Montana, and Nevada are also among the top origins and destinations for air cargo, highlighting the importance DEN and Colorado's transportation system plays in regional goods movement. Japan, United Kingdom, and Germany are among the top trading partners shipping air cargo in and out of Colorado. Maximizing the efficiency of highway and even rail access to major air hubs and air-related distribution hubs is critical to preserving freight capacity at DEN.

Colorado Air and Space Port

Adams County's CASP, also known as the Front Range Airport (FTG), is unique in the Denver metropolitan area CASP is the only general aviation airport without major nearby residential areas. The airport's 3,100 acres of land makes CASP larger than all other general aviation airports in the area combined. CASP is located six miles from Denver International Airport, and provides all-weather aviation facilities, with access to I-70.

CASP supports local and state governments through being the location of a Colorado National Guard armory, as well as the Colorado Department of Transportation Aeronautical Division and Colorado State Patrol office. CASP maintains a foothold in the technological development of sub-orbital flight and aerospace research and development. This horizontal launch facility establishes Colorado as a major North American commercial space hub and positions Colorado as an integral part of an emerging international system of spaceports. The airport's 2004 Master Plan focused on the long-term development of the airport with a focus on promoting and enhancing general aviation activities, providing opportunities to develop air cargo operations to satisfy regional demands, providing continued growth prospects for aviation-related industries, and promoting continued local economic growth and development. Most of those projects have yet to be executed. In particular, the focus on air cargo operational development at CASP has been tabled indefinitely [73]. The 2004 Airport Master Plan anticipated air cargo playing a prominent role in the future of CASP, assuming that CASP and neighboring DEN would enter into a Joint Operating Agreement (JOA) to create a non-competitive and synergistic air cargo environment that would enable the two airports to open new markets and maximize operational efficiencies. This JOA ultimately did not materialize, and air cargo operators are not currently based at CASP, with all primary cargo operators electing to operate at DEN. [74]

[73] Airport Master Plan Front Range Final Report. Prepared for: Adams County Colorado. Prepared by: Jviation, Inc. 2019.

[74] Jviation, Inc. 2019.

5.3.2 Air Cargo Trends

Air cargo economics are subject to global and national variables including aviation and truck fuel prices, ocean shipping rates, rail cars and changes in international trade patterns. During the pandemic, air cargo served a critical role, ensuring that vital commodities and medical supplies are transported to consumers. Many airlines have shifted operations away from scheduled passenger service towards specialized cargo operations.

The continued growth of e-commerce and online shopping is expected to drive an increase in air cargo. Consumers continue to expect goods ordered online to arrive within days. Depending on the location of distribution centers and customers, air cargo is often the only way to provide fast and reliable delivery. With increased demand for air cargo, Amazon Air has made investments throughout Colorado including fulfillment centers in Colorado Springs and Denver. In 2022, Amazon opened an 800,000 square foot distribution center near the Colorado Springs airport. Amazon also plans to build a 600,000 square foot distribution and fulfillment facility in Loveland, just 45 minutes north of DEN. Regional airports, with lower operating costs and less congestion compared to larger hubs, play an important role in supporting the growth of air cargo. In 2022, Colorado's governor and Burrell Aviation shared their plans for a 65-acre development project for cargo handling, aircraft maintenance, and other logistics activities near Colorado Springs Airport.

The Federal Aviation Administration (FAA) is modernizing the air traffic control system through the deployment of NextGen. Impacting both passenger and cargo flights, this system will increase reliability, safety, and capacity at the Nation's airports while reducing delay and fuel use by switching air traffic control from a radar-based to a satellite-based system. Longer term market pressures stemming from the adoption of connected and autonomous trucks may dampen air cargo growth within the U.S. as truck convoys can in theory move more goods and a lower cost and with a smaller time differential between air and ground. Although it is challenging to predict the impact of technology adoption on overall volume, this trend is likely to impact supply chain decisions and truck flows that link warehouses to airports.

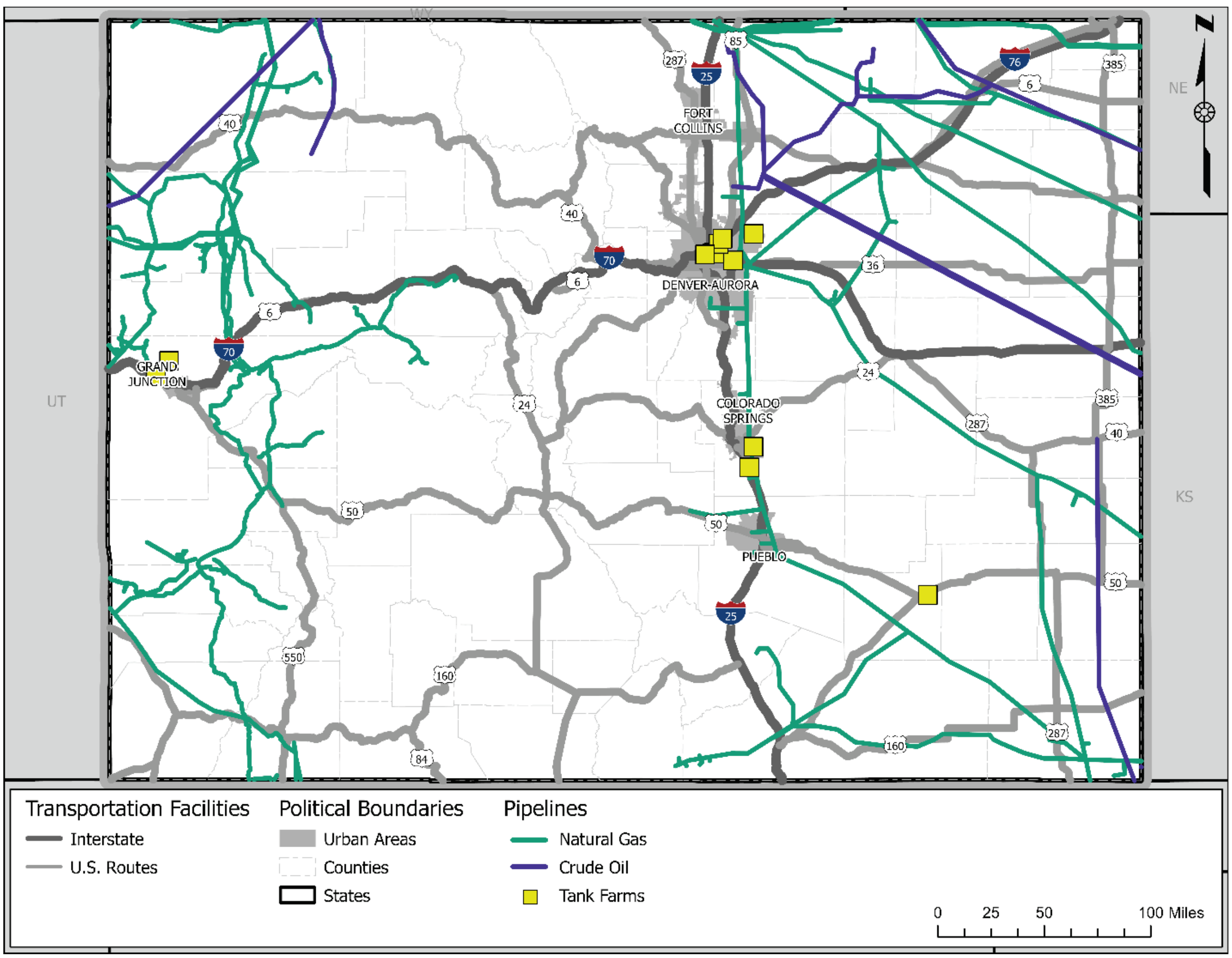
5.4 Colorado's Pipeline System

Pipelines transport liquid and natural gas from refineries and chemical plants to consumers and businesses. Colorado has significant crude oil and natural gas deposits and is among the top 10 states with the largest energy production. For crude oil production, Colorado accounts for around 4 percent of the total crude oil output and ranks fifth in the U.S. Around 80 percent of the State's crude oil production comes from Weld County, just north of Denver. The Piceance Basin in the northwest is also a significant crude-oil producer. Figure 5.7 shows that the crude oil pipelines are concentrated in northeast and northwest Colorado. Tank farms, which store oil and petroleum products that are distributed to end users or other storage facilities by truck, are clustered around the Denver area. Denver has two petroleum refineries that produce a total capacity of 103,000 barrels of crude oil per day. With increased use of horizontal drilling and hydraulic fracturing technologies, Colorado's crude oil output in 2022 increased by around five times the output of 2010. Although production declined due to the pandemic, crude oil production rebounded in 2022, increasing by 3 percent year-on-year. As crude oil output from the Niobrara Shale in the northeast continues to increase, more pipelines are constructed to transport crude oil to other states.

In terms of natural gas reserves, Colorado is the eighth largest producer, accounting for 4 percent of total reserves in the country. Colorado has 10 underground natural gas storage fields and about 141 billion cubic feet of combined storage capacity, equal to 1.5 percent of the U.S. total. The state's storage capacity increased by one-third from 2010 to 2021, primarily from increased underground storage in depleted gas fields. Between 2000 to 2022, Colorado's natural gas output more than doubled. Several major interstate pipelines cross Colorado and ship natural gas to six states. The Rockies Express Pipeline (REX) is a 1,698 mile natural gas pipeline from Rio Blanco County in northwest Colorado to Monroe County in eastern Ohio. REX started operating in 2009 and has a capacity of 1.8 billion cubic feet.

Colorado has two natural gas trading hubs at interstate pipeline interconnections. The Cheyenne hub, the larger of the two, is located in the Denver-Julesburg Basin near the Colorado-Wyoming border, while the White River hub is located in the Piceance Basin. The Cheyenne Hub Enhancement became operational in June 2020, adding 1.6 billion cubic feet per day of throughput capacity and increasing natural gas deliveries from eastern Colorado into the Cheyenne hub. The project increased interconnectivity and deliverability between the REX and interstate transmission systems.

Figure 5.7 Pipeline System in Colorado



Source: Colorado Department of Natural Resources.

5.5 Colorado's Inland/Commercial Ports and Intermodal Terminals

5.5.1 What is an Inland Port?

Prior to the Port of Virginia establishing the Front Royal Inland Port in 1989, the term "inland port" generally referred to ports located on rivers and lakes, e.g., Pittsburgh or Chicago. The Port of Virginia's completion of Front Royal broadened the definition to include methods for expanding capacity at landlocked seaports. Over the last three decades, inland ports have evolved as multimodal logistics parks at interior sites with good connections to global trade gateways. The availability of developable land with strong air, rail, and highway access by itself is a stimulus, enabling many inland ports to arise organically from private development with Government support coming later. Other common inland port examples include Greer, South Carolina; Rickenbacker (Columbus, Ohio); Salt Lake City, Utah; Fort Worth—Alliance, Texas; and Winnipeg, Canada.

Today the term inland port, which can also be referred to as a commercial port, is loosely used to refer to lake, river, and railyard adjacent facilities handling intermodal international containerized cargo transported from seaports. There is little consistency in how analysts, investors, regulators, and beneficial cargo owners (BCO) define inland ports. Inland ports typically have facilities for transloading or transferring goods from one mode of transportation to another, such as from a container ship to a train or a truck. Warehouses or distribution centers for storing and processing goods, as well as customs and inspection facilities for clearing goods through customs, can be co-located in inland ports. Airports supporting cargo operations, particularly international cargo can also be classified as "inland ports" (see Section 5.3). The *2022 CDOT Inland Port Study* provides a similar definition used to identify candidate inland port sites. The study is referenced throughout this section to ensure consistency among published documents across the agency.

One of the main benefits of inland ports is to reduce congestion and improve efficiency in the transportation system. By providing an alternative to seaports and airports, where space is often constrained, inland ports can help alleviate congestion at these facilities, which can be a bottleneck for the movement of goods. Inland ports can also help reduce transportation costs by providing more direct access to major transportation routes, which can reduce the distance that goods need to travel by truck or train.

Knowing where critical assets function in some form as an inland port is more important to long term planning than conforming to an imprecise definition. The *2022 CDOT Inland Port Study* defines inland ports as a cluster of facilities serving the multimodal exchange of containers, air cargo operations, and large concentrations of distribution centers and/warehouses near major transportation hubs (airports, highways, railroads) where a range of activities from cross-docking to storage and sortation currently take place or will take place once completed [75]. All of these may have but are not required to have direct rail intermodal service to seaports that handle containerized international trade, and may be privately owned, publicly owned or governed by public-private partnerships.

As a landlocked state, Colorado does not have a designated Government division to oversee port administration such as the Port of Virginia or Port of New York and New Jersey. Colorado also has not

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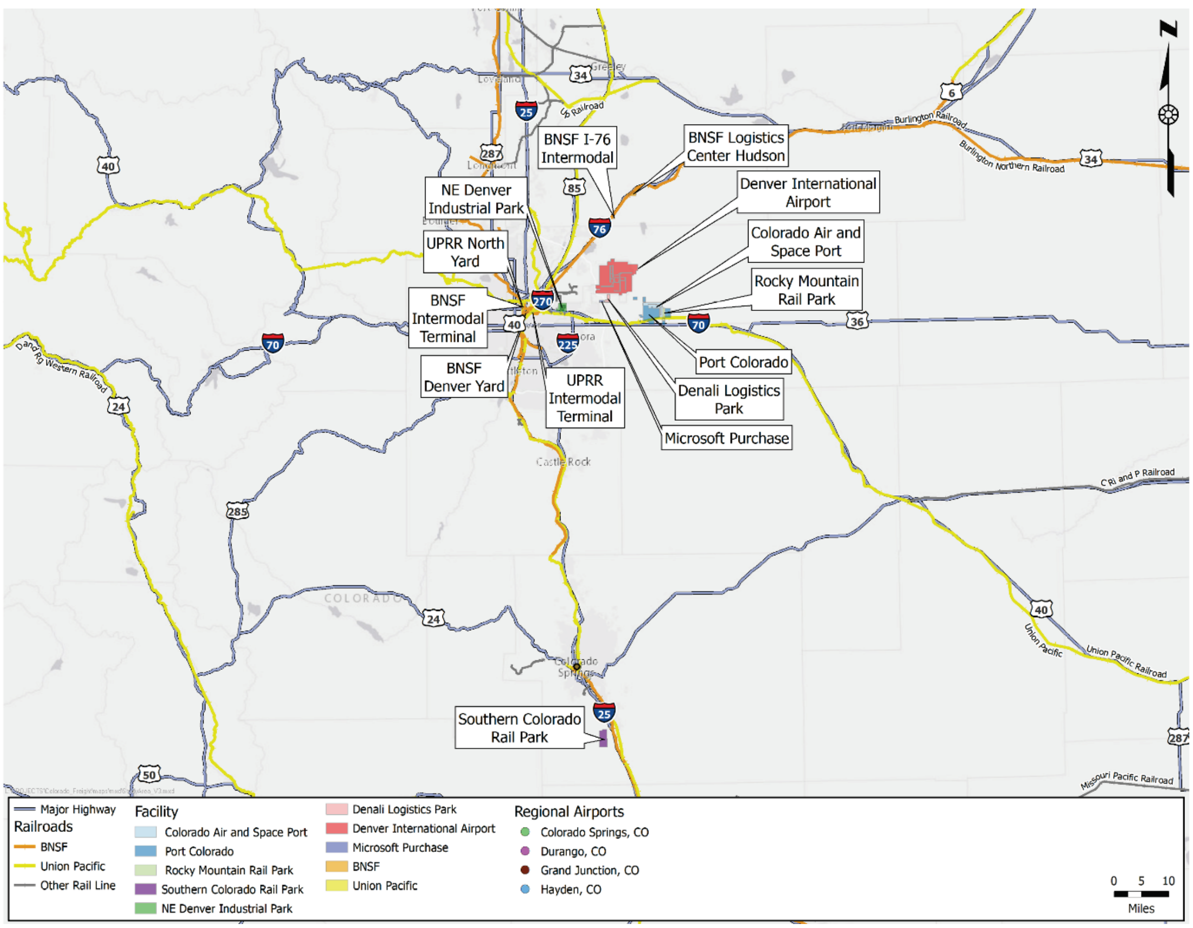
[75] CDOT Inland Port Study 2022 | Colorado Department of Transportation—Freight and Permitting.

established a governing agency overseeing commercial port or inland port development, as is the case in Utah, which created the Utah Inland Port Authority. However, Colorado has established assets built by public and private enterprises that when viewed together, effectively services the state in the same form and function as an officially designated inland port or commercial port. In place of master-planned, commercial port/inland port development led by the state, Colorado benefits from organic development driven by both private sectors, i.e., railroads, industrial real estate developers.

Colorado Commercial Ports

Figure 5.8 exhibits the location of assets that are taking on one or more inland port / commercial port functions within the state of Colorado. Collectively, these assets, mostly located within Adams, Denver and Weld counties, are fulfilling the mission of an officially designated commercial port / inland port. Some of these assets are privately owned, i.e., railroad intermodal terminals, while others are controlled by state authorities with private sector collaboration, i.e., Denver International Airport. Proximity to ground transportation including major highways and rail networks in Colorado are also shown in Figure 5.8 as these are essential conduits to facilities functioning as inland ports. Each of the sites represents a focus area for real estate and industrial development growth, where transportation access from multiple modes should be planned for in the future.

Figure 5.8 Colorado Assets Functioning as Commercial Ports



Source: CDOT Open Data Portal.

5.5.2 Railroad Owned Facilities

Colorado's railroads operate intermodal terminals and other rail service yards within Colorado, as shown in Figure 5.8. These facility types, while similar in some cases to inland ports, can serve different purposes. Namely, the three types of services which dictate rail yard usage are described below:

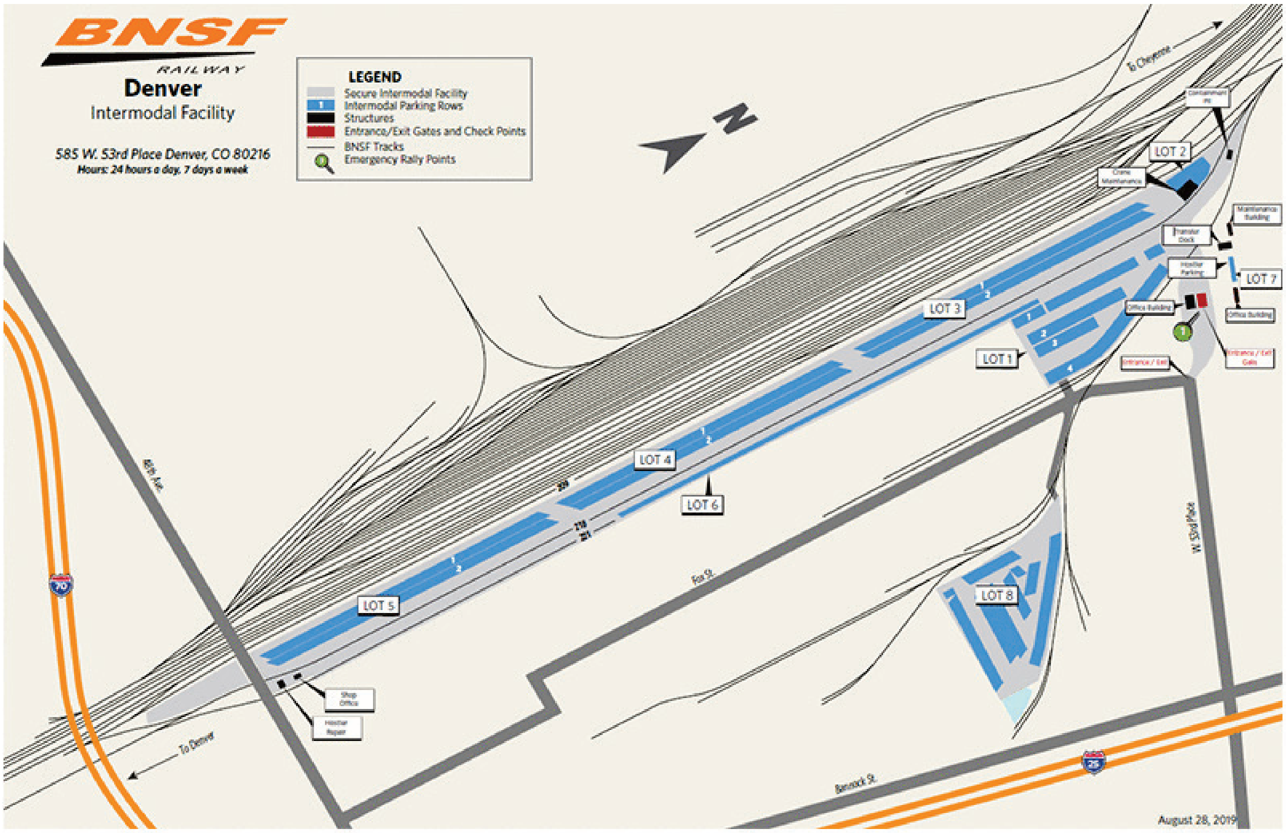
- **Intermodal rail service**, which is defined in the rail industry as containers and trailers moving on rail flat cars, is an important contributor to commerce in Colorado. Intermodal is the leading cargo transported by rail into the state. It accounts for 32 percent of terminating rail carloads. As a comparison, the next highest volume is coal at 23 percent of inbound carloads, a commodity that continues to experience reduced production.
- **Carload rail service**, also known as manifest service, refers to the shipment of goods in individual rail cars or blocks of railcars. The rail cars are collected from individual customers and brought together in major terminals to be made up into trains heading in a common direction. The trains are then broken up and last mile carriers distribute the individual cars or blocks of cars to customers. Examples that typically move in carload service include lumber, stone, and pulp products.
- **Unit train rail service** is the movement of rail freight where the train is made of up one commodity and all the cars are the same. The train moves between origin and destination without being broken up. Commodities that often move but are not required to move in unit trains include coal, ethanol and crude oil. When not moving in unit trains these commodities are served in the carload (manifest) network.

Burlington Northern Santa Fe Railway (BNSF)

Figure 5.9 illustrates the BNSF network in Colorado, which accesses the below facilities that are taking on inland port activities in some form. Beyond Colorado, the BNSF intermodal network comprises 25 terminals on its lines in 13 states and two terminals, Atlanta and Northwest Ohio, that it accesses by agreement with eastern railroads. The network handles international and domestic traffic, both containers and trailers. BNSF also serves intermodal terminals at each of the West Coast ports and the Port of Houston.

- **BNSF Denver Intermodal Facility**, illustrated in Figure 5.9, BNSF's Colorado intermodal terminal is located at 585 W 53rd Place in Denver and operates 24/7. The Denver terminal has direct intermodal connections from five locations with Chicago having two types of service, guaranteed service and priority UPS-LTL service. Denver is also served by intermodal trains from two international gateways, the Port of Tacoma and the Port of Long Beach. Denver has outbound BNSF intermodal trains to eight locations, with two services to Chicago.

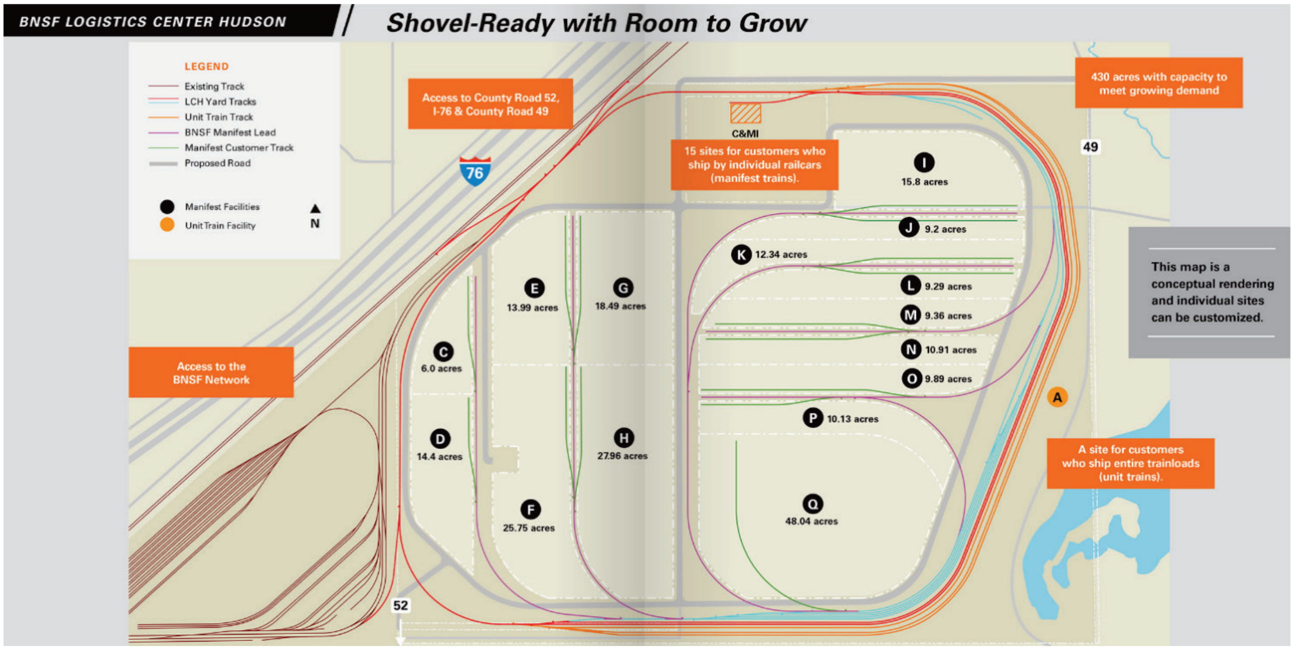
Figure 5.9 Denver Intermodal Terminal



Source: BNSF Railway Co.

- **BNSF Hudson Logistics Center** encompasses 430 acres located 25 miles north of Denver International Airport and 30 miles northeast of downtown Denver (Figure 5.10). Within Hudson, BNSF currently operates four separate area providing logistics services to specific commodities or customers. Three additional customer/commodity specific areas are under development. In sum, the Hudson Logistics Center is a multi-customer, multi-commodity business park with a transload terminal. BNSF Hudson Logistics Center differs from private business parks by investing directly in the development of the facility to create sites in under-served, strategic, and primarily end-user markets. The remaining open sites are completely permitted and shovel-ready with rail infrastructure, including mainline connections and on-site common track and inner roads already in place. These facilities are designed to serve both manifest mixed freight and unit train single commodity customers, including long lead tracks that keep trains from blocking the mainline and allow for separate unit train and manifest operations. BNSF Hudson Logistics Center has access to the BNSF network, CO 52, I-75, and CO 49. Pictured in Figure 5.10, there are 15 sites for customers who ship by individual railcars (manifest trains) and a site for customers who ship entire train loads (unit trains). This logistics center has the capacity to meet growing demand (BNSF Railway n.d.a).
- **BNSF I-76 Intermodal** is a planned intermodal facility on the BNSF mainline and adjacent to I-76 between Lochbuie and Hudson. To date, BNSF has been focused on acquiring land to support a new 2,700 acre intermodal terminal, including filing eminent domain petitions in Weld County District Court. The site would be in addition to the Hudson Logistics Center.

Figure 5.10 BNSF Logistics Center Hudson



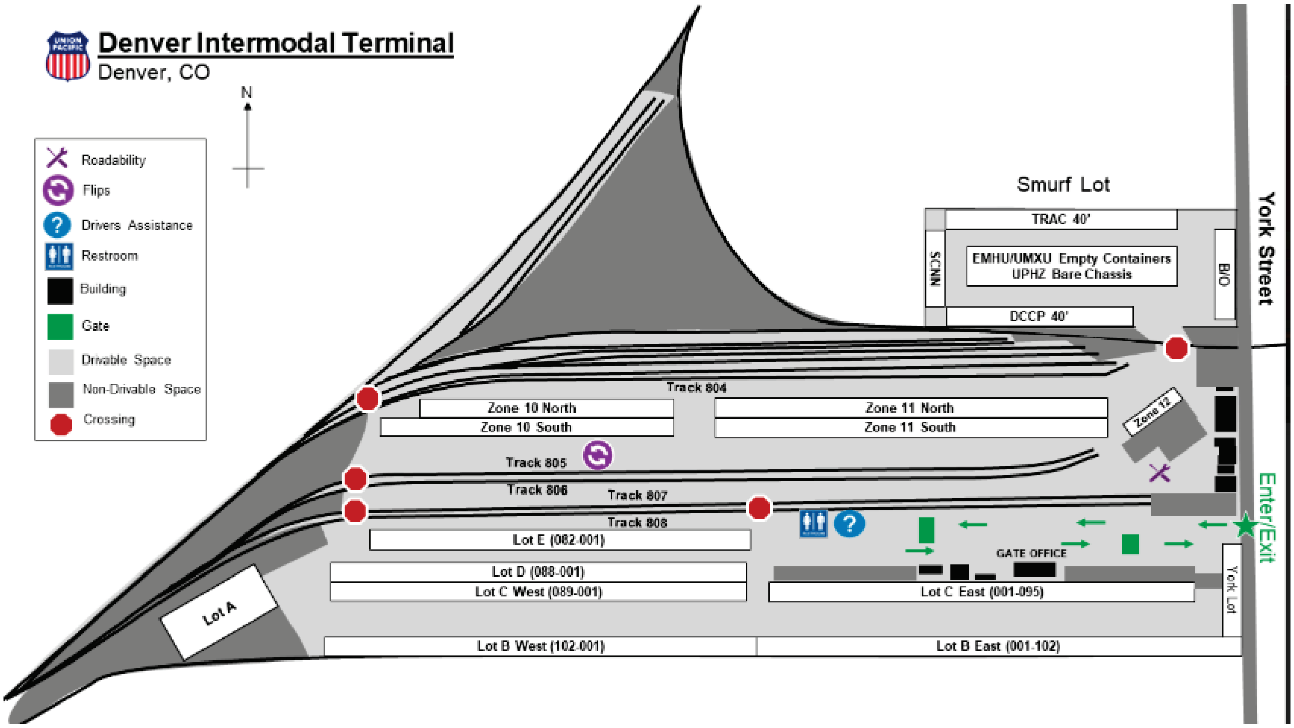
Source: BNSF Railway Co.

Union Pacific Railroad (UPRR)

Figure 5.11 illustrates Union Pacific's Colorado network that services facilities discussed below that function as inland ports. Beyond Colorado, UPRR's intermodal network serves 32 terminals located in 16 different states, including international gateways and Pacific and Gulf ports. Some regions such as Chicago and Southern California have multiple intermodal terminals on Union Pacific.

- **Union Pacific Denver Intermodal Terminal** is located in metropolitan Denver at 4085 York St. The UPRR Denver terminal has direct inbound service from five markets and direct outbound service to four of those markets' terminals. Pictured in Figure 5.11, the UPRR Denver terminal has direct outbound service to Houston, Long Beach, Northern California and Salt Lake City. Inbound service to Denver originates from Chicago, Salt Lake City, Long Beach, Houston and Northern California.

Figure 5.11 UPRR Denver Intermodal Terminal



Source: Union Pacific Railroad Co.

- **Port Colorado,** a privately-owned multimodal mixed use industrial and logistics park, is currently in the early stages of development. Port Colorado is adjacent to the CASP. For three miles along the southern property boundary, Port Colorado parallels the Union Pacific Railroad, which is the only railroad that will have access rights. Currently under development is a 65-acre rail-to-truck transload facility located along the frontage of Union Pacific's mainline and the I-70 corridor.
- **Rocky Mountain Rail Park** is a 620-acre rail served industrial park owned and under development by Rocky Mountain Industrials, Inc. (RMI). It is in unincorporated Adams County and is adjacent to CASP. Similar to Port Colorado, Union Pacific will be the only rail carrier with access. 150 acres to the south of East Colfax Avenue does not have rail access; however, the 420 acres to the north of Colfax Avenue are suitable for industries requiring rail. As shown in Figure 5.12, in February 2022, an 83-acre property within the Rocky Mountain Rail Park sold for $35.46M, including an under-construction building occupying the parcel. The same parcel had been traded for $10.95M a year earlier without the building. RMI has executed an agreement with Patriot Rail Co., LLC to provide the last mile operational rail services for the Rocky Mountain Rail Park. At full buildout, RMI expects 15 miles of track within its property to serve various customer locations. Patriot Rail will handle all rail interchange traffic directly with Union Pacific.

Figure 5.12 Rocky Mountain Rail Park

Source: Rocky Mountain Industrials, Inc.

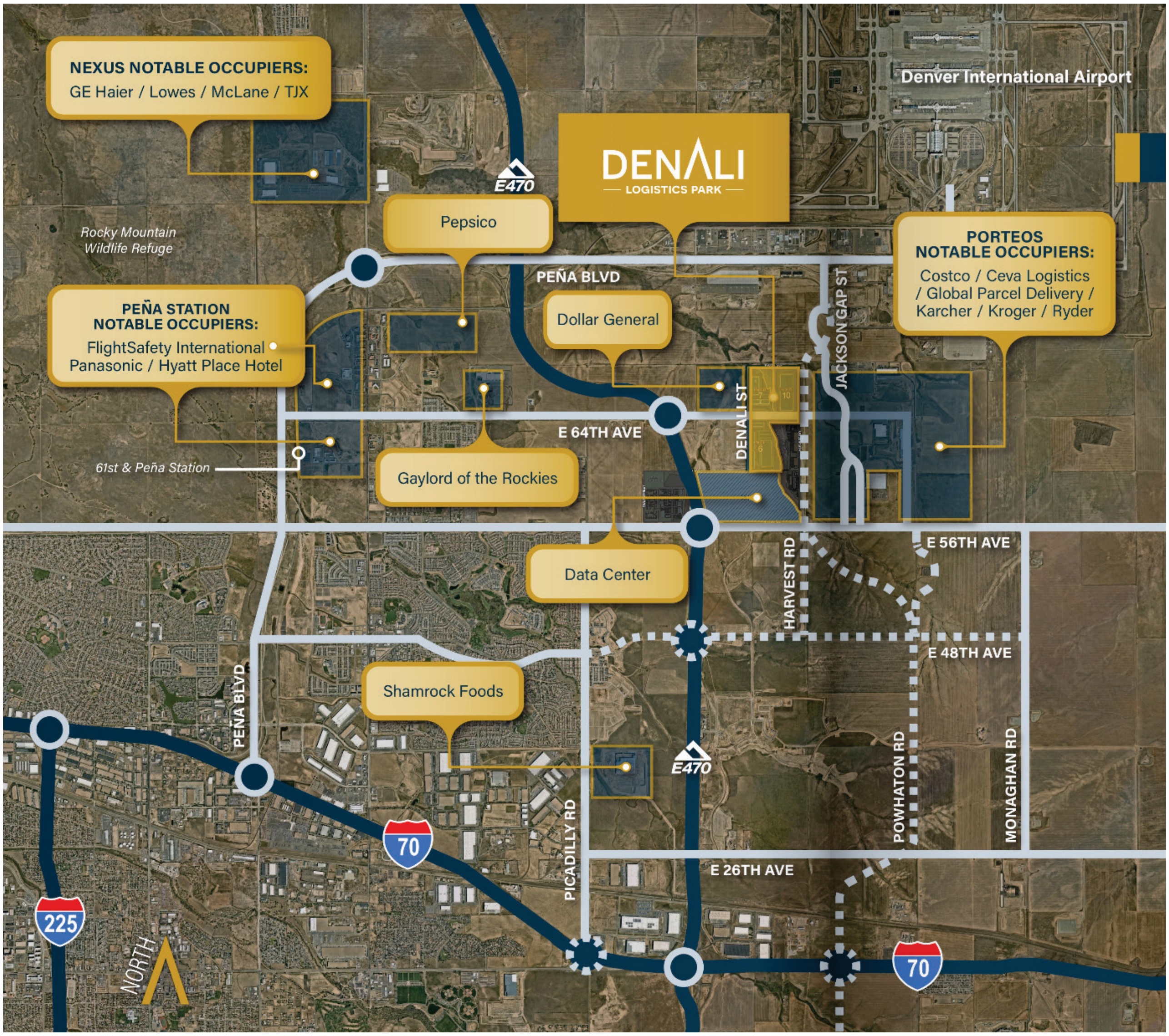
- **Northeast Denver Logistics Park** is an industrial neighborhood within the city limits of Denver that is host to 3PL, construction, retail, distribution and industrial supply services. Union Pacific has direct access to many of the industrial buildings within this section of Denver via branch lines that parallel the primary corridor streets or run through the back alleys of the buildings.
- **Southern Colorado Rail Park** will be located along the front range on over 3,000 acres of rural land situated between the Colorado Springs Nixon Power Plant and Fort Carson Military Reservation. While still under development, the project would extend an existing dual service rail spur (UP and BNSF) to facilitate commercial development as well as support modal connectivity at Fort Carson.

5.5.3 Logistics and Industrial Parks Without Rail Access

In 2021, Global Real Estate Developer Hines and Denver-based developer Fulenwider announced a partnership to develop Class A industrial property straddling E-470 approximately one-mile south of Denver International Airport. Branded as Denali Logistics Park, the site consists of 216 acres with sufficient space to develop 3 million square feet of industrial property. The site can accommodate buildings as large as 1.2 million square feet. Denali offers economic incentives including Federal Opportunity Zone, Adams County Enterprise Zone, and Limon Foreign Trade Zone.

As shown in Figure 5.13, Denali Logistics Park is within close proximity to multiple adjacent logistics centers for food, beverage, retail and appliance businesses. Also illustrated are the planned roads that will be added by as industrial development expands south of Denver International Airport, template that paints a vision of how different industrial developments, logistics parks, and distribution centers and support infrastructure are anticipated to evolve in the next decade.

Figure 5.13 Denali Logistics Park



Source: Global Real Estate Developer Hines and Denver-based developer Fulenwider.

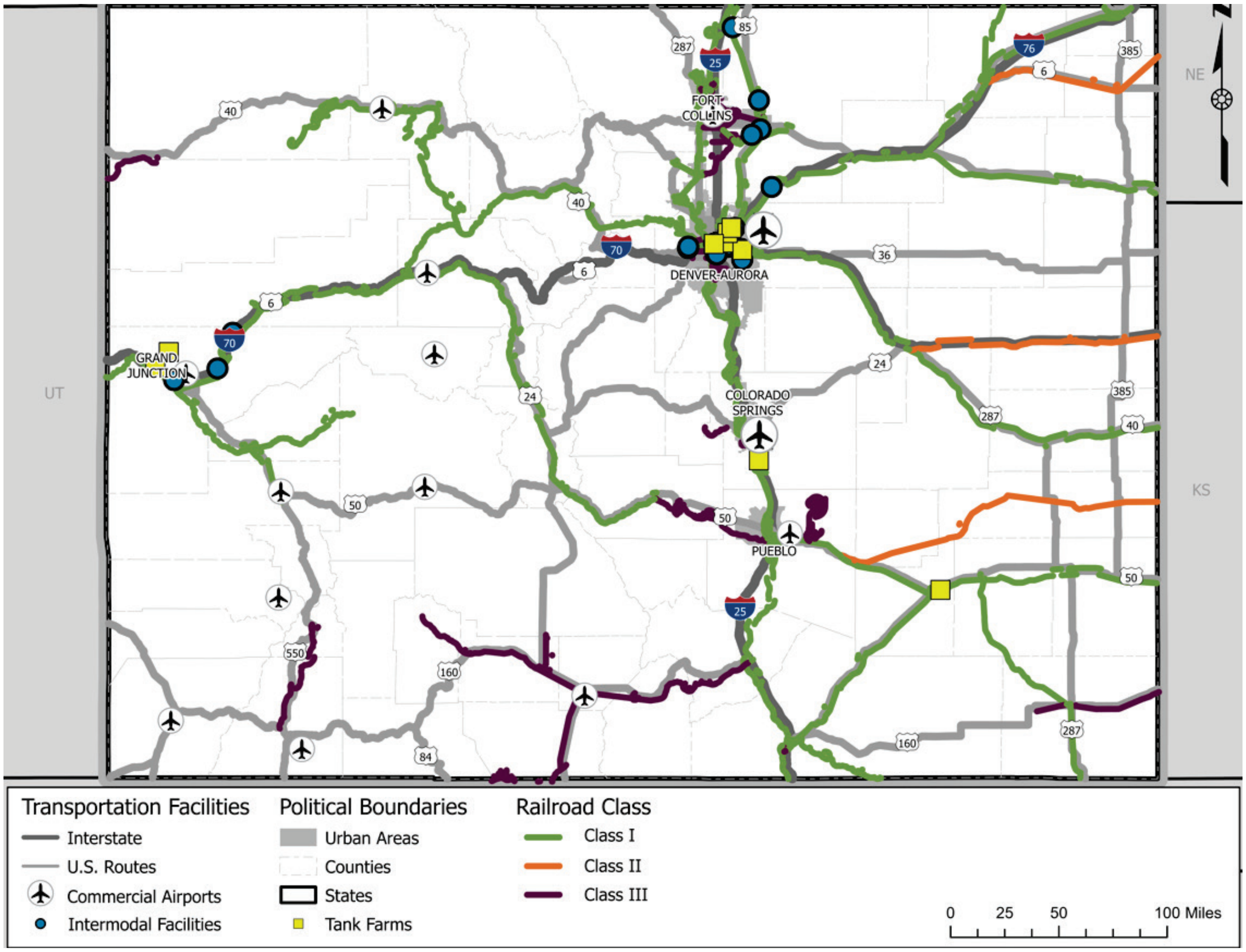
Microsoft

On March 29, 2022, Microsoft announced purchase of 260 acres south of Denver International Airport and adjacent to the Denali Logistics Park as shown in Figure 5.13. How Microsoft plans to use this land remains unclear, but speculation suggests that one possibility might be data warehousing/server centers.

5.5.4 Colorado's Intermodal Network

The combined locations of Colorado's intermodal facilities, including rail lines, airports, tank farms, and intermodal logistics parks are shown in Figure 5.14. While many of these facilities are concentrated in Denver, each type of facility can be found throughout the state. This allows for freight and logistics partners to have non-highway options when shipping goods in, out, and through Colorado.

Figure 5.14 Colorado's Intermodal Network



Source: Cambridge Systematics.

5.6 Colorado's Military Facilities

National military assets are critical components of threat recognition, personnel and equipment staging, and strategic response. Colorado is home to some of the Nation's most important military assets. This section identifies the state's military installations and the supporting highway and rail freight infrastructure, and defines the importance of these freight assets to the national safety and security.

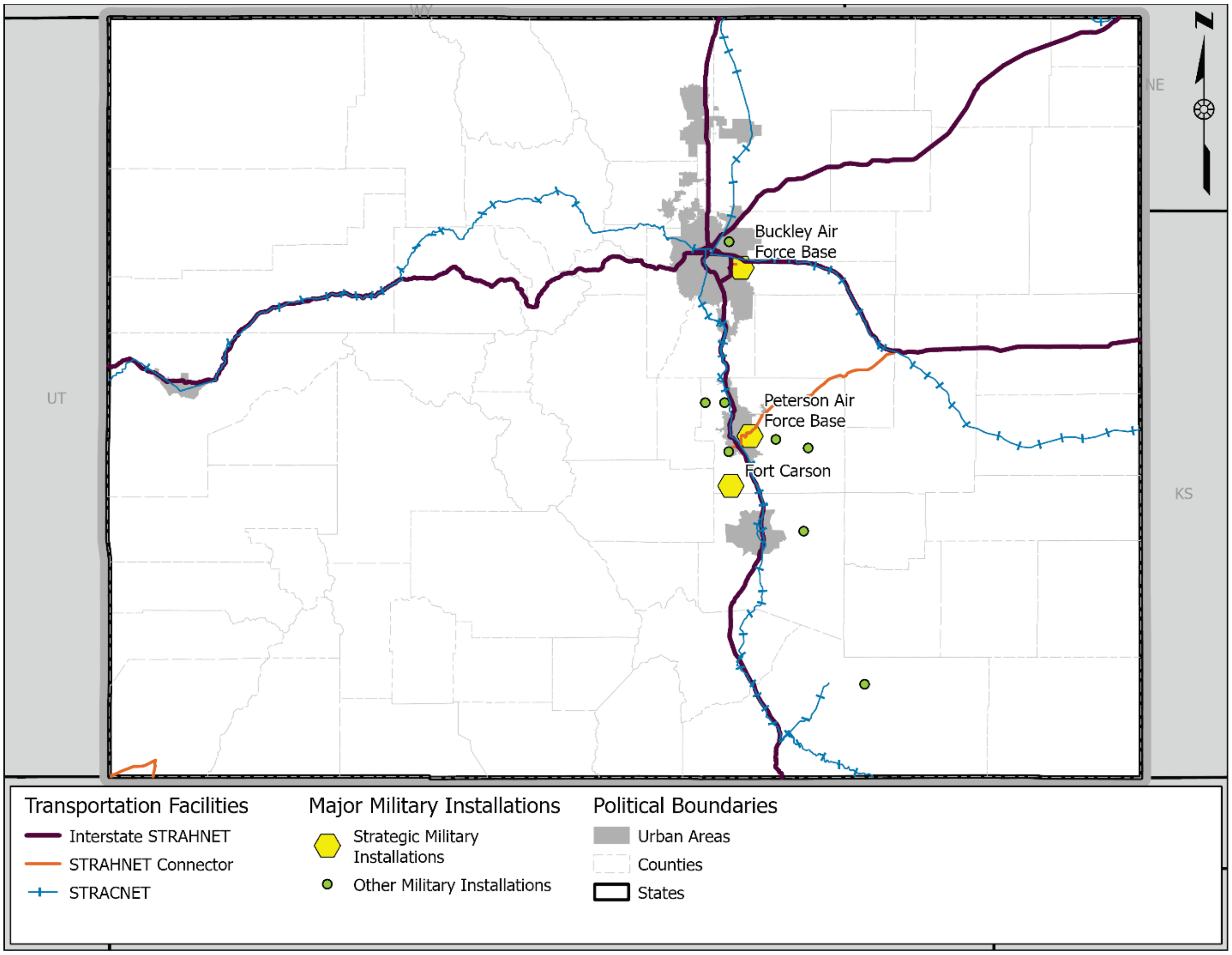
The three main military assets in Colorado are military installations, the Strategic Highway Network (STRAHNET), and the Strategic Rail Corridor Network (STRACNET). Military installations are those facilities, storage, training, housing, and general building, equipment, or personnel related footprints from which military operations are staged. Fort Carson, The Airforce Academy, Peterson Air Force Base (AFB), and Buckley AFB are among the 11 installations in the state. Additionally, Fort Carson, Peterson AFB, and Buckley AFB are the three strategic military installations in the state. Military installations are the primary infrastructure for readiness, providing the facilities to support all military operations. Fort Carson also serves as one of 18 national Power Projection Platforms (PPPs), which are "military installations that strategically deploy one or more high-priority active component brigade and/or mobilize and deploy high-priority reserve component units."[76]

The STRAHNET is the series of interstate and connector roadways that make up the military critical highway routes. In Colorado, there are 1,056 miles of STRAHNET, of which 953 miles are interstate and 103 miles are highway connectors. The connectors are the access routes between military installations and the interstate routes. Connectors also represent the military's critical freight corridors as they are necessarily required to accommodate military freight. These truck movements include everything from equipment and armament to personnel. The Fort Carson PPP is served by Magrath Avenue to I-25 which links with the New Mexico border in the state, continuing southward for ultimate deployment at the Port of Beaumont/Port Arthur in Texas.

The STRACNET are the rail corridors across the state that are critical to military freight and deployment. Nationally, there are over 36,000 miles of STRACNET serving more than 120 military installations. Colorado contains 1,067 of these miles, providing access across both the mountain and front range corridors. These railways are particularly important for the movement of large, heavy equipment between installations and seaports. Union Pacific (UP) owns the majority of the STRACNET mileage in the state, with BNSF owning a small portion in southern Colorado. Notably, many of the military installations in Colorado contain rail access, including importantly Fort Carson as the single PPP in the state. Figure 5.15 shows the STRACNET, STRAHNET, and the strategic military installations in the state.

[76] Department of Defense, 2022.

Figure 5.15 Colorado Military Installation, STRAHNET, and STRACNET



Source: Army Surface Deployment and Distribution Command (SDDC), U.S. Department of Defense (DOD), 2023.

In addition to the significance of STRAHNET routes to military freight, PPPs are a subset of the STRAHNET defined by their criticality to rapid response. PPPs represent the 5,000 most critical miles of public roadways, and are essential for Nation defense. Fort Carson is the U.S Army installation served by Colorado's PPP, a critical personnel base as home to the U.S. Army's 4th Infantry Division. About 130 of the approximately 1,000 miles of PPP between Fort Carson and the Port of Beaumont and Port Arthur are within Colorado, almost exclusively on I-25 southbound from Fort Carson to the Colorado-New Mexico border. Figure 5.16 shows an exhibit of the Fort Carson PPP as published by the Department of Defense.

Figure 5.16 Fort Carson Power Projection Platform

Source: Army SDDC, U.S. DOD, 2023.

6

Technological and Environmental Tie-Ins to Colorado's Freight Network

6.1 Innovative Technology Strategies

6.1.1 Highway

In recent years, there have been many technological developments that have the potential to improve freight safety and operations on the highway system. Roadway infrastructure investments alone will not be able to fully meet freight system needs related to safety, economic competitiveness, mobility, and reliability. New technology applications can improve freight system efficiency, increase logistics reliability, reduce freight industry costs, and enhance safety. Moreover, emerging freight transportation technology developments in the private sector—such as truck automation, real-time logistics tracking, and big data—represent opportunities for CDOT to support, partner on, and develop, new freight network technology applications to assist in meeting these needs.

The remainder of this section will identify and assess current technology, data-sharing, and operations-based strategies to address current and future freight safety and mobility challenges and enable the State to take advantage of technology developments in freight transportation automation and information systems. Table 3.1 lists a set of roadway technology innovations for freight, along with a brief description of their technology readiness, roadside infrastructure needs, and regulatory considerations. The table also indicates which of these innovations has been adopted (or tested) in Colorado. The remainder of this section describes each of these freight innovations in greater detail.

Table 6.1 Summary of Freight Technology Innovations

Innovation/ Application	Technology Readiness	Infrastructure Needs	Regulatory Considerations	Adopted in Colorado?
Telematics and Freight Traveler Information	Adopted	• N/A	• N/A	Yes
Electronic data loggers (for hours of service)	Adopted	• N/A	• Must adhere to FMCSA requirements	Yes

Innovation/ Application	Technology Readiness	Infrastructure Needs	Regulatory Considerations	Adopted in Colorado?
T5xAutomation at Ports / Intermodal Terminals	Adopted	• Private infrastructure[1]	• N/A	Yes
Automation at warehouses	Adopted	• Private infrastructure[2]	• N/A	Yes
In-motion size and weight inspection and electronic screening	Adopted	• Requires roadside technology and communications	• Must adhere to FMCSA requirements	Yes
Advanced Driver Assistance Systems (ADAS)	Emerging	• N/A	• National Highway Traffic Safety Administration (NHTSA) has authority to mandate ADAS features	Yes
Drayage Optimization	Emerging	• N/A	• N/A	No
Smart trailers	Emerging	• N/A	• Must adhere to FMCSA requirements	No
Connected and Automated Vehicles (CAV) for freight	Testing	• May require digital CAV infrastructure, including roadside communications and processing • May require dedicated CAV lanes or enhanced striping and signage	• NHTSA has authority to mandate CAV technology and standards • States might have other regulations related to CAV	No
Freight platooning and vehicle-to-vehicle (V2V) technology	Testing	• May require changes to roadway and pavement design standards if widely adopted	• NHTSA has authority to mandate V2V technology and standards • States might have other rules and regulations related to platooning	No
Data Analytics/ Artificial Intelligence (AI)	Testing	• N/A	• N/A	No
Freight signal priority (FSP)	Testing	• Requires FSP technology and communications at traffic signals	• N/A	No

Key: FMCSA = Federal Motor Carrier Safety Administration; NHTSA = National Highway Traffic Safety Administration; V2V = vehicle-to-vehicle

1 E.g., BNSF Intermodal Terminal Denver uses RailPass to facilitate efficient gate entry.

2 E.g., Amazon uses proprietary gate technology to facilitate entry and exist of vehicles from facilities.

Applications and Trends

Telematics and Freight Traveler Information

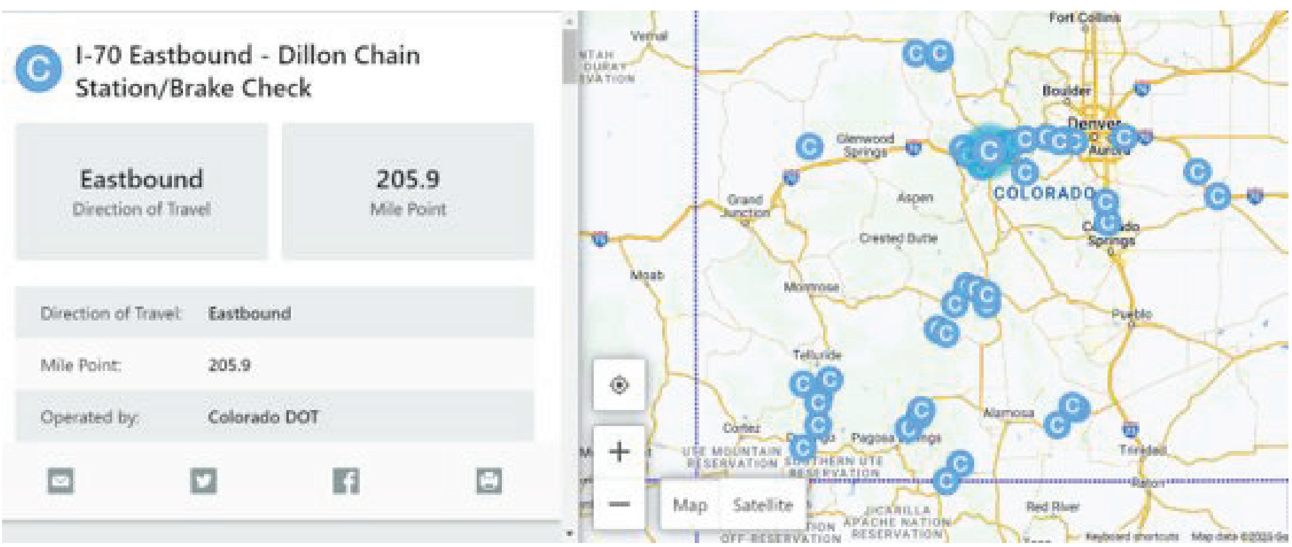
Telematics is the integrated use of communications and information technology to transmit, store, and receive information from telecommunications devices to remote objects over a network. In the trucking industry, this often involves having an aftermarket device installed in the cab that can send and receive tailored information from a third-party service provider. Telematics systems can also be used for fleet management purposes such as to monitor remote assets and drivers. Leading telematics service providers include Trimble, Geotab, Solera, and Verizon Connect.

Telematics traveler information typically includes freight-specific information such as dynamic route guidance, route restrictions, low bridge heights, parking availability information, weather information, work zone status, rail crossing information, and border/port wait times. Some basic freight traveler information is also available through state departments of transportation and third-party data integrators such as INRIX and Waze. For example, Drivewyze, a transportation software provider, recently partnered with Waze to provide location-specific slowdown information to truck drivers through the Drivewyze Connected Truck platform. These telematics services can improve efficiency and reduce costs for trucking companies.

CDOT currently provides freight traveler information through their statewide traffic information website COTrip.org (Figure 6.1). This website provides the following freight-related information to truckers:

- Chain control
- Weather conditions
- Truck parking locations
- Hazardous materials routes
- Construction restrictions
- Runaway ramp locations

Figure 6.1 COtrip Website—Chain Station Locations



Source: COtrip Traveler Information.

Electronic Data Loggers (for Hours of Service)

An in-cab device that is required in commercial vehicles is the electronic data logger (EDL). EDLs are devices installed in the cab to automatically record and monitor commercial drivers' compliance with regulations around work hours. EDLs also record data on the vehicle's engine, movement, and miles driven. Truck drivers, fleet managers, and dispatchers can use the EDL's real-time information about the driver's status to ensure fleet compliance with industry regulations, support planning of schedules, and adherence to required inspections. There are many companies that provide EDLs as they have become ubiquitous in the trucking industry.

> Since 2019, CDOT has been communicating to EDLs in the cab of trucks on the I-70 mountain corridor as a pilot with PrePass and Drivewyze. Their goal is to positively impact driver behavior by notifying the driver of a safety sensitive location upcoming or road closures. During the 2020 and 2021 fires and slides that closed Glenwood Canyon, through this partnership, CDOT was able to notify drivers of closures while they were still in Utah or Nebraska.

Automation at Ports, Intermodal Terminals, and Warehouses

There have been many developments to automate various goods movement functions such as receiving, stocking, and picking at both warehouses and ports. This type of automation relies on robotics and advanced sensing. As an example, the British online-only supermarket Ocado has built fully automated warehouses that can run 24-hours a day without having to hire late-night shift workers. The warehouse is populated with over a thousand robots that lift, move, or sort groceries day and night, processing 3.5 million items every week. Their actions are coordinated by a central computer, which ensures that the robots are used as efficiently as possible. All robots are interchangeable, which makes it easy to replace them if they break down or to add more if Ocado wants to scale up operations. Similarly, Amazon employs automated technology within certain fulfillment centers. In addition, Amazon employs automated gate technology, including app-based software that allows drivers to efficiently proceed in and out of facilities. BNSF Railway encourages truck drivers accessing intermodal terminals to use their proprietary RailPass application to minimize gate time and proceed efficiently through an intermodal facility. The primary benefit from automating intermodal terminals, fulfillment centers, and facilities functioning as inland ports and warehouses is efficiency and cost savings.

In-motion Size and Weight Inspection and Electronic Screening

There are many technologies commercially available that monitor vehicle compliance with traffic safety laws without stopping for manual inspection. Some of the key technologies include weigh-in-motion (WIM) and electronic screening for driver safety and credential compliance. The primary benefit of these technologies is in improved safety, but these technologies also have labor productivity benefits associated with their use in reducing enforcement and inspection work.

WIM technology can be deployed on the highway mainline or on the entrance ramp to a site. In either scenario, trucks are weighed as they pass over the WIM at speed. Although this measurement is not accurate enough to issue a weight citation directly it can screen out trucks with empty loads or that are obviously under or over the allowed weight.

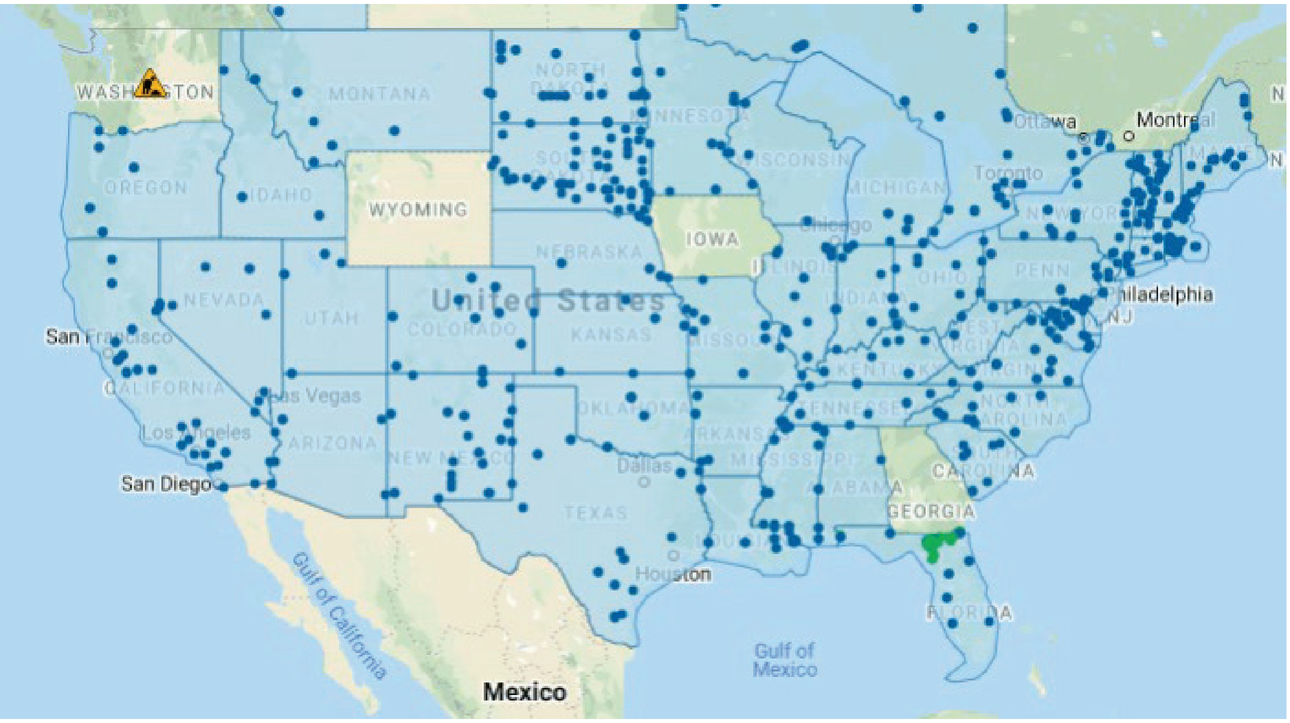
> CDOT currently has a WIM program in place with WIM assets installed at port of entry stations throughout the state.

Prescreening is typically done using transponders or smart phones. Under the transponder approach, trucks enroll in a program such as PrePass and are assigned a small wireless transponder designed to be mounted on the windshield. When one of these trucks approaches an equipped inspection site, an electronic reader mounted over the roadway automatically scans the transponder and identifies the vehicle and checks for compliance. Trucks not meeting compliance are required to pull over.

> Drivewyze is deployed at 17 inspection sites in Colorado.

The smart phone approach is based on services provided by mobile application providers such as Drivewyze and, more recently, PrePass from Help Inc. In this approach, the enrollment process starts with the driver downloading and installing an application on their mobile phone. When the driver starts their trip, they turn on the application and start driving. The application will alert the driver when they cross a boundary drawn in a mapping program (a practice called geo-fencing) and are approaching an inspection location. Like the transponder approach, the vehicle is identified and compared against a list of criteria. Once a decision has been made, the driver is notified to continue driving or to pull into the inspection site via an alert on their cell phone. Figure 6.2 shows how widespread the Drivewyze application is deployed in the United States.

Figure 6.2 Drivewyze Bypass Service Locations



Source: Drivewyze Coverage Map 2022.

Advanced Driver Assistance Systems

Advanced Driver Assistance Systems (ADAS) are technologies that make vehicles safer by automating, improving, or adapting tasks involved in operating a vehicle. ADAS rely on a variety of vehicle-based sensors including radar lidar, ultrasound, and video cameras. Examples of ADAS applications include forward collision warning, automated braking, lane departure warning, and blind spot warning (Figure 6.3). These safety-focused systems have been appearing in new automobiles and trucks for many years and their use is expected to continue to grow.

Figure 6.3 ADAS Concept for Trucks

Source: Fleet Equipment Magazine 2021. https://www.fleetequipmentmag.com/advanced-truck-driver-assistance-systems/.

ADAS are in the early stage of adoption and are emerging as a mature new technology. They have the advantage of providing immediate benefits while being part of the suite of technologies that lead in time to connected and automated vehicles, and therefore are both practical and forward-looking. The primary benefit of ADAS is safety, which is a top concern of motor carriers and their drivers. Beyond their innate value in protecting human life, safety improvements reduce accident and insurance costs in trucking, as well as risks of expensive litigation. In addition, ADAS technology is often combined with telematics to help monitor the condition of vehicles and reduce operating costs.

Drayage Optimization

Drayage is the transportation of freight for short distances by trucks. It may include trucking between terminals, or trucking from terminals to warehouses, distribution centers, or directly to the final destination. Software solutions exist that provide insight into supply chain analytics and support and optimize drayage operations through better coordination and monitoring of the process. There are also mathematical models to match drayage truck capacity and trailer/container availability and appointment scheduling at intermodal (rail and port) terminals. As an example, Amazon Relay, a technology platform hosting over 55,000 trucking companies ranging in size from single-cab owner-operators to large fleets, connects freight loads with available capacity, and moves hundreds of thousands of loads per week. In 2021, Amazon launched drayage on Relay, servicing domestic and international container customers. In addition, new data is becoming available from emerging technologies such as telematics and CAVs that opens opportunities to understand freight movements in more granular detail and determine ways to better optimize drayage operations.

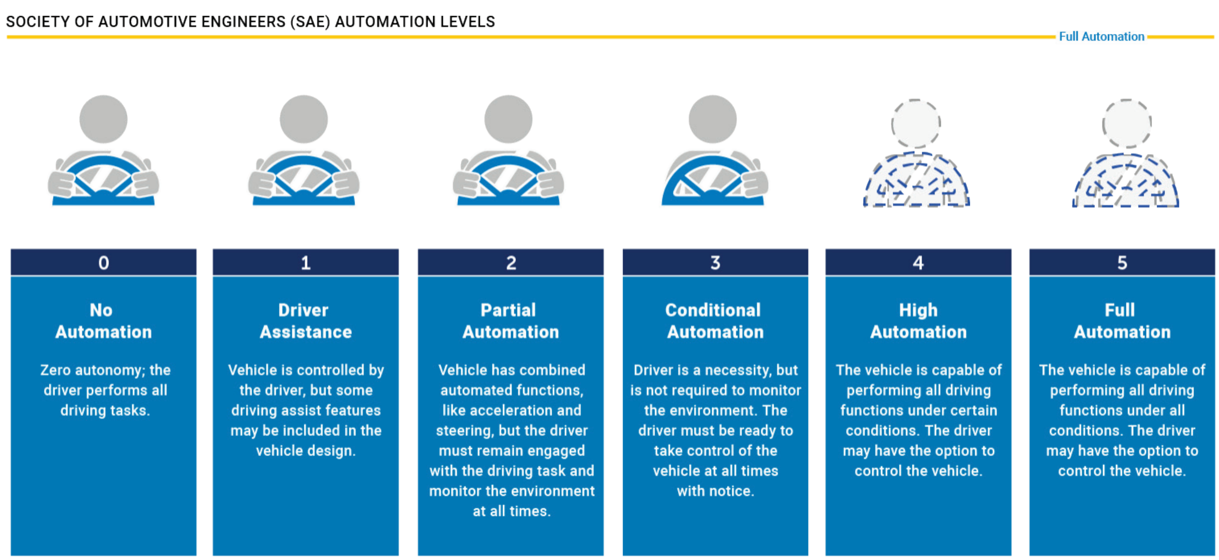
Smart Trailers

Smart trailers can include any type of trailer, from flatbed to reefer that provides insights into the status of the trailer and its cargo using sensors that measure a wide array of features, including mileage, location, temperature, humidity, shock, and vibration. Smart trailers are typically equipped with telematics technology (described in the Telematics and Freight Traveler Information section) that can provide real-time data visibility and reporting to fleet owners. This technology helps fleet owners optimize their operations and protect their assets.

CAVs for Freight

In recent years, there have been many advancements in truck automation or "self-driving trucks." These advancements have coincided with the progression of the broader automated vehicle (AV) industry. AVs are complex systems of hardware and software that perform the primary driving functions of vehicles (i.e., steering, acceleration, and braking) with varying degrees of decreased human intervention. The automated driving system (ADS) includes sensing, communicating, monitoring, navigating, and decision-making, depending on the level of automation. Vehicles can be categorized into six levels of automation, from no automation to full automation, as defined by the Society of Automotive Engineers (SAE) (Figure 6.4).

Figure 6.4 Society of Automotive Engineers Levels of Vehicle Automation



Source: Federal Highway Administration 2018 https://ops.fhwa.dot.gov/automationdialogue/presentations/azwksp102418/index.htm.

Most of the ADAS systems described above would fit into the SAE level 1 or 2 descriptions and have already been adopted by the trucking industry. There are several companies currently testing SAE level 3 and 4 trucks on roads today, but these systems are still not mature enough for widespread deployment. Examples of these companies include Aurora Innovation, Embark Technologies, and TuSimple. These companies are focusing on testing truck automation in specific operational design domains such as only on divided highways until the technology becomes mature enough to operate in all environments. Most industry experts believe that freight movement is likely to be one of the first AV use cases to come to market but that it will be initially limited to specific operational design domains. Level 5 trucks that can operate anywhere in all conditions are still many years away from being ready for full deployment.

There are many enabling technologies that could improve AV safety and reliability and lead to a faster deployment timeline. Enabling technologies for AVs include a combination of vehicle-to-vehicle (V2V) communication, radar and cameras, in-vehicle sensor and control systems, and vehicle-to-infrastructure (V2I) communications. AVs that are supported by V2I or V2V communications are referred to as CAVs. Some of the benefits of CAVs include improved safety, efficiency, mobility, and cost reductions.

Freight Platooning and V2V Technology

Freight platooning uses V2V technology to enable trucks to communicate with each other and automatically control their speeds to allow them to travel at short headways, saving fuel and reducing driver workload. This technology is probably a SAE level 1 or 2 system and not as advanced as the SAE level 3 though level 5 CAVs described above. Freight platooning connects one or two following trucks to a lead truck that is manually driven, allowing the following trucks to mimic the actions of the leader. Some of the key benefits include safety and fuel reduction due to improved aerodynamics.

Platooning, where the lead vehicle has a driver to monitor the operation while the others simply follow, is a key first step towards full automation. Freight platooning of three trucks using V2V technology has been successfully tested by the Federal Highway Administration and Volvo Trucks (Figure 6.5) and initial tests demonstrated potential fuel savings of nearly 10 percent. However, the future market for freight platooning is somewhat uncertain. Daimler, a major truck manufacturer, discontinued efforts around platooning in 2019, and Volvo Trucks has shifted their focus from platooning to fleet electrification and fully automated trucks. Nevertheless, freight platooning may be effective in certain niches such as on dense freight corridors where the length of haul is deemed cost-effective for freight platooning.

Figure 6.5 Federal Highway Administration/Volvo Truck Platooning Demonstration

Source: Federal Highway Administration.

Data Analytics/Artificial Intelligence

Another recent development in trucking technology is the use of data analytics and artificial intelligence (AI) to improve transportation operations. Data analytics and AI use a wide variety of statistical and mathematical tools to gain insights from data to support human-like decision-making. Traffic data is generated from different sources, such as from traditional agency-owned road sensors and from private sector probe-based data aggregators like Google Maps and Waze. The integration of data from multiple sources, and the analysis and sharing of large datasets or "big data" is crucial to understand travel patterns, and to help understand traffic conditions and operate transportation systems more efficiently. The primary benefit from data analytics and AI is better productivity and efficiency for trucking companies.

Freight Signal Priority

FSP is a V2I application that has been tested and evaluated in some locations but has not been widely deployed. FSP leverages V2I technology installed in trucks and at the roadside. The roadside V2I technology is connected to a traffic signal and provides wireless connectivity between the

> FSP has not yet been deployed in Colorado.

connected truck and the traffic signal. The truck can transmit its location and a request for a green light to the traffic signal, and the signal can be programmed to either extend the green time to allow the truck to make it through the intersection without stopping or reduce the red time to decrease the delay encountered by trucks.

FSP has been deployed in several location around the world, including San Diego, California, Arlington, Texas, Palm Beach, Florida, Sydney, Australia, and many cities throughout Europe. FSP can minimize the travel time, stops and total delay for trucks, which can result in reduced fuel usage and reduced vehicle emissions.

Regulatory Considerations

As indicated in Table 6.1, some of the freight innovations described in this section will involve regulatory considerations. Since the NHTSA regulates the manufacture of motor vehicles and motor vehicle equipment, the freight innovations that fall in this category may be impacted by NHTSA actions. These include ADAS, CAV technology, and V2V technology, which enables freight platooning. NHTSA issues and enforces all Federal Motor Vehicle Safety Standards, which may include these vehicle-based technologies. Currently, none of the technology innovations listed above are mandated by NHTSA, but they could be in the future. NHTSA can also provide special exemptions to the Federal Motor Vehicle Safety Standards for some types of automated vehicles including freight delivery vehicles.

The other Federal agency that may have regulatory authority over some of the technological innovations described is the Federal Motor Carrier Safety Administration (FMCSA). The FMCSA regulates the operations of commercial vehicles, which typically focuses on the drivers, but also includes in-cab equipment. For example, the FMCSA has mandated that all commercial vehicles must be equipped with EDLs to log their drivers' hours of service. The FMCSA also sets standards for some of the freight safety innovations (e.g., electronic roadside screening). If these types of technologies are implemented, they will need to adhere to any applicable FMCSA requirements.

In 2017, Colorado passed Senate Bill 17-13, which authorizes the use of ADSs in Colorado as long as they meet all applicable state and Federal laws. If the ADS cannot meet all applicable state and Federal laws, then CDOT and Colorado State Patrol are responsible for approving their operation in the state. This applies to passenger vehicles and commercial vehicles.

Finally, some of these technologies may be regulated at the state level. For example, rules pertaining to automated trucks and freight platooning vary from state to state. Some states have very strict regulations regarding truck automation (e.g., California does not allow it) and some states have very lenient regulations regarding truck automation (e.g., Texas welcomes testing in its state).

Infrastructure Needs

Only a few of the freight technological innovations require infrastructure modifications or enhancements (Table 6.1). Electronic roadside screening and WIM technology will require equipment and communications systems to be installed at the roadside so they are able to communicate with trucks in motion and complete the necessary transactions. Smart truck parking systems will require sensors that can detect the availability of truck parking spaces and a communications system at the parking location that can relay this information to the appropriate traveler information systems. FSP systems require that a roadside processing unit and a V2I communications system be installed alongside the traffic signals to support the FSP application.

Finally, safe operation of freight CAVs will likely depend on some level of physical and digital infrastructure enhancements. On the physical side, enhancements such as more accurate and visible road striping and signage and embedding sensors in street signs to facilitate infrastructure-to-vehicle communication may be required to optimize CAV performance. Some CAV applications may even require special lanes dedicated to CAVs. In terms of digital CAV technologies that rely on data, information and communication technologies will need to be supported by public agencies. Public agencies may need to support connecting technologies by providing digitized road network data (i.e., maps), work zone information, and support for communication links. Ensuring that these connecting technologies are harmonized and standardized across jurisdictions is important for the success of automation technologies.

6.1.2 Rail

Market, Operational and Regulatory Challenges

Over the last decade, most of the leading Class I railroads have prioritized delivering lower operating ratios (a financial measure of total operating expenses divided by total revenues) over franchise growth, an operational practice frequently referred to as Precision Scheduled Railroading (PSR). Although specifics vary by railroad, a PSR strategy generally involves reducing staff, running longer trains, and combining train types. For example, intermodal trains might be combined with manifest (mix-carload) services. Often, longer trains are operated with distributed power, where locomotives are located in the front, middle and end of a train. Elimination of assets deemed surplus reduces cost and requires less labor to maintain and operate the property. Railroads implementing PSR will also try to simplify networks by eliminating handling yards that classify individual cars and blocks of cars enroute to destinations. In addition, railroads will try to de-market less profitable business and focus on increasing rates for remaining customers.

In simple terms, the result has been that the railroad industry is moving less freight by foregoing less profitable freight while realizing higher rates from the remaining customers. In a study published by Oliver Wyman in March 2023, the four leading U.S. Class I Railroads (BNSF, UP, CSX, NS) increased revenue per train mile from $91 to $195 between 2006 and 2021. Over the same time period, revenue ton-miles and total train-miles decreased 15 percent and 24 percent, respectively.

This industry trend has caught the attention of U.S. regulators, specifically the Surface Transportation Board, which reported in 2021 that since 2010, the five U.S.-based Class I railroads spent $191 billion on share buybacks and dividends in contrast to $138 billion in capital expenditures. Between 2002 and 2021, the railroad industry has lost 2 percent of market share to trucks. Since every 1 percent of freight market share lost from rail to truck results in five million tons of carbon dioxide (CO_2) released into the atmosphere, this has resulted in 123 million tons of extra CO_2 that otherwise could have been avoided.[16] More scrutiny from U.S. regulators is expected going forward given Surface Transportation Board Chair Martin Oberman's statement, "This cannot be allowed to continue."

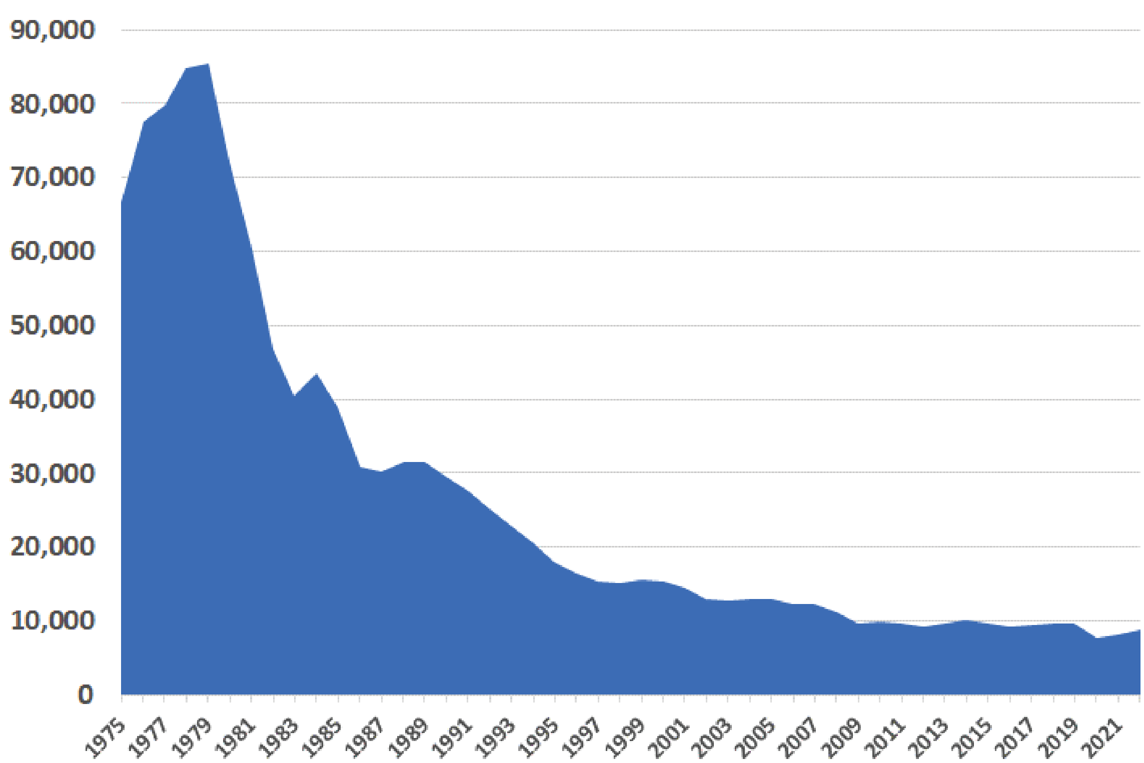
Railroad networks have also gone through extensive changes in the last five years, particularly those that are pursuing the PSR strategy. For example, Union Pacific closed the Hinkle classification yard in Oregon and Pine Bluff classification yard in Arkansas, while redirecting capital away from construction of Brazos classification yard in Texas. Other U.S. freight rail classification yards, where merchandise railcars are sorted into blocks and organized into new trains or routed for local delivery, have been opened, closed and re-opened over relatively short periods of time, such as Norfolk Southern's Bellevue (Moorman) Yard. Concurrently, the Class I freight railroads have also been combining train types, i.e., putting intermodal cars on the rear of a merchandise train on opportune slots in the network, which makes better utilization of train crews and capacity. The combined Class I U.S. railroad network continues to evolve as freight traffic dynamics, management approaches to optimizing resources, and priorities set by shareholders evolve.

Safety

As Figure 6.6 shows, the total number of accidents and incidents on U.S. railroads has decreased by 89% from the 1979 peak. However, while the overall trend is favorable over the last five decades, major incidents that cause significant loss of life or damage and are tabulated as a single occurrence greatly influence safety practices and regulatory policy. For example, the collision between a Metrolink commuter train and Union Pacific freight train in California in 2009 precipitated the Federal mandate of PTC, a technology designed to prevent train-to-train collisions and speeding.

In addition, the implementation of PSR has brought about the operation of longer trains, which has been subject to increased scrutiny from railway labor and regulators. In April 2023, the Federal Railroad Administration issued a non-binding safety advisory concerning recommended practices for the operation of long trains following derailments of trains exceeding 200 cars, 12,250 feet in length, or 17,000 tons.

Figure 6.6 Total U.S. Rail Accidents and Incidents Since 1975



Source: Federal Railroad Administration, Accident/Incident Overview, railroads.dot.gov.

Most recently, on February 3, 2023, a Norfolk Southern train carrying 150 cars derailed near East Palestine, Ohio, a town just west of the Pennsylvania border with a population of 4,800. Five of the derailed cars were carrying the hazardous material vinyl chloride, a cancer-causing substance that is a key ingredient for hard plastic resins used in construction and health care. Officials ordered a 2-mile radius evacuation, and in consultation with Norfolk Southern, decided to release the contents of one car into a trench where it was burned off, releasing a dramatic plume of toxic smoke (Figure 6.7). The Ohio Department of Natural Resources estimated that the deliberate release caused the death of 3,500 fish, and as of August 2023 Norfolk Southern estimates the total cost from the derailment to have exceeded $800 million.

Figure 6.7 Norfolk Southern East Palestine, Ohio (Derailment in February 2023)

Source: The Morning Journal, www.morningjournal.com.

The Norfolk Southern East Palestine Derailment precipitated a deluge of safety bills proposed in the U.S. Congress. The governors of Ohio and Pennsylvania as well as state and local legislators have similarly made public calls for increased regulatory control and safety oversight of interstate freight moving on railroads. National coalitions, including the National League of Cities and National Association of Counties have joined in these calls for bipartisan rail safety legislation.

Bills proposed in Congress as of May 2023 include: 1) Railway Safety Act (S.576); 2) Assistance for Local Heroes During train Crises Act (S.844); 3) Railway Accountability Act (S.1044); 4) Decreasing Emergency Railroad Accident Instances Locally (DERAIL) Act (H.R. 1238); 5) Reducing Accidents in Locomotives Act (H.R. 1633); and 6) Railway Safety Act of 2023 (H.R. 1674).

President Biden has thrown support behind the Railway Safety Act (S.576/H.R. 1674), which would augment requirements for trains transporting hazardous materials as well as develop additional regulations such as hazmat train length and weight. The bill also includes a mandate for two-person crew on freight trains. [77]

Applications and Trends

Locomotives, Fuel Consumption, and Carbon Emissions

The U.S railroad industry consumed more than 3.4 billion gallons of fuel in 2019. Globally, while railroads are less carbon intensive than other transportation modes, the industry contributed to 3 percent of global emissions in the transportation sector. [78] In the United States, U.S. Freight Railroads were responsible for 1.7 percent of transportation greenhouse gas emissions in the transportation sector, compared to 23.4 percent from trucks. [79]

Saving fuel reduces expenses and improves operating margins for freight railroads of all sizes while reducing carbon output. In addition, freight rail customers that are looking to minimize their carbon footprint are looking to railroads to reduce their reliance on fossil fuels. For example, Amazon, has publicly set a goal of reaching net-zero carbon emissions by 2024, 10 years ahead of the Paris Climate Agreement. To that end, Amazon has set the goal of powering all operations run by Amazon (which does not include contractors and assets not owned by Amazon) with renewable energy by 2025. [80]

Locomotive technology continues to advance as railroads push to save fuel and reduce emissions. New locomotives and rebuilt locomotives come with standard features such as anti-idling systems that shut down a locomotive when not in use and restart as needed automatically. All major Class I railroads have installed energy management systems in some form to large segments of the over the road units. Energy management provides engineers with prompts on a display in the locomotive to proactively reduce throttle as opportunities arise along a route and use the train's momentum to save fuel. New York Air Brake and Wabtec are the two suppliers of the energy management systems known as LEADER and Flex Optimizer, respectively, both which have auto-throttle technology, which is essentially "cruise control" for freight trains.

All Class I railroads are also making more use of distributed power, a technology that has been around for nearly 50 years but was mostly consigned to heavy-haul routes moving across rail lines with steep grades. Under distributed power, locomotive units are dispersed throughout the train length, with the lead unit controlling secondary and tertiary units that are located in the middle or at the end of the train. The practices reduce in-train forces, rail and equipment wear, and can save fuel versus conventional power arrangements where all units are located on the head end of the train.

Alternative U.S. Freight Locomotive Energy and Fuels

North American railroad suppliers have also added battery powered units to their product line ups. Battery-electric locomotives are designed to help railroads take advantage of fuel and emissions savings

[77] Progressive Railroading, May 2023, pp. 2.

[78] https://www.statista.com/statistics/1185535/transport-carbon-dioxide-emissions-breakdown/.

[79] American Association of Railroads, 2023.

[80] Amazon Climate Pledge (aboutamazon.com).

while not having to construct overhead catenary infrastructure required for full electric locomotives. In 2021, Wabtec Locomotive introduced the FLXdrive locomotive (Figure 6.8), a 100 percent battery-electric locomotive. Wabtec tested the FLXdrive locomotive in partnership with BNSF, placing the unit between conventional diesel units on trains operating between Barstow and Stockton, California. Results from 13,000 miles of testing included 6,200 gallons saved, no enroute mechanical failures, and 60 tons of CO_2 reduced. Since 2021, Wabtec has evolved the FLXdrive into FLXdrive 2.0, which provides 8.5 megawatt-hours of capacity that enables the unit to operate at 4400 horsepower for up 40 minutes. Batteries are recharged through dynamic braking, through which kinetic energy is converted back to electrical energy stored in the batteries and high-capacity stationary charging stations located at locomotive terminals.

Figure 6.8 Wabtec Flexdrive Locomotive

Source: Wabtec.

Confirmed orders for the Wabtec FLXdrive units have come from Union Pacific (10 units), Rio Tinto (global mining/minerals company; four units), Vale (global mining; three units) and BHP Western Australia (global resources; two units). In North America, Union Pacific's 10 FLXdrive locomotives are expected to be delivered at the end of 2023 and will be deployed in select terminals.

Progress Rail, a division of Caterpillar, which is the other primary supplier of freight locomotives to Class I railroads in North America, has also developed a battery power locomotive. Known as the EMD Joule Battery-Electric Locomotive, the product line offers various configurations for different global markets. Similarly, Union Pacific has committed to purchasing 10 EMD Joule units that will be tested in rail yards in California and Nebraska. Combining Progress Rail, Wabtec, and related infrastructure, Union Pacific will invest $100 million.

Freight rail manufacturers are also offering locomotives that can run on alternative fuels such as liquified natural gas and compressed natural gas. Wabtec offers the NextFuel Locomotive and conversion kit (for certain models of existing locomotives). Under the NextFuel program, which moved to full production in 2018, the locomotive consumes natural gas that is supplied via a tender (a specialized fuel car) in either liquified or compressed state. Similarly, Caterpillar's Progress Rail has natural gas conversion and locomotive offerings in its product line that include dynamic gas blending and direct injected gas, which allow 80 percent and 95 percent diesel substitution, respectively. Progress Rail also relies on a tender to supply compressed or liquified natural gas. Florida East Coast Railway, a Class II railroad that runs from Jacksonville to Miami, has been operating 12 pairs of locomotives (24 locomotives) connected to 12 tenders in regular line hauls service since 2017.

Shipper Technology

An ongoing challenge for rail freight customers has been tracking and receiving updates on the status of their freight moving on the railroad. Tracking freight can become more challenging for customers when moving across multiple railroads and shortlines (last-mile carriers). All Class I railroads have been investing and improving their online and app-based customer and freight management systems to provide better information to customers in real-time. However, collaboration across individual companies remains an essential element to providing a better experience for rail customers. One collaborative example is RailPulse, a joint venture effort designed to bring open-platform telematics to the merchandise car network in North America. Founding partners included shortline holding companies WATCO and Genesee and Wyoming, Class I carrier Norfolk Southern, and railcar manufacturers GATX and Trinity Rail. In 2022, RailPulse signed a 10-year agreement with Railinc, a for-profit subsidiary of the Association of American Railroads that provides software, data, and messaging services across the railroad industry. Subsequent partners that joined RailPulse include the Union Pacific (Class I) and Greenbrier Companies (railcar manufacturer).

Amazon Intermodal and Relay Drayage

In addition to procuring intermodal services from traditional intermodal service providers such as J.B. Hunt, Schneider, and Swift, Amazon initiated operating its own 53-foot domestic intermodal containers within North America with a fleet of several hundred containers in 2018. The program grew to 1,200 containers by the end of 2020 and 12,000 containers in the U.S. fleet by late 2022. To support the Amazon-owned containers that were managed by Amazon Transportation, the intermodal team initially created drayage contracts with 10 established drayage providers in markets in which Amazon Intermodal operated. As the program scaled, Amazon needed to similarly scale the drayage services to support the growth. The resultant solution evolved into introducing drayage on Amazon Relay, an Amazon-owned multi-faceted trucking technology platform that enables trucking companies to book Amazon loads and trucking contracts. Amazon Relay launched in 2018 for servicing traditional 53-foot dry vans and was expanded to support drayage moving trailer and containers in an out of rail yards by the end of 2021. Over 55,000 trucking companies participate in Amazon Relay, which delivers hundreds of thousands of truck movements in the middle-mile network per week.

Asset Management

Track geometry monitoring and inspection is an essential and critical process for maintaining a railroads line in a state of good repair to prevent derailments. Track geometry for mainlines on Class I railroads has typically been done with a dedicated track geometry train (Figure 6.9) that uses specialized equipment on board to inspect and collect data on track condition, or with a hi-rail vehicle, which is essentially a truck with special attachments that allows the vehicle to run on track. Field personnel generally accompany the inspection train as it rides over the territory for which they are responsible. One of the challenges to running dedicated track geometry trains and hi-rail vehicles is finding track time and capacity to run the train or block the line for the hi-rail inspection.

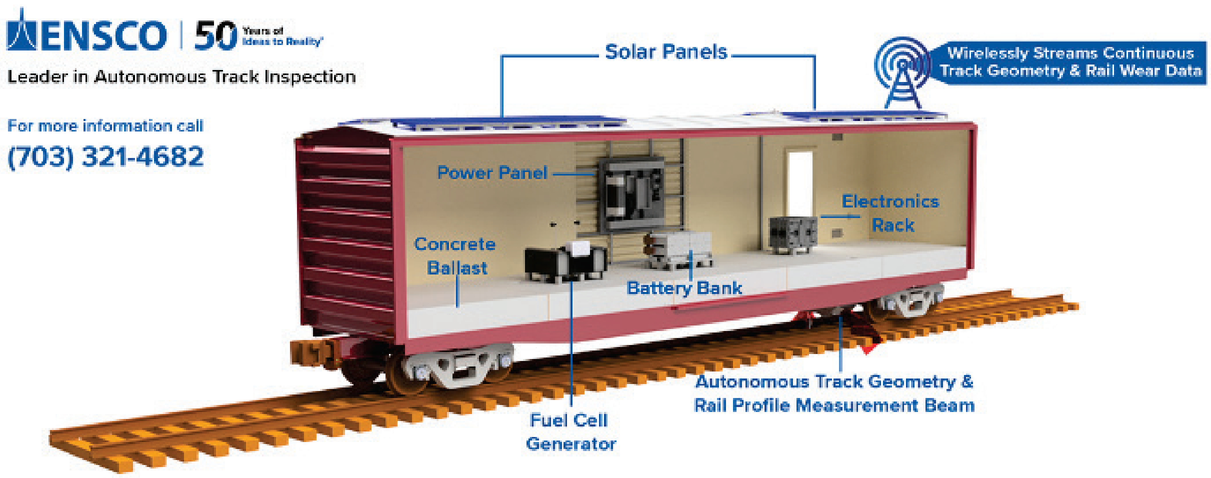
Figure 6.9 BNSF Track Inspection Train

Source: Progressive Railroading.

A solution employed by several Class I railroads is to run a special boxcar containing track inspection equipment within the consist of a regularly scheduled train (Figure 6.10). Similar to a geometry train, the specialized boxcar assesses gauge, cross-level, warp, twist, surface, alignment, and rail wear. Concrete ballast provides stability to the car, and onboard equipment is powered via solar panels attached to the roof and by reserve fuel cells. Similar to the equipment deployed on a geometry train, the special boxcar uses a beam that capture track conditions, records the data to onboard systems, and reports the results to the railroad's back-office headquarters immediately. Class I railroads using this technology report a higher number of defects found as result of using the special boxcar to supplement the traditional geometry train. [81]

[81] Railway Track & Structures, June 2019, pp. 14-21.

Figure 6.10 Ensco Modified Boxcar for Track Inspection



Source: Progressive Railroading.

The U.S. has 140,000 miles of rail network that includes 61,000 bridges. Bridges are inspected at regular intervals by railroad maintenance departments to maintain these assets in a state of good repair and identify defects that can be addressed proactively before failure and potentially catastrophic derailments. Similar to track inspections, bridge inspections have traditionally required taking a track out of service so the inspection crews can do a full evaluation of all critical points of potential failure. Over the last 10 years, Class I railroads have evolved and expanded their bridge inspection forces using unmanned aerial vehicles (UAV), also known as drones, to facilitate and supplement more traditional bridge inspection procedures. The use of drones allows bridge engineers to examine structures in difficult-to-reach places and from angles that conventional equipment cannot reach. In addition, drones do not require track to be taken out of service, which increases reliability of the transportation service provided by the railroad.

Leveraging PTC for Additional Efficiency

Following the passage of the Railway Safety Act in 2008, U.S. railroads invested a total of $10.6 billion to fully implement PTC across 57,536 required freight and passenger route miles in the U.S. network to meet the Federal deadline by December 31, 2020. [82, 83] PTC prevents train-to-train collisions, train overspeed, train run-through misaligned switchers, and unauthorized train movement through track work limits. The technology required the integration of wayside, back office, and locomotive technology that had to be interoperable across all railroads. Since implementation, railroads have been looking for ways to leverage benefits from the technology that go beyond the basic safety thesis. As the PTC mandate compelled the railroads to replace equipment that had become obsolete, railroads are seeing fewer delays from old equipment. It also established an information backbone that railroads can use across systems to proactively manage infrastructure assets through data mining and resolving issues before they occur. More benefits are expected in the coming years as processes, technology, and data systems evolve that leverage the PTC investment.

[82] Association of American Railroads.

[83] Federal Railroad Administration.

Highway-Rail Intersection GPS Based In-Vehicle Warning Systems

The concept of providing highway vehicles with warning systems to warn drivers of approaching trains dates back to the 1990s. Minimum viable products have been developed and tested, but have been unable to scale to widespread adoption due to excessive cost, interconnectivity, and limitations of hardware and software.

The advancement of mobile technology and the implementation of PTC by railroads is opening the door to further develop systems that could provide in-vehicle warnings of oncoming trains. The Federal Railroad Administration sponsored two studies produced in 2012 and 2022. [84, 85] The more recent study outlines Phase 2 of the Rail Crossing Violation Warning application whereby connected vehicles approaching highway-rail intersections are warned of an imminent violation of an active grade-crossing warning system. The critical connection is between roadside-based subsystems for highways and the track-circuit-based train detection system. Testing demonstrated that a reliable application for enhancing technology can be built using available technology, with future work recommended to include more field testing, pilot deployment projects, further integration with emerging communication protocols, and additional functionality that can handle complex situation such as multiple main-tracks and pedestrian violations.

U.S. Department of Transportation Colorado Testing Center

Colorado is home to the Federal Railroad Administration's Transportation Technology Center (Figure 6.11), which celebrated its 50th anniversary in 2021, putting Colorado at the center of long-term rail innovation and technology development. Located in Pueblo, Colorado, the center advances rail safety, research, technology, and innovation by providing a proving ground and extensive testing facilities to experiment, validate, and improve rail infrastructure, communications, and equipment.

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[84] https://railroads.dot.gov/sites/fra.dot.gov/files/fra_net/2784/Highway-Rail%20Intersection%20ITS%20GPS%20Based%20In-Vehicle%20Warning%20Systems_20121231_FINAL.pdf.

[85] https://railroads.dot.gov/sites/fra.dot.gov/files/2022-02/RCVW%20Phase%20II%20Project%20Report.pdf.

Figure 6.11 Federal Railroad Administration Transportation Technology Center (Pueblo, CO)

Source: Federal Railroad Administration.

The Transportation Technology Center encompasses 52 square miles and provides over 50 miles of test track, including a 2.7-mile high tonnage loop, 13.5-mile test track with catenary system, transit test track, precision test track, and a wheel/rail loop. Other facilities include hydraulic stands for mounting entire railcars and impact facilities that test crashworthiness.

6.1.3 Last-Mile Delivery Strategies

Last-mile delivery is a term used for the transportation of merchandise from the nearest distribution hub to the final destination, such as a home or business. This stage of the supply chain has become increasingly important in recent years as the transportation logistics industry has shifted to smaller, more frequent shipments direct to homes. More transload (transfer and interchange) points are being developed, moving freight distribution ever closer to the end consumer. Freight and people movement interactions will increase as a result of this changing supply chain dynamic (e-commerce, direct-to-consumer, same day delivery). Amazon is the best-known firm deploying this strategy today.

This direct-to-customer shift is already creating parking issues in metropolitan areas as delivery vehicles stop to deliver on nearly every street. Parking strategies and infrastructure are important considerations. Policies for road sharing are also important. Making last-mile delivery more efficient and less impactful on the environment will require looking at new delivery strategies and technologies. Some of the emerging technologies supporting last-mile delivery include cargo bikes and trailers, delivery robots, and UAVs, also referred to as drones.

Cargo Bikes

A cargo bike is a human-powered vehicle designed and constructed specifically for transporting freight. Cargo bike designs include a cargo area consisting of an open or enclosed box, a flat platform, or a wire basket, usually mounted over one or both wheels, low behind the front wheel, or between parallel wheels at either the front or rear of the vehicle. The frame, drivetrain, and wheels must be constructed to handle loads larger than those on an ordinary bicycle. An electric cargo bike adds an electric motor and battery to a cargo bike. This provides extra power and assistance up to a speed limit governed by electric bike laws.

Cargo bikes (Figure 6.12) are increasingly being used for last-mile delivery, especially in dense urban areas. Cargo bikes and trailers can use bike lanes and travel where trucks and vans cannot and often carry smaller standardized mini-containers that can travel on vessels, trucks, or vans. Some cargo bikes are not currently allowed in bike lanes in certain areas due to their size, speed, or number of wheels. A typical cargo bike travels at speeds of 12 to 25 miles per hour and can carry a maximum load of about 400 pounds. Their width is typically about three feet, allowing them to travel in most bike lanes. Some cargo bikes are equipped with various sensors and displays to show location, engine power, wear, and weather.

Figure 6.12 UPS Quad Cargo Bike

Source: UPS.

Cargo bikes have been successfully introduced in various markets across the world and for different types of deliveries. Fed Ex and UPS have conducted several large-scale field trials with cargo bikes and are ramping up their use. Some cargo bike products are being developed to meet the requirements for specific markets such as grocery delivery. Cargo bikes are generally popular with both industry and the public, while also being easy to adopt. However, increased use is causing some jurisdictions to reconsider existing sidewalk and bike lane policies.

Delivery Robots

A delivery robot is an autonomous, electric-powered robot that provides last-mile delivery services via local streets and sidewalks. An operator may remotely monitor and take control of the robot in certain situations that it cannot resolve by itself, such as when it is stuck in an obstacle. Delivery robots can be used in various settings, including food delivery, package delivery, hospital delivery, and room service.

Delivery robots can reduce transportation costs for consumers while delivering small to medium sized loads in a green, safe, and efficient way. Testing and pilot projects are ongoing throughout the world, with fully autonomous robots delivering goods in a variety of use cases, both on roads and in campus environments. Delivery robots can deliver anything from convenience goods and e-commerce packages to groceries and electronics. Robots developed by Nuro have full heating, ventilation, and air conditioning (HVAC) systems and are designed with grocery delivery in mind. Sodexo has procured "Kiwibots" for food delivery at 50 college campuses across the United States. While delivery robots typically travel at slower speeds and off the main roadway, the Nuro robot can travel on neighborhood streets at up to 25 miles per hour (Figure 6.13).

Figure 6.13 Nuro Delivery Robot on Shared Roadway

Source: Nuro.

Although several states such as Pennsylvania, Virginia, Idaho, Florida, and Wisconsin have made it legal for delivery robots to operate on streets and sidewalks, densely populated urban areas have been slower to follow suit. It could be quite some time before large cities such as New York City allow delivery robots to operate on their streets and sidewalks. In 2019, New York City officials banned delivery robots, claiming that delivery robots violate vehicle and traffic laws that prohibit self-driving cars and motor vehicles on sidewalks.

Drones and UAVS

A delivery drone is a type of UAV used for distributing packages to consumers during the last-mile delivery process. Drone delivery is an intermodal technology likely to expand in the next five years. Offering a wide range of benefits, the major focus is on increased connectivity and reliability. As e-commerce direct-to-customer shipping grows, this intermodal technology allows for more efficient goods movement to the final consumer, especially in urban areas. Drone delivery also has applications in remote, less densely populated rural areas where the cost to deliver is high. Drones are likely to fill a niche in inspection roles or in local delivery of certain goods such as pharmaceuticals and other medical supplies, or in delivery to remote areas with few roads.

Most drones are fully autonomous and can take off and land vertically, making their use in dense urban areas practical (Figure 6.14). Their main infrastructure need is having enough space to take off and land safely, resulting in the use of building rooftops as a common staging area for delivery drones. Their delivery range and load can vary based on battery capacity and other limitations. Delivery range can be up to 300 miles and maximum loads range from 300 to 500 pounds. However, most drones carry packages that weigh under five pounds.

One of the main challenges of using drones for last-mile delivery is that they must comply with various regulations and standards that govern the use of airspace, privacy, security, and noise. The Federal Aviation Administration regulates the use of drones in the United States. All drones must be registered, except those that weigh less than 0.55 pounds. Also, delivery drones are prohibited from operating within five miles of an airport and must stay under 400 feet in altitude to avoid interfering with other aircraft. Drones also have to avoid collisions with other drones, birds, or buildings and ensure safe landing and delivery of goods.

Figure 6.14 Delivery Drone Taking Off from Rooftop

Source: ZF.

Delivery drones offer a green alternative that leverages the airways to provide fast delivery of high-value, time-sensitive goods. UAV use cases are being tested and validated, including hub-to-hub, hub-to-van, rooftop deliveries, and direct-to-customer. A number of companies are currently testing UAVs, including Google, FedEx, and Walmart. UPS has a new division, Flight Forward, that is focused on drone delivery solutions.

6.2 Environment

With the 2023 update to the State Freight Plan and State Freight Advisory Committee Guidance, environmental topics are intended to address quantifiable goals, baseline conditions, and estimates of air pollution and greenhouse gas emissions. [86] The environmental analysis of state freight plans are directed to address the following four goal areas:

ENVIRONMENTAL GOAL AREAS

AREA 1. The severity of impacts of extreme weather and natural disasters on freight mobility

AREA 2. Impacts of freight on local air pollution

AREA 3. Impacts of freight movement on flooding & stormwater runoff

AREA 4. Impacts of freight on wildlife habitat loss

The following sections speak to these goal areas, with goal areas addressed highlighted in callout boxes.

6.2.1 Extreme Weather and Natural Disasters

GOAL AREAS ADDRESSED

AREA 1. The severity of impacts of extreme weather and natural disasters on freight mobility

AREA 3. Impacts of freight movement on flooding & stormwater runoff

In November 2018, the Colorado Department of Transportation signed New Policy Directive 1905.0, "Building Resilience into Transportation Infrastructure and Operations." By this directive, CDOT is charged with supporting resilience goals by incorporating resilience into strategic decisions regarding transportation assets and operations by taking steps that include implementing a risk-based asset management approach and improving the Department's response and recovery efforts. CDOT is also charged with considering resilience in enterprise activities and operations.[1]

The State of Colorado defines resilience as "the ability of communities to rebound, positively adapt to, or thrive amidst changing conditions or challenges, including human-caused and natural disasters, and to maintain quality of life, healthy growth, durable systems, economic vitality, and conservation of resources for present and future generations."[2] The State also refers to the definition developed by the American Association of State Highway and Transportation Officials (AASHTO), which defines resilience as "the ability to prepare and plan for, absorb, recover from, or more successfully adapt to adverse events."

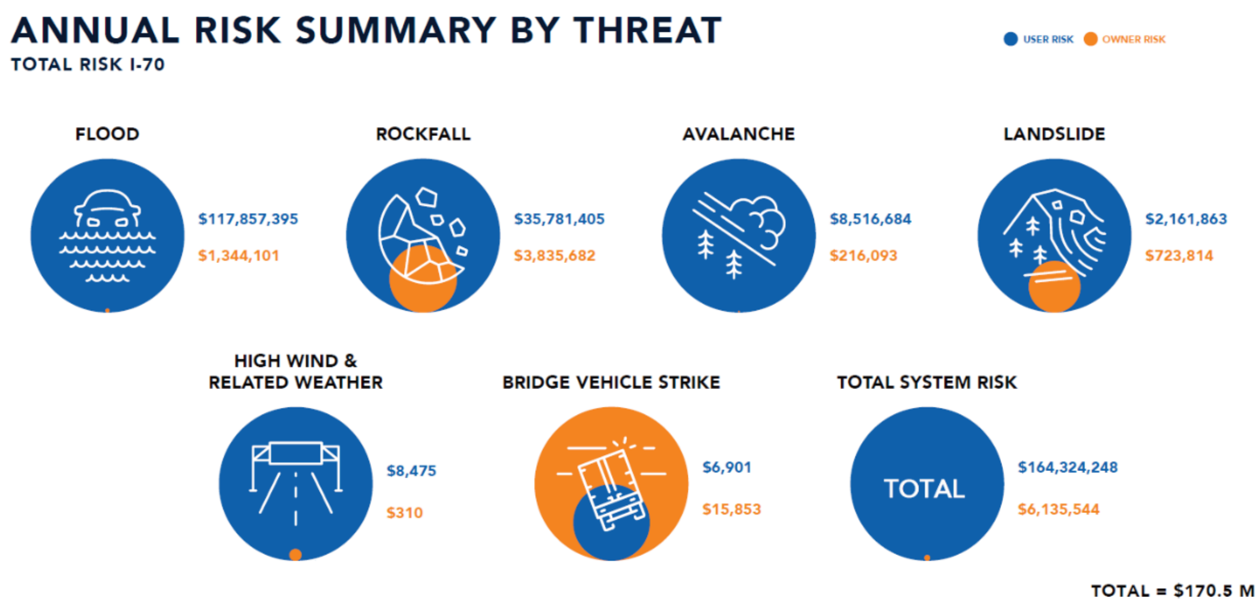
CDOT's Resilience Program defines resilience and provides many resources developed at a program website, including fact sheets, studies, case study summaries, guides, tools, and mapping applications. Two resources that are particularly helpful in identifying a "baseline" of the state's potential vulnerability to extreme weather and stormwater resources include an interactive map titled Resilience in Colorado

[86] State Freight Plan and State Freight Advisory Committee Guidance.

that shows the location of critical roadways, floodplains (100-year and 500-year), drought areas (showing locations that experience moderate, extreme, and severe impacts), areas at risk of wildfire, locations at risk of a variety of geohazards (including rockfall, landslide, and debris flow), detail view of areas prone to certain disaster (including the Glenwood Canyon stretch of I-70 and Red Mountain Pass), and major avalanche paths.

Another key resource is the Department's Risk and Resilience Analysis Procedure (also referred to as the "RnR"). The manual provides a seven-step guide for calculating risk for eleven common threat-asset pairs. The procedure focuses on threats that include flooding, rockfall, and fire debris flow, all of which are associated with a high number of major disaster declarations. Following the steps provides an estimate of total annual risk (broken down by owners and users) that can be combined with an economic analysis for risk management that compares the mitigation benefit to the annual cost of mitigation in order to determine the benefit-cost ratio of any individual action to address risk. An overview of risks identified for the I-70 corridor is included in Figure 6.15. According to the analysis, risks associated with flood, rockfall, avalanche, landslide, high wind and related weather, and bridge vehicle strike exceed $170 million.

Figure 6.15 Annual Risk Summary by Threat for the I-70 Corridor



Source: I-70 Corridor Risk and Resilience Pilot (2017), https://www.codot.gov/programs/planning/assets/plans-projects-reports/reports/i70rnr_finalreport_nov302017_submitted_af.pdf.

6.2.2 Air Quality and Emissions

GOAL AREAS ADDRESSED

AREA 2. Impacts of freight on local air pollution

Transportation is the largest source of greenhouse gas (GHG) emissions in Colorado. [87] Within the sector, medium and heavy duty vehicles (M/HDV) are the second-largest source of GHG emissions, accounting for 22 percent of on-road GHG emissions, despite making up less than 10 percent of vehicles in Colorado. In 2019, there were around 480,000 heavy duty vehicles registered in the state, emitting over 5.3 million tons of GHG. [88] In addition to GHG emissions, M/HDV are among the largest contributors to mobile source emissions of NOx, which reacts with the atmosphere to form ozone and particulate matter (PM). M/HDVs contribute 30 percent of on-road NOx emissions and 40 percent of on-road PM emissions. The Front Range region, which includes Denver, is in nonattainment for the 2015 eight-hour ozone standard. All counties in Colorado are in attainment for all other National Ambient Air Quality Standards. [89]

Reducing emissions across all vehicle types will be crucial for Colorado to achieve economy-wide emissions cuts of at least 65 percent by 2035, 75 percent by 2040, 90 percent by 2045, and net-zero by 2050 (as set in SB 23-016). Pursuing strategies that accelerate the transition to zero emissions vehicles (ZEV) has the potential to reduce GHG emissions by 45 percent, NOx emissions by 54 percent and PM emissions by 53 percent by 2050 from a 90 percent baseline scenario. [90]

Colorado has explored a variety of strategies and programs to reduce emissions from M/HDVs and increase adoption of M/HDV ZEVs to 30 percent of new sales by 2030 and 100 percent by 2050.The Colorado Clean Truck Strategy aims to transition Colorado's M/HDVs to low and zero emissions alternatives by investing in charging infrastructure and creating incentives for truck fleets to switch to ZEVs. These strategies include accelerating opportunities for fleet turnover, developing a robust infrastructure network to support ZEVs (described more below), incorporating clean technologies into key freight corridors and highway projects, exploring opportunities for cleaner national fleets, exploring emissions reductions for last mile freight delivery, working with and assisting truck dealerships and private maintenance shops in supporting workforce development and ZEV implementation, and encouraging private fleets to become partners in the Environmental Protection Agency's (EPA) SmartWay program.

In April 2023, Colorado's Air Quality Control Commission adopted new rules to accelerate the transition to ZEVs. Colorado became the eighth state to follow California's lead in adopting the Advanced Clean Trucks (ACT) rule, one of the strategies identified in its Clean Truck Strategy. The ACT rule requires manufacturers of M/HDVs to sell an increasing percentage of zero-emissions models. The rule takes effect for trucks with model year 2027, with the sales standard percentage incrementally increasing through 2035. The Low-NOx rule establishes new standards for gas and diesel-powered truck engines, improves testing requirements for engines, and extends warranties. The new rule is projected to lower nitrogen

[87] Colorado Greenhouse Gas Reduction Roadmap, 2022 https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap-20 .

[88] CDPHE (2023). 2021 Greenhouse Gas Inventory Update. https://drive.google.com/file/d/1SFtUongwCdZvZEEKC_VEorHky267x_np/view.

[89] United States Environmental Protection Agency (2023). Colorado Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants. Retrieved from: https://www3.epa.gov/airquality/greenbook/anayo_co.html.

[90] Colorado Legislature Senate Bill 23-016. Retrieved from: 2023a_016_signed.pdf (colorado.gov).

oxide emissions standard for new vehicles by 90 percent compared to existing standards. In addition to these rules, Colorado has established new grant programs to incentivize operators and manufacturers and help them meet the targets set by the ACT rule. The Clean Fleet Vehicle and Technology Grant Program, launched in March 2023, reimburses up to 60 percent of the cost of new electric trucks. This is described in greater detail below, in Section 6.4: Targeting emissions from freight.

6.2.3 Wildlife

Transportation infrastructure can impact wildlife by causing fatalities, fragmenting habitat, bisecting migration routes, and altering hydrology. As new infrastructure is added or as traffic on existing infrastructure increases, it can negatively impact wildlife. These impacts can be mitigated through a variety of different strategies, many of which are in place in Colorado.

GOAL AREAS ADDRESSED

AREA 4. Impacts of freight on wildlife habitat loss

In 2005, the State launched the State Wildlife Action Plan (SWAP) and revised it in 2015. SWAP serves as a comprehensive document that outlines the primary threats facing various wildlife categories and outlines essential conservation measures. The SWAP analysis found that the State is home to 159 vertebrate and mollusk Species of Greatest Conservation Need (SGCN), and approximately 15 percent of these species have been adversely affected by the presence of transportation corridors. Through the SWAP, the State established a commitment to updating biodiversity status on a five- to ten-year cycle. As of 2015, monitoring plans were in place for 114 of the SGCN species found in Colorado. [91]

Colorado has an average of 3,300 wildlife fatalities reported annually, at a cost of approximately $1.1 billion in property damage and $66.3 million in medical expenses. [92, 93] Among the mortalities, 9,000 mule deer are killed on highways every year. Within the freight sector, according to the crash database from CDOT, there were nearly 26,000 truck-involved crashes on Colorado's roadway network during 2017—2021. Approximately 1.2 percent of these truck-involved crashes involved wild animals. The appearance of wildlife on highways is fatal for both animals and drivers, especially for trucks with heavy loads that take longer to respond to emergencies. As shown in Figure 6.16, the number of wild animal-involved crashes reached a peak of 1,010 in 2018. As a result of coordinated efforts by CDOT and Colorado Parks & Wildlife on wildlife safety prioritization, the number of truck-related wildlife crashes has decreased since 2018.

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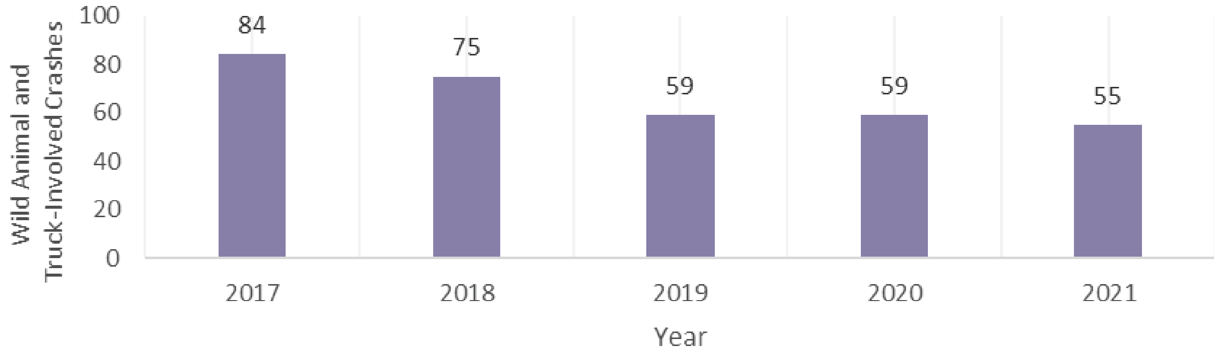
91 https://cpw.state.co.us/Documents/WildlifeSpecies/SWAP/CO_SWAP_ExecutiveSummary.pdf.

92 Colorado Department of Transportation. https://www.codot.gov/programs/environmental/wildlife/wildlifeonthemove.

93 Colorado Wildlife & Transportation Alliance. https://www.coloradowta.com/home/.

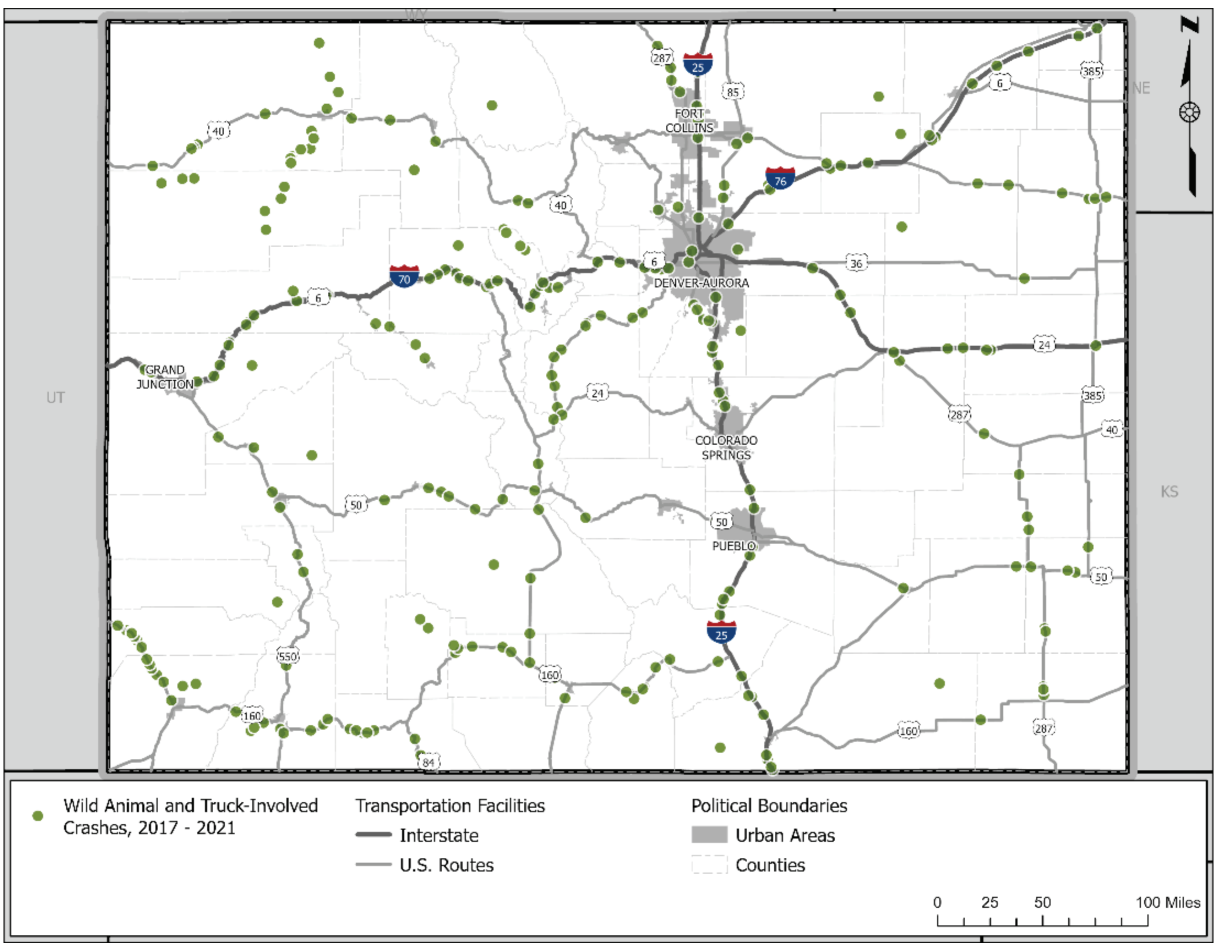
Figure 6.16 Trends in Wild Animal Involved Truck Crash from 2017-2021



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Spatially speaking, more of the wild animal crashes related to truck movement happened west of I-25, suggesting that the mountainous region has more wildlife activity than the eastern part of the state (Figure 6.17).

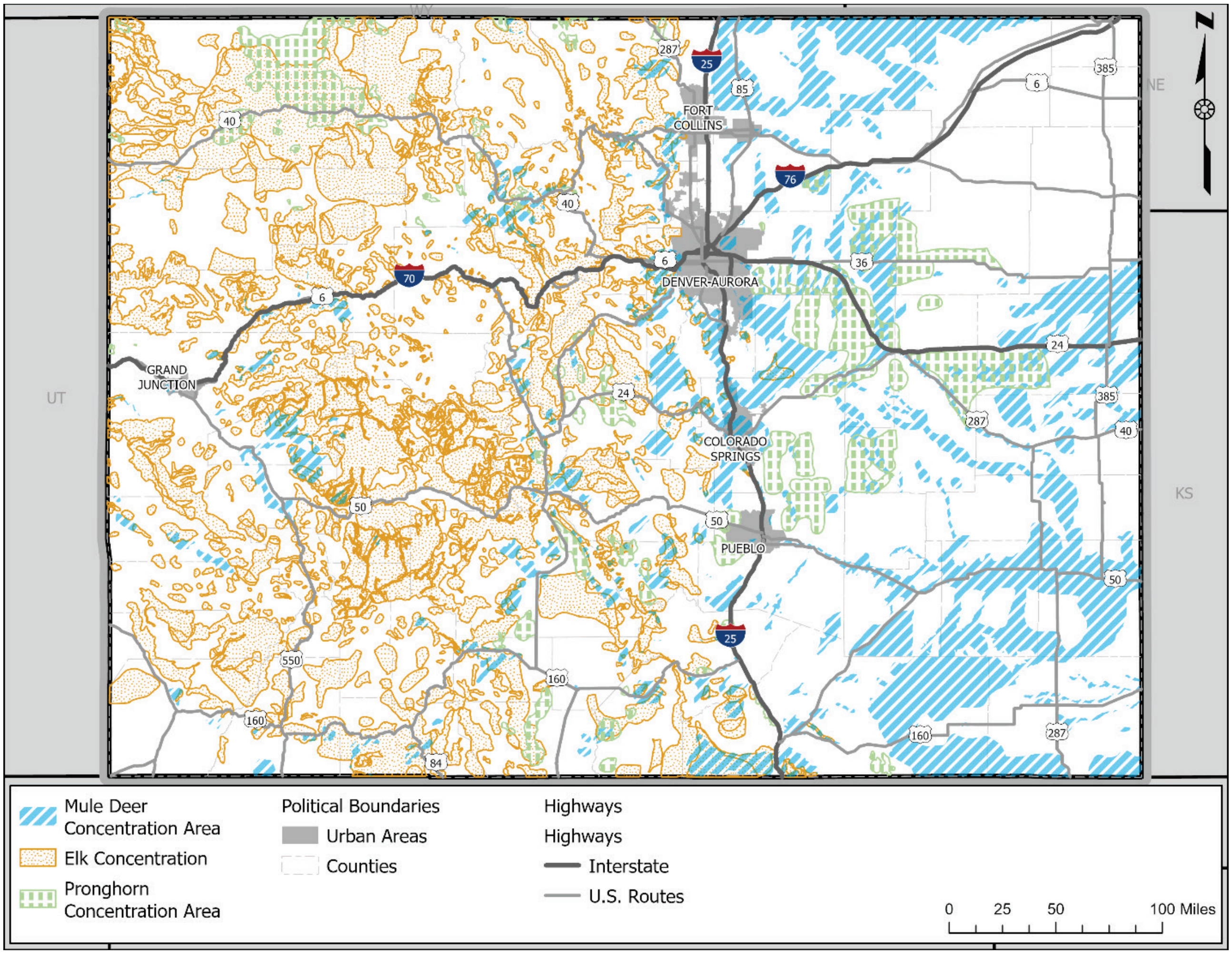
Figure 6.17 Wild Animal Involved Truck-Related Crash Distribution



Source: Crash Data, Colorado Department of Transportation, 2017–2021, https://www.codot.gov/safety/traffic-safety/data-analysis/crash-data.

Figure 6.18 confirms this trend and highlights the distribution of three primary wild animal species in Colorado: mule deer, elk, and pronghorn. Notably, elk populations are predominantly clustered west of I-25, mule deer habitats are more concentrated on the eastern side of I-25, and pronghorn habitat exhibits a more dispersed pattern across the state compared to the other two species. Major highway corridors including I-70 and I-25 cut in particular cut through identified habitat areas, and as a result, see a higher concentration of wild-animal crashes and associated economic loss.

Figure 6.18 Wildlife Concentration Area



Source: Colorado Parks and Wildlife species data. 2019. https://hub.ArcGIS.com/maps/9a845acae8f34d718caf9fd9a0e5e177/about.

One of the initiatives that has put downward pressure on the number of wildlife involved crashes is a collaboration between CDOT and Colorado Parks & Wildlife (CPW) to both identify appropriate locations and to construct wildlife crossings. Currently, there are 63 overpasses and underpasses, as well as wildlife fencing along the highways in Colorado, which allow wildlife to move across highways safely, especially during the big game species' migration season. This work was supported by two wildlife prioritization studies in 2019 and 2022 to identify the most critical highway segment for wildlife protection in Colorado's Western Slope and the combined Eastern Slope and Plains region. The Western Slope Prioritization Study prioritized sections of SH 13 in CDOT Region 3 and U.S. 160 in CDOT Region 5. [94] The Eastern Slope and Plains Study found a greater need for wildlife-related interventions in the Plains compared to the Eastern Slope. [95] Both studies provide critical guidance in ongoing work to protect wildlife.

6.3 Targeting Emissions From Freight

The state began aggressive efforts to reduce emissions associated with freight beginning in 2015, with Executive Order D 2015-013 passed by Governor John Hickenlooper to establish responsibility for environmental leadership in all State agencies and departments to achieve greenhouse gas (GHG) reduction goals and reduce emissions for state-owned fleets. Targets were applied to all vehicles in the state starting in 2019 with the passage of HB19-1261, the *Climate Action Plan to Reduce Pollution*.

ELEMENTS OF COLORADO'S CLEAN TRUCKS STRATEGY

- Achieve 100 percent zero-emission medium- and heavy-duty fleet vehicle purchases where technically feasible and able to meet safety and mission critical operation needs by no later than 2040.
- Increase adoption of medium- and heavy-duty zero emission vehicles sales to at least 30 percent of new sales by 2030 and 100 percent by 2050.
- Increase adoption of zero-emission medium- and heavy-duty vehicles to 35,000 vehicles on the road by 2030.
- Improve coordination with partners to facilitate the disposal of the oldest and most-polluting vehicles with 2017 or newer emissions technology and retire at least 500 of the oldest vehicles on the road by 2027.
- Form partnerships for sufficient medium- and heavy-duty charging and hydrogen fuel infrastructure.

Freight emissions have been a focus of study and policy development since 2021. The *Colorado Medium- and Heavy-Duty Vehicle Study* (2021), considered how particular strategies could support statewide GHG reduction goals, and found that aggressive strategies could reduce the state's GHGs by nearly half (approximately 3.3 million metric tons of CO2 equivalent). The 2022 Clean Trucks Strategy built on previous studies with support of leadership at three state agencies (Colorado Energy Office, Colorado Department of Transportation, and Colorado Department of Public Health and Environment) to consolidate strategies for Government vehicles and formalize specific strategies for the medium- and heavy-duty vehicle market. The focus on analysis is ongoing, and continues with initiatives like the 2023 study on *Medium- and Heavy-Duty Charging Infrastructure in the State of Colorad*o, which identifies locations and corridors for the near- and longer-term rollout of infrastructure suitable for zero-emission freight vehicles (shown in Figure 6.19).

This work is supported both through extensive in-state funding opportunities and multi-state partnerships. In 2021, the state also passed a $750 million transportation bill to establish new state enterprises to support a sustainable transportation system, including the Clean Fleet Enterprise (which provides support for eligible light-, medium-, and heavy-duty fleet vehicles) and the Community Access Enterprise (which provides support for charging infrastructure used by fleets). The state is also supported by partnerships that include the REV West Memorandum of Understanding (MOU) to develop electric-vehicle charging

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[94] https://www.codot.gov/programs/research/pdfs/2022/wildlife-prioritization/cdot-2019-01-weboptimized.pdf.

[95] https://www.codot.gov/programs/research/pdfs/2022/wildlife-prioritization/eswps-report.

infrastructure along key corridors, the Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Action Plan to set zero-emission sales targets, and the Western Interstate Hydrogen Hub LLC with other states to submit an application (unsuccessful) for a hydrogen hub. Upon adopting the Advanced Clean Trucks regulation in 2023, the state joined a collation of 10 states requiring vehicle manufacturers to sell an increasing percentage of zero-emission trucks starting with 2027 model year trucks.

Table 6.2 provides a review of recent actions taken to reduce emissions associated with freight vehicles.

Table 6.2 State Activities to Reduce Emissions in Medium- and Heavy-duty Vehicles

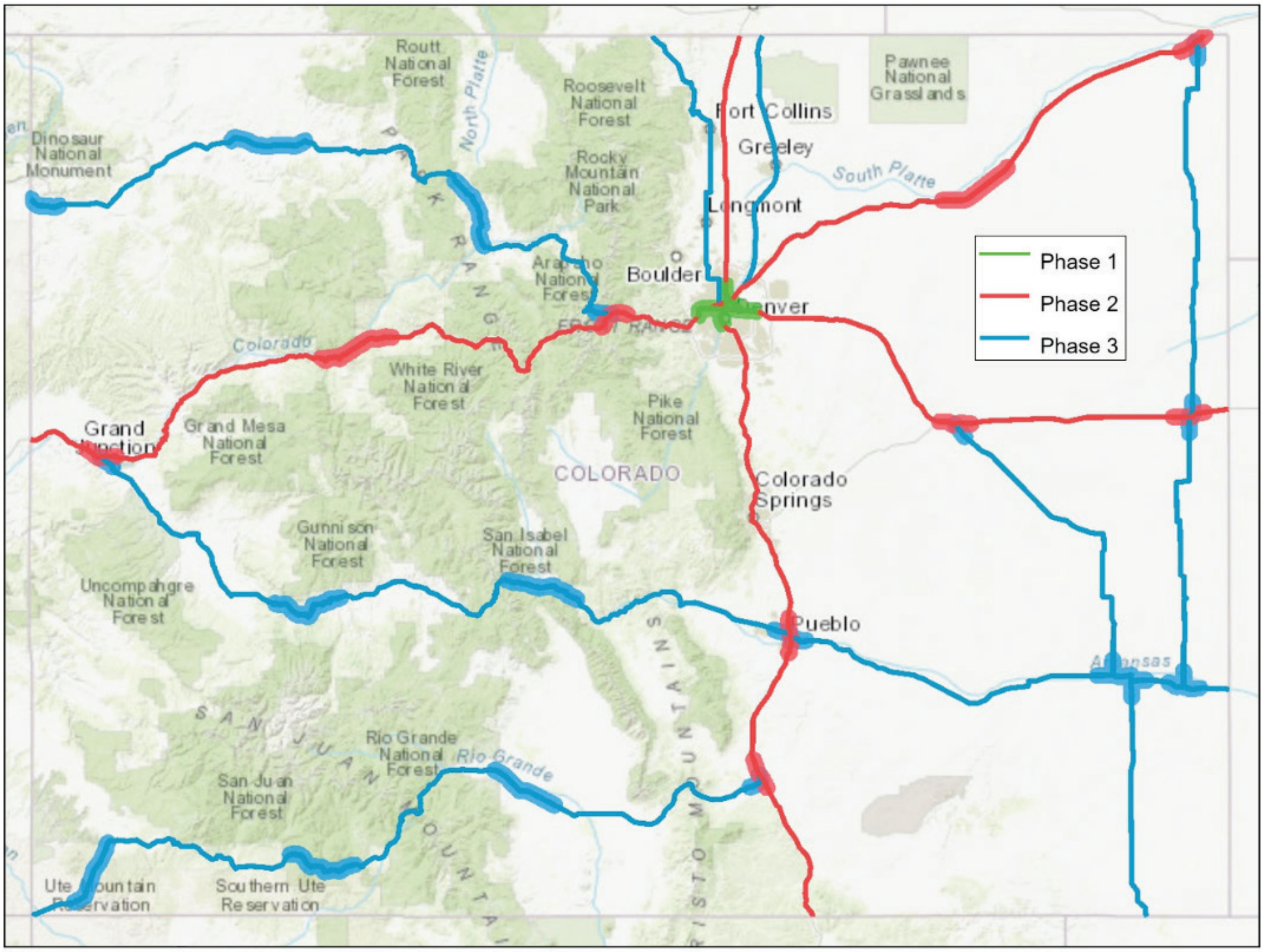
Year	Title	Description
2015	EO D 2015-013, Greening of State Government	Set initial goals for petroleum reduction and associated greenhouse gas (GHG) emissions, including a per-vehicle reduction target of 4% on an annual basis or 2% for exempt vehicles for State agencies and departments.
2017	REV West Memorandum of Understanding (MOU)	Provided a framework for creating an intermountain West EV Corridor across major transportation corridors in eight western States.
2017	EO D 2017-15, Supporting Colorado's Clean Energy Transition	Directed State agencies to develop a plan to electrify Colorado's transportation corridors.
2018	Regulation 201, the Colorado Low Emission Automobile Regulation (CLEAR)	Required all new light- and medium-duty vehicles and aftermarket catalytic converters sold in Colorado to meet Low Emission Vehicle (LEV) standards.
2018	EO D 2018 026 Concerning the Greening of State Government	Set a goal to reduce GHG emissions from state fleet vehicles by at least 15% by the end of FY2022-2023 from a FY2014-2015 baseline.
2019	EO B 2019 002, Supporting a Transition to Zero Emission Vehicles	Directed the Colorado Department of Public Health and Environment (CDPHE) to develop a ZEV program, directs remaining Volkswagen settlement money to be used to transition buses and trucks to be electric-powered, creates interagency working group, and requires CDOT to develop a policy and plan to ensure the agency's support of electrification.
2019	EO D 2019 016 Amending and Replacing Executive Order D 2018 026 Concerning the Greening of State Government	Updated previous goal for state fleet vehicles to reduce GHG emissions from State operations by at least 26% by the end of FY2024-2025 over the FY2014-2015 baseline.
2019	HB19-1261, Climate Action Plan to Reduce Pollution	Set statewide GHG reduction targets: by 26% in 2025, by 50% in 2030, and by 90% by 2050.
2019	SB 19-096, Collect Long-term Climate Change Data	Required the Colorado Air Quality Control Commission (AQCC) to collect GHG emission data. Bill facilitated implementation of measures to support the State in cost-effectively meeting its GHG reduction goals.
2020	Colorado Electric Vehicle Plan 2020 updated	Update to the 2018 EV plan, with consideration for large-scale transition to ZEVs and trucks. Set a goal that 100% of medium- and heavy-duty vehicles be zero-emission.
2020	Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Action Plan	Colorado joins a coalition of states to adopt goals that at least 30 percent of new medium- and heavy-duty vehicles sales be zero-emission by 2030, and 100 percent by 2050. As of October 2023, 17 states, the District of Columbia, and the Canadian province of Quebec are members of this coalition

Year	Title	Description
		(facilitated by the Northeast States for Coordinated Air Use Management [NESCAUM]).
2021	SB 21-260 Sustainability of the Transportation System	Established three new state enterprises to support a sustainable transportation system, including the Clean Fleet Enterprise (which provides support for eligible light-, medium-, and heavy-duty fleet vehicles) and the Community Access Enterprise (which provides support for charging infrastructure used by fleets). Also created the freight mobility and safety branch in CDOT's transportation development division.
2021	Colorado Greenhouse Gas Pollution Reduction Roadmap	Examined sources of GHG emissions in Colorado and found that transportation was the largest source of emissions. To achieve goals, identified a need for 100% of truck sales to be zero-emission by 2050.
2021	Colorado Medium- and Heavy-Duty Vehicle Study	Studied effect of aggressive strategies to support an accelerated transition to medium- and heavy-duty zero-emission vehicles. Found that strategies could reduce the state's GHGs by nearly half (approximately 3.3 million metric tons of CO2 equivalent) and achieve similar reductions in nitrogen oxide (NOx) and particulate matter (PM).
2022	2022 Colorado Clean Truck Strategy	Identified strategies to reduce emissions from medium- and heavy-duty vehicles.
2023	Advanced Clean Trucks	Colorado adopts California's Advanced Clean Trucks rule requiring truck manufactures to sell an increasing percentage of zero-emission trucks starting with 2027 model year trucks.
2023	Western Interstate Hydrogen Hub	Colorado, as a member of the Western Interstate Hydrogen Hub LLC (WIH2), submitted an unsuccessful application for a $1.25 billion grant from the U.S. Department of Energy to build a regional hydrogen hub.
2023	Medium- and Heavy-Duty Charging Infrastructure in the State of Colorado	Colorado-focused analysis of the M/HD charging market, overview of M/HD charging needs analysis for Colorado, and strategic analysis to inform the development of Colorado's forthcoming M/HD charging incentive program. Study presented range of needs (considering an average case, conservative case) and target locations for near- and longer-term rollout.

In Colorado, preliminary medium- and heavy-duty charging priority areas have been identified through Colorado's Medium/Heavy Duty Charging Infrastructure in the State of Colorado. [96] Figure 6.19 shows the location of the preliminary locations.

[96] https://drive.google.com/file/d/1n-nkMVHdEYMnPweHMZcsyUfZ6fg8xrwy/view.

Figure 6.19 Medium- and Heavy-Duty Priority Areas



Source: Colorado Medium and Heavy-Duty (M/HD) Charging Corridors Map (2023). https://experience.ArcGIS.com/experience/9f2da35d8f0a4d0aaec8db151f668696.

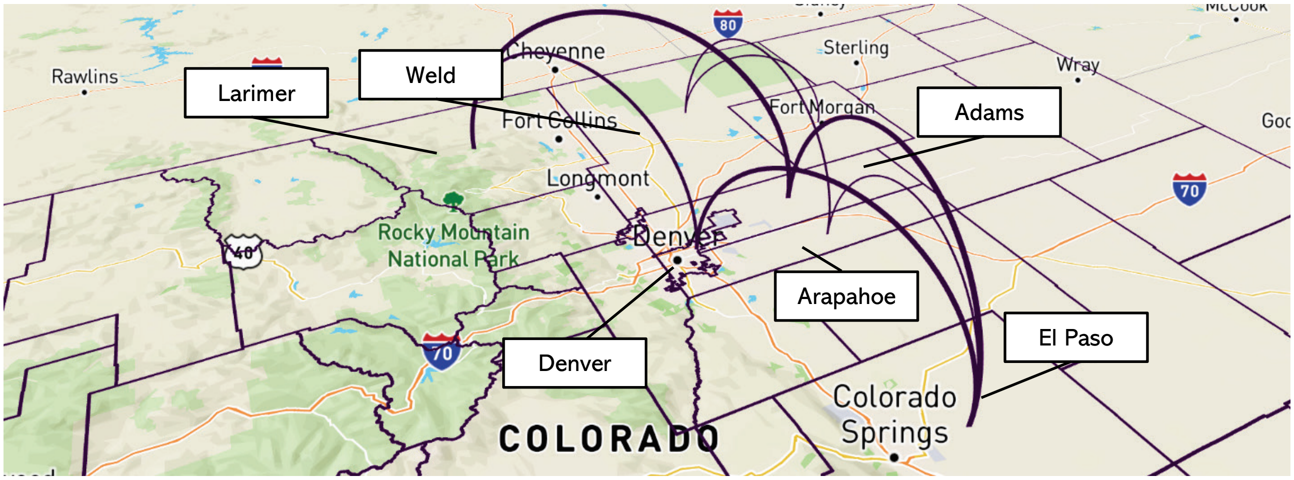
In Colorado, medium- and heavy-duty zero-emission vehicles may initially take advantage of the relatively mature technology available to support battery electric propulsion and a growing network of charging infrastructure. As of October of 2023, there are 314 medium-duty vehicles available for purchase (including trucks, cargo vans, and step vans) compared to 116 heavy duty trucks. [97] The North American Council for Freight Efficiency (NACFE) believes that up to 50 percent of regional trips are "electrifiable," particularly short and medium hauls (less than 100 mile trips from a depot).

In Colorado, other locations that may be more likely to demand charging infrastructure in the near-term were identified using the Geotab dataset on medium-duty trips to identify which counties generate/receive a high number of trips between 75 and 125 miles (average) before a stop of at least eight hours. These trips are concentrated in the Front Range area between El Paso County (including Colorado Springs) and Larimer County (including Fort Collins). Figure 6.20 shows that there are large

[97] https://globaldrivetozero.org/tools/zeti-data-explorer/.

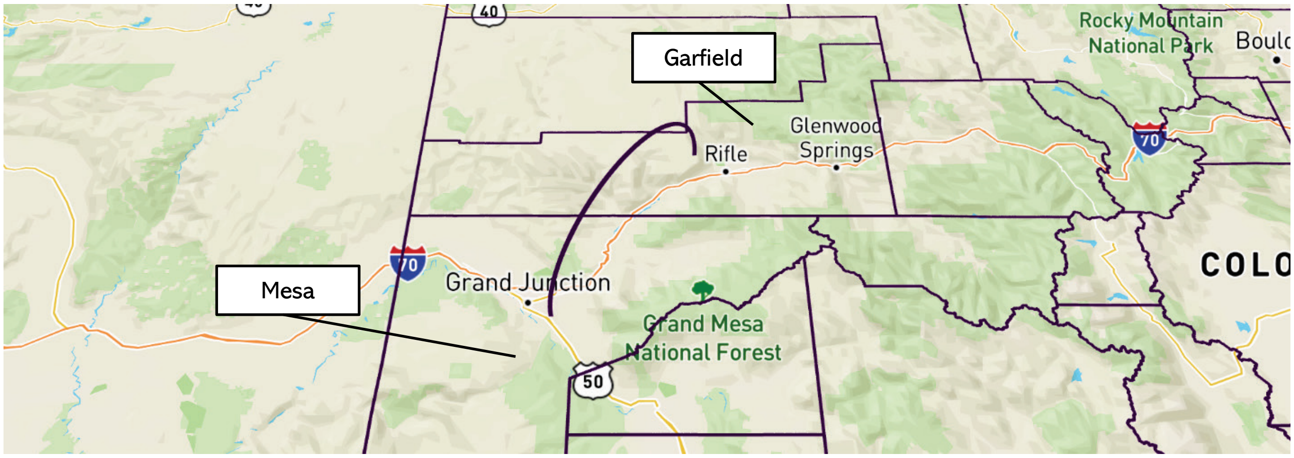
number of trips between El Paso and northern counties (including Denver, Adams, and Arapahoe). There are also a high number of trips between Adams and Larimer Counties.

Figure 6.20 Front Range Medium-Duty Vehicle Trips (Emphasis on Number of Trips)



On the Western Slope, Figure 6.21 shows that are also a high number of medium-duty truck trips between Mesa and Garfield Counties that are average between 75 and 125 miles. More than 3,000 truck trips originated in either Mesa or Garfield and ended in the neighboring county.

Figure 6.21 Western Slope Medium-Duty Trips (Emphasis on Number of Trips)



7

Moving Forward

This chapter describes Colorado's freight vision and goals; performance-based approach; key strategy and action framework; investing resources; and implementation activities.

7.1 Linking Goals, Strategies, Performance, and Investments

As indicated in CDOT's Accountability and Transparency Wildly Important Goals (WIG)—ensure efficient use of taxpayer funds and efficient construction project delivery—CDOT is committed to maximizing the impact of limited funds to improve freight system safety, mobility, economic vitality, maintenance, and sustainability. This performance-based investment approach directly links statewide freight goals and performance measures to help inform investment decisions and to prioritize projects for funding. Performance measures enable CDOT to evaluate current conditions, set future targets, and assess progress toward those targets.

Investment emphasis areas identified in the CFP support Colorado's multimodal freight goals as well as CDOT's WIGs and national freight program goals. Within each statewide goal area, potential freight projects are evaluated with freight performance measures and data-driven criteria. Projects are further prioritized through stakeholder-driven processes, including the active involvement of the FAC and Colorado Transportation Commission. This project prioritization and selection process helps evaluate the expected performance impacts of projects and determine how that project may achieve goals and performance targets. CDOT is working to develop additional data sources and analysis methods to generate improved performance data available at the project level. This process is continually evolving and will be updated and revised over time to incorporate new data and criteria.

At the goal level, potential investment actions are identified to best utilize available funding sources. Dedicated freight funding sources, such as the NHFP, as well as other funds sources, such as Statewide Planning Funds or Freight Operations Funds, may be utilized to make progress on identified strategies. Supporting investment actions are identified in the CFP implementation framework described later in this chapter. With competing investment priorities, this approach enables CDOT to focus on projects and priorities that most directly impact goods movement and have the most significant potential to improve mobility, system performance, and safety.

7.1.1 Colorado's Freight Vision and Goals

Businesses and consumers across the state rely on a system of roads, rail lines, airports, and intermodal facilities to deliver goods on time, safely, and at minimal cost. The FAC worked with industry partners to develop a future vision for how Colorado delivers now and in the future: "Colorado's multimodal freight system will support the economic vitality of the state by providing for the safe, efficient, coordinated, and reliable movement of freight." This vision recognizes the critical importance of goods movement to statewide and regional economies. Colorado's multimodal freight vision and goals support national and state goals and focus on safety, mobility, economic vitality, maintenance, and sustainability.

COLORADO'S FREIGHT PLAN VISION

Colorado's multimodal freight system will support the economic vitality of the state by providing for the safe, efficient, coordinated, and reliable movement of freight.

CDOT is committed to working with business, agency, and regional and local planning partners to advance investments, actions, and policies that will achieve this vision. This plan recognizes that with current funding constraints and growing future needs, Colorado still has room for improvement and progress to be made. CDOT's approach to investment decision-making for dedicated freight funding is discussed later in this chapter.

Aligning National and State Goals

Each fiscal year, CDOT produces a Performance Plan, as required under Colorado Revised Statute C.R.S. § 2-7-204, also known as the State Measurement for Accountable, Responsive and Transparent (SMART) Act. The Performance Plan is CDOT's strategic roadmap that informs partners about the upcoming fiscal year's Wildly Important Goals (WIGs). The WIG's are ambitious, short-term goals that align the Governor's Key Priorities with CDOT's strategic priorities. For fiscal year 2023-2024, the WIGS are:

- **Advancing Transportation Safety—**Advance the safety of Colorado's transportation system so all travelers arrive at their destination safely.
- **Accountability & Transparency—**Ensure efficient use of taxpayer funds and efficient construction project delivery.
- **Clean Transportation—**Reduce pollution from the transportation sector.
- **Statewide Transit—**Relieve traffic congestion with connected statewide transit and rail services. [98]

Colorado's multimodal freight goals support national multimodal freight goals established by the FAST Act and revised by the BIL. These national goals focus on investments in infrastructure and operational improvements that strengthen economic competitiveness, reduce the cost of transportation, improve reliability, and increase productivity. Safety, security, and resiliency are also emphasized, along with improving the state of good repair of the highway system. CDOT's Policy Directive 14 (PD-14) provides

[98] *Performance Plan and Reports.* Colorado Department of Transportation. https://www.codot.gov/performance/performance-plan.

performance targets to measure the success of the Department's efforts to improve in the following key areas: safety, asset management, and mobility. National goals also align with CDOT's recent efforts to innovate and leverage advanced technology and support state flexibility to address freight connectivity.

As revised by the BIL, the goals of the National Highway Freight Program are:

- To invest in infrastructure improvements and operational improvements that strengthen economic competitiveness, reduce congestion, reduce the cost of freight transportation, improve reliability, and increase productivity;
- To improve the safety, security, efficiency, and resiliency of freight transportation in rural and urban areas;
- To improve the state of good repair of the National Highway Freight Network;
- To use innovation and advanced technology to improve the safety, efficiency, and reliability of the National Highway Freight Network;
- To improve the efficiency and productivity of the National Highway Freight Network;
- To improve the flexibility of States to support multi-State corridor planning and the creation of multi-State organizations to increase the ability of States to address highway freight connectivity; and
- To reduce the environmental impacts of freight movement on the National Highway Freight Network. [99]

Table 7.1 shows how the Colorado Freight Plan Goals are aligned with the National Freight Goals, PD-14 and Colorado's Wildly Important Goals.

Table 7.1 Linking Shared National and State Goals

Colorado Freight Plan Goals	National Freight Goals	Colorado Wildly Important Goals
• Safety & Security • Mobility • Maintenance • Economic Vitality • Sustainability & Resiliency	• Safety and security • Congestion • Reliability • Goods Movement • Innovation and Technology • State of Good Repair • Economic Efficiency and Productivity • Multi-State Planning • Resiliency • Environmental	• Advancing Transportation Safety • Accountability and Transparency • Accountability and Transparency • Statewide Transit • Clean Transportation

[99] *Implementation Guidance for the National Highway Freight Program as Revised by the Bipartisan Infrastructure Law*. USDOT. https://ops.fhwa.dot.gov/freight/documents/NHFP_Implementation_Guidance.pdf.

7.1.2 Strategies Approach

Strategies for accomplishing the State Freight Plan goals evaluated through this process are presented in Section 7.2. They include strategies within the prior Colorado Highway Freight Plan, actions to address needs and issues raised through the plan development process, recommendations from stakeholders, and best practices from other state freight planning efforts.

7.1.3 Managing for Performance

Planning at CDOT is performance-based. This means that limited available funding is allocated to projects to support performance goals and objectives. Performance-based planning is embedded in all of CDOT's activities—from policies, to programs, and project decisions.

CDOT develops an overarching performance-based Statewide Transportation Plan that sets long-term aspirational goals for the statewide transportation system. The Statewide Transportation Plan integrates modal and operational plans, incorporates input from planning partners and the public, and provides performance data and analysis from a statewide and multimodal perspective.

The FAST Act includes guidelines for assessing performance within state freight plans. At the Federal level, CDOT reports to FHWA several measures, including four that are specific to the Colorado Freight Plan Goals:

- **Highway Safety—**Five year average number of fatalities
- **Highway Infrastructure Condition—**Bridges in good condition on the NHS
- **Highway Reliability—**Truck Travel Time Reliability Index (TTTR)
- **Emissions Reductions—**NO_X emissions reduce through Congestion Mitigation and Air Quality (CMAQ) projects, 4-year cumulative [100]

CDOT's Policy Directive (PD)-14 provides performance targets beyond those reported to FHWA to measure the success of CDOT's efforts in the following key areas: safety, asset management, and mobility. [101]

Measuring performance relies on the availability of quality, timely, and specific data to assess current conditions, to establish objectives and targets, and to link program goals to project level decisions. CDOT collects and analyzes data from a variety of sources to track road and rail safety trends, pavement and bridge conditions, congestion levels, and truck travel time reliability, among other measures.

CDOT can directly influence decision-making, and ultimately performance outcomes, in some areas, but not others. For example, resource allocation decisions made by CDOT can directly impact roadway conditions or bridge load restrictions on the state highway system. However, CDOT lacks direct influence over other areas covered by the CFP; for example, indicators such as overall goods movement volumes,

[100] *State Performance Dashboard—Colorado.* USDOT. https://www.fhwa.dot.gov/tpm/reporting/state/state.cfm?state=Colorado.

[101] *Policy Directive 14: "Policy Guiding Statewide Plan Goals and Objectives."* Colorado Department of Transportation. https://www.codot.gov/programs/tam/pd-14-performance-targets.

decisions made by private railroads and publicly-owned air cargo facilities, or the sustainability of commercial vehicle fleets as these outcomes depend on macroeconomic conditions and private business decision-making. The performance measures and targets described within the CFP are focused on those areas and those modes that CDOT can most directly address—primarily the safety, mobility, and maintenance of the state highway system.

Targets for freight system performance measures are set through CDOT's ongoing performance management processes, including updates to statewide targets set through PD-14 and through supporting plans such as the Statewide Transportation Plan and Asset Management Plan. Targets are set through a data-driven process that examines relationships between performance and investment and trends in current and future conditions. Updates to federally required performance targets, such as TTTR, will be established by CDOT and incorporated into updates to the CFP. State-specific targets, such as truck parking availability, are based on findings from CDOT research efforts and ongoing data analyses. Reflecting limitations in transportation funding, particularly freight-specific funding, targets may not always show improvements over existing conditions.

CDOT will track and report performance, as appropriate, through regular performance management processes including PD-14 and federally required performance reporting. As data becomes available and measures and targets are revised, CDOT will update CFP system performance measures through implementation planning and plan update cycles.

7.1.4 Funding Sources

Transportation funding for projects in the region can come from a number of sources including Federal programs, state programs, and funds raised locally within the region. In November 2022 the Infrastructure Investment and Jobs (IIJA) Act was passed which authorized multiple new formula and discretionary transportation funding programs for fiscal years 2022 through 2026.

National Highway Freight Program (NHFP) is a dedicated freight funding source established under the FAST Act and continued under the BIL. Generally, NHFP funds must contribute to the efficient movement of freight on the National Highway Freight Network (NHFN) and be identified in a freight investment plan included in the State's freight plan. For fiscal years 2022–2026, NHFP funds are projected to be over $97.6 million for Colorado. [102] Table 7.2 lists several funding sources available for freight related projects. Descriptions of each are included in Appendix C.

[102] Federal Highway Administration, Bipartisan Infrastructure Law—Funding, https://www.fhwa.dot.gov/bipartisan-infrastructure-law/funding.cfm, Accessed 11/15/2023.

Table 7.2 Funding Sources for Freight Projects

Funding Source	Abbreviation	Federal Formula	Federal Discretionary Grants	State
National Highway Freight Program	NHFP	●	-	-
National Highway Performance Program	NHPP	●	-	-
Surface Transportation Block Grant	STBG	●	-	-
Highway Safety Improvement Program	HSIP	●	-	-
Congestion Mitigation and Air Quality Improvement Program	CMAQ	●	-	-
Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation	PROTECT	●	●	-
Carbon Reduction Program	CRP	●	-	-
National Electric Vehicle Infrastructure Program	NEVI	●	-	-
Railway-Highway Crossings Program	RHCP	●	-	-
Nationally Significant Multimodal Freight and Highway Projects Program	INFRA	-	●	-
National Infrastructure Project Assistance Grant Program	MEGA	-	●	-
Rural Surface Transportation Grant Program	RSTP	-	●	-
Rebuilding American Infrastructure with Sustainability and Equity Program	RAISE	-	●	-
Railroad Crossing Elimination Grant Program	RCE	-	●	-
Innovative Technology Deployment Program	ITD	-	●	-
Clean Ports Program	CPP	-	●	-
Charging and Fueling Infrastructure Grants	CFI	-	●	-
Reduction of Truck Emissions at Port Facilities	RTEPF	-	●	-
Direct Current Fast-Charging Plazas Program	DCFC	-	-	●
Colorado Clean Diesel Program	-	-	-	●
Energy/Mineral Impact Assistance Fund Grant	EIAF	-	-	●
Innovative Motor Vehicle Income Tax Credits	-	-	-	●
Fleet Zero-Emission Resource Opportunity	Fleet-ZERO	-	-	●
Clean Fleet Vehicle & Technology Grant Program	-	-	-	●
Xcel Energy Rebates, Advisory Services, and other Transportation Electrification programs	-	-	-	●

7.2 Colorado Freight Plan Implementation Framework

The following sections outline the CFP's key strategies, performance measures, and investment actions within each goal. This framework provides guidance and direction to CDOT, FAC, and planning partners and forms the basis of ongoing implementation efforts. The strategies are further defined by:

- **Stakeholder Priority**—Level of support based on interviews, working group input, and outreach. Actions can be considered to have strong support if mentioned frequently or if consensus is reached by working groups. Moderate support may indicate several strong advocates or general interest in potential actions. Low support indicates little to no awareness of the need for action.
- **Timeline**—Actions are assumed to meet conservative estimates for development and roll-out. Actions are assessed on whether progress is reasonably feasible within a given lead time. Some actions may face significant barriers to implementation (e.g., funding, legislation, policy, resources, staff capacity, etc.) that could extend the timeline.
- **Lead**—Priority is given to actions where CDOT is the likely lead implementer and responsible agency. Other actions may require CDOT in the lead role with internal or external partnerships needed for action. Actions that do not address traditional CDOT roles or where CDOT is not the lead implementer are considered to need significant partner leadership and support.

Within each goal area is a table listing relevant performance metrics. Where performance targets are incorporated they align with Policy Directive 14 (PD-14), the policy guiding statewide plan goals and objectives. Not all performance metrics are linked directly to PD-14 and therefore do not have state adopted targets. It is important to note that some performance measures, particularly those associated with maintenance, are not exclusively impacted by freight related activity, but are essential to the movement of goods across Colorado's freight infrastructure. One such example is road condition which is impacted be all road users, and therefore not exclusively the responsibility of freight planning, but is a critical component of mobility and reliability in the freight network.

Finally, each goal area has identified potential funding sources and investment opportunities that can be leverage to improve performance and work towards achieving and enhancing goals.

7.2.1 Enhance Safety and Security for Commercial Carriers Safety

Table 7.3 Safety Goals

Goal Source	Goals
Colorado Multimodal Freight Plan Goals	Safety & Security
National Freight Goals	Safety & Security
Colorado Wildly Important Goals	Advancing Transportation Safety

Table 7.4 Safety Strategies

Action	Stakeholder Priority	Timeline	Lead
Commercial Vehicle Safety—Prioritize identified commercial vehicle safety hotspots and other locations with specific safety challenges for funding within NHFP project selection.	High	Short-term	CDOT
Prioritize Truck Parking Investments—Utilize statewide truck parking assessment to prioritize network gaps and solutions for funding and implementation of public parking projects.	High	Ongoing	CDOT
Emergency Truck Parking—Establish partnerships with facilities that have large, underutilized parking lots, that could serve as overflow parking during emergency road closures.	High	Short-term	CDOT
Truck Parking Information—Design and deploy a Colorado Truck Parking Information Management System	High	Ongoing	CDOT
Truck Parking Partnerships—Support private sector and public agency partners in exploring innovative pilot programs or public-private initiatives to expand the availability of privately-owned truck parking facilities.	High	Ongoing	CDOT
Operational Safety Enhancements—Evaluate where and what enhancements are needed, and establish a secure funding source, for improvements and maintenance of chain stations, runaway truck ramps, safety pull-outs, and other highway freight network operational and safety features.	High	Ongoing	CDOT
Rail Safety—Streamline delivery of the Railway-Highway Crossings (Section 130) Program, including project prioritization and risk assessments for future projects.	Medium	Ongoing	CDOT
Safety Data—Enhance internal data and analytical capabilities to identify and assess commercial vehicle safety hotspots and integrate needs into regional and state project selection processes.	Medium	Short-term	CDOT
Communications-Continue to build on the Mountain Rules information campaign, in partnership with the Colorado State Patrol, Colorado Motor Carriers Association, and in-cab driver alert providers, to enhance safety for truckers traveling through the state's mountainous areas.	Low	Ongoing	CDOT

Table 7.5 Safety Measures

Performance Measure	Current Condition	State or Federal Target
Commercial Vehicle Involved Incident Rate per 1M Truck VMT (*This measure tracks the annual number of crashes involving commercial motor vehicles per million truck miles driven*)	1.21	-
Number of Highway-Rail Incidents (*This measure tracks the annual number of highway-rail incidents involving motor vehicles and freight or passenger trains*)	7	-
Available Public Truck Parking Spaces per 100,000 Daily Truck VMT (*This measure tracks the number of public truck parking spaces available per 100 thousand truck miles driven*)	10	-
Available Public and Private Truck Parking Spaces per 100,000 Truck VMT (*This measure tracks the number of public and private truck parking spaces available per 100 thousand truck miles driven)*	103	-

Table 7.6 Safety Investments

Fund Source	Investment Action
NHFP	Commercial vehicle safety is an identified FAC priority investment area and projects with safety benefits are prioritized within the NHFP funding area.
NHFP HSIP CMAQ STB NHFP RAISE grant INFRA grant FMCSA High Priority (HP) Grant	Truck parking is an identified priority investment area and projects including truck parking elements are prioritized within the NHFP funding area. Additional programmatic and discretionary Federal funding is also available.
Section 130	Support Division of Project Support efforts to prioritize highway-rail crossing risks and streamline delivery of the Railway-Highway Crossings Section 130 funding program.
HSIP FASTER	Coordinate ongoing safety investments to leverage safety funding sources to address commercial motor vehicle hotspot locations.

7.2.2 Improve Mobility and Efficiency of Goods Movement

Table 7.7 Mobility Goals

Goal Source	Goals
Colorado Multimodal Freight Plan Goal:	Mobility
National Freight Goals:	Congestion Reliability Goods Movement Innovation and Technology
Colorado Wildly Important Goal:	Accountability and Transparency

Table 7.8 Mobility Strategies

Action	Stakeholder Priority	Timeline	Lead
Mobility Data—Enhance internal data and analytical methods to identify highway bottlenecks and congestion points that contribute to travel time or reliability issues and link to funding opportunities.	High	Short-term	CDOT
Incident Management—Continue to support and expand CDOT capabilities for commercial vehicle incident management, including the Heavy Tow program for commercial vehicles on Colorado Freight Corridors.	High	Ongoing	CDOT
Management and Operations—Continue coordination with CDOT TSM&O and local and regional planning partners to identify potential Intelligent Transport Systems (ITS) applications for commercial vehicles (e.g., ramp meter bypass, lane management, express lanes) and identify opportunities for funding and implementation of projects.	High	Short-term	CDOT
Freight Coordination—Coordinate with local and regional planning partners to address identified local freight issues, including truck parking needs, restrictive freight policies, curb management practices, roadway design, and other mobility constraints.	High	Mid-term	CDOT
Freight Information—Continue to enhance CDOT's freight webpage (https://freight.colorado.gov/), a platform to disseminate information on freight trip planning, truck routes, real-time travel information, truck parking, safety and capacity constraints, and other information.	Medium	Ongoing	CDOT
Freight Technology—Support private-sector partner efforts to deploy innovative technologies or pilot test freight technologies including in-cab communications, truck platooning, connected commercial vehicles, and other safety and mobility technologies.	Medium	Mid-term	FAC
At-grade Railroad Crossings—Work with local communities and industry to reduce truck delays at at-grade railroad (RR) crossings through improved communications and routing.	Low	Ongoing	CDOT
Military Freight—Continue coordination with the U.S. Department of Defense to identify and improve routes critical to national defense.	Medium	Ongoing	CDOT

Table 7.9 Mobility Measures

Performance Measure	Current Condition	State or Federal Target
Truck Travel Time Reliability Index (Federal measure) (*This measure shows the variability of travel times specifically for trucks on the highway network. High TTTR indicates unreliable truck travel times, low TTTR values indicate more reliable travel times. Target set based on National performance Metrics*)	1.39	1.46
Annual Average Incident Clearance Times on Key Corridors (*This measure describes the average time to clear an incident along key corridors in the state, including interstates and major U.S. corridors. Target set by CDOT PD-14*)	Average 24 mins across all highways	Average 20 mins across all highways

Table 7.10 Mobility Investments

Fund Source	Investment Action
NHFP	Prioritize commercial motor vehicle mobility investments within NHFP program.
State Planning & Research (SPR)	Utilize statewide planning funds to enhance data and analytical capabilities.
Accelerated Innovation Deployment (AID)	Demonstration program supports the implementation of proven operational and material innovations in surface transportation.
Commercial Driver's License Program Implementation (CDLPI)	Awards funding to state commercial driver's license (CDL) programs to achieve compliance with Federal licensing and programmatic standards.
High Priority Innovative Technology Deployment (HP-ITD) Program	The HP-ITD Program supports the deployment of CMV and driver safety technology, including the implementation and maintenance of intelligent transportation system applications or CVIEW.
Other	Coordinate with CDOT, regional and local partners to leverage existing fund sources to address highway, rail, and air cargo mobility and connectivity needs.

7.2.3 Maintain the System

Table 7.11 Maintain Goals

Goal Source	Goals
Colorado Multimodal Freight Plan Goal	Maintenance
National Freight Goals	State of Good Repair
Colorado Wildly Important Goal	Accountability and Transparency

Table 7.12 Maintain Strategies

Action	Stakeholder Priority	Timeline	Lead
Bridge Constraints—Identify and prioritize bridges on freight corridors or freight support corridors that are currently restricting freight corridors due to load, height, or width restrictions.	High	Ongoing	CDOT
Freight Rail Condition—Develop and implement an assistance program (loan fund, grant program, or hybrid) to fund critical capacity needs and track upgrades for short-line railroads.	Medium	Long-term	CDOT
System Condition—Identify and implement maintenance and improvement projects on the Colorado Freight Corridors by integrating freight specific projects into current CDOT project development, selection, and funding processes.	Low	Short-term	CDOT
Mitigate Pavement Deterioration—Evaluate improvements that may be required to reduce or impede the deterioration of roadways traveled by heavy vehicles.	Low	Mid-term	CDOT
Sustainable Funding—Identify sustainable funding sources for maintenance and operation of freight highway infrastructure.	Medium	Short-term	CDOT

Table 7.13 Maintain Measures

Performance Measure	Current Condition	State or Federal Target
Percent of Bridge Crossings over Interstates, U.S. Routes and State Highways with a Vertical Clearance less than the Statutory Maximum Vehicle Height of 14 feet-6 inches	2.01%	1.0%
Percent of Bridge Crossings over Interstates, U.S. Routes and State highways with a Vertical Clearance less than the Minimum Design Requirement of 16 feet-6 inches	19.8%	18%
Percent of CDOT-Owned Bridges Posted for Load	0.4%	0.1%
Percent of CDOT-Owned Bridges with a Load Restriction	2.4%	0.9%
High/Moderate Drivability Life for Colorado Freight Corridors	79%	80%
Percent of State Highway Total Bridge Deck Area Not Structurally Deficient for Colorado Freight Corridors (Federal measure)	94.4%	90.0%

Note: All targets set consistent with PD-14 standards.

Table 7.14 Maintain Investments

Fund Source	Investment Action
Surface Treatment Program (STP)	Coordination with state and regional asset management programs to identify and fund improvements on Colorado Freight Corridors and other critical freight routes
-	Implement a state-funded grant, tax incentive, or loan assistance program to fund short-line railroad system maintenance and capital upgrade needs.

7.2.4 Improve Economic Vitality and Industry Competitiveness

Table 7.15 Economic Goals

Goal Source	Goals
Colorado Multimodal Freight Plan Goal:	Economic Vitality
National Freight Goals:	Economic Efficiency and Productivity Multi-State Planning
Colorado Wildly Important Goal:	Statewide Transit

Table 7.16 Economic Strategies

Action	Stakeholder Priority	Timeline	Lead
Education and Communications—Continue working with industry partners in support of the Colorado Delivers communications initiative.	Medium	Ongoing	CDOT
Economic Development—Develop a process with Engineering Regions and TPRs to identify potential projects that improve rural and urban economic competitiveness and advance projects into regional planning and project selection processes.	High	Short-term	CDOT
Economic Coordination—Develop ongoing coordination processes with state, regional, and local economic development agencies to identify and advance multimodal freight improvement needs—including highway, rail, or air cargo connectivity to existing and future industrial, free trade, or economic redevelopment areas such as a consolidated intermodal freight port (sometimes referred to as inland port).	Medium	Mid-term	CDOT
Freight Workforce—Support public agency partners in evaluating freight and logistics workforce needs and developing programs to address specific needs—such as fixed route transit, car and van pooling, and other shared mobility options to improve reliable access to logistics jobs.	Medium	Mid-term	FAC
Trade and Logistics—Support public agency or civic partner organizations in developing a statewide export, manufacturing, and trade and logistics strategy to support an increase in outbound freight shipments.	Medium	Long-term	FAC
Economic Benefits—Develop data and methods to support identification, evaluation, and prioritization of freight projects with economic development benefits or impacts.	Low	Mid-term	CDOT

Table 7.17 Economic Measures

Performance Measure	Current Condition	State or Federal Target
Annual Cost of Congestion to Commercial Motor Vehicles (*This measure is the cost of congestion exclusively from traffic on the roadways*)	$312,000,000	-

Table 7.18 Economic Investments

Fund Source	Investment Action
NHFP	Evaluate potential economic vitality benefits and prioritize projects identified for funding within NHFP funding program
SPR	Utilize statewide planning funds to implement coordination and project identification efforts among regional and local planning partners

7.2.5 Improve Sustainability and Reduce Environmental Impacts

Table 7.19 Sustainability Goals

Goal Source	Goals
Colorado Multimodal Freight Plan Goal:	Sustainability & Resiliency
National Freight Goals:	Resiliency Environmental
Colorado Wildly Important Goal:	Clean Transportation Statewide Transit

Table 7.20 Sustainability Strategies

Action	Stakeholder Priority	Timeline	Lead
Supply Chain Efficiency—Coordinate with industry partners on opportunities to improve supply chain efficiencies, including load-matching resulting in reduced emissions and environmental impacts.	High	Mid-term	FAC
Consolidated Intermodal Freight Port—Coordinate with state, regional, and local land use agencies to identify and advance a consolidated intermodal freight port (sometimes referred to as inland port) to facilitate private investment in zero emission fueling infrastructure and more efficient freight operations, rail access, intermodal transfers, and workforce transit.	High	Long-term	FAC
Highway Mobility and Operational Improvements—Improve mobility (and reduce associated emissions) by removing barriers associated with truck operations (e.g., deficient bridges) and by leveraging ITS to better operate highways.	Medium	Short-term	CDOT
Encourage Fleet Turnover—Support the Colorado Clean Truck Strategy through continued partnerships focused on retiring the oldest vehicles on the road.	High	Long-term	CEO, CDPHE, CDOT
Pursue Partnerships for Charging Infrastructure. Expand partnerships both within and across states to support medium- and heavy-duty zero emission charging and fueling infrastructure.	Medium	Ongoing	CEO, CDPHE, CDOT
Mitigate Wildlife Habitat Loss—Continue collaboration with Colorado Parks & Wildlife to identify appropriate locations to construct wildlife crossings. Continue collaboration with Colorado Parks and Wildlife to mitigate wildlife collision and identify potential wildlife crossings to ensure safety for all and alleviate wildlife conservation threats.	Medium	Ongoing	CDOT

Action	Stakeholder Priority	Timeline	Lead
System Risk and Redundancy—Coordinate with CDOT's Resilience Program to evaluate potential natural hazard risks (e.g., extreme weather, natural disasters, flooding) identified in the interactive map titled Resilience in Colorado, to key freight corridors and identify redundant routes and necessary improvements to ensure redundancy of the system.	High	Ongoing	CDOT

Table 7.21 Sustainability Measures

Performance Measure	Current Condition	State or Federal Target
Number of Wildlife Incidents *(This measure is a count of the number of incidents between road users and wildlife)*	714	-
Percent sales of M/HDV ZEVs *(This measure is the share of medium and heavy vehicle sales that are electric vehicles. Target from Colorado Clean Truck Strategy)*	Limited	30% by 2030 100% by 2050
Percent sales of state-owned M/HD ZEV fleets *(This measure is the share of state owned medium and heavy vehicles that are electric. Target from Colorado Clean Truck Strategy)*	Limited	100% by 2040 where technically feasible
Percent on-road M/HD ZEVs *(This measure is the share of all medium and heavy vehicles that are electric. Target from Colorado Clean Truck Strategy)*	Limited	35,000 by 2030 100% long-term
Replace oldest and most polluting vehicles and replace with newer emissions technology. *(This measure is the share of vehicles that have emissions technology that is from the year 2000 or more recently. Target from Colorado Clean Truck Strategy)*	16% of vehicles built before 2000	Reduction in percentage of vehicles built before 2000

Table 7.22 Sustainability Investments

Fund Source	Investment Action
Clean Fleet Vehicle and Technology Grant Program	Grants for light-, medium-, and heavy-duty fleet vehicles that use low-emission technology (including electric, fuel cell, and recovered methane). Grants also available for scrapped vehicles and converted vehicles.
Clean Ports	Federal discretionary grant to reduce air pollutants at ports and intermodal truck-rail facilities.
CMAQ	Federal-aid program targeted at reducing congestion and improving air quality, including funding for projects for intelligent transportation systems, idle-reduction/advanced truck technology programs, e-cargo pilots, and others.
Colorado Clean Diesel Program/Diesel Emissions Reduction Act (DERA)	Funding for projects that achieve significant reductions in diesel emissions and exposure.
DCFC Plazas Program	State grant program for high-speed charging in communities and along highway corridors.
Energy/Mineral Impact Assistance Fund (EIAF)	Funding for projects that increase sustainable community development, livability, and resilience.
Fleet Zero-Emission Resource Opportunity (Fleet-ZERO)	Grants for fleet owners and operators to install electric vehicle charging infrastructure.
Grants for Charging and Fueling Infrastructure	Grant to support development of publicly accessible charging infrastructure for medium- and heavy-duty vehicles (including battery electric, hydrogen, propane, and natural gas).
Innovative Motor Vehicle Tax Credits	Tax credits toward the purchase of lease of light-, medium-, or heavy-duty electric trucks.
NHFP	Prioritize projects identified for NHFP funding that reduce delay, or address bottlenecks, that contribute to excess truck emissions
Reduction of Truck Emissions at Port Facilities	Grant program to reduce truck idling at port facilities and intermodal port transfer facilities.
SPR	Utilize statewide planning and implementation funding to support FAC and private and public partner efforts to achieve supply chain efficiencies
Utility rebates, services, and other support	Xcel Energy and other utilities provide support to fleets toward the purchase of electric vehicles and supporting infrastructure.
Wildlife Crossings Pilot Program	Supports construction projects that improve habitat connectivity and reduce wildlife-vehicle collisions.

7.3 Investing Resources

The Bipartisan Infrastructure Law (BIL) requires that CDOT direct National Highway Freight Program funding on the National Highway Freight Network within the state, which includes critical rural and urban freight corridors. CDOT must develop a fiscally-constrained Freight Investment Plan that documents an investment approach for Federal funding through the National Highway Freight Program. CDOT's Freight Investment Plan identifies specific projects in support of the strategies described in Chapter 7, and is updated every two years with input from freight stakeholders across the state. This chapter addresses requirements of the Freight Investment Plan and CDOT's approach for developing it.

7.3.1 National Highway Freight Network and Critical Freight Corridors

To qualify for Federal freight funding under the National Highway Freight Program (NHFP) freight investment projects must be located on, or impact, freight movement on the National Highway Freight Network (NHFN).

The NHFN is comprised of several component systems. These systems are designated by FHWA and are identified by CDOT in consultation with regional and local planning partners. Together, the NHFN includes the following designations:

- **Primary Highway Freight System (PHFS)** is a national network of highways identified by USDOT from measurable national data as the most critical portions of the freight transportation system, and includes important freight intermodal connectors.
- **Other Interstate highways not included on the PHFS**. This designation from USDOT includes portions of Interstate highways not included on the PHFS.
- **Critical Rural Freight Corridors (CRFC).** These are public roads not in urbanized areas that provide access to significant freight generators or routes, or provide connectivity between regions ensuring the flow of goods throughout the state. Colorado may designate up to 600 miles of rural corridors under this designation.
- **Critical Urban Freight Corridor (CUFC).** These are public roads in urbanized areas that provide access to significant freight generators or routes, or provide connectivity within the urban area regions ensuring the flow of goods throughout the region and state. Colorado may designate up to 150 miles of urban corridors under this designation.

In Colorado, USDOT has designated 974.2 miles as part of the national network including, 789.1 PHFS miles, 12.6 PHFS intermodal connector miles, and 172.5 miles of other interstate highways not included on the PHFS. These corridors are shown in Table 7.23.

Table 7.23 USDOT Designated Freight Corridors in Colorado

Designation	Route/Facility Description	Length (Miles)
PHFS	I225 from I25 to I70	12.47
PHFS	I25 from NM/CO Line to CO/WY Line	298.69
PHFS	I270 from I76 to I70	4.92
PHFS	I70 from UT/CO Line to CO/KS Line	450.29
PHFS	I76 from I70 to U85	12.57
PHFS	S2 from CO12R to I70	0.49
PHFS	S470 from CO22A to I70	7.42
PHFS	U6 from CO11L to I270	0.24
PHFS	U85 from I25 to 2.04 Miles South of I25	2.04
	PHFS Total Miles:	**789.13**

Designation	Route/Facility Description	Length (Miles)
PHFS Intermodal Connectors	Burlington Northern RR Transfer Facility (53rd Pl. to Broadway to 58th Ave to I- 25)	1.02
PHFS Intermodal Connectors	Conoco Pipeline Transfer (U.S. 6: W 0.8 mi on 56th Avenue to Terminal Entrance at Brighton Blvd)	0.82
PHFS Intermodal Connectors	Union Pacific RR Transfer Facility (Colorado Blvd: W 1.4 mi on 40th Ave to terminal entrance at Williams St)	1.49
PHFS Intermodal Connectors	Denver International Airport / Pena Blvd (E 470 interchange E 0.7mi)	4.38
PHFS Intermodal Connectors	Union Pacific RR Auto Transfer (I-76: E 0.1 mi on 96th Ave, N 1.0 mi on I-76 Frontage Road to Terminal Entrance)	0.51
PHFS Intermodal Connectors	Burlington Northern RR Auto Transfer (I-76: E 1.7 mi on 88th Ave, N 0.2 mi on Yosemite Ave to terminal entrance)	1.64
PHFS Intermodal Connectors	Kaneb Pipeline Transfer (I-76: E 0.1 mi on 88th Ave, S 1.2 mi on Brighton Rd, E 0.3 mi on 80th St to entrance at Krameria St.)	1.52
PHFS Intermodal Connectors	Southern Pacific RR Transfer Facility (I-76: South on Pecos Street to Terminal Entrance at 56th Avenue)	1.22
	PHFS Intermodal Connectors Total Miles:	**12.60**
Interstate not on PHFS	I-270 from I-25 to I-76	0.96
Interstate not on PHFS	I-76 from US85 to CO/NE Line	171.54
	Interstate not on PHFS Total Miles:	**172.50**

Source: National Highway Freight Network Map and Tables for Colorado (https://ops.fhwa.dot.gov/Freight/infrastructure/ismt/state_maps/states/colorado.htm).

The Critical Rural and Urban Freight Corridors are updated periodically by CDOT in conjunction with updates to the Freight Investment Plan. A map of the NHFN and listing of currently designated Critical Rural and Urban Freight Corridors in Colorado are shown in Appendix A.

7.3.2 National Highway Freight Program

The NHFP is a formula-based funding program that supports investments in the NHFN. To be funded through the NHFP, potential projects must be incorporated within a state Freight Investment Plan (FIP) and contribute to efficient goods movement on the NHFN. Funding eligibility covers all planning, feasibility, preconstruction, mitigation, and construction activities for highway, bridge, and multimodal capacity, safety, and operational projects. Investments in technology, safety, operations, parking, security, and alternative fuels to improve system performance are also eligible. Strategic planning, analysis, and data collections efforts are also eligible through this program. Each fiscal year, up to 30 percent of NHFP funds may be used for intermodal or freight rail projects, including improvements located within private facilities.

Colorado's FIP provides a framework to leverage and direct NHFP funding toward targeted programmatic investment areas. The projects listed in Appendix B were developed with input from the FAC and CDOT

Engineering Regions, in consultation with regional and local planning partners including MPOs and Transportation Planning Regions.

7.3.3 Colorado Freight Investment Plan

Colorado’s multimodal freight system investment needs significantly exceed dedicated freight funding available through the NHFP. To balance needs against available funding, while improving Colorado’s multimodal freight network, CDOT employs a performance-based process to guide allocation of NHFP funding.

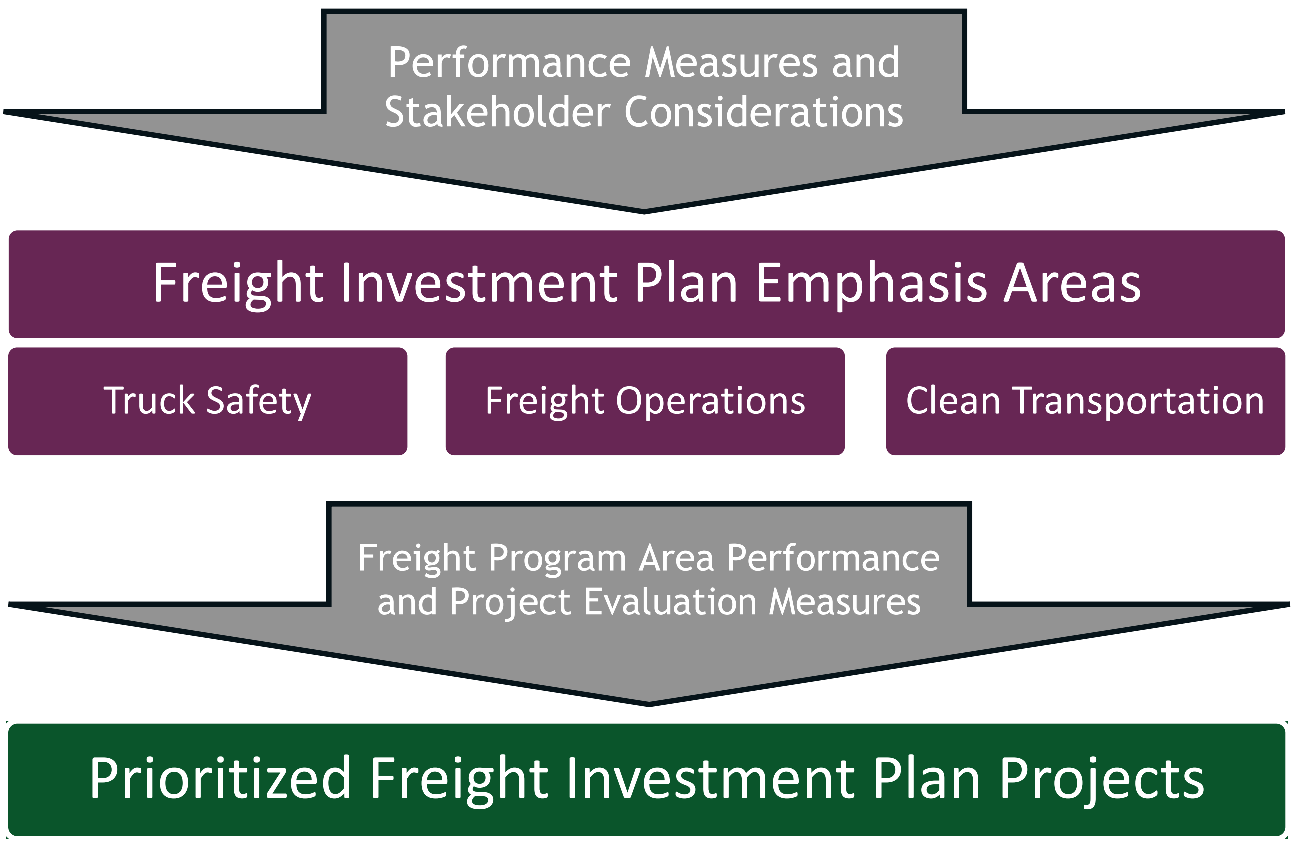
To be considered for funding under Colorado’s multimodal FIP, projects should clearly:

- Support NHFP and CFP multimodal freight goals and performance targets;
- Emphasize safety, mobility, or condition improvements on Colorado Freight Corridors that benefit trade and transport on a broader regional or interstate level;
- Demonstrate a clear freight nexus that directly impact freight-reliant industries or where goods movement is the primary rationale and direct beneficiary of the improvement;
- Indicate how funds will address immediate freight issues and advance projects toward construction and implementation; and
- Address high-priority focus areas of truck safety, freight operations and clean transportation.

The FIP directs future freight-related investments toward investments that directly support national and state performance goals. CDOT works with local agencies and regional planning partners to identify key needs and potential investments that align with the CFP systemwide goals of safety, mobility, economic vitality, maintenance, and sustainability. Performance measures, project evaluation criteria, and project prioritization principles are also developed with partners to guide project selection. Projects are evaluated in cooperation with the FAC and Engineering Regions and prioritization results are used as input into final programming decisions. By prioritizing freight projects and considering state, system, and stakeholder investment priorities, CDOT’s process maximizes investments and delivers a more effective freight program. This strategic investment and decision-making approach is visualized in Figure 7.1.

Figure 7.1 Investment and Decision Approach

Shared National and State Goals					
Colorado Freight Plan Goals	• Safety & Security	• Mobility	• Maintenance	• Economic Vitality	• Sustainability & Resiliency
National Freight Goals	• Safety and security	• Congestion • Reliability • Goods Movement • Innovation and Technology	• State of Good Repair	• Economic Efficiency and Productivity • Multi-State Planning	• Resiliency • Environmental
Colorado Wildly Important Goals	• Advancing Transportation Safety	• Accountability and Transparency		• Statewide Transit	• Clean Transportation
PD-14	• Safety	• Mobility	• Asset Management		



7.3.4 Colorado Freight Plan Investment Emphasis Areas

To meet present needs, priority investment emphasis areas are identified to guide NHFP project selection. This programmatic investment approach enables CDOT to direct freight funding to target present system needs. Investment emphasis areas are identified through the CFP planning process and in consultation with FAC members, industry stakeholders, and planning partners. These priorities link directly to national goal areas, state goals and performance targets, and identified system needs.

To allocate NHFP funding, CDOT will focus on freight investments that address the following emphasis areas:

- **Truck Safety**—Improving safety for all travelers is the number one priority for CDOT. Commercial vehicles were involved in over 4,852 crashes in 2021. Colorado's challenging road and weather conditions, challenging geography, and increasing highway congestion create challenges for commercial truck drivers. Safety improvements that reduce conflicts between trucks and passenger vehicles or obstacles, add shoulders or passing lanes, implement weather-related improvements, or provide safety information to travelers can help Colorado reach its safety goals.

  CDOT is currently assessing statewide crash data to identify patterns and specific commercial vehicle hotspot locations. Current results are discussed in more detail in Chapter 4 of this plan. This data driven analysis results in the identification of specific project opportunities to make commercial vehicle travel safer. Potential NHFP projects are assessed based on safety-related performance measures, including overall truck volume, crash severity, crash hotspot recurrence, and other project level measures.

- **Freight Operations**—The COVID-19 global pandemic revealed deficiencies in global supply chains that slowed delivery of critical goods to businesses and consumers.

  Colorado is actively pursuing operational improvements within the highway freight network to reduce the friction in the supply chain. These include:

  - Safe parking options for overnight rest, during inclement weather, and while waiting for appointment times;
  - ITS to better operate highways, chain stations, and safety pullouts;
  - In-cab communication systems to alert drivers to hazards;
  - Runaway truck ramps that are well maintained; and
  - Weigh-in-motion stations that dramatically reduce enforcement delays without compromising safety and compliance.

> "Freight operations are the practical work of moving goods from a shipper to a receiver, a subset of activities that constitute logistics (or supply chain) management. In the United States, the private sector is responsible for most freight operations. The public sector also has a role in freight operations through its ownership and management of the Nation's highway system, ports, and inland waterways, and its regulation and taxation of freight movement."
>
> Source: Federal Highway Administration, https://ops.fhwa.dot.gov/freight/publications/fhwaop03004/operat.htm#:~:text=Freight%20operations%20are%20the%20practical,(or%20supply%20chain)%20management.

- **Clean Transportation**—Transportation is the second-largest source of GHG emissions in Colorado. [103] Within the sector, medium and heavy duty vehicles (M/HDV) are the second-largest source of GHG emissions, accounting for 22 percent of on-road GHG emissions, despite making up less than 10 percent of vehicles in Colorado. In 2019, there were around 480,000 heavy duty vehicles registered in the state, emitting over 5.3 million tons of GHG. Reducing emissions across all vehicle types will be crucial for Colorado to achieve its target of a 50 percent reduction in statewide emissions by 2030 and 100 percent by 2050.

  Reducing pollution from the transportation sector, one of CDOT's Wildly Important Goals, can be accomplished through coordinated efforts of many stakeholders. Actions such as such as eliminating bottlenecks to reduce emissions from congestion, reducing truck VMT by removing barriers (e.g., deficient bridges) to more direct routes, accelerating the transition to zero emission trucks by providing charging stations on key freight corridors, and facilitating emerging technologies and last-mile delivery trends such as e-cargo bikes can all reduce emissions associated with freight.

Colorado's investment priorities may be updated over time as improvements are made and as project benefits are realized or as freight system challenges and needs shift. CDOT is also continuing to develop analyses and data (e.g., bottlenecks, safety hotspots, and operational improvements) to identify and prioritize specific projects within programmatic investment areas.

7.4 Implementation Planning

CDOT is committed to implementing the vision, goals, strategies, and actions identified in the CFP. Ongoing implementation efforts will build on the framework for action identified within this plan. Two overarching focus areas for the FAC and CDOT include developing industry partnerships and continuing education and communications initiatives.

7.4.1 Developing Partnerships

CDOT recognizes that private industry and public planning partners are critical to implementing the priority strategies and actions identified in this plan. CDOT alone does not have the resources or capacity to act on all opportunities or to make progress on every strategy. Establishing new connections and supporting joint efforts with private and public partners is essential to funding, organizing, championing, and maintaining progress. The FAC provides critical connections to private industry and local and regional planning partners.

Around the country, there are examples of successful partnerships to address critical freight issues. In one state, the Department of Transportation and state Chamber of Commerce jointly funded research to develop statewide trade, transportation, and logistics strategies. This research ultimately led to attention from the Governor, Legislature, and agency partners and resulted in the allocation of additional state funding for needed transportation investments in critical trade infrastructure. In other areas of the country, universities, businesses, and transportation agencies are jointly sponsoring and funding efforts to

[103] CDPHE (2023). Colorado Greenhouse Gas Metrics. https://cohealthviz.dphe.state.co.us/t/EnvironmentalEpidemiologyPublic/views/ColoradoGreenhouseGasMetricsDashboard/Introduction?%3AshowAppBanner=false&%3Adisplay_count=n&%3AshowVizHome=n&%3Aorigin=viz_share_link&%3AisGuestRedirectFromVizportal=y&%3Aembed=y.

develop innovative and technology driven solutions to first and last mile and urban delivery challenges. These joint efforts provide support for living laboratories and real world tests of new approaches and technologies that would not otherwise be possible. Other efforts have brought state, regional, and local agency and transportation planning partners together to launch collaborative efforts to identify freight oriented land uses and develop cohesive regional strategies to address goods movement issues ranging from local hazardous material routes, land use planning, freight investments, and forward looking transportation policies. State programs that provide financial assistance and support to local communities, businesses, and railroads are in some cases jointly administered by a Department of Transportation and Department of Economic Development.

Building on these examples and other national best practices, CDOT will work with industry associations; trade groups; businesses; state, regional, and local agencies; and, other planning partners to identify opportunities for cooperation and collaboration. The FAC will provide direction, guidance, connections, and support for partnerships and will act as champions for key strategies and implementation efforts.

7.4.2 Education and Communications

Through conversations with industry stakeholders and outreach to the public, the need for enhanced education and communications became clear. There is a perception among industry partners that the traveling public, elected officials, and decision-makers are not fully aware of how critical the freight transportation system is to Colorado's economic competitiveness and quality of life.

To provide for educational initiatives and to build broad support for future freight and transportation investments, the 2019 CFP set out a strategy for communication efforts by CDOT and partners. The purpose of this overarching initiative was to make information available on what products move, how goods move, how transportation infrastructure impacts business costs and industry competitiveness, how transportation connections support economic development opportunities, how many jobs and businesses rely on freight transport, and how the ability for Colorado's freight systems to move goods reliably, efficiently, and safely affects daily lives.

Audiences for these messages include members of the traveling public, state, regional, and local agency partners, elected officials and decision-makers at all levels, as well as industry and advocacy organizations. Messaging was unified under the universal brand—Colorado Delivers. This brand was selected by members of the JPAC and FAC as a single statement that resonates across audiences and reinforces the vision and goals of the CFP and industry partners.

Creating a unified brand is important for linking the communications efforts of multiple partners and building consistent visibility and recognition over time. Similar efforts to brand Colorado grown produce and foods and to recognize products made in Colorado have been successful in influencing consumer choices and have been adopted by retailers and manufacturers in their own marketing materials. The Colorado Delivers brand is consistent with the State of Colorado brand guidelines and the logos and visuals utilized by state agencies, including CDOT. However, this brand is open source and available for use and promotion by business partners, industry associations, and state and regional agencies and planning partners.

Colorado Delivers is partnership platform to help move forward with solutions to address the most significant challenges facing manufacturers, producers, carriers, and freight and logistics businesses in Colorado. The branding and communications materials of Colorado Delivers is an opportunity for Colorado's private and public sector partners to better tell the story of freight in Colorado—why it matters to our economies and communities and what we can do together to make transportation more reliable, more safe, more sustainable, more efficient, and more cost-competitive for businesses and consumers.

7.5 Continuous Planning

The CFP is a flexible and agile document providing future guidance, direction, and actions for CDOT, public and private partners, and the FAC. This plan is focused on furthering market opportunities for businesses in Colorado by improving mobility and the efficiency of the multimodal transportation system, addressing critical near term needs and risks, enhancing economic competitiveness, and aligning resources and planning processes. Together, agency and industry partners are committed to acting on the strategies, critical issues, and key implementation opportunities identified in this plan.

CDOT will continue to build on and improve this plan over time. Implementation plans and appendix information will be updated and revised to reflect industry perspectives and priorities, to track performance outcomes, to gauge progress on strategies, and to reflect revisions to the FIP. CDOT, with support from the FAC and industry and planning partners, will direct implementation of these tactics and provide connections, resources, partnerships, and guidance to move forward.

CDOT appreciates the efforts of the partners that made this plan possible and that continue to engage and work collectively toward implementation. This document is Colorado's' industry-driven roadmap to improve the safety, efficiency, and reliability of multimodal freight movements and to leverage partnerships between public and private stakeholders to continue to ensure that Colorado delivers.

A

Truck Congestion and Bottlenecks

A.1 Overview

The main truck bottlenecks in Colorado were identified through an economic analysis of truck GPS data. The analysis used findings from *NCHRP Research Report 925 Estimating the Value of Truck Travel Time Reliability* estimate the costs that congestion causes to trucking companies and businesses that use trucking services. [104] This represents an improvement over analyses that only estimate costs to trucking companies and ignore broader supply chain impacts. Our approach identifies bottlenecks through a more complete estimation of congestion costs to industries and the broader economy, which is critical for prioritizing and right-sizing solutions.

Table A.1 lists the steps in the analysis. First, 2022 travel-time data from the National Performance Management Research Data Set (NPMRDS) published by the Federal Highway Administration (FHWA) was used to calculate two congestion metrics recommended by NCHRP Research Report 925: Vehicle Hours of Excess Travel (VHET) and Vehicle Hours of Unreliability (VHU). The first metric quantified the impact of recurring congestion while the later metric quantified non-recurring congestion. The monetization parameters from NCHRP Report 925 were then used to estimate the user costs incurred by trucks as they face recurring and non-recurring congestion. Congestion metrics were only calculated throughout the National Highway System.

The estimated user costs were then used to identify the locations generating high costs to the movement of freight and representing bottlenecks for truck operations. The roadway network was broken up into Urban Denver Metro, Urban Other, and Rural categories, so that congested roads are prioritized relative to other roads of the same type. Otherwise bottlenecks in the Denver Metro region would dominate the statewide analysis. The thresholds used to identify bottlenecks were set at the 95th percentile user costs per mile (top 5 percent of segments generating congestion costs). Once segments were identified as bottlenecks, they were aggregated into clusters if the bottlenecks were nearby and judged to be caused by similar factors.

[104] Guerrero, S. E., Hirschman, I., Bryan, J., Noland, R., Hsieh, S., Schrank, D., and Guo, S. 2019. NCHRP Research Report 925: Estimating the Value of Truck Travel Time Reliability, Transportation Research Board, National Academies of Science, Engineering and Medicine.

The top bottlenecks were analyzed to determine whether they were caused by roadway construction work zones, which would exclude them from project development considerations. Work zone data was collected by analyzing CDOT records of construction logs for the year 2022.

The final step involves the estimation of how much different industries and supply chains are impacted by congestion, using commodity flow data from TRANSEARCH. This also includes an estimation of how many of the trucks impacted by delays are empty and traveling through the state. Bottlenecks with a higher share of non-empty trucks, with origins or destinations in Colorado, should be prioritized.

Table A.1 Bottleneck Identification Overview

Objective	Steps
Calculation of Congestion Metrics	1. Processed National Performance Management Research Data Set 2. Utilized NPMRDS daily truck volumes and national hourly truck traffic profiles 3. Estimated recurring congestion and non-recurring congestion metrics (VHET and VHU) 4. Estimated trucking company and shipper congestion user costs
Identification of Bottleneck	1. Categorized roadway network by Urban Denver Metro Region, Urban Other, and Rural 2. Set bottleneck thresholds 3. Clustered bottlenecks 4. Identified bottlenecks likely caused by construction work zones
Estimation of Industry Impacts	1. Estimated commodity flows of key industries by truck 2. Joined commodity flows to congestion metrics and bottlenecks 3. Estimated congestion costs to different industries

A.2 Congestion Metrics

Truck bottlenecks were identified as the places on the roadway system that cause the highest user costs to the movement of freight. This perspective is useful for the following reasons:

- It considers not just the costs of delays on trucking—in terms of driver wages and additional fuel used—but also considers the costs that congestion generates for shippers and receivers, from late shipments and increasing buffers throughout the supply chain.
- It adopts the perspective of system users, capturing how congestion affects businesses and industries, as opposed to relying on ad-hoc travel time ratios or indices.
- It prioritizes bottlenecks and develops solutions that are proportional to the severity of the bottleneck.
- The following section describes how the congestion metrics were calculated.

A.2.1 Travel Time Data

Data from NPMRDS were acquired that report the travel times of trucks in Colorado every 15 minutes of 2022, resulting in 167 million travel time observations. INRIX compiled this data set from providers of location services for truck fleets.

NPMRDS reports only travel times on the National Highway System, which in Colorado includes 6,884 segments, summing 10,132 centerline miles of roadway. The Federal Highway Administration (FHWA) defines the National Highway System as "roadways important to the Nation's economy, defense, and mobility," including interstates, other principal arterials, the Strategic Highway Network, major strategic highway network connectors, and intermodal connectors. Therefore, this network is likely to consider most of the roads that are important for freight operations in the state. NPMRDS segments tend to be shorter in urban areas—where there is a higher density of intersections and interchanges—but longer in rural areas. Opposite directions of travel are treated separately in this data.

Several steps were taken to process the NPMRDS following guidance from NCHRP Report 925 so that the congestion metrics could be calculated accurately and consistently:

- Travel time records were excluded from the analysis if they took place on weekends or during major holidays (New Year's Day, Martin Luther King Jr. Day, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving, and Christmas).
- Travel time records were averaged at the 15-minute level to reduce the influence of idiosyncratic variation on congestion estimates (this helps exclude the fact that different people tend to drive at different speeds when estimating roadway congestion and reliability). Roadway segments that had less than 300 records per direction were excluded.
- Records calculated from historical averages were excluded because they would have artificially reduced the measure of non-recurring congestion.

A.2.2 Hourly Volumes

The congestion metrics considered how truck volumes vary throughout the network and for different hours of the day. It is possible, and even likely, that roads with poor speeds and reliability see few trucks, because truck drivers avoid known bottlenecks. Truck drivers also avoid driving during congested hours of the day if they can. The congestion metrics therefore considered truck volumes at the hourly level, so that the bottlenecks identified reflect when trucks are traveling and not just where congestion occurs on the roadway network.

For Colorado, data was not available that describes how truck volumes vary by hour of the day. Therefore, national time-of-day profiles were used instead, describing the typical operations of trucks on roads with different functional classification. This data was applied to the daily truck volumes for Colorado to approximate time-of-day patterns of truck travel.

A.2.3 Recurring and Non-Recurring Congestion Metrics

The congestion metrics used to identify bottlenecks were developed by NCHRP Report 925, which outlines an approach for quantifying recurring and non-recurring congestion using travel time data and estimating associated user costs. Distinguishing between recurring and non-recurring congestion is important because research shows that freight users are much more concerned about non-recurring congestion. Trucking companies account for recurring congestion—typical slowdowns during peak time of the day—in their delivery schedules; however, they have difficulty anticipating and managing non- recurring congestion. Moreover, most shippers and receivers place a premium on delivery schedules being met, because late shipments can disrupt production, cause stock-outs at stores, or lead to a missed intermodal transfer at an airport, seaport, or rail terminal. On-time performance, which is one of the most important factors in modern-day supply chains, becomes much more difficult to achieve with high levels of non-recurring congestion.

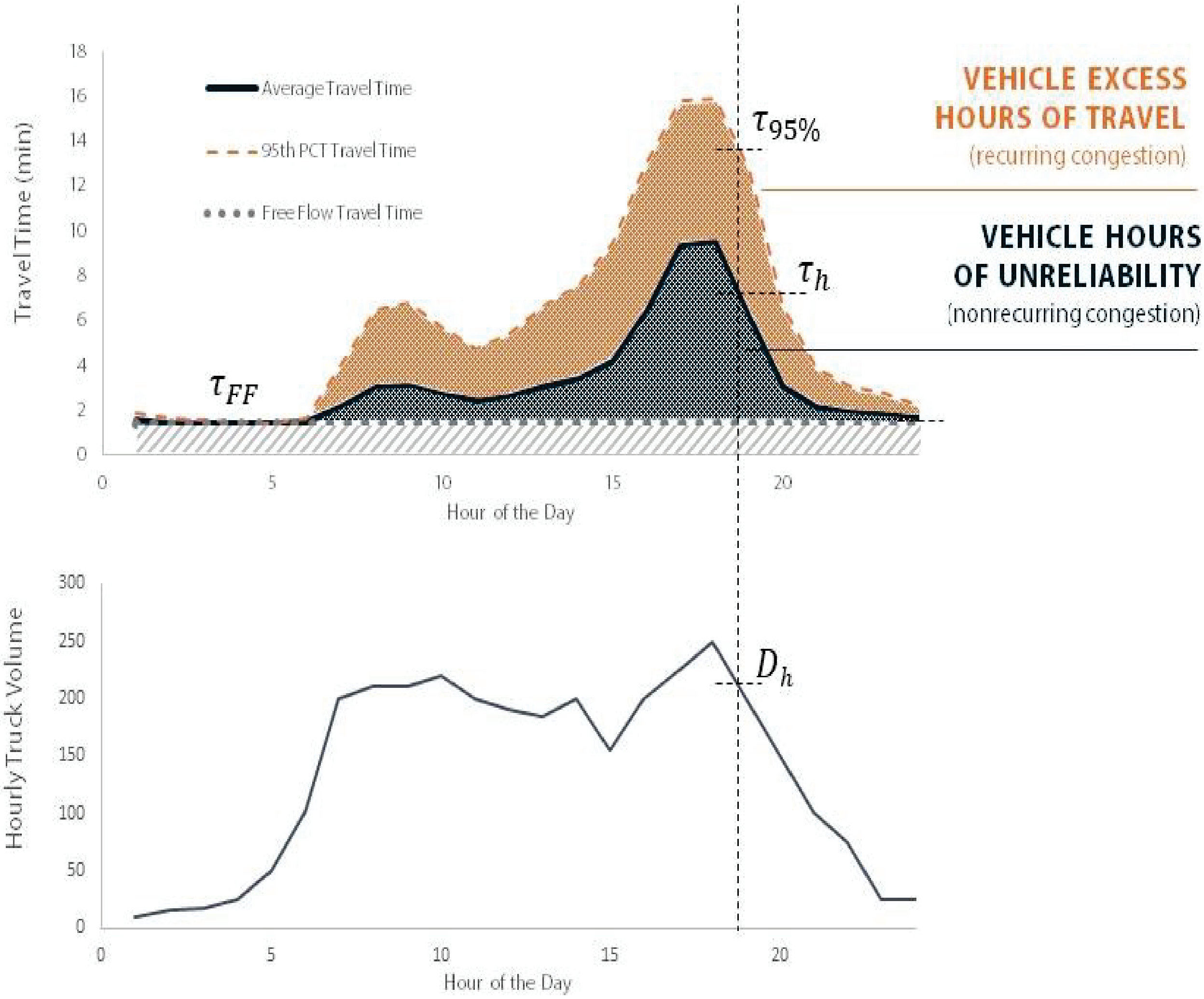
Quantifying recurring and non-recurring congestion separately enables the full costs of congestion to be estimated. Other congestion metrics that rely on travel time indices or ratios do not distinguish between these two separate phenomena, which means that they cannot be used to estimate the costs of congestion. Many studies that seek to estimate the costs of congestion in freight transportation consider only the impacts of delays on vehicle operating costs (e.g., driver wages, fuel consumption) and do not consider the broader supply chain implications of increasing uncertainty in travel times. These broader implications, which research shows are critical for costing the full impacts of congestion, are considered by the congestion metrics used in this study.

To estimate the recurring and non-recurring congestion metrics, the following calculations need to be conducted using the travel time data for each roadway segment:

- The average travel time during hour h, defined as τh.
- The free-flow travel time, taken as the 10th percentile travel time across all hours of the day, defined as τFF.
- The 95th percentile travel time during hour h—representing how slow travel times could get 5 percent of the time (1 in 20)—defined as $95\%\tau h$.

Figure A.1 visualizes these metrics for a representative roadway segment. This figure also includes a plot of truck volumes for each hour of the day, which is defined as Dh.

Figure A.1 Example Calculation of Congestion Metrics



Source: WSP analysis of NPMRDS data

The congestion metrics were calculated as:

- **Recurring congestion** (dark blue shaded area in Figure A.1) was quantified as VEHT (the number of hours of travel above free flow conditions). VEHT was estimated by comparing average travel times to the free-flow travel time, and then summing as follows:

$$VEHT = \sum_{\forall h} (\bar{\tau}_h - 10\%\tau) D_h \; / \; l$$

The metric was divided by the centerline length l of the segment to be able to compare between segments of different lengths.

- **Non-recurring congestion** (orange shaded area in Figure A.1) was quantified as VHU accumulated in each segment, which was calculated as the difference between the 95th percentile travel time and the average travel time, and summing for each hour of the day as follows:

$$VHU = \sum_{\forall h} (95\%\tau_h - \bar{\tau}_h) D_h \ / \ l$$

This measure sums the hours of uncertainty that trucks face while traveling throughout the day. This is a superior way of measuring unreliability than the often-used travel time indices or ratios, because it is additive and focuses on non-recurring congestion. (The other metrics do not distinguish clearly between recurring and non-recurring congestion, making it difficult to interpret and monetize).

A.2.4 User Costs

The congestion metrics were translated into costs using monetization factors from NCHRP Report 925. This study conducted a stated-preference survey in the United States to quantify how motor carriers and shippers value travel time unreliability, relative to expected travel times and shipment costs. This represents the largest survey conducted to estimate how roadway congestion affects the freight sector. The advantage of using these monetization factors is that the costs caused by recurring congestion can be added to the costs caused by non-recurring congestion, leading to a single user cost metric that combines both effects. The total congestion cost per mile for each segment was calculated as:

$$C = \$66 * VEHT + \$160 * VHU$$

In this calculation, \$66 is the cost of operating a truck for one hour based on American Transportation Research Institute Operational Cost of Trucking Report, and \$160 is the costs incurred for each hour of unreliability.

A.3 Identification and Clustering of Bottlenecks

The thresholds used to identify bottlenecks were set at the top 5 percent of user costs per mile in each bottleneck type (Urban Denver Metro, Urban Other, and Rural). Different thresholds for the user cost metric were used to identify bottlenecks in rural areas versus urban areas. Bottlenecks in urban areas typically have different magnitude and characteristics than bottlenecks in rural areas. If the same threshold was used throughout the state, the highly congested roads in metropolitan areas would dominate the results. Table A.2 shows these thresholds. Roads were classified as being Urban Other or Rural based on the distinction made in NPMRDS (originally coming from the U.S. Census Bureau). Urban Denver Metro was defined as urban roads in the counties of Denver, Adams, Arapahoe, Douglas, Jefferson, Boulder, Gilpin, Broomfield, Clear Creek, and generally follow the boundaries governed by the Denver Regional Council of Governments (DRCOG).

Bottlenecks that were judged to be caused by roadway construction work zones were excluded from further consideration. Work zones cause significant slowdowns to traffic, however they represent temporary restrictions that will be resolved once construction activities end. Therefore, these do not represent bottlenecks that need addressing.

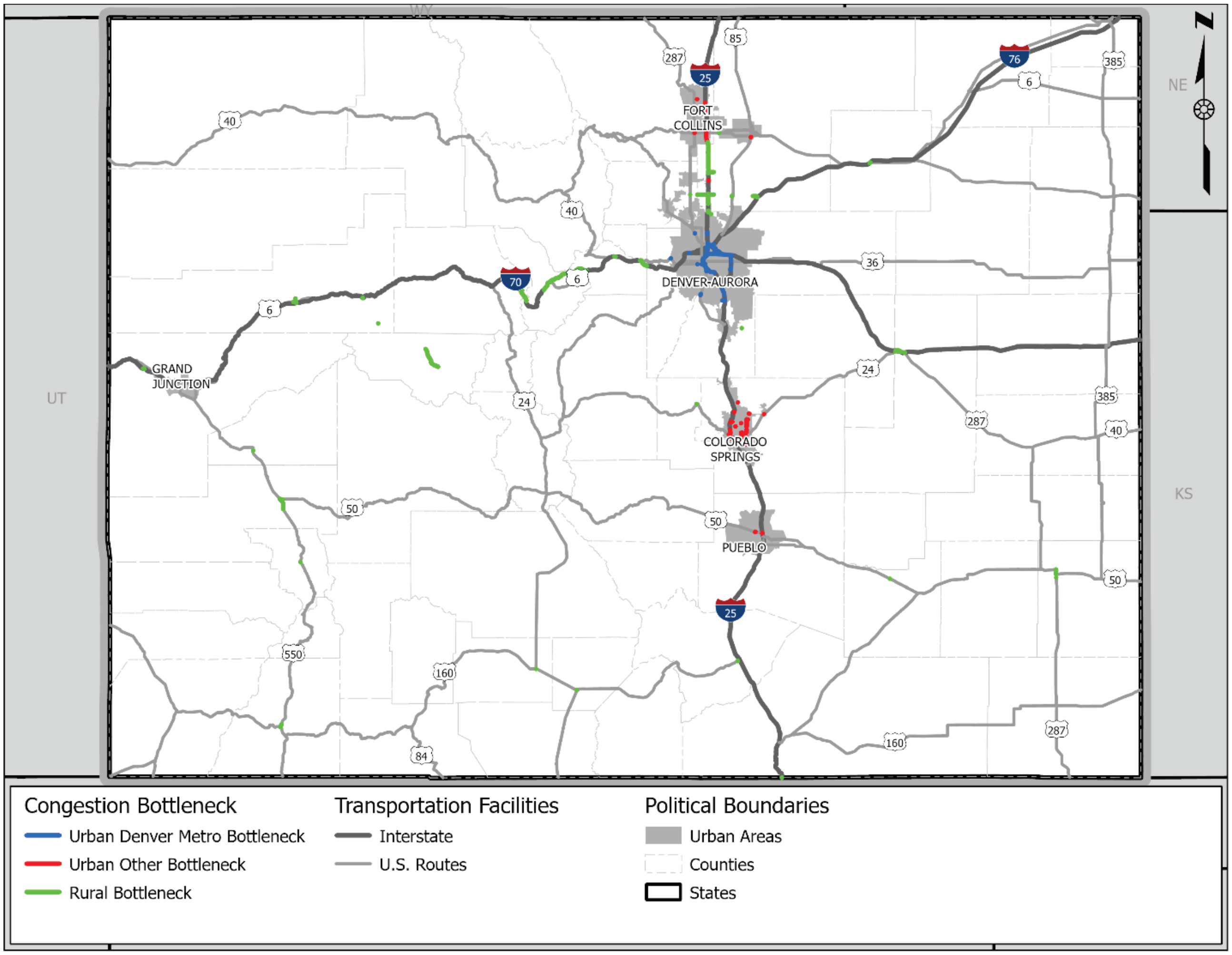
There were 155 roadway segments in Urban Denver Metro with user costs higher than the threshold (in NPMRDS each segment is defined by a unique Traffic Message Channel TMC), totaling 50 centerline miles of roadway. In Urban Other, 69 roadway segments were above the threshold, combining for 21 centerline miles of roadway; in Rural, 91 roadway segments were above the threshold, combining for 99 miles of roadway. In total, roughly 42 percent of the bottleneck distance was identified in urban areas and sixty percent in rural areas. Figure A.2 displays a map of the bottlenecks, showing thorough coverage throughout Colorado, but concentrated in urban regions across the state, as highlighted in Figure A.3 through Figure A.6.

Table A.2 Truck Bottleneck Thresholds and Totals

Bottleneck Type	User Cost Threshold ($/mile-day)	Bottleneck Centerline Roadway Miles	Number of Bottleneck Segments (TMCs)
Urban Denver Metro	23,318	50	155
Urban Other	11,487	21	69
Rural	5,531	99	91
Total	-	**170**	**315**

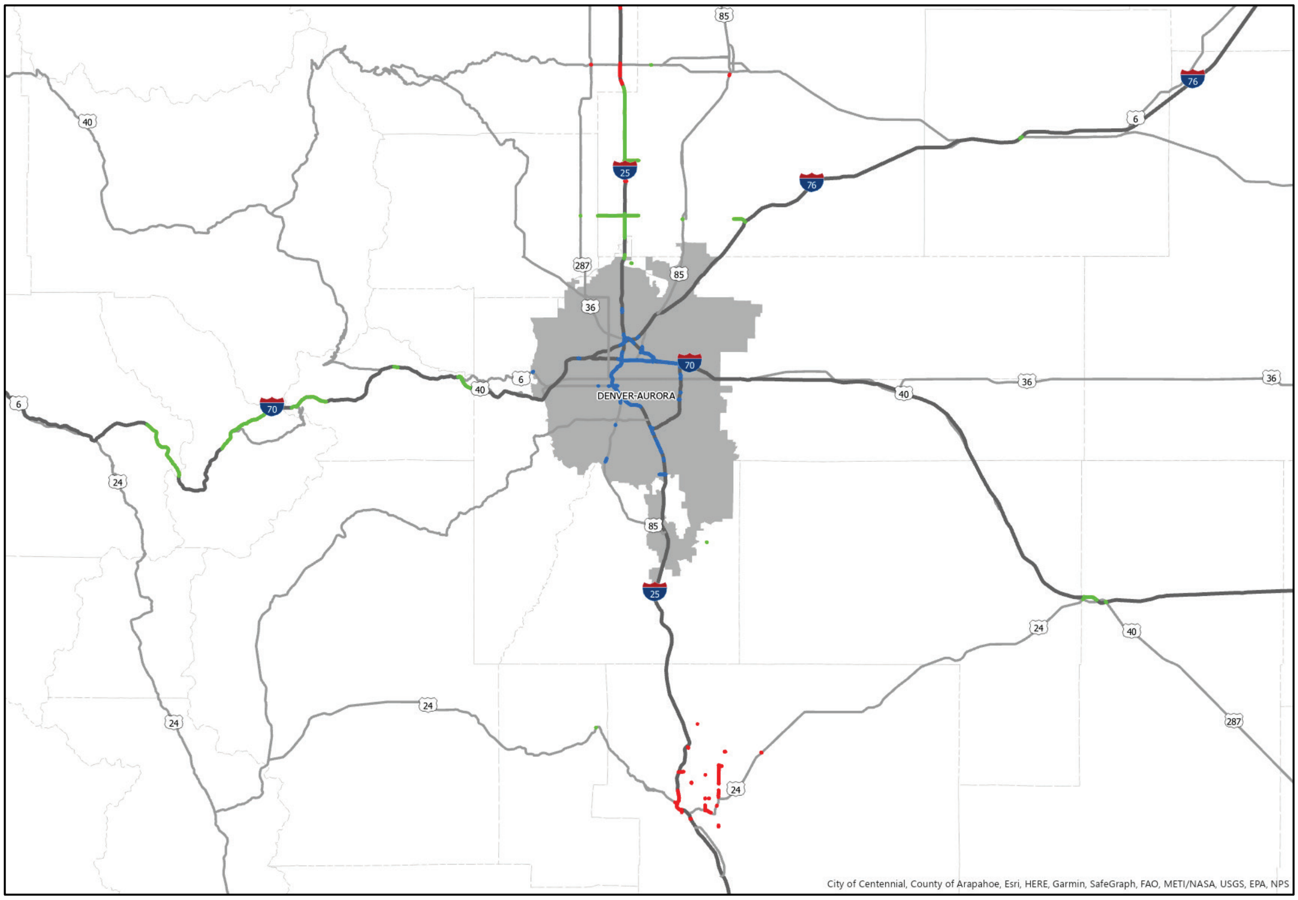
Source: WSP analysis of NPMRDS data.

Figure A.2 Truck Bottleneck Locations—Statewide



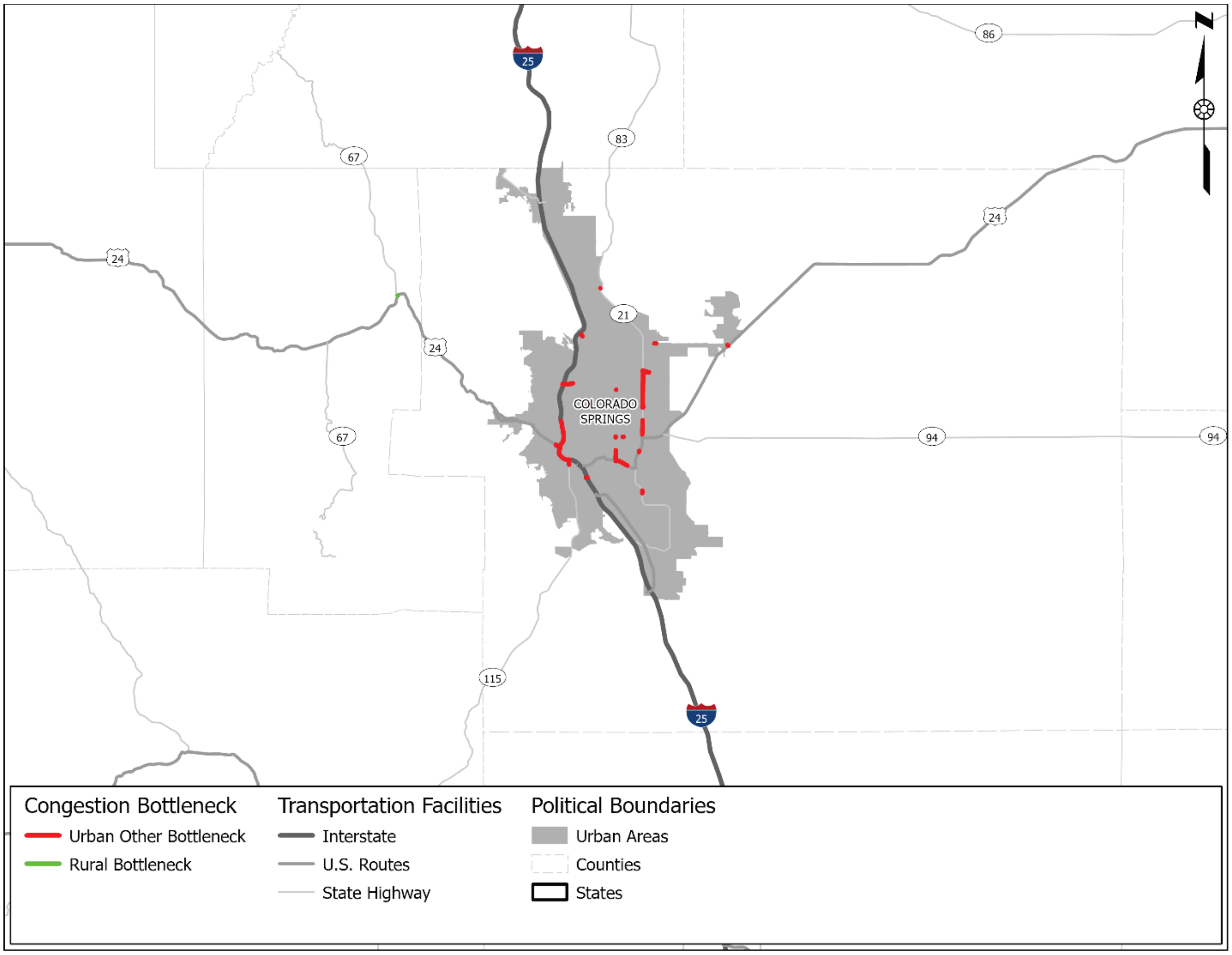
Source: WSP analysis of NPMRDS data.

Figure A.3 Truck Bottleneck Locations—Denver Metro Region



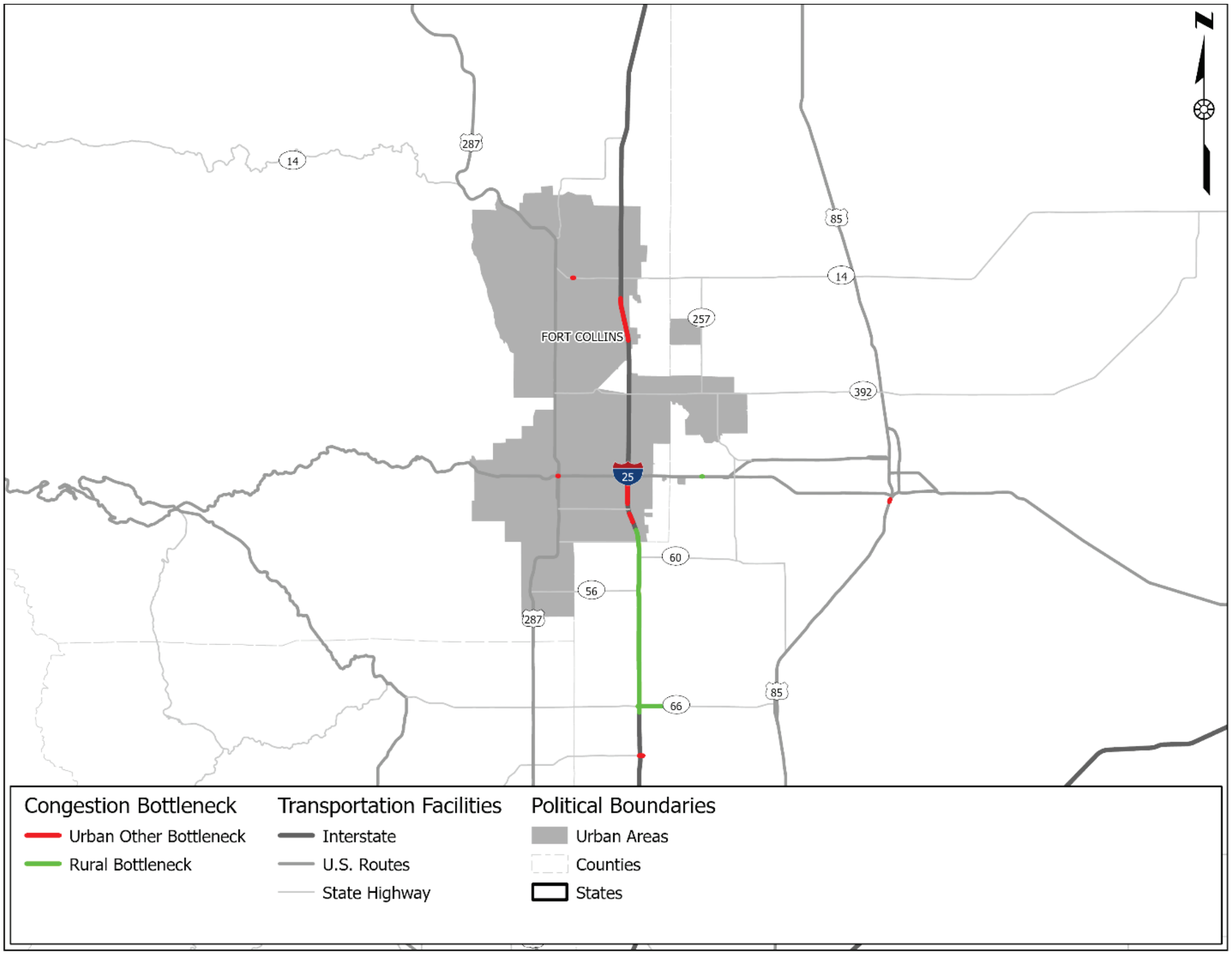
Source: WSP analysis of NPMRDS data.

Figure A.4 Truck Bottleneck Locations—Colorado Springs



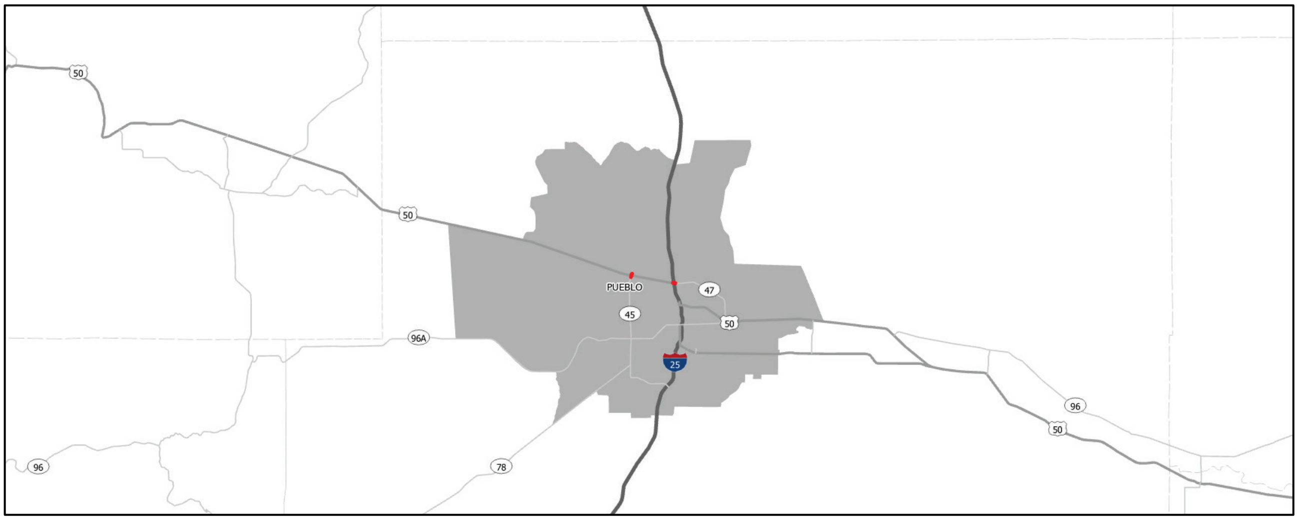
Source: WSP analysis of NPMRDS data.

Figure A.5 Truck Bottleneck Locations—Fort Collins



Source: WSP analysis of NPMRDS data.

Figure A.6 Truck Bottleneck Locations—Pueblo



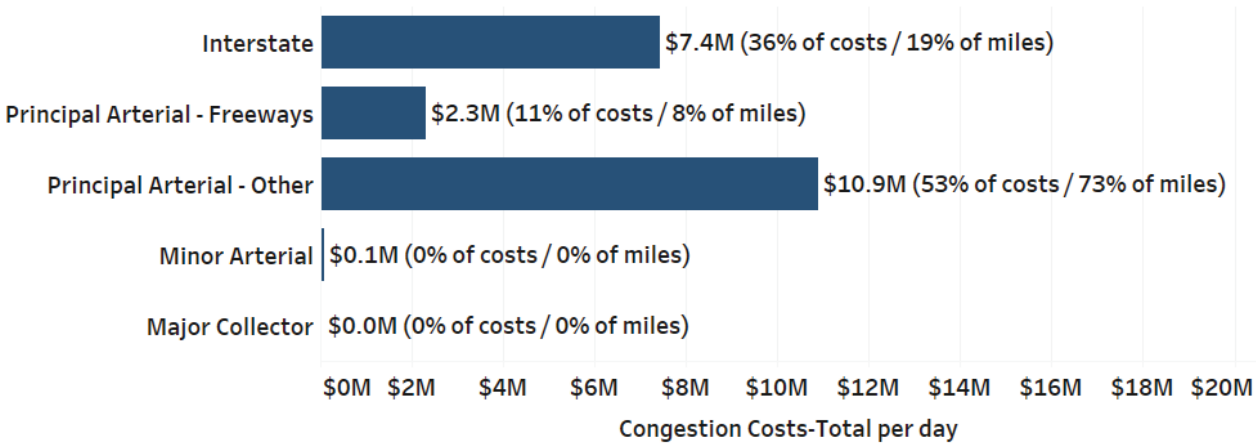
Source: WSP analysis of NPMRDS data.

A manual process was conducted to combine consecutive bottlenecks into bottleneck clusters. Especially in urban areas, where the network is segmented more finely, numerous consecutive segments were designated as bottlenecks. For simplicity, and ease of interpreting the results, consecutive and near consecutive segments were combined into bottleneck clusters. In some cases, nearby roads that are not consecutive were combined into the same cluster if the underlying cause of the bottleneck was judged to be the same. This resulted in 64 Rural bottleneck clusters, 48 Urban Denver Metro bottlenecks, and 45 Urban Other bottlenecks.

A.4 Costs and Impacts of Congestion

It was estimated that, on a typical weekday, congestion causes $20.7 million in costs to trucking companies and shippers (throughout the NHS in Colorado). Interstates contribute almost 36 percent of all congestion costs, even though they account for approximately 19 percent of NHS mileage. Other freeways and principal arterials (excluding interstates) account for 81 percent of total mileage and 64 percent of the total congestion costs, see Figure A.7. Congestion accruing on minor arterials and major collectors account for insignificantly small congestion costs to freight.

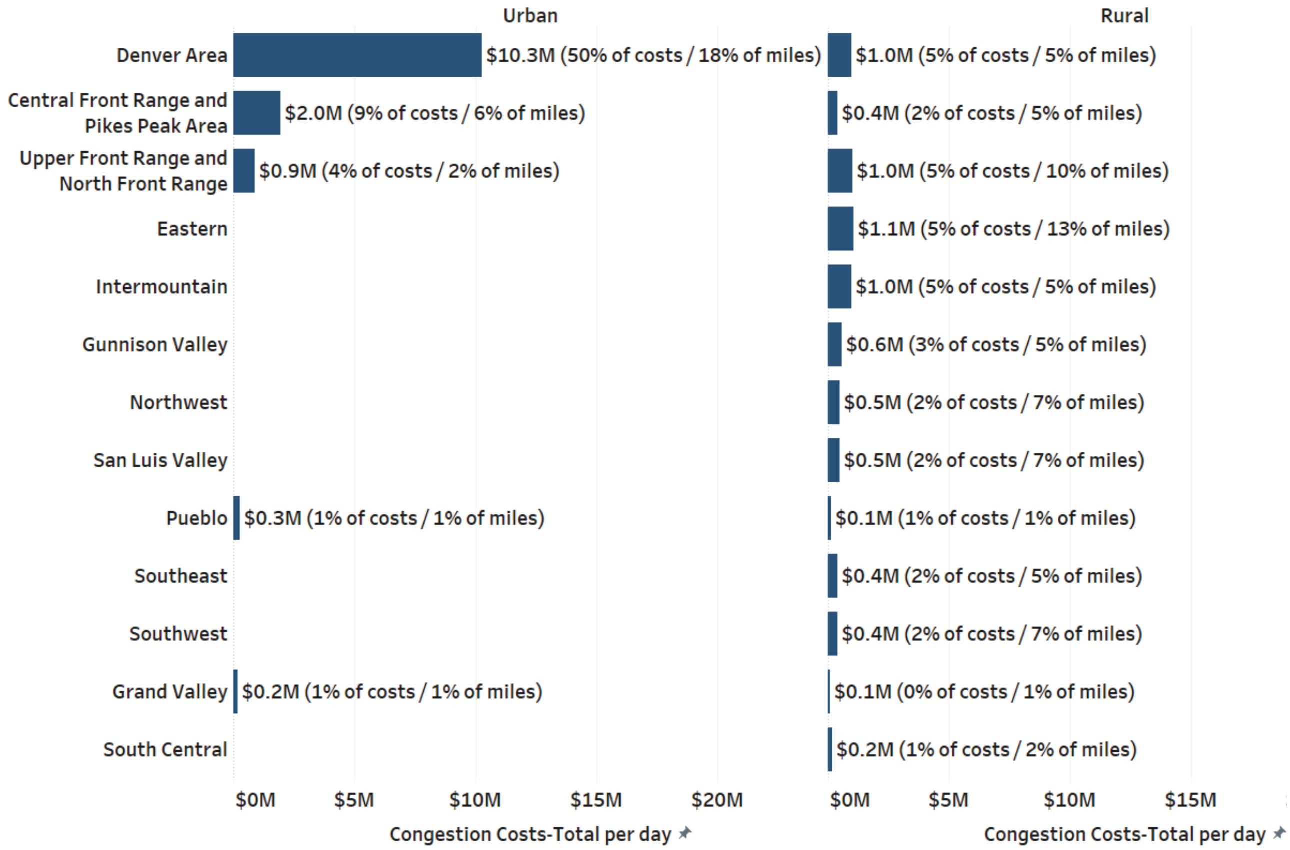
Figure A.7 Congestion Costs per day ($) by Roadway Functional Class



Source: WSP analysis of NPMRDS data.

Most congestion costs throughout the country accrue in urban areas. These areas have a higher density of freight activity (such as a concentration of industry or consumer retail), and are home to transportation facilities such as ports, airports and rail terminals. In Colorado, urban areas overlapping with the Denver Metro region account for 50 percent of total congestion, at approximately $10.3M per day in recurring and non-recurring congestion impacts (see Figure A.8). Other urban segments in Pueblo, Grand Valley, Central Front Range TPR, Pikes Peak Area, Upper Front Range TPR, and North Front Range account for 15 percent of total impacts at $3.4M per day in congestion costs. The figures reported here include congestion costs accrued both at identified truck bottlenecks as well as the rest of the NHS.

Figure A.8 Congestion Costs per day ($) by Region



Source: WSP analysis of NPMRDS data.

The geographic variations in congestion seen above differentially impact supply chains in Colorado, as these have varying freight demand patterns across the state. Supply chain-specific impacts were estimated by apportioning the total congestion costs at any given location based on the relative value of goods for supply chains flowing through that roadway segment. These supply chain values were derived from commodity movements obtained from TRANSEARCH, routed onto the TRANSEARCH highway network and then conflated with the NPMRDS network by means of a spatial join in Graphical Interface System (GIS) software. This process was completed for all supply chain groups shown in Table A.3.

Table A.3 Commodity Composition of Supply Chains

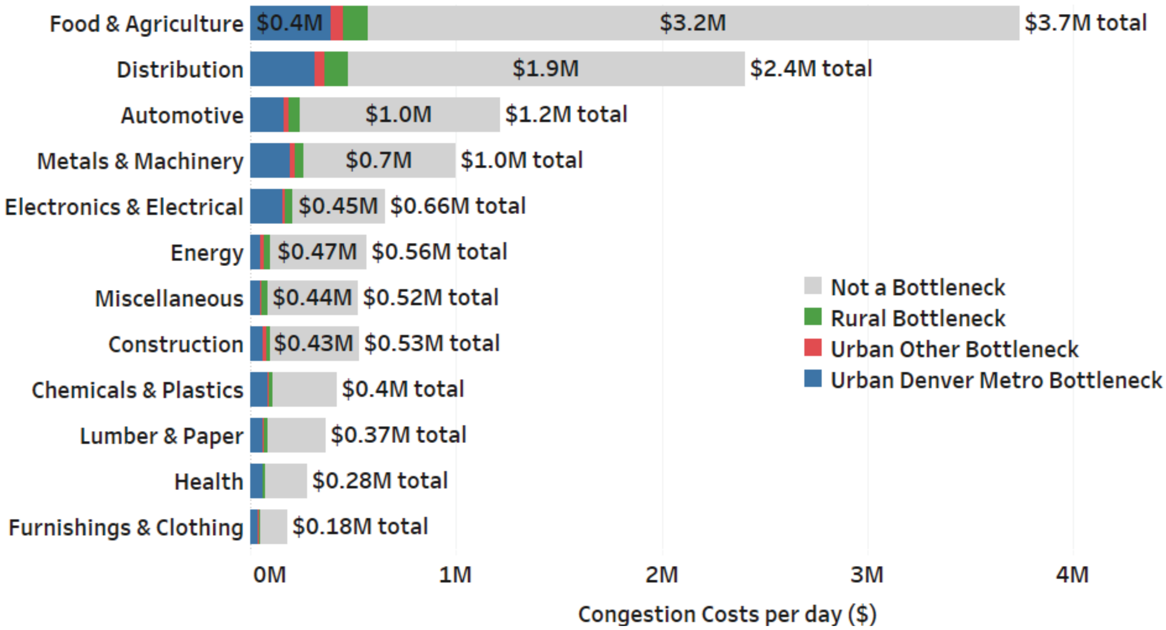
Supply Chain Group	Commodity
Automotive & Transportation Equipment	• Electrical Equipment • Primary Metal Products • Fabricated Metal Products • Rubber or Miscellaneous Plastics • Carburetors, Pistons, etc. • Transportation Equipment • Ordinance or Accessories
Chemicals & Plastics	• Chemicals or Allied Products • Waste or Scrap Materials • Rubber or Miscellaneous Plastics
Construction	• Clay, Concrete, Glass or Stone • Machinery • Electrical Equipment • Nonmetallic Minerals • Fabricated Metal Products • Petroleum or Coal Products
Distribution	• Secondary Traffic • Mixed Miscellaneous Shipments
Electronics & Electrical Goods	• Electrical Equipment • Machinery • Instruments, Photo Equipment, Optical Equipment
Energy	• Coal • Petroleum or Coal Products • Crude Petroleum or Natural Gas
Food & Agriculture	• Agricultural Chemicals • Farm Machinery • Farm Products • Fertilizer • Food or Kindred Products • Tobacco Products • Fresh Fish or Marine Products
Furnishings & Clothing	• Apparel or Related Products • Machinery • Chemicals or Allied Products • Miscellaneous Manufacturing Products • Furniture or Fixtures • Rubber or Miscellaneous Plastics • Leather or Leather Products • Textile Mill Products

Supply Chain Group	Commodity
Health	• Pharmaceutical Products • Health-related Instruments, Optical Equipment
Lumber & Paper	• Forest Products • Clay, Ceramic • Lumber or Wood Products • Printed Matter • Paper and Woodworking Machinery • Pulp, Paper or Allied Products • Paper Waste and Scrap
Metals & Machinery	• Clay, Concrete, Glass or Stone • Metallic Ores • Fabricated Metal Products • Ordnance or Accessories • Machinery • Primary Metal Products • Waste or Scrap Materials
Miscellaneous	• All other commodities not elsewhere classified

The highest value supply chains face significant localized congestion costs in the Denver Metro region as well as in bottlenecks across the state. The food and agriculture supply chain faces the biggest congestion impact in Colorado, with congestion costs totaling $3.7 million per day across the state roadway network, of which $0.4 million accrue at truck bottlenecks in the Denver Metro region (Figure A.9). Owing to the dispersed nature of production in this supply chain—with farms, processors and warehouses across the state—the congestion costs experienced are a function not only of localized impacts but also the high relative length of truck trips in this industry. As such, over 85 percent of the congestion costs impacting this supply chain are accrued at locations that are not considered bottlenecks. These flows are impacted by congestion on interstates to and from the Denver Metro region, notably I-25, I-70, I-270, and I-76.

The automotive and distribution supply chains on the other hand see lower average trip lengths in the state but higher localized congestion costs accruing from the Denver Metro region (about 50 percent of statewide congestion costs as compared to about 30 percent for food & agriculture). The distribution supply chain which comprises flows connecting industry warehouses and other fulfilment centers to major freight corridors, is particularly impacted by congestion on I-25, as well as other arterial and connector roadways that provide access to freight clusters in the Denver Metro region.

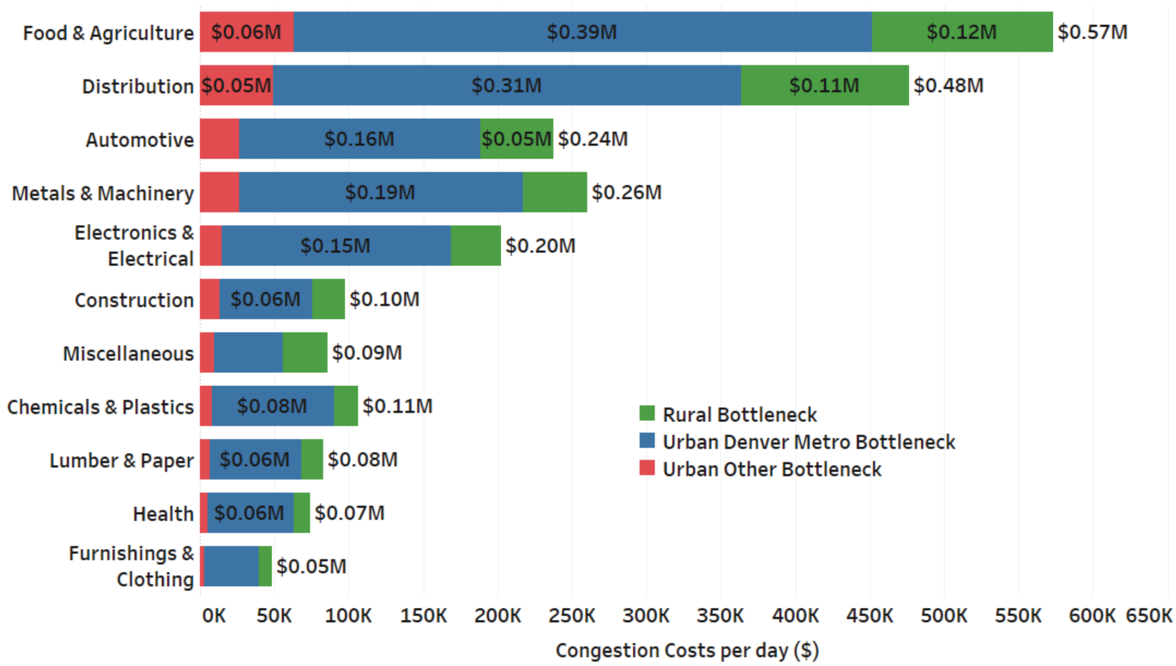
Figure A.9 Daily Congestion Costs ($) by Industry group and Region Type



Source: WSP analysis of NPMRDS and TRANSEARCH data.

A similar story unfolds when looking at truck bottleneck locations across the state (Figure A.10). The food and agriculture industry is most impacted (congestion costs of over $570k per day), followed by distribution, automotive, metals and machinery, and electronics and electrical goods. Bottlenecks in the Denver Metro region account for over two-thirds of statewide bottleneck costs accrued by each of the supply chains analyzed.

Figure A.10 Bottleneck Congestion Costs per day ($) by Supply Chain Groups (bottleneck locations only)



Source: WSP analysis of NPMRDS and TRANSEARCH data.

A.5 Top Bottlenecks

This section describes the top 20 bottleneck clusters in Colorado for each of the bottleneck types (Urban Denver Metro, Urban Other, Rural) and the estimated costs they generate.

A.5.1 Urban Denver Metro Region

The top 20 bottleneck clusters in the Denver Metro region are listed in Table A.4 and mapped in Figure A.11. In total, these bottlenecks represent 42 centerline miles of roadway that generate $1.83 million of congestion costs to trucks and supply chains each day. As indicated by the northbound and eastbound notations in the bottleneck names, the mileage and user costs listed in this table are for specific direction of travel.

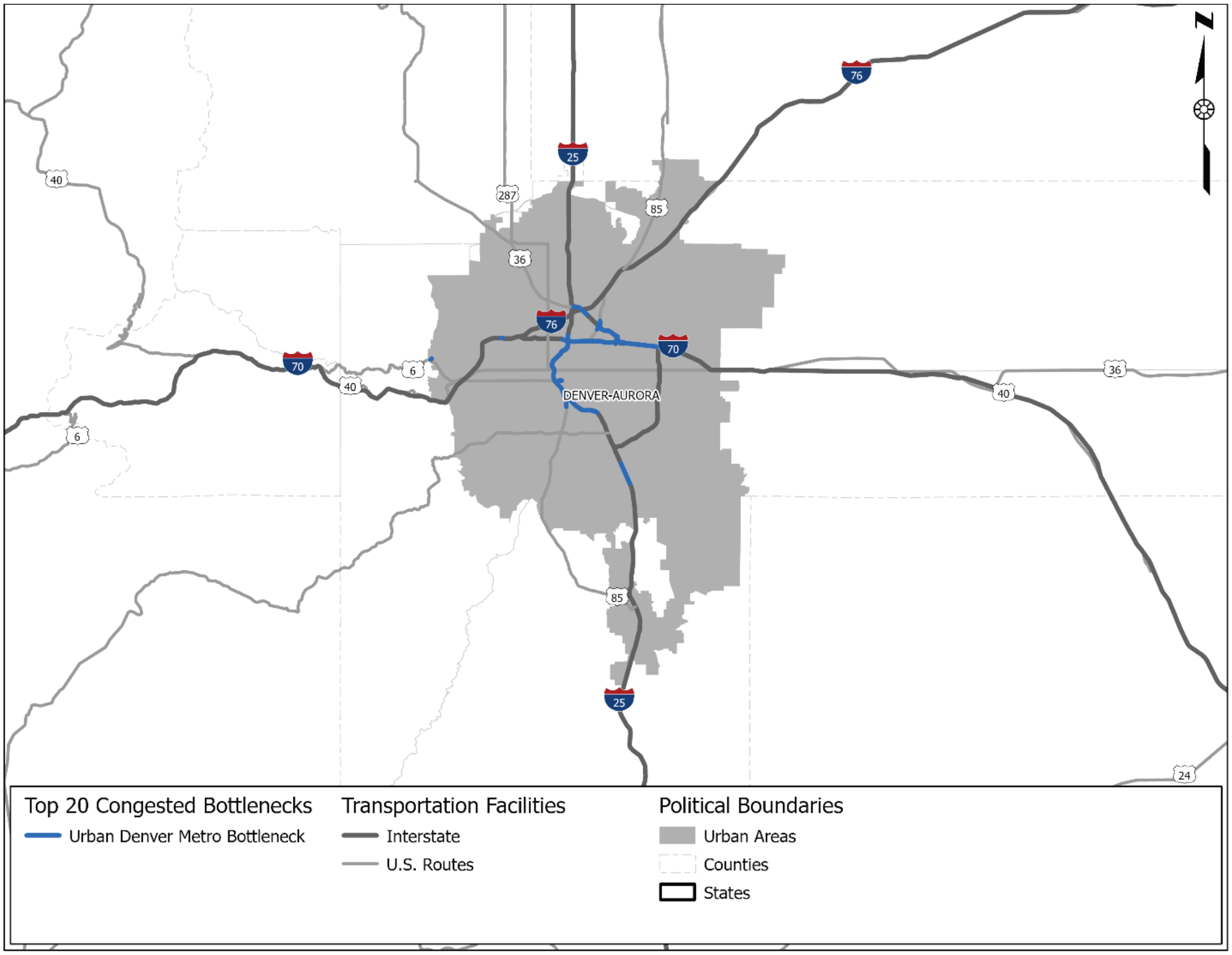
The supply chains most impacted by these top 20 bottlenecks in Denver Metro are shown in Table A.4.

Table A.4 Top 20 Bottlenecks in Urban Denver Metro Region

Rank	ID	Bottleneck Name	Total Miles	Average Daily Truck Volume	Congestion Costs ($/day)
1	108	SB I-25 from I-70 Exit 214 to W 23rd Ave	5.19	7,256	$247,396
2	68	NB I-25 from S Downing St to 15th St	5.79	6,786	$227,321
3	152	WB I-270 from Central Park Blvd to U.S.-85	3.12	5,189	$175,273
4	26	EB I-70 FR from Brighton Blvd to CO-2	2.16	7,225	$151,609
5	158	WB I-70 from Quebec St to Filmore St	2.80	4,650	$140,858
6	24	EB I-25 from S Santa Fe Dr to Evans Ave/Exit 203	3.49	5,924	$118,765
7	30	EB I-70 from I-270 to I-225	4.05	6,996	$114,048
8	29	EB I-70 from I-25/Exit 274 to 1175 Ft east of Brighton Blvd	1.92	6,490	$111,408
9	37	EB I-76 from Washington St to York St/I-76 on ramp	1.57	5,235	$110,803
10	70	NB I-25 from W Florida Ave to W Alameda Ave	1.56	3,415	$62,372
11	61	NB I-25 FR from Park Ave W/Exit 213 to I-70	1.36	11,566	$61,634
12	67	NB I-25 from on ramp at E Dry Creek Rd to on ramp at E Orchard Rd	2.14	6,898	$56,133
13	74	NB I-76 FR from 64th Ave to I-270	1.41	4,663	$43,607
14	93	SB CO-35 from E 49th Ave to I-70	0.89	1,961	$41,041
15	23	EB I-25 FR from Exit 205/S Downing St to on ramp at S University Blvd	0.56	5,924	$35,187
16	64	NB I-25 from CO-224/Exit217A to I-25 NB on ramp	1.01	9,472	$30,155
17	81	NB U.S.-85 from E 56th Ave to E 62nd Ave	0.77	2,480	$28,305
18	138	WB CO-36 from I-25 NBFR to Ridgegate Pkwy	0.98	1,299	$25,752
19	105	SB I-25 from E 55th Ave to E 52nd Ave	0.88	8,007	$24,613
20	36	EB I-76 from E 64th Ave to Washington St	0.95	4,674	$23,967
N/A	N/A	**TOTALS**	**42.60**	-	**$1,830,247**

Source: WSP analysis of NPMRDS data.

Figure A.11 Top 20 Bottlenecks in Urban Denver Metro Region



Source: WSP analysis of NPMRDS data.

Table A.5 Supply Chains affected by Top 20 Bottlenecks in Urban Denver Metro Region (Percent of Trucks)

Rank	Bottleneck Name	Automotive	Chemicals & Plastics	Construction	Distribution	Electronics & Electrical	Energy	Food & Agriculture	Furnishings & Clothing	Health	Lumber & Paper	Metals & Machinery	Miscellaneous	Through Trucks	Empty Trucks
1	SB I-25 from I-70 Exit 214 to W 23rd Ave	0.8	1.4	29.6	9.1	0.6	2.5	15.5	0.2	0.1	1.6	1.6	1.5	3.4	32.2
2	NB I-25 from S Downing St to 15th St	0.7	1.0	26.7	8.1	0.6	2.4	12.0	0.2	0.1	1.3	1.7	2.6	2.9	39.8
3	WB I-270 from Central Park Blvd to U.S.-85	1.0	1.0	12.1	4.7	0.4	0.6	11.4	0.1	0.0	1.0	1.3	1.3	42.2	22.9
4	EB I-70 FR from Brighton Blvd to CO-2	2.3	4.8	7.0	8.5	1.6	0.2	35.3	0.7	0.2	3.4	5.3	2.9	0.0	27.6
5	WB I-70 from Quebec St to Filmore St	3.0	6.3	6.8	9.2	1.1	0.4	32.5	1.0	0.3	4.9	5.5	2.5	0.0	26.6
6	EB I-25 from S Santa Fe Dr to Evans Ave/Exit 203	0.6	0.7	25.1	7.9	0.5	2.4	9.6	0.1	0.1	1.1	1.7	3.2	2.6	44.4
7	EB I-70 from I-270 to I-225	1.4	2.0	10.9	5.3	0.5	0.4	14.9	0.3	0.1	1.7	2.0	1.5	37.4	21.5
8	EB I-70 from I-25/Exit 274 to 1175 Ft east of Brighton Blvd	1.8	3.6	14.0	8.7	1.4	0.8	29.8	0.6	0.2	2.7	4.2	2.5	1.1	28.7
9	EB I-76 from Washington St to York St/I-76 on ramp	0.9	0.8	12.5	4.6	0.2	1.7	8.8	0.1	0.0	1.1	1.2	2.3	35.0	30.8
10	NB I-25 from W Florida Ave to W Alameda Ave	0.6	0.7	25.5	7.5	0.5	2.4	9.6	0.1	0.1	1.1	1.7	3.3	2.7	44.1
11	NB I-25 FR from Park Ave W/Exit 213 to I-70	0.8	1.3	29.9	9.1	0.6	2.5	15.2	0.2	0.1	1.6	1.6	1.5	3.4	32.2
12	NB I-25 from on ramp at E Dry Creek Rd to on ramp at E Orchard Rd	1.0	1.0	21.8	9.7	0.2	3.3	11.0	0.1	0.1	1.2	1.3	3.6	2.7	43.1
13	NB I-76 FR from 64th Ave to I-270	0.7	0.7	17.0	3.9	0.3	1.3	7.9	0.1	0.0	0.9	1.2	1.9	37.8	26.3
14	SB CO-35 from E 49th Ave to I-70	1.5	2.2	10.9	5.5	0.5	0.3	15.8	0.3	0.1	1.9	2.2	1.3	35.9	21.5
15	EB I-25 FR from Exit 205/S Downing St to on ramp at S University Blvd	0.6	0.7	25.5	7.5	0.5	2.4	9.6	0.1	0.1	1.1	1.7	3.3	2.7	44.1
16	NB I-25 from CO-224/Exit217A to I-25 NB on ramp	0.8	0.8	19.5	6.4	0.4	0.9	10.2	0.1	0.1	1.2	1.6	1.4	27.6	29.1
17	NB U.S.-85 from E 56th Ave to E 62nd Ave	0.9	1.0	12.6	7.2	0.1	3.9	9.0	0.1	0.0	1.5	1.4	4.3	4.3	53.5
18	WB CO-36 from I-25 NBFR to Ridgegate Pkwy	1.0	1.1	22.6	9.5	0.3	3.4	10.7	0.1	0.1	1.2	1.4	3.6	2.3	42.6
19	SB I-25 from E 55th Ave to E 52nd Ave	0.5	0.7	34.0	9.2	0.3	2.9	11.4	0.1	0.1	1.3	0.9	1.2	4.1	33.2
20	EB I-76 from E 64th Ave to Washington St	0.7	0.6	15.6	2.9	0.2	1.3	7.0	0.1	0.0	0.8	1.2	2.1	42.8	24.7

Source: WSP analysis of NPMRDS data.

A.5.2 Urban Other

The top 20 bottleneck clusters in the other urban regions of the state are listed in Table A.6 and mapped in Figure A.12. In total, these bottlenecks constitute 18.5 centerline miles of roadway in the urban regions around the state (excluding Denver Metro), generating $287 thousand of user costs to trucks each day.

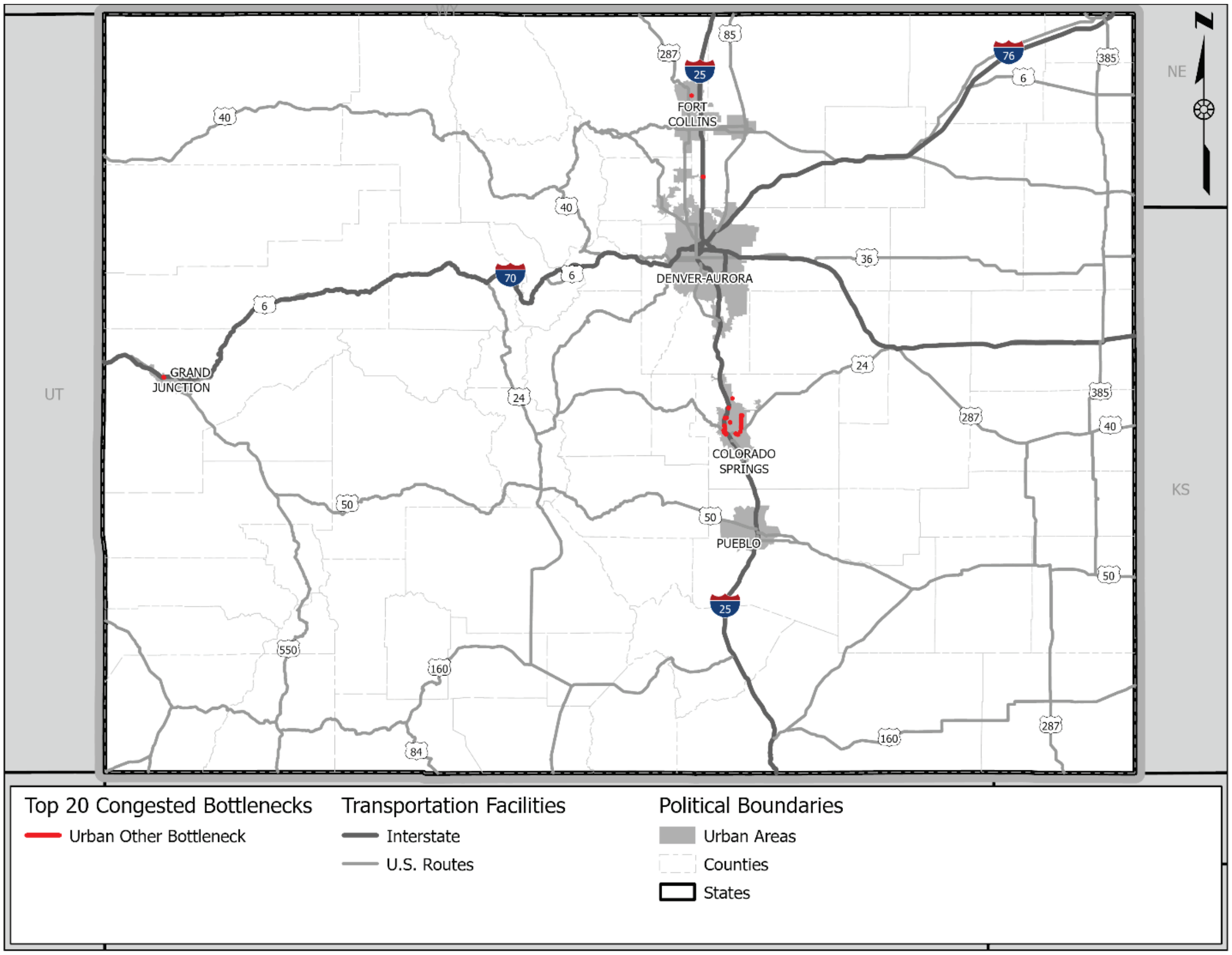
The supply chains most impacted by these top 20 other urban bottlenecks include food and agriculture, construction, and distribution (Table A.8). Through trucks and empty units contribute significantly to congestion at these bottlenecks, with share of total congestion costs ranging from 22 percent to 88 percent.

Table A.6 Top 20 Urban Other Bottlenecks

Rank	ID	Bottleneck Name	Total Miles	Average Daily Truck Volume	Congestion Costs ($/day)
1	69	NB I-25 from S Tejon St to W Fontanero St/Exit 144	3.35	4,484	$57,253
2	48	NB CO-21 from Constitution Ave to Stetson Hills Blvd	2.78	1,745	$49,951
3	109	SB I-25 from U.S.-34 to CO-66	2.48	3,827	$35,580
4	103	SB I-25 from CO-34 to Harmony Rd	2.61	3,071	$32,862
5	49	NB CO-21 from U.S.-24 to Palmer Park Blvd	1.07	1,640	$14,517
6	163	WB Jet Wing Dr to CO-83	0.97	1,250	$13,267
7	149	WB E Garden of the Gods Rd from U.S.-85 to I-25	0.71	680	$11,759
8	54	NB CO-83 from U.S.-24 to Airport Rd	0.81	917	$9,760
9	18	EB E Garden of the Gods Rd from I-25 to U.S.-85	0.69	681	$9,656
10	2	EB CO-24 from W I-25 FR to E I-25 FR	0.23	965	$8,298
11	164	WB Stetson Hills Pkwy from Charlotte Pkwy to CO-21	0.50	814	$7,827
12	136	WB CO-24 from E I-25 FR to W I-25 FR	0.24	963	$7,104
13	127	SB U.S.-85 from I-25 EBFR to E Ramona Ave	0.40	609	$5,158
14	38	EB Stetson Hills Pkwy from CO-21 to Charlotte Pkwy	0.43	860	$5,019
15	77	NB U.S.-50 at IH-70	0.21	668	$3,829
16	84	NB W Cimarron St at I-25	0.30	676	$3,792
17	121	SB U.S.-50 at IH-70	0.24	691	$3,517
18	21	EB E Woodmen Rd from 2025 ft east of Tuft Blvd to Black Forest Rd	0.15	755	$2,727
19	3	EB CO-47 from N Elizabeth St to Pueblo Mall Blvd	0.16	769	$2,710
20	98	SB E Union Blvd at E Fillmore St	0.12	937	$2,702
N/A	N/A	**TOTALS**	**18.5**	-	**$287,288**

Source: WSP analysis of NPMRDS data.

Figure A.12 Top 20 Urban Other Bottleneck Clusters



Source: WSP analysis of NPMRDS data.

Table A.7 Supply Chains Affected by Top 20 Bottlenecks in Urban Other Regions (Percent of Trucks)

Rank	Bottleneck Name	Automotive	Chemicals & Plastics	Construction	Distribution	Electronics & Electrical	Energy	Food & Agriculture	Furnishings & Clothing	Health	Lumber & Paper	Metals & Machinery	Miscellaneous	Through Trucks	Empty Trucks
1	NB I-25 from S Tejon St to W Fontanero St/Exit 144	1.0	2.0	16.3	10.7	0.3	4.6	19.2	0.1	0.1	1.6	2.6	4.6	6.2	30.8
2	NB CO-21 from Constitution Ave to Stetson Hills Blvd	4.6	5.8	9.7	8.7	1.0	0.9	16.4	1.4	0.4	3.8	3.1	3.6	0.0	40.8
3	SB I-25 from U.S.-34 to CO-66	0.8	0.6	21.1	4.3	0.3	3.5	7.7	0.1	0.0	1.0	1.2	3.6	21.3	34.5
4	SB I-25 from CO-34 to Harmony Rd	0.7	0.5	22.7	3.8	0.2	3.0	8.3	0.1	0.0	0.9	1.1	3.2	18.2	37.2
5	NB CO-21 from U.S.-24 to Palmer Park Blvd	0.0	0.0	1.3	0.1	0.0	0.2	12.2	0.0	0.0	0.0	0.0	0.1	0.0	86.2
6	WB Jet Wing Dr to CO-83	0.9	0.9	25.7	3.9	0.2	5.0	9.5	0.2	0.1	1.1	1.1	4.9	0.0	46.6
7	WB E Garden of the Gods Rd from U.S.-85 to I-25	1.0	2.0	16.1	10.7	0.4	4.5	19.4	0.1	0.1	1.6	2.6	4.6	6.3	30.5
8	NB CO-83 from U.S.-24 to Airport Rd	0.9	0.9	25.7	3.9	0.2	5.0	9.5	0.2	0.1	1.1	1.1	4.9	0.0	46.6
9	EB E Garden of the Gods Rd from I-25 to U.S.-85	1.0	2.0	16.1	10.7	0.4	4.5	19.4	0.1	0.1	1.6	2.6	4.6	6.3	30.5
10	EB CO-24 from W I-25 FR to E I-25 FR	0.7	0.5	21.5	4.1	0.3	3.1	7.5	0.1	0.0	0.9	1.1	3.2	18.8	38.2
11	WB Stetson Hills Pkwy from Charlotte Pkwy to CO-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	WB CO-24 from E I-25 FR to W I-25 FR	0.7	0.5	21.5	4.1	0.3	3.1	7.5	0.1	0.0	0.9	1.1	3.2	18.8	38.2
13	SB U.S.-85 from I-25 EBFR to E Romona Ave	0.8	1.6	17.0	9.2	0.3	3.8	18.3	0.1	0.1	1.3	2.1	6.1	4.9	34.7
14	EB Stetson Hills Pkwy from CO-21 to Charlotte Pkwy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	NB U.S.-50 at IH-70	0.6	1.6	3.8	2.7	0.4	0.5	10.3	0.4	0.1	1.1	1.8	2.6	71.4	2.9
16	NB W Cimarron St at I-25	0.7	1.7	21.7	7.5	0.2	4.1	13.8	0.1	0.0	1.1	1.8	4.0	3.3	39.9
17	SB U.S.-50 at IH-70	0.6	1.6	3.8	2.7	0.4	0.5	10.1	0.4	0.1	1.0	1.8	2.5	71.7	2.8
18	EB E Woodmen Rd from 2025 ft east of Tuft Blvd to Black Forest Rd	1.5	3.8	12.3	22.2	0.0	0.0	20.8	0.1	0.0	2.5	2.1	12.1	0.0	22.7
19	EB CO-47 from N Elizabeth St to Pueblo Mall Blvd	0.9	1.6	18.9	8.3	0.2	4.5	14.7	0.1	0.1	1.3	1.8	5.8	6.2	35.6
20	SB E Union Blvd at E Fillmore St	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: WSP analysis of NPMRDS data.

A.5.3 Rural

The top 12 bottleneck clusters in the rural regions in the state are listed in Table A.8 and mapped in Figure A.13. In total, these bottlenecks constitute 87.3 centerline miles of roadway in rural regions around the state, generating $593 thousand of user costs to trucks each day.

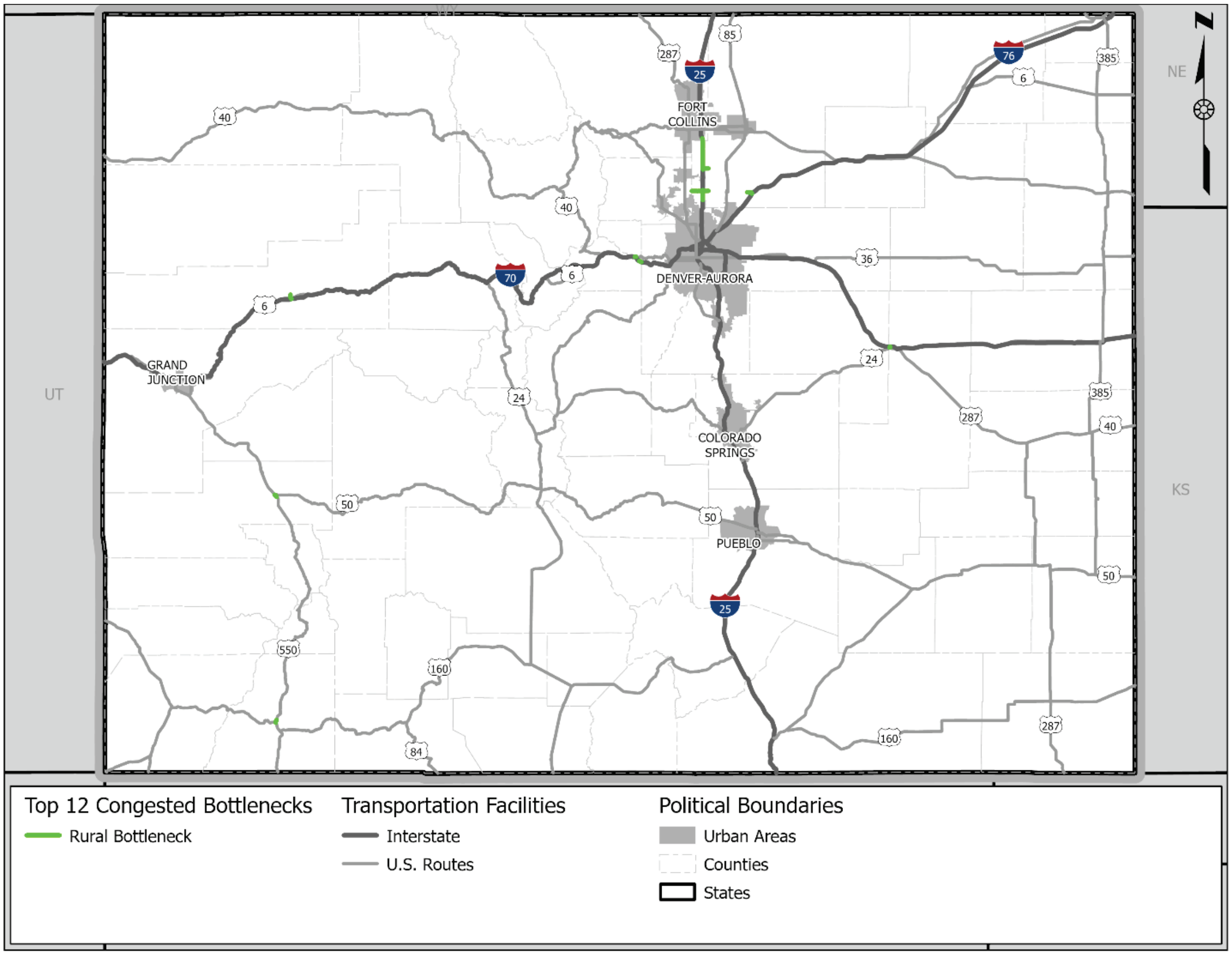
The supply chains most impacted by these top 20 rural bottlenecks include food and agriculture, construction, and distribution (Table A.9).

Table A.8 Top 20 Rural Bottlenecks

Rank	ID	Bottleneck Name	Total Miles	Average Daily Truck Volume	Congestion Costs ($/day)
1	65	NB I-25 from CO-66 to U.S.-34	10.78	3,675	$81,461
2	32	EB I-70 from U.S.-6 to Eisenhower Memorial Tunnel	7.87	1,505	$66,916
3	111	SB I-70 from Pitkin Creek to Shrine Pass Rd	10.02	1,400	$55,792
4	95	SB CO-82 from Lake Wildcat to Cooper	8.79	369	$53,672
5	161	WB I-70 from U.S.-6 to Straight Creek	7.88	1,539	$48,761
6	109	SB I-25 from U.S.-34 to CO-66	6.66	3,715	$42,904
7	140	WB CO-52 from Colorado Blvd to County Line	5.99	451	$36,042
8	104	SB I-25 from CO-52 to CO-8	3.54	4,420	$25,502
9	34	EB I-70 from U.S.-6/Exit 216 to Stevens Gulch Rd/Exit 221	3.61	1,459	$24,116
10	73	NB I-70 from Homestead Rd to	2.02	1,502	$22,220
11	143	WB CO-66 from I-25 to CO-13	2.11	659	$21,741
12	72	NB I-70 from CO-9 to U.S.-6	2.99	1,958	$17,722
13	162	WB I-70 from U.S.-6/Exit 216 to Stevens Gulch Rd/Exit 221	2.58	1,502	$16,424
14	78	NB U.S.-550 from Chipeta Rd to E Niagara Rd	2.25	503	$13,400
15	5	EB CO-52 from CO-41 to I-76 NBFR	1.88	620	$13,191
16	88	SB CO-13 from 20th St to IH-70	1.81	441	$11,655
17	76	NB U.S.-287 from U.S.-50 to CO-196	1.76	907	$10,967
18	120	SB U.S.-287 from U.S.-50 to CO-196	1.85	860	$10,695
19	160	WB I-70 from U.S.-287 to Williams Ave	1.80	1,375	$10,246
20	154	WB I-70 from Eisenhower Johnson Tunnel East to Loveland Valley Lodge	1.11	1,502	$9,816
N/A	N/A	**TOTALS**	**87.30**	-	**$593,243**

Source: WSP analysis of NPMRDS data.

Figure A.13 Top 20 Rural Bottleneck Clusters



Source: WSP analysis of NPMRDS data.

Table A.9 Supply Chains Affected by Top 20 Bottlenecks in Rural Regions (Percent of Trucks)

Rank	Bottleneck Name	Automotive	Chemicals & Plastics	Construction	Distribution	Electronics & Electrical	Energy	Food & Agriculture	Furnishings & Clothing	Health	Lumber & Paper	Metals & Machinery	Miscellaneous	Through Trucks	Empty Trucks
1	NB I-25 from CO-66 to U.S.-34	0.8	0.6	21.1	4.3	0.3	3.5	7.7	0.1	0.0	1.0	1.2	3.6	21.2	34.5
2	EB I-70 from U.S.-6 to Eisenhower Memorial Tunnel	0.6	1.3	8.5	3.8	0.3	0.4	8.5	0.3	0.1	1.0	1.5	2.0	61.7	10.0
3	SB I-70 from Pitkin Creek to Shrine Pass Rd	0.7	1.5	5.4	4.1	0.3	0.3	8.9	0.3	0.1	1.0	1.7	2.1	67.7	6.0
4	SB CO-82 from Lake Wildcat to Cooper	0.4	0.2	7.4	7.8	0.0	3.7	5.0	0.1	0.0	0.6	0.1	20.4	0.0	54.3
5	WB I-70 from U.S.-6 to Straight Creek	0.6	1.3	8.5	3.8	0.3	0.4	8.5	0.3	0.1	1.0	1.5	2.0	61.7	10.0
6	SB I-25 from U.S.-34 to CO-66	0.8	0.6	21.1	4.3	0.3	3.5	7.7	0.1	0.0	1.0	1.2	3.6	21.3	34.5
7	WB CO-52 from Colorado Blvd to County Line	0.7	0.7	20.6	2.8	0.4	1.8	12.7	0.0	0.0	1.0	0.8	1.8	0.1	56.6
8	SB I-25 from CO-52 to CO-8	0.8	0.5	20.5	4.1	0.2	3.9	6.6	0.1	0.0	0.9	1.1	3.8	19.3	38.2
9	EB I-70 from U.S.-6/Exit 216 to Stevens Gulch Rd/Exit 221	0.6	1.3	8.5	3.8	0.3	0.4	8.5	0.3	0.1	1.0	1.5	2.0	61.7	10.0
10	NB I-70 from Homestead Rd to	0.6	1.2	10.1	3.5	0.2	0.5	7.5	0.3	0.1	0.9	1.8	1.9	58.6	12.9
11	WB CO-66 from I-25 to CO-13	0.2	0.1	24.1	2.1	0.1	0.2	6.2	0.0	0.0	0.2	0.3	0.6	1.2	64.8
12	NB I-70 from CO-9 to U.S.-6	0.6	1.3	8.1	3.7	0.3	0.3	8.4	0.3	0.1	1.0	1.6	1.7	63.3	9.2
13	WB I-70 from U.S.-6/Exit 216 to Stevens Gulch Rd/Exit 221	0.6	1.3	8.5	3.8	0.3	0.4	8.5	0.3	0.1	1.0	1.5	2.0	61.7	10.0
14	NB U.S.-550 from Chipeta Rd to E Niagara Rd	0.2	0.4	17.5	2.7	0.0	2.6	18.2	0.1	0.0	1.1	0.4	5.4	14.3	37.0
15	EB CO-52 from CO-41 to I-76 NBFR	1.4	2.3	4.8	2.4	0.9	0.0	34.4	0.1	0.1	3.0	2.4	0.8	12.2	35.2
16	SB CO-13 from 20th St to IH-70	0.5	1.1	5.4	3.2	0.2	0.7	10.1	0.3	0.1	0.8	1.2	2.3	59.4	14.7
17	NB U.S.-287 from U.S.-50 to CO-196	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	SB U.S.-287 from U.S.-50 to CO-196	0.7	3.1	7.1	2.2	0.3	1.3	32.8	0.1	0.0	0.6	1.2	1.7	27.4	21.6
19	WB I-70 from U.S.-287 to Williams Ave	2.4	3.6	6.2	5.6	0.6	0.2	21.7	0.4	0.1	2.3	2.6	3.4	34.5	16.3
20	WB I-70 from Eisenhower Johnson Tunnel East to Loveland Valley Lodge	0.6	1.3	8.5	3.8	0.3	0.4	8.5	0.3	0.1	1.0	1.5	2.0	61.7	10.0

Source: WSP analysis of NPMRDS data.

B

Critical Rural & Urban Freight Corridors

Updated July 2023

CDOT, and the state's Metropolitan Planning Organizations (MPOs), are responsible for identifying and designating Critical Rural Freight Corridors (CRFC) and Critical Urban Freight Corridors (CUFC) in accordance with the FAST Act. These roads join the Primary Highway Freight System (PHFS) and other Interstate highways to comprise the National Highway Freight Network (NHFN). By focusing on improvements to these critical corridors, CDOT will direct resources toward improving the safety, efficiency, and reliability of Colorado's intermodal and highway freight transportation systems.

CDOT developed criteria and guidelines to identify Colorado's CRFC and CUFC routes. The consultation process and identification guidelines included:

- Analysis of location criteria and corridor segments in connection with established project needs identified in the Colorado Freight Plan, State Freight and Passenger Rail Plan, and CDOT's Development Program.
- Screening for consistency with identified Colorado Freight Corridors.
- Identification of corridor sub-segments aligned with areas of project need, rather than entire corridors.
- Review and input from MPOs, Engineering Regions, and Transportation Planning Region planning partners.
- Review and input by members of the Colorado Freight Advisory Council.

A CRFC or CUFC must be certified by the Federal Highway Administration (FHWA) before NHFP funds may be authorized for a freight project. CDOT will continually evaluate and update corridor designations in Colorado based on identified needs. This designation and de-designation process will take place on an ongoing basis with stakeholders and the FHWA.

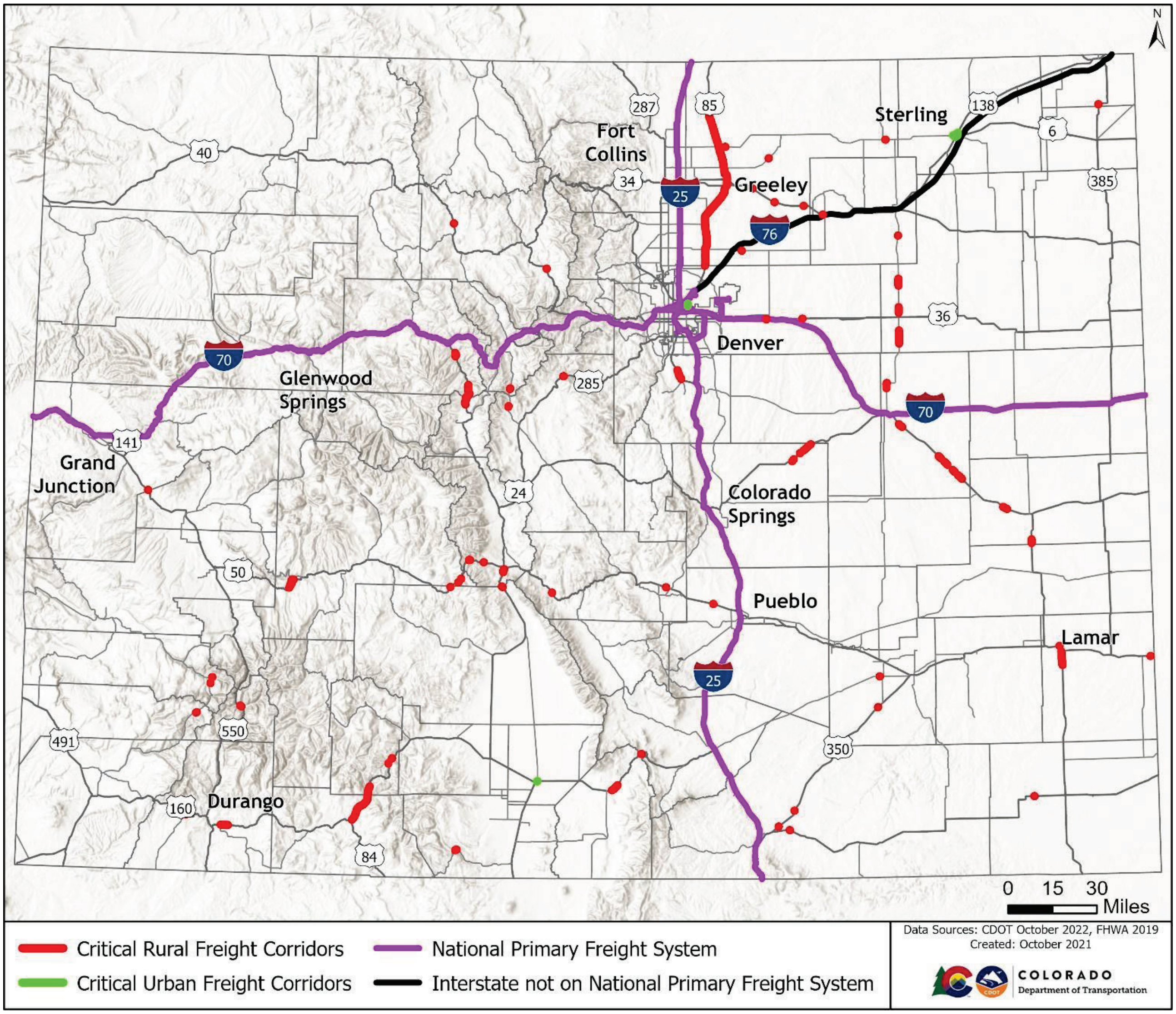
The following total corridor mileage has been currently designated in Colorado:

- *Critical Rural Freight Corridors.* Colorado has been allotted 600 miles to designate as CRFC. **A total of 127.99 miles are currently designated as CRFC.**

- *Critical Urban Freight Corridors.* Colorado has been allotted 150 miles to designate as CUFC. **A total of 5.02 miles are currently designated as CUFC.**

Shown in the map and tables below, these segments meet guidance and criteria from the FHWA for the selection of CRFC and CUFC.

Figure B.1 Routes Map



B.1 Routes List

Table B.1 Critical Urban Freight Corridors

Project	Route	MP Beg	MP End	Extent (mi)	FHWA Corridor Identification
SH 14: Sterling "S" Curve	State Highway 14 (014C)	236.0	236.9	0.92	J, K
SH 14: Sterling "S" Curve	U.S. Route 138 (138A)	0.0	1.0	1.00	J, K
SH 14: Sterling "S" Curve	U.S. Route 138 (138Z)	0.0	0.6	0.60	J, K
SH 14: Sterling "S" Curve	U.S. Route 6 (006J)	404.0	405.0	1.00	J, K
SH 14: Sterling "S" Curve	U.S. Route 6 (006Z)	0.0	0.6	0.60	J, K
U.S. 85 Vasquez: I-270 to 62nd Avenue Interchange	U.S. Route 6 (006H)	292.9	293.8	0.90	H, J, K
Total CUFC Mileage	N/A	-	-	**5.02**	N/A

Table B.2 Critical Rural Freight Corridors

Project	Route	MP Beg	MP End	Extent (mi)	FHWA Corridor Identification
Port-of-Entry Mobile Site Pullout Improvements	State Highway 10 (010A)	61.50	61.60	0.10	G
Port-of-Entry Mobile Site Pullout Improvements	State Highway 14 (014C)	212.60	212.70	0.10	C, D, F, G
Mountain Pass Chain Up Stations and Safety Needs	State Highway 145 (145A)	54.70	55.00	0.30	D, G
Mountain Pass Chain Up Stations and Safety Needs	State Highway 145 (145A)	68.90	69.00	0.10	D, G
Mountain Pass Chain Up Stations and Safety Needs	State Highway 145 (145A)	71.60	71.70	0.10	D, G
Mountain Pass Chain Up Stations and Safety Needs	State Highway 17 (017A)	16.80	17.40	0.60	D, G
Port-of-Entry Mobile Site Pullout Improvements	State Highway 392 (392B)	131.50	131.60	0.10	G
SH 9: North of Hoosier Pass Chain Station	State Highway 9 (009C)	72.10	72.40	0.30	D, G
SH 9: South of Hoosier Pass Chain Station	State Highway 9 (009C)	79.90	80.20	0.30	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 160 (160A)	176.60	176.70	0.10	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 160 (160A)	260.00	262.60	2.60	D, G

Project	Route	MP Beg	MP End	Extent (mi)	FHWA Corridor Identification
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 160 (160A)	276.70	276.80	0.10	D, G
Wolf Creek Fiber West & ITS	U.S. Route 160 (160A)	144.50	158.00	13.50	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 285 (285B)	118.90	119.30	0.40	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 285 (285B)	125.00	126.10	1.10	D, G
North Kenosha Pass Chain Station	U.S. Route 285 (285D)	207.80	208.00	0.20	D, G
U.S. 287: Lamar Reliever Route	U.S. Route 287 (287A)	73.00	77.60	4.60	A, B, D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 287 (287B)	123.30	124.50	1.20	A, B, D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 34 (034A)	148.40	148.50	0.10	D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 36 (036D)	102.80	102.90	0.10	D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 40 (040A)	173.50	173.60	0.10	D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 40 (040A)	224.30	224.40	0.10	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	390.00	391.50	1.50	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	407.30	408.40	1.10	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	410.00	411.40	1.40	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	414.00	414.90	0.90	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	416.50	417.60	1.10	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	417.90	418.30	0.40	D, G
U.S. 40/U.S. 287: Passing Lanes	U.S. Route 40 (040H)	435.80	437.40	1.60	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 50 (050A)	190.10	190.20	0.10	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 50 (050A)	193.50	193.60	0.10	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 50 (050A)	195.50	195.60	0.10	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 50 (050A)	204.50	204.90	0.40	D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 50 (050A)	209.70	209.80	0.10	D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 50 (050A)	52.70	52.80	0.10	D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 50 (050A)	288.20	288.30	0.10	D, G
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 50 (050A)	305.50	305.60	0.10	D, G

Project	Route	MP Beg	MP End	Extent (mi)	FHWA Corridor Identification
Port-of-Entry Mobile Site Pullout Improvements	U.S. Route 50 (050B)	466.30	466.40	0.10	A, B, D, G
Mountain Pass Chain Up Stations and Safety Needs	U.S. Route 550 (550B)	71.40	71.90	0.50	D, G
U.S. 85: Louviers to Meadows Widening	U.S. Route 85 (085B)	191.20	194.40	3.20	D, G
U.S. 85: Corridor Improvements	U.S. Route 85 (085C)	236.00	265.00	29.00	D, G
U.S. 85: Corridor Improvements	U.S. Route 85 (085L)	265.00	291.00	26.00	D, G
SH 71 Climbing Lanes	State Highway 71 (071D)	110.95	112.70	1.75	A, D, G
SH 71 Climbing Lanes	State Highway 71 (071D)	129.10	131.55	2.45	A, D, G
SH 71 Climbing Lanes	State Highway 71 (071D)	131.75	133.50	1.75	A, D, G
SH 71 Climbing Lanes	State Highway 71 (071D)	139.65	141.40	1.75	A, D, G
SH 71 Climbing Lanes	State Highway 71 (071D)	148.70	150.45	1.75	A, D, G
U.S. 34 Weather Cameras	U.S. Route 34 (034A)	122.00	122.10	0.10	B, D, G
U.S. 34 Weather Cameras	U.S. Route 34 (034A)	131.00	131.10	0.10	B, D, G
U.S. 34 Weather Cameras	U.S. Route 34 (034A)	141.00	141.10	0.10	B, D, G
2022 Chain Station Improvements	U.S. Route 160 (160A)	174.20	174.30	0.10	D, G
Weigh-in-motion Program and Safety Enhancements	U.S. Route 50 (050B)	433.00	433.10	0.10	A, D, G
Weigh-in-motion Program and Safety Enhancements	State Highway 160 (160A)	74.59	74.69	0.10	A, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 160 (160C)	453.86	453.96	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 160 (160C)	356.32	356.42	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	340.91	341.01	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	344.73	344.83	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 350 (350A)	35.30	35.40	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 350 (350A)	57.26	57.36	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 350 (350A)	10.30	10.40	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	State Highway 52 (052A)	32.61	32.71	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 385 (385D)	291.54	291.64	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 350 (350A)	2.55	2.65	0.10	A, B, D, G

Project	Route	MP Beg	MP End	Extent (mi)	FHWA Corridor Identification
Timber Structure Repairs on Truck Routes	State Highway 14 (014C)	155.60	155.70	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	State Highway 52 (052A)	32.61	32.71	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	State Highway 71 (071D)	165.70	165.80	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	341.66	341.76	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	346.20	346.30	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	346.97	347.07	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	347.42	347.52	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	348.37	348.47	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 24 (024G)	349.40	349.50	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	U.S. Route 50 (050A)	238.78	238.88	0.10	A, B, D, G
Timber Structure Repairs on Truck Routes	State Highway 15	29.53	30.53	1.00	B, D, G
Timber Structure Repairs on Truck Routes	State Highway 114	40.39	41.39	1.00	B, D, G
U.S. 50: Little Blue Canyon	U.S. Route 50 (050A)	123.00	127.00	4.00	D, G
U.S. 24 Chain Down Station Improvements	U.S. Route 24 (024A)	162.00	170.00	8.00	B, D, G
U.S. 24 Chain Up Station Improvements	U.S. Route 24 (024A)	147.50	149.50	2.00	B, D, G
U.S. 160 Elmore's Corner to CR 225 Project, SA#20980	U.S. Route 160 (160A)	91.50	93.90	2.40	D, G
CDOT Bridge—Bennett SH 79	State Highway 79 (079A)	0.001	0.136	0.135	A, B, D, G
SH 71 Climbing Lanes North of Limon	State Highway 71 (071D)	111.50	112.10	0.60	B, D, G
SH 71 Climbing Lanes North of Last Chance	State Highway 71 (071D)	139.50	140.30	0.80	B, D, G
SH 71 Climbing Lanes 10 miles North of Last Chance	State Highway 71 (071D)	149.10	151.00	1.90	B, D, G
Total CRFC Mileage	N/A	-	-	**127.99**	N/A

B.2 De-Designated Routes List

Table B.3 Closed Freight Corridors

Project	Route	MP Begin	MP End	Extent (mi)	FHWA Corridor Identification
U.S. 287: Lamar Reliever Route	U.S. Route 50 (050B)	432.50	437.00	4.50	A, B, D, G
U.S. 160: Wolf Creek Safety Improvements	U.S. Route 160 (160A)	158.00	173.00	15.00	C, D, F, G
Truck Parking—Region 5	U.S. Route 160 (160A)	46.50	46.50	0.00	D, G
Truck Parking—Region 5	U.S. Route 160 (160A)	191.40	191.40	0.00	D, G
U.S. 287: Passing Lane South of Lamar	U.S. Route 287 (287A)	3.10	5.00	1.90	A, B, D, G
U.S. 287: Passing Lane South of Lamar	U.S. Route 287 (287A)	23.30	25.70	2.40	A, B, D, G
Total De-Designated Corridor Mileage	N/A	-	-	**23.80**	N/A

C

Project List

Table C.1 FY2024 NHFP Projects

Project	NHFP	State Match	Total
I-70 Vail Pass Safety Improvements—Continuation STIP Number: TBD CFP Emphasis Area: Freight Mobility, Freight Safety This project will address commercial vehicle safety along a critical corridor and challenging mountain pass. New auxiliary climbing lanes will be constructed along eastbound I-70 from MP 185 to 190. Additional corridor safety improvements including shoulder widening and reconstructing downhill curves at MP 186 and 188, both locations of safety hotspots.	$1.60	$0.40	$2.00
I-70 Glenwood Canyon Freight Improvements—Continuation STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility, Freight Sustainability I-70 Glenwood Canyon corridor frequently experiences closures due to weather events and natural disasters. Improvements to this corridor includes installing guardrail that meets current crash standards, replacing deteriorated tunnel paving in 5 tunnels, replacing modular bridge joints that have exceeded twice their designed lifespan, various structure repairs in multiple active geohazard zones, installing an electric generator replacement at the Hanging Lake Tunnels, constructing a concrete debris flow channel above the Hanging Lake Tunnel Cinnamon Creek operations complex, and improving cross passage access to truck parking at 3 rest areas nearby.	$1.20	$0.30	$1.50
U.S. 24 Chain Up & Down Station Improvements—Continuation STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility Dedicated chain up and down stations on CO 24 are critical as many travelers, including large trucks, use CO 24 and CO 91 when I-70 Vail Pass is closed. CO 24 is a narrow 2 lane roadway predominately with 11' lanes and 2' shoulders. There is a slightly widened shoulder near MM 148 that acts as a southbound chain up station however the narrowness of the chain station forces drivers to chain up while protruding into the roadway itself. In addition, the existing widened shoulder does not have lighting and there is poor signage, as a result many truck drivers drive past the 'chain station' and end up spinning out and blocking traffic. Improvements would significantly increase shoulder width at a designated chain down station, add lighting and signage.	$0.40	$0.10	$0.50

Project	NHFP	State Match	Total
Region 5 2022 Chain Station Improvements—Continuation STIP Number: SR56689.077 Chain Station Improvement Project will provide adequate lighting and space for trucks to pull over and for drivers to chain up safely. Construction improvements will include installation of new light-emitting diode (LED) lighting on both sides of the vehicles, signing and striping, as well as the installation of variable message signs on mountain passes. Some locations will also be lengthened and widened, including paving, in order to accommodate more trucks. Widening and lighting of the chain up stations will increase the buffer between the trucks and live lanes of traffic.	$2.40	$0.60	$3.00

Table C.2 FY2023 NHFP Projects

Project	NHFP	State Match	Total
I-70 Vail Pass Safety Improvements STIP Number: TBD CFP Emphasis Area: Freight Mobility, Freight Safety This project will address commercial vehicle safety along a critical corridor and challenging mountain pass. New auxiliary climbing lanes will be constructed along eastbound I-70 from MP 185 to 190. Additional corridor safety improvements including shoulder widening and reconstructing downhill curves at MP 186 and 188, both locations of safety hotspots.	$7.12	$1.78	$8.90
I-70 Vail Pass Truck Parking Expansion STIP Number: TBD CFP Emphasis Area: Truck Parking, Freight Safety This project will provide for significant new truck parking capacity through development of a dedicated and full-time parking facility with 22 new track parking spaces at MP 189 of I-70.	$0.20	$0.80	$4.00
I-70 Vail Pass Rest Area Truck Parking STIP Number: TBD CFP Emphasis Area: Truck Parking, Freight Safety This project provides for the redevelopment of existing rest area facilities and parking to better accommodate trucks. Commercial vehicle improvements to year-round facilities include: upgrade water and wastewater, improved access and safer turning movements for trucks, and separation of truck parking from recreational and passenger vehicle traffic. Dedicated truck parking spaces will increase by 18 additional spaces for a total of 20 expanded and improved parking spaces.	$2.48	$0.62	$3.10
Dynamic Speed Warning System I-70 Floyd Hill and Straight Creek—FY23 Continuation STIP Number: SST7079.001 CFP Emphasis Area: Freight Mobility, Freight Safety This project is a continuation of a FY20 award to implement a preventative warning system to alert CMV drivers when they are traveling at an unsafe speed as they approach a steep decline. The system uses Weigh-in-Motion (WIM) technology along with speed radar to analyze how fast the CMV and its load are traveling. This FY23 continuation allows for additional deployment locations and study of post-implementation effects on driver speeds.	$0.28	$0.07	$0.35

Project	NHFP	State Match	Total
I-70 Roadside Facilities in Clear Creek County STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Sustainability Due to the lack of on-highway rest stops between Vail Pass and the Denver metro area, human waste has become a critical issue in the I-70 corridor throughout Clear Creek County. Installation of facilities at chain stations, weigh stations, and other locations are needed to help significantly reduce human waste and trash at other recreational, commercial, and residential unauthorized areas for these activities. This would mitigate impacts to wildfire risk from dying trees and impacts to sensitive environmental habitats and water resources, and increase efficiency in trash and human waste collection.	$0.80	$0.20	$1.00
North Pueblo Overflow Truck Parking Lot STIP Number: TBD CFP Emphasis Area: Freight Safety, Truck Parking Interstate closures during major weather events cause significant burden to Pueblo businesses. During these events, truck parking inundates roads, ramps, and parking lots all throughout town. This parking lot will provide a convenient location to concentrate up to an estimated 50 trucks to park and provide important amenities to drivers. CDOT will seek a P3 Partnership to take the long-term maintenance responsibility of this parking lot.	$2.00	$0.50	$2.50
South Trinidad Overflow Truck Parking Lot STIP Number: TBD CFP Emphasis Area: Freight Safety, Truck Parking Interstate closures Over Raton Pass during major weather events causes significant burden to Trinidad businesses as truck parking inundates roads, ramps, and parking lots all throughout town. This parking lot will provide a convenient location to concentrate 50 truck parking spaces. CDOT will seek a P3 Partnership to take the long-term maintenance responsibility of this parking lot.	$1.20	$0.30	$1.50
I-25 and U.S.-50B Interchange Improvements STIP Number: TBD CFP Emphasis Area: Freight Mobility, Freight Safety US50B is a major freight corridor leaving Pueblo traveling east to Kansas. The I-25 interchange at U.S.-50B includes the overpass bridge, has a very low clearance, and has been struck by freight trucks 15-20 times in the last 5-7 years. The bridge has no shoulders offering a refuge for disabled trucks or vehicles. Finally, on and off ramps on west and east sides have unsafe tight curves causing trucks to seek a detour. This project will reconstruct the bridge, correct horizontal on-off ramp geometry and increase shoulder widths.	$4.80	$1.20	$6.00
I-70 Glenwood Canyon Freight Improvements STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility, Freight Sustainability I-70 Glenwood Canyon corridor frequently experiences closures due to weather events and natural disasters. Improvements to this corridor includes installing guardrail that meets current crash standards, replacing deteriorated tunnel paving in 5 tunnels, replacing modular bridge joints that have exceeded twice their designed lifespan, various structure repairs in multiple active geohazard zones, installing an electric generator replacement at the Hanging Lake Tunnels, constructing a concrete debris flow channel above the Hanging Lake Tunnel Cinnamon Creek operations complex, and improving cross passage access to truck parking at 3 rest areas nearby.	$0.60	$0.15	$0.75

Project	NHFP	State Match	Total
U.S. 24 Chain Up & Down Station Improvements STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility Dedicated chain up and down stations on CO 24 are critical as many travelers, including large trucks, use CO 24 and CO 91 when I-70 Vail Pass is closed. CO 24 is a narrow 2 lane roadway predominately with 11' lanes and 2' shoulders. There is a slightly widened shoulder near MM 148 that acts as a southbound chain up station however the narrowness of the chain station forces drivers to chain up while protruding into the roadway itself. In addition, the existing widened shoulder does not have lighting and there is poor signage, as a result many truck drivers drive past the 'chain station' and end up spinning out and blocking traffic. Improvements would significantly increase shoulder width at a designated chain down station, add lighting and signage.	$1.60	$0.40	$2.00
I-25 Wellington Truck Parking—Continuation STIP Number: SR46600.101 CFP Emphasis Area: Freight Safety, Truck Parking This funds the continuation of 2021 funded studying to add a truck parking lot north of Fort Collins off I-25 North, near Wellington. The exact number of spaces to be added will depend on ROW constraints, design configuration, and environmental considerations. CDOT's Truck Parking Assessment implementation identifies this area as one of the state's truck corridor segments with the highest shortfall of spaces. Study continuation funding will result in a specific location chosen to design the new truck parking lot.	$0.40	$0.10	$0.50
US160 Elmore's Corner Project: CO172 to La Plata County Road 225 STIP Number: TBD CFP Emphasis Area: Freight Safety This project will correct significant operational and safety issues identified along U.S. 160 from CO 172 to La Plata County Road 225. The need is based on the projected increase in travel demands on highway capacity and efficiency, and to mitigate the poor sight distance, steep roadway grades, lack of shoulders, insufficient recovery zones, steep embankments, lack of turn lanes, and lack of wildlife crossings.	$1.60	$0.40	$2.00
Freight Bridge Investment Plan Study STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility There is a need to identify and prioritize bridges that are currently restricting freight corridors due to bridge load, height, or width restrictions. This study would identify all bridges and major culverts located on freight corridors that require treatments to reduce load, height, or width restrictions. Using a data-driven approach, structures and treatments will be prioritized and preliminary project bundles will be developed to aid in planning and programming structures for treatment, and result in freight corridor resilience and direct routing.	$0.20	$0.05	$0.25

Project	NHFP	State Match	Total
Fatigue Crack Mitigation on Freight Bridges Pilot STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility This project would ensure a more resilient freight network on some of Colorado's most important freight routes, prevent and reduce the percentage of Poor bridge deck area on the National Highway Freight Network. 51 steel superstructure bridges currently exhibit fatigue cracks, which pose a threat to the overall condition, safety, and longevity of the structures. Fatigue crack appearance and propagation is exacerbated by heavy loads carried by these structures. This pilot project would work to mitigate the existing fatigue cracks in approximately 15 bridges utilizing a relatively low-cost drill and bushing gun method. If left unmitigated, fatigue cracks can continue to grow, compromising the strength and stiffness of the steel bridge structure and can result in the fracture and failure of the steel. Additionally, extensive fatigue cracking results in a downgrade of the National Bridge Inventory rating of a bridge, negatively impacting the percentage of Poor bridge deck area in the state.	$0.88	$0.22	$1.10
FY2023 Subtotals	**$27.80**	**$6.79**	**$33.95**

Table C.3 FY2022 NHFP Projects

Project	NHFP	State Match	Total
Pool Project- Metro Chain Stations STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility This funding pool focuses on chain stations nearer urbanized areas, where traffic volumes and lack of chain stations create hazardous conditions during inclement weather events. The first locations are north and south of Monument Hill, an area that experienced 20 chain law events over the last three winters.	$2.40	$0.60	$3.00
Pool Project—Weigh-in-motion STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility This funding pool focuses on improvements to the weigh-in-motion (WIM) assets located at the six Port of Entry (POE) stations. An inspection and analysis of WIM assets will prioritize and provide cost estimates for needed repairs/replacements. Funds remaining after the inspection and analysis will be used to repair/replace three to four WIM systems and enhance safety through low-cost improvements.	$1.60	$0.40	$2.00
Timber Bridges Repair and Reinforcement STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility This funding pool focuses on the repair and structural reinforcement of timber structures that will improve load ratings allowing trucks to travel on these bridges and avoid a re-routing situation which will contribute to more efficient freight movement, operations and greenhouse gas emission reduction. To date 62 structures on freight corridors have been identified that will benefit from this type of repair.	$3.20	$0.80	$4.00
I-70 EB Runaway Ramp STIP Number: TBD CFP Emphasis Area: Freight Safety This provides construction funds for the Denver West runaway truck ramp in a location that experienced a severe, multi-fatality crash in 2019 and is a frequent site of overheated truck brakes. This project provides a safe option to stop for trucks with compromised brakes before entering the urban, often congested areas.	$3.28	$0.82	$4.10
SH 71 Climbing Lanes STIP Number: TBD CFP Emphasis Area: Freight Safety This project funds the construction for the addition of climbing lanes at three locations on this corridor that currently have no passing opportunities.	$3.60	$0.90	$4.50
EJMT Hazmat Study Continuation STIP Number: TBD CFP Emphasis Area: Freight Safety, Freight Mobility In 2020 CDOT completed the Transportation of Hazardous Materials through Eisenhower-Edwin C Johnson Memorial Tunnel Study in cooperation with the USDOT, FHWA, CSP and stakeholders. The completed study identified areas of focus for next steps. NHFP funds requested will investigate the next steps for six identified items to mitigate risk and improve the safety of transporting hazmat on this portion of I-70/U.S. 6.	$0.28	$0.07	$0.35
FY2022 Subtotal	**14.36**	**3.59**	**17.95**

Table C.4 FY2021 NHFP Projects

Project	NHFP	State Match	Total
SH 79 over I-70 Bridge Design, STIP Number: TBD	$1.60	$0.40	$2.00
I-70 West Vail Pass Auxiliary Lanes—FY21 Continuation, STIP Number: SIN7021	$1.60	$0.40	$2.00
Timber Structure Repairs on Truck Routes, STIP Number: TBD	$1.60	$0.40	$2.00
Weigh-in-motion Program and Safety Enhancements, STIP Number: TBD	$1.60	$0.40	$2.00
Metro Area Chain Stations, STIP Number: TBD	$2.40	$0.60	$3.00
I-70 EB Aux Lane and Truck Parking, STIP Number: SIN7022	$2.80	$0.70	$3.50
I-25 Wellington Truck Parking, STIP Number: SR46600.101	$0.40	$0.10	$0.50
SH 71 Climbing Lanes, STIP Number: SR46600.068	$1.20	$0.30	$1.50
On-System Bridge Ratings, STIP Number: TBD	$2.10	$0.53	$2.63
U.S. 34 Weather Cameras, STIP Number: SR46600.100	$0.42	$0.10	$0.52
Region 5 2022 Chain Station Improvements, STIP Number: SR56689.077	$1.47	$0.37	$1.84
I-70 EB Runaway Ramp, STIP Number: SR17002.101	$0.40	$0.10	$0.50
I-70 WB Climbing Lane Bakerville to EJMT, STIP Number: SR10267.001	$1.20	$0.30	$1.50
FY2021 Subtotals	**$18.79**	**$4.70**	**$23.49**

Table C.5 FY2019 and 2020 NHFP Projects

Project	NHFP	State Match	Total
U.S. 40/U.S. 287 Passing Lanes—FY20 Continuation, STIP Number: SR46600.085	$1.60	$0.40	$2.00
Wolf Creek Fiber West & ITS, STIP Number: SR56157.025	$0.32	$0.08	$0.40
I-25 South Monument Hill Climbing Lane—FY20 Continuation, STIP Number: SR13322.001	$6.40	$1.60	$8.00
I-25 Southbound Chain-Up Station Improvements at Larkspur, STIP Number: SR13322.001	$0.50	$0.15	$0.65
Dynamic Speed Warning System I-70 Floyd Hill and Straight Creek Scoping, STIP Number: SST7079.001	$0.33	$0.07	$0.40
North Kenosha Pass Chain Up Station, STIP Number: SR26867.101	$3.70	$0.80	$4.50
State Highway 9—South of Hoosier Pass, STIP Number: SR26867.102	$3.70	$0.80	$4.50
State Highway 9—North of Hoosier Pass, STIP Number: SR26867.102	$3.70	$0.80	$4.50
I-70 West Vail Pass Auxiliary Lanes—FY19 Continuation, STIP Number: SIN7021	$3.70	$0.80	$4.50
U.S. 50—Little Blue Canyon, STIP Number: SR36607.003	$0.46	$0.10	$0.56
I-70 EJMT—Trailer Snow Removal System, STIP Number: SST7079.002	$0.24	$0.06	$0.30
Truck Specialized Parking Services Maintenance and Monitoring, STIP Number: SST7079.003	$0.19	$0.04	$0.23
I-70 Truck Parking Information Management System, STIP Number: SST7079.004	$0.80	$0.18	$0.98
FY2019/2020 Subtotals (including closed projects)	**$35.25**	**$7.97**	**$43.22**

Table C.6 FY2018 NHFP Projects

Project	NHFP	State Match	Total
I-25 South Monument Hill Climbing Lane, STIP Number: SR13322.001	$2.00	$0.50	$2.50
I-70 Garfield County Truck Parking—FY18 Continuation, STIP Number: SR37014.001	$1.30	$0.33	$1.63
U.S. 40/U.S. 287 Passing Lanes—FY18 Continuation, STIP Number: SR46600.085	$3.60	$0.90	$4.50
FY2018 Subtotals (including closed projects)	**$14.20**	**$3.55**	**$17.75**

Table C.7 FY2017 NHFP Projects

FY2017 NHFP Projects	NHFP	State Match	Total
I-25: City Center Drive to 29th Street, STIP Number: SPB3865	$1.60	$0.40	$2.00
I-70 West: Vail Pass Auxiliary Lanes, STIP Number: SR36607.028	$1.60	$0.40	$2.00
U.S. 85: Louviers to Meadows Widening, STIP Number: SR16719.030	$4.88	$1.22	$6.10
U.S. 85/Vasquez: I-270 to 62nd Avenue Interchange, STIP Number: SR16720.999	$3.20	$0.80	$4.00
U.S. 85: Corridor Improvements, STIP Number: SR46600.031	$1.60	$0.40	$2.00
U.S. 287: Lamar Reliever Route, STIP Number: SR26867.082	$0.80	$0.20	$1.00
SH 14: Sterling "S" Curve, STIP Number: SR46606.045	$6.00	$1.50	$7.50
Port-of-Entry Mobile Site Pullout Improvements, STIP Number: SST7079.005	$0.80	$0.20	$1.00
Truck Parking Information Management System (TPIMS), STIP Number: SST7003.126	$0.80	$0.20	$1.00
FY2017 Subtotals (including closed projects)	**$28.60**	**$7.16**	**$35.75**

Table C.8 Freight Investment Plan Summary Table

Source	FY16[1]	FY17	FY18	FY19[1]	FY20	FY21	FY22	FY23	FY24	Total
Colorado NHFP Apportionment Selections	$0.00	$28.60	$14.20	$0.00	$35.25	$18.79	$14.36	$27.08	$7.00	$145.28
Federal NHFP Available Totals	$15.54	$14.77	$16.14	$18.22	$20.17	$20.27	$18.50	$18.50	$19.51	$161.62
Annual Non-Allocated NHFP Funds	$15.54	($13.83)	$1.94	$18.22	($15.08)	$1.48	$4.14	($8.58)	$12.51	$3.83
Total Non-Allocated NHFP Funds Balance	$15.54	$1.71	$3.65	$21.87	$6.79	$8.27	$12.41	$30.91	N/A	N/A
State Match (HUTF) Totals	$0.00	$7.16	$3.55	$0.00	$7.97	$4.70	$3.59	$6.79	$1.40	$35.16
Total NHFP Selections (Fed + State Match)	$0.00	$35.76	$17.75	$0.00	$43.22	$23.49	$17.95	$33.95	$7.00	$179.12

1 CDOT issued a combined call for projects for FY 16/17, and FY19/20 funding allocation years.

Note: The Statewide Transportation Improvement Program (STIP) numbers are provided, when available, on the top line of each FIP project. The FIP identifies projects and funds by the calendar year they are prioritized/selected and may vary from the STIP funding year which represents budget and financial obligation.

Table C.9 Completed & Closed NHFP Projects[1]

Fiscal Year	Project	NHFP	State Match	Total
FYs 2019 & 2020	Passing Lanes on U.S. 40/U.S. 287—FY19 Continuation, STIP Number: SR46606.085	$3.70	$0.80	$4.50
FYs 2019 & 2020	Mountain Pass Chain Up Stations and Safety Needs, Region 5—FY19&20 Continuation, STIP Numbers: SR56689.069 & SR46606.085	$3.70	$0.80	$4.50
FYs 2019 & 2020	U.S. 160 and State Highway 17 Intersection Improvement Project, STIP Number: SR56689.037	$1.23	$0.27	$1.50
FYs 2019 & 2020	I-25 Repair Structure P-18-BP, STIP Number: SR26867.100	$0.98	$0.22	$1.20
FY2018	U.S. 287 Passing Lane South of Lamar, STIP Number: SR26867.064	$3.60	$0.90	$4.50
FY2018	Mountain Pass Chain Up Stations and Safety Needs, Region 5—FY18 Continuation, STIP Number: SR56689.069	$1.92	$0.48	$2.40
FY2018	Sleeping Ute Truck Parking—Region 5, STIP Number: SR56689.073	$1.78	$0.44	$2.22
FY2017	I-25: Valley Highway Phase 3.0: Santa Fe to Bronco Arc, STIP Number: SR16719.028	$0.80	$0.20	$1.00
FY2017	I-70 Garfield County Truck Parking, STIP Number: SR36607.016	$1.60	$0.40	$2.00
FY2017	Mountain Pass Chain Up Stations and Safety Needs—Region 5, STIP Number: SR56689.069	$2.03	$0.52	$2.55
FY2017	U.S. 160 Wolf Creek Safety Improvements, STIP Number: SR56689.068	$1.28	$0.32	$1.60
FY2017	U.S. 50: Little Blue Canyon, STIP Number: SR36607.003	$1.60	$0.40	$2.00
N/A	**Closed Subtotal**	**$24.22**	**$5.75**	**$29.97**

1 Projects that have been full constructed and fiscally closed that were funding with NHFP past funds include the list below. These project locations have been de-designated as critical freight corridors.

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