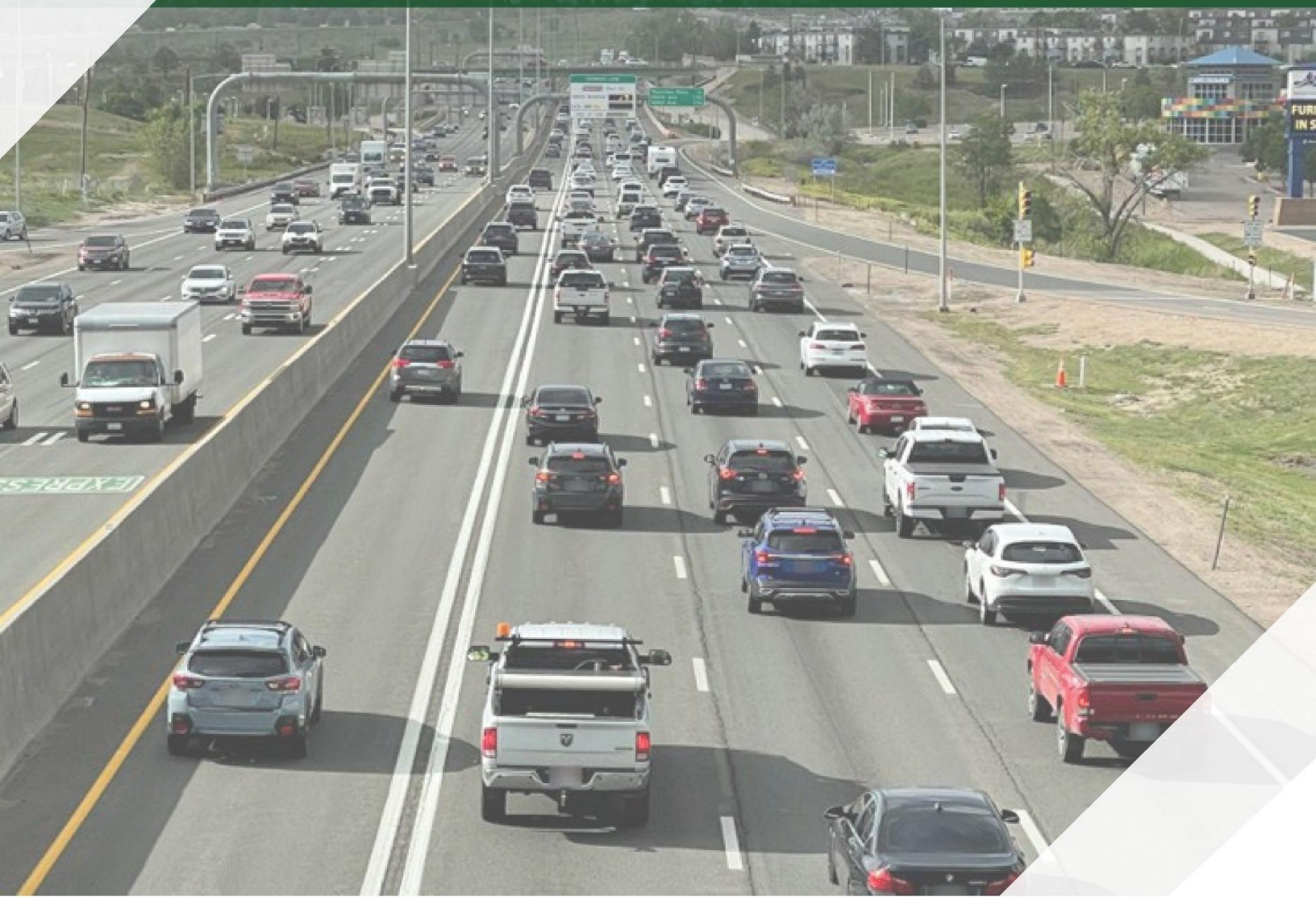
I-25 (US 36 to 104th Avenue)

Safety and Operations Improvements Project



Greenhouse Gas Technical Report

October 2026

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Authorship Attribution Statement

Spheros Environmental conducted MOtor Vehicle Emission Simulator (MOVES) and Infrastructure Carbon Estimator (ICE) modeling of greenhouse gas (GHG) emissions and calculated the lifetime GHG emissions and the Social Cost of Carbon (SCC) for the Interstate 25 (I-25) from United States Highway 36 (US 36) to 104th Avenue project. Spheros Environmental authored **Section 1**, **Sections 5-8**, and **Attachments B, C, and D** of this report. All other sections and **Attachment A** of the report were authored by specialists in the Colorado Department of Transportation (CDOT) Air and Climate Section.

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Greenhouse Gas Technical Report

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Contents

Acronyms and Abbreviations iv

1.0 Introduction 1
1.1 Project Background 1
1.2 Report Overview 2

2.0 Alternatives 4
2.1 No Action Alternative 4
2.2 Build Alternative 4

3.0 Regulatory Environment 5

4.0 Affected Environment 6
4.1 GHGs and Transportation 6
4.2 Factors that Affect Transportation GHGs 7
4.2.1 Operational 7
4.2.2 Construction 7
4.2.3 Maintenance 8
4.3 Trends in Transportation Emissions of GHGs 8
4.4 Climate Change Effects in Colorado 8
4.5 Climate Change Effects on Transportation Infrastructure 9
4.6 Measures Taken to Address Climate Change in Colorado 10
4.6.1 CDOT GHG Reduction Targets 11
4.6.2 Local Climate Action Plans and Goals 12

5.0 Applicable Guidance 14

6.0 Project Scoping and Interagency Consultation 15

7.0 Methodology 16
7.1 Overview 16
7.2 Pollutants Considered 16
7.3 Analysis Approach 16
7.3.1 Study Area 16
7.3.2 Modeling of Operational, Construction, and Maintenance Emissions 17
7.3.3 Lifetime Operational GHG Emissions 18
7.3.4 Life Cycle Assessment and SCC 18

8.0 Project-Level GHG Analysis Results 21
8.1 Direct Effects 21
8.2 Indirect Effects 23
8.3 Cumulative Effects 24
8.4 Social Cost of Carbon 25

9.0 Project-Level GHG Analysis Effects 27
9.1 Purpose of Supplemental Analysis 27
9.1.1 Supplemental Analysis Overview 27

9.1.2 The Speed and Emissions Relationship 28
9.1.3 Analysis Focus: Scenario Year and Season, Travel Time Periods, and Vehicle Types 30
9.1.4 Scenario Year and Season 30
9.1.5 Travel Time Periods 30
9.1.6 Qualitative Supplemental Analysis – Link Level Approach 32
9.1.7 Supplemental Analysis Segment Level Findings 33
9.1.8 Supplemental Analysis Findings and Conclusions 34
9.2 Related Projects with GHG Impacts 35

10.0 Consideration of Indirect Effects 37
10.1 Upstream Fuel Cycle Emissions 37
10.2 Indirect Effects Not Quantified in the Analysis 37
10.2.1 Safety Improvements 37
10.2.2 Land Use 38

11.0 Mitigation/GHG Commitment Considerations 42

12.0 Resilience Considerations 43

13.0 Community Impact Considerations 45

14.0 Conclusion 47

15.0 References 48

Attachments

Attachment A. Project Information
Attachment B. Greenhouse Gas Analysis Work Plan
Attachment C. Greenhouse Gas Operational Emissions Analysis Methods
Attachment D. Greenhouse Gas Analysis Supplemental Tables

Figures

Figure 1. Project Limits 3
Figure 2. Lifetime Direct GHG Emissions (MT CO_2e Over the Project Lifetime) 22
Figure 3. Annual Direct GHG Emissions and VMT (MT CO_2e and Miles Per Year) 23
Figure 4. Annual Indirect GHG Emissions (MT CO_2e Per Year) 24
Figure 5. Annual Cumulative GHG Emissions (MT CO_2e Per Year) 25
Figure 6. Total Lifetime SCC by Discount Rate and Alternative (Calendar-Year 2020 USD) 26
Figure 7. Northbound AM and PM Peak Predicted Hourly Average Speeds on GP Lanes in the Project Segment 31
Figure 8. Southbound AM and PM Peak Predicted Hourly Average Speeds on GP Lanes in the Project Segment 31
Figure 9. Heat Island Severity Index 46

Tables

Table 1. Colorado Annual Transportation Emissions (MMT CO_2e) 8
Table 2. Climate Change Impacts on Transportation Infrastructure 10
Table 3. GHG Transportation Planning Reduction Levels (MMT of CO_2e) 12
Table 4. Lifetime Direct GHG Emissions (MT CO_2e Over the Project Lifetime) 21
Table 5. Lifetime Indirect Emissions Associated with the Project Alternatives (MT CO_2e) 24
Table 6. Cumulative GHG Emissions (MT CO_2e) 24
Table 7. Total Lifetime SCC (Calendar-Year 2020 USD) 26
Table 8. Passenger Vehicles Versus Trucks Combined CO_2e Emissions Rates (Tailpipe and Evaporative) by Vehicle Speed in the Project Horizon Year (2050) for Summer AM Conditions 29
Table 9. Northbound, Southbound and Total Segment Link-Level Relative Percent Difference for Peak AM and PM CO_2e Emission Rates 34

Acronyms and Abbreviations

Acronym or Abbreviation	Full Name
%	percent
°F	degree(s) Fahrenheit
AADT	average annual daily traffic
APCD	Air Pollution Control Division
AVFT	Alternate Vehicle Fuel and Technology
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Department of Public Safety
CEO	Colorado Energy Office
CH_4	methane
COVID-19	Coronavirus Disease 2019
CO_2	carbon dioxide
CO_2e	CO_2 equivalent
CRS	Colorado Revised Statutes
CSA	community study area
CTIO	Colorado Transportation Investment Office
DI	Disproportionately Impacted
DRCOG	Denver Regional Council of Governments
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
EV	electric vehicle
FAQ	Frequently Asked Question
FHWA	Federal Highway Administration
GHG	greenhouse gas
GP	general-purpose
gpm	grams per mile
GVMPO	Grand Valley Metropolitan Planning Organization
GWP	global warming potential
HB	House Bill
HFC	hydrofluorocarbon
HOV3+	high occupancy vehicle with three or more occupants
IPCC	Intergovernmental Panel on Climate Change
IWG SC-GHG	Interagency Working Group on Social Cost of Greenhouse Gases
I-25	Interstate 25
I-270	Interstate 270
I-70	Interstate 70
I-76	Interstate 76
ICE	Infrastructure Carbon Estimator
I/M	inspection and maintenance
LOS	level oMT metric tons
MMT	million metric tons
MOVES	MOtor Vehicle Emission Simulator
mph	mile(s) per hour
MP	milepost
MPO	metropolitan planning organization
MSAT	mobile source air toxic
MT	metric tons
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NFRMPO	North Front Range Metropolitan Planning Organization
N_2O	nitrous oxide
PACOG	Pueblo Area Council of Governments
PM	particulate matter
PPACG	Pikes Peak Area Council of Governments

Acronym or Abbreviation	Full Name
RS	regionally significant
RTD	Regional Transportation District
RTP	Regional Transportation Plan
RunSpecs	run specifications
SB	Senate Bill
SCC	Social Cost of Carbon
SOV	single occupancy vehicle
TC	transportation capacity
TDM	travel demand model
TOC	Transit-Oriented Community
U.S.	United States
US 36	United States Highway 36
USD	U.S. dollars
VMT	vehicle miles traveled
ZEV	zero emission vehicle

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1.0 Introduction

The Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) are proposing transportation improvements to Interstate 25 (I-25) between the United States Highway 36 (US 36)/I-76/I-270 interchange and 104th Avenue (**Figure 1**).

This technical report was prepared to support evaluation of greenhouse gases (GHGs) from the I-25 (US 36 to 104th Avenue) Safety and Operations Improvements project (the project). It documents the analysis of GHG emissions that was conducted to meet state regulatory requirements. The air quality analysis of the proposed project that was conducted to meet Federal and State requirements is documented under separate cover.

GHGs are a class of pollutants that contribute to global warming and climate change. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs) are considered the primary transportation-sector GHGs. Each of these GHGs has a different global warming potential (GWP), which is a measure of how much energy a GHG absorbs in a given time period relative to that of CO_2. For example, in terms of its capacity to absorb energy, the emission of one ton of CH_4 is equivalent to the emission of 25 tons of CO_2 (based on the 100-year GWP of CH_4 used in this analysis). All transportation-sector GHGs are often quantified together as CO_2 equivalent (CO_2e) to standardize their global warming effect.

GHG emissions are produced from construction and maintenance of transportation projects and operation of vehicles on project roadways. Construction of transportation projects results in GHG emissions from the operation of construction equipment, worker travel, materials transport, and embodied carbon materials. Maintenance of transportation facilities results in GHG emissions from the use of fuel for snow removal, vegetation management, and other routine maintenance practices (CDOT, 2024).

1.1 Project Background

CDOT previously completed an Environmental Impact Statement and other planning efforts that recommended improvements to the segment of I-25 documented in this report. Because the project includes features that were not evaluated and approved in the **North I-25 Record of Decision 1** (FHWA and CDOT, 2011), this project is undergoing a new evaluation. The following project information can be found in **Attachment A**:

- Project History
- Project Limits
- Purpose and Need
- Proposed Action Description

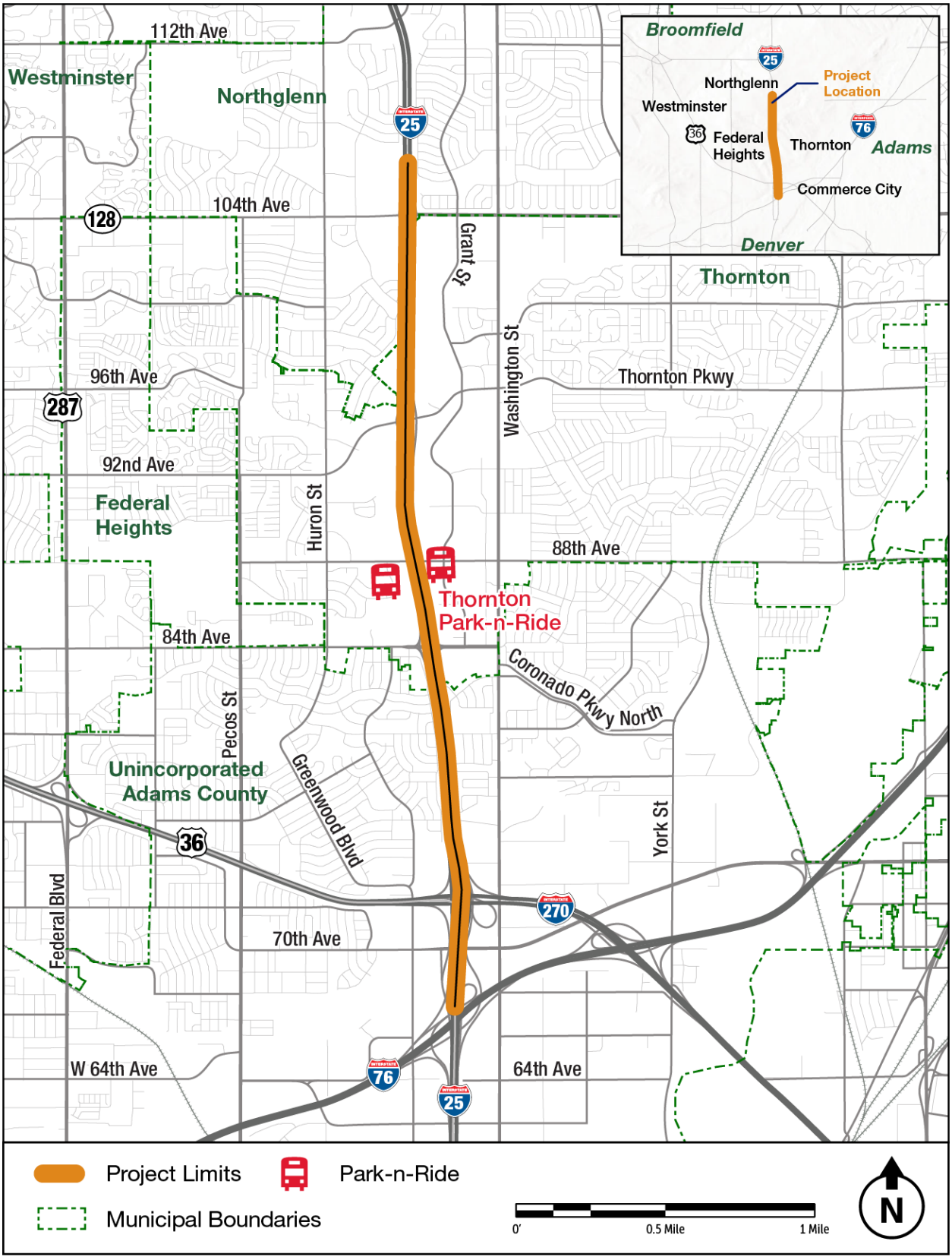
The GHG analysis documented in this report considered two project alternatives, which are described in greater detail in **Attachment A**:

- **No Action Alternative**, which would maintain the existing I-25 highway configuration of three general-purpose (GP) lanes and one Express Lane in each direction.
- **Build Alternative**, which would include three GP lanes in each direction with a fourth southbound GP lane from 104th Avenue to Thornton Parkway; a new northbound climbing lane from 84th Avenue to 104th Avenue; and an Express Lane in each direction, along the inside shoulder, with an expanded four-foot buffer from the adjacent GP lane.

1.2 Report Overview

The key analyses documented in this report include estimates of the direct GHG emissions from operation, construction, and maintenance of the project alternatives and the indirect (upstream) GHG emissions associated with those activities, and the Social Cost of Carbon (SCC) associated with the project. The report describes the methods used to estimate the GHG emissions and calculate the SCC, the potential impacts of GHGs, and considerations of GHG commitments, resilience, and community impacts. It also provides a discussion of the project alternatives, the affected environment, and applicable regulations and guidance.

Figure 1. Project Limits



2.0 Alternatives

The GHG analysis considered one Build Alternative and the No Action Alternative, and results of the analysis were compared between the project alternatives. The current cross-section of the project segment of I-25, representing the No Action Alternative, and the proposed Build Alternative are described in **Attachment A**. Additional information about the development and evaluation process for the project alternatives is included in the Alternatives Development Technical Report for the Environmental Assessment (EA) document that was developed under the National Environmental Policy Act (NEPA) process.

2.1 No Action Alternative

The No Action Alternative evaluates operations of I-25 if the Build Alternative would not occur along the project corridor. The No Action Alternative would maintain the existing highway configuration and does not address the project purpose and need but is carried forward as a baseline for comparison in the evaluation of the project.

Under the No Action Alternative, the corridor would require substantial ongoing maintenance and continuous repairs to bridges and pavement. These frequent maintenance activities would be necessary to keep the roadway operational and would lead to recurring lane closures, traffic disruptions, and temporary impacts on travel time and reliability. Furthermore, the underlying infrastructure deficiencies would persist, necessitating increasingly complex and potentially impactful repairs over time.

2.2 Build Alternative

The Build Alternative would improve approximately five miles of I-25 between US 36 and 104th Avenue. The Build Alternative would fulfill the project purpose and need by adding a new southbound GP lane from 104th Avenue to south of 84th Avenue, adding a new northbound climbing lane from the I-76 entrance ramp to 104th Avenue, and creating auxiliary lanes northbound and southbound between the 84th Avenue and Thornton Parkway interchanges and northbound between I-270 and 84th Avenue.

3.0 Regulatory Environment

State transportation GHG regulations include CDOT's GHG Transportation Planning Standard, issued by Colorado's Transportation Commission on December 16, 2021. Under this regulation, CDOT and the state's five metropolitan planning organizations (MPOs) are required to achieve individually set GHG reduction levels at four time horizons: 2025, 2030, 2040, and 2050. To determine compliance with these reduction levels, agencies are required to model their existing transportation networks and all future regionally significant (RS) projects in their transportation planning documents using travel demand models (TDMs) and the U.S. Environmental Protection Agency (EPA) MOtor Vehicle Emission Simulator (MOVES) model. Overall, the regulation encourages CDOT and MPOs to develop long-range transportation plans that support travel choices that reduce GHG emissions.

The other key state transportation GHG regulation applicable to this project was Colorado Revised Statutes (CRS) 43-1-128(4)(a), which requires planned RS/Transportation Capacity (TC) projects to "use Environmental Protection Agency Approved Models to determine air pollutant emissions for the planned project." An RS/TC project in the Denver Regional Council of Governments' (DRCOG) Regional Transportation Plan (RTP) is one that is already included in their comprehensive regional GHG analysis as part of the requirements for the GHG Transportation Planning Standard. However, the planning-level analysis does not address the need to model emissions at the project level for NEPA to comply with CRS 43-1-128(4)(a). The I-25 from US 36 to 104th Avenue project meets CDOT's established definition of an RS/TC project (CDOT, 2022a); thus, the quantitative analysis documented in this report was specifically conducted to meet the requirements of state law.

4.0 Affected Environment

GHGs are a class of gases that contribute to the planet's greenhouse effect, whereby gases in the atmosphere absorb and trap infrared radiation (heat) from the sun. The primary GHGs are CO_2, CH_4, N_2O, fluorinated gases, and water vapor, although water vapor emissions from anthropogenic sources are short lived and do not substantially affect global concentrations. Observed increases in well-mixed GHG concentrations since around the year 1750 are unequivocally caused by GHG emissions from human activities (Intergovernmental Panel on Climate Change [IPCC], 2023). This increase in the concentration of atmospheric GHGs is increasing the amount of heat trapped in Earth's atmosphere, a phenomenon known as global warming. In 2019, atmospheric CO_2 concentrations reached 410 parts per million, higher than at any time in at least 2 million years, while concentrations of CH_4 and N_2O were higher than at any time in at least 800,000 years (IPCC, 2023).

This increased concentration of GHGs in the atmosphere and the subsequent warming of the planet is creating long-term shifts in the weather patterns that have come to define local, regional, and global areas. This phenomenon has come to be known as climate change. Global surface temperatures have increased by approximately 1.1 degrees Celsius above pre-industrial levels as of 2020 (IPCC, 2023). Because GHGs mix evenly in the atmosphere, the climate effects observed in a geographic region are not directly attributed to the emissions that occur from that region.

Global net anthropogenic GHG emissions were estimated to be 59.0 ± 6.6 gigatons of CO_2e ($GtCO_2e$) in 2019, approximately 54 percent (%) higher than in 1990 (IPCC, 2023). The largest share of these emissions originated from the energy, industry, transport and building sectors, with CO_2 from fossil fuel combustion and industrial processes representing the greatest share by species, followed by CH_4 (IPCC, 2023). Each GHG has a different GWP, and each GHG has a different atmospheric lifetime: CO_2 has a lifetime of anywhere from 300 to 1,000 years (National Aeronautics and Space Administration [NASA], 2019), and CH_4 and N_2O have lifetimes of approximately 12 years and 116 years, respectively (IPCC, 2021). For ease of understanding, GHGs are often measured together as CO_2e, standardizing the warming effects of each gas relative to the most prevalent anthropogenic GHG, CO_2. For example, one ton of CH_4 is equivalent to 25 tons of CO_2, because it has a GWP 25 times greater than that of CO_2 based on its 100-year GWP (EPA, 2024a).

4.1 GHGs and Transportation

GHG emissions from transportation sources include CO_2, CH_4, N_2O, and various HFCs. GHG emissions result from operational, construction, and maintenance activities associated with transportation projects. The majority of GHG emissions from transportation result from CO_2 emissions from the combustion of petroleum-based products, such as gasoline and diesel fuel, in internal combustion engines. Relatively small amounts of CH_4 and N_2O are also emitted during fuel combustion, while HFC emissions result from leaks and end-of-life disposal of air conditioning systems used in vehicles (EPA, 2025). In 2022, the transportation sector

accounted for the largest portion of total GHG emissions in the U.S.: 28%, with CO_2 accounting for 97.7% of GHG emissions within the sector (EPA, 2024b). Because CO_2 constitutes the predominant share of transportation-sector GHG emissions, most transportation-sector GHGs are expressed together as CO_2e, standardizing the warming effects of each gas relative to CO_2.

Unlike criteria pollutants and air toxics, which have localized health and environmental impacts and are therefore analyzed using methods such as hot-spot analysis in nonattainment or maintenance areas, GHGs behave differently in the atmosphere and require a different analytical approach. Because GHGs mix uniformly in the global atmosphere regardless of where they are emitted, their effects on the climate are not tied to any specific geographic location. One ton of CO_2 emitted during construction in Colorado has the same global warming effect as one ton of CO_2 emitted anywhere else in the world. As a result, GHG analysis focuses on cumulative emissions over the lifetime of a project, including construction, operational, and maintenance emissions, rather than on localized concentrations. This cumulative perspective is reflected in the life-cycle assessment approach used in this analysis, which accounts for the total CO_2e emissions associated with the project from construction through the 2050 horizon year.

4.2 Factors that Affect Transportation GHGs

4.2.1 Operational

Operational GHG emissions result from vehicle travel on a transportation infrastructure project, such as vehicles driving on a road or trains on a track. According to the 2021 Colorado GHG Inventory, prepared by the Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD), on-road transport, which constitutes both passenger and freight travel, accounted for 82% of transportation operational emissions in the state. Notably, the operation of light-duty passenger vehicles is the largest contributor to transportation-sector emissions. Off-road transport, including aviation and rail, accounts for the other 18% of transportation operational emissions in the state (CDPHE APCD, 2021).

Operational GHG emissions from CDOT projects are the motor vehicle tailpipe emissions increases or decreases that typically result from changes in vehicle speed related to congestion and added or avoided vehicle travel on the transportation network. Operational emissions are the largest share of transportation-sector GHGs. Operation of vehicles traveling on the transportation network is also associated with indirect emissions of GHGs that result from the production of fuel used by the vehicles.

4.2.2 Construction

Construction GHG emissions are the result of construction processes such as the operation of construction equipment, the transportation emissions associated with fuel used to transport construction materials, and the embodied carbon resulting from the production of construction materials.

4.2.3 Maintenance

Maintenance GHG emissions result from the fuels used to maintain transportation facilities, such as snow removal, vegetation management, and other routine maintenance practices.

4.3 Trends in Transportation Emissions of GHGs

The **2025 Colorado Statewide Inventory of Greenhouse Gas Emissions and Sinks Executive Summary Report** (CDPHE APCD, 2026)[1] provides the latest data set by which to compare historical emission data trends with the state's GHG reduction targets. The 2025 inventory shows that transportation GHG emissions have decreased steadily between 2005 and 2020 (see **Table 1**) but increased in 2023. There was a substantial drop between 2015 and 2020, due in large part to the Coronavirus Disease 2019 (COVID-19) pandemic. The 2025 inventory projects that transportation emissions will decrease after 2025 due to current and anticipated emission-reduction efforts. **Table 1** shows Colorado's annual transportation emissions in million metric tons (MMT) of CO_2e.

Table 1. Colorado Annual Transportation Emissions (MMT CO_2e)

2005	2010	2015	2020	2023
29.138	28.212	27.470	25.077	29.279

4.4 Climate Change Effects in Colorado

Colorado's climate is changing. The state has warmed 2.5 degrees Fahrenheit (°F) since the beginning of the 20th century, and temperatures have remained consistently higher than the long-term (1895-2020) average since 1998 (Frankson et al., 2022). Future estimates predict an additional 2.5–5.0°F of warming in Colorado by 2050 (Colorado Water Conservation Board, n.d.). Six of the eight warmest years on record for Colorado have occurred since 2012 (Frankson et al., 2022). These changes to Colorado's climate are causing increases in extreme temperatures, droughts, wildfires, and more frequent and severe floods.

While droughts are a natural part of Colorado's climate, their intensity has increased within the state. There are many river basins that originate in the state, and any changes in precipitation patterns pose enormous risks to water supplies for cities and farms across the region. Colorado has been in nearly constant drought since 2001, with three historic droughts occurring in 2002, 2012, and 2018 (Frankson et al., 2022).

Higher temperatures and increased intensities of droughts have increased the frequency, severity, and extent of wildfires. The 20 largest wildfires in Colorado history have all occurred in the last 20 years (Colorado Department of Public Safety [CDPS], n.d.). Prior to 2002,

[1] When published in December 2025, portions of the inventory in the **2025 Colorado Statewide Inventory of Greenhouse Gas Emissions and Sinks Executive Summary** remained in public review and were subject to change. The inventory was then published in January 2026, and the Executive Summary Report was subsequently updated in February 2026 with correction of 2023 emissions (in Table 5 of the report). In Table 1 of this report, annual transportation emissions are from the February 2026, updated **2025 Colorado Statewide Inventory of Greenhouse Gas Emissions and Sinks Executive Summary**.

Colorado had never recorded a fire that burned more than 100,000 acres. By 2021, the state had experienced five such fires, four of which occurred after 2018 (CDPS, n.d.). Colorado's five most destructive fires according to the number of homes lost have all occurred since 2012 (CDPS, n.d.). With the exception of California, Colorado has the highest concentration of at-risk homes (i.e., 332,716) and significant estimated reconstruction costs (i.e., $140.9 billion) (Corelogic, 2023).

Emissions from transportation, when combined with higher temperatures, are affecting Colorado's air quality, particularly in urban areas with high volumes of traffic. In addition to GHGs, many other air pollutants are also emitted from transportation-related processes. Pollutants emitted from vehicles, including particulate matter (PM), volatile organic compounds, and nitrogen oxides, have direct impacts on the health of Coloradans. Individuals who live closest to Colorado's busiest roads, economically disadvantaged and minority populations, are often the most affected (Boehmer et al., 2013). Living in an area with high levels of air pollution is directly linked to higher rates of asthma, pulmonary disease, cardiovascular disease, reproductive complications, and mortality (Boehmer et al., 2013). Reducing GHG emissions from transportation also reduces the emissions of other air pollutants, which may lead to additional benefits to public health and the environment (World Health Organization, 2022).

4.5 Climate Change Effects on Transportation Infrastructure

Colorado's transportation system is designed to withstand certain climate- and weather-related stressors based on historical weather and climate conditions. However, climate change is creating long-term shifts in the weather patterns that have previously defined local, regional, and global areas, causing increased risk to Colorado's transportation infrastructure. It is critical to consider how future changes in climate will impact Colorado's existing and future planned transportation infrastructure and respond, design, and mitigate appropriately.

Table 2 was created with reports developed by the University of Colorado's Western Water Assessment program, in collaboration with the Colorado Water Conservation Board, which develops state-specific climate change information on both observed and anticipated changes to Colorado's climate (Bolinger et al., 2024; Colorado Department of Agriculture et al., 2015).

Table 2. Climate Change Impacts on Transportation Infrastructure

Projected Climate Change Effects	Potential Impacts on State Highways and Rail
Temperature Effects: Higher average temperatures Increase in the intensity and duration of extreme heat events Drought and low stream and groundwater flow Substantially worsened wildfire risk	Increased thermal expansion of bridge joints and paved surfaces, which can cause buckling and degradation Impacts to roadway pavement integrity, increases in traffic-related rutting and migration of liquid asphalt, and greater need for maintenance Stress on bridge integrity due to temperature expansion of concrete joins, steel, asphalt, protective cladding, coats, and sealants High temperatures can force rails out of alignment, cause rail equipment to fail, and increase the risk of derailment Wetland mitigation site failure Increased noxious weeds, invasive plants Loss of roadside vegetation, leading to erosion and landslides, particularly in areas deforested by wildfires Increased frequency of dust storms
Precipitation Effects: Increase in winter statewide precipitation Increased magnitudes of heavy and extreme precipitation events	Regional changes in snow- and ice-removal costs Increase in snow slides Increases in weather-related delays and traffic disruptions Increases in road washouts, landslides, rock falls, and mudslides that damage roadways and affect traveler safety Drainage systems likely to be overloaded more frequently and severely Increased peak streamflow could affect scour rates and influence the size requirements for bridges and culverts

4.6 Measures Taken to Address Climate Change in Colorado

In 2019, Governor Jared Polis signed House Bill (HB) 19-1261, which set statewide GHG emission reduction targets and mandated new considerations for the Air Quality Control Commission. In 2023, Governor Polis signed Senate Bill (SB) 23-016, which updated and added additional GHG reduction targets. These targets include:

- Reduce 2025 GHG emissions by at least 26% of 2005 levels
- Reduce 2030 GHG emissions by at least 50% of 2005 levels
- Reduce 2035 GHG emissions by at least 65% of 2005 levels
- Reduce 2040 GHG emissions by at least 75% of 2005 levels
- Reduce 2045 GHG emissions by at least 90% of 2005 levels
- Achieve net zero GHG emissions by 2050

The Colorado Greenhouse Gas Pollution Reduction Roadmap (Roadmap) (Governor's Office, 2024), published in early 2021 and updated in early 2024, identified distinct goals or actions for specific economic sectors to meet the GHG targets of HB 19-1261. The Roadmap reports that reducing growth in driving via transportation planning and infrastructure is a critical tool in the state's battle against climate change. The subsequent development and implementation of the GHG Transportation Planning Standard turned one of the recommendations from the Roadmap into a requirement and is a key element in Colorado's strategy for reducing emissions from the transportation sector. The GHG Transportation Planning Standard works alongside several other strategies identified in the Roadmap,

including increasing Coloradans' access to electric vehicles (EVs) (including trucks and buses), implementing a clean trucking strategy and fleet rules, reducing vehicle miles traveled (VMT), developing a Front Range Passenger Rail system, improving land use planning, and creating indirect source rules.

To address transportation construction emissions, HB 21-1303, the "Buy Clean Colorado Act", directed CDOT to establish policies to reduce GHG emissions over time by accounting for and limiting the GWP of key construction materials in state-funded building and transportation projects. The eligible construction materials include asphalt and asphalt mixtures, cement and concrete mixtures, and steel. On January 1, 2025, CDOT established a policy with GWP limits for each eligible material that will encourage manufacturers of construction projects to reduce their GHG emissions and require architects, engineers, and contractors to specify greener construction materials where those materials are practical and economically feasible.

4.6.1 CDOT GHG Reduction Targets

In December 2021, Colorado's Transportation Commission adopted the GHG Transportation Planning Standard with the goal of improving air quality, reducing smog, and providing more sustainable options for travelers across Colorado. The GHG Transportation Planning Standard (Governor's Office, 2024) builds on the state's effort to rapidly deploy electric vehicles by encouraging a future transportation system that improves transit, biking, and walking options. The rule focuses specifically on reducing VMT from mostly on-road, passenger vehicles by increasing travel choice options.

The rule requires CDOT and the state's five MPOs to quantify the total GHG emissions expected from their updated transportation plans in 2025, 2030, 2040, and 2050 and show reductions in GHGs over time. The transportation plans must meet set GHG reduction amounts in the compliance years of 2025, 2030, 2040, and 2050 (see **Table 3**). These reduction levels are achieved relative to the baseline GHG emissions of the MPO's RTP or CDOT 10-Year Plan adopted as of January 2022 (CDOT, 2026a). Agencies must use sophisticated travel models, alongside vehicle emissions models, to make this determination, with each emission reduction target differing for each agency and metro region.

Table 3. GHG Transportation Planning Reduction Levels (MMT of CO_2e)

Regional Areas	2025 Reduction Level (MMT)	2030 Reduction Level (MMT)	2040 Reduction Level (MMT)	2050 Reduction Level (MMT)
DRCOG	0.27	0.82	0.63	0.37
North Front Range Metropolitan Planning Organization (NFRMPO)	0.04	0.12	0.11	0.07
Pikes Peak Area Council of Governments (PPACG)	N/A	0.15	0.12	0.07
Grand Valley Metropolitan Planning Organization (GVMPO)	N/A	0.03	0.02	0.01
Pueblo Area Council of Governments (PACOG)	N/A	0.03	0.02	0.01
CDOT/Non-MPO	0.12	0.36	0.30	0.17
Total	0.43	1.5	1.2	0.7

4.6.2 Local Climate Action Plans and Goals

In 2015, Adams County adopted the Sustainable Adams County 2030 Plan (Adams County Government, 2021). While the plan does not have specific emission reduction targets for the county, the plan speaks broadly about the county's intention to support the statewide GHG targets established in HB 19-1261. However, the plan establishes goals in eight separate topic areas, including the transportation sector. Transportation sector goals include decreasing county fleet emissions through vehicle and operational efficiency and fuel switching, supporting EV mobility and infrastructure across all of Adams County, and supporting alternative modes of transportation and mobility for all Adams County residents.

In 2023, the City of Commerce City published its first Sustainability Action Plan. The plan highlights that the City of Commerce City is striving to achieve GHG reductions that align with the state level goals originally established in HB 19-1261. There are three transportation-specific sustainability aspirations: support and promote equitable EV adoption, reduce idling by 20% by 2030 and 80% by 2050, and achieve a mode shift of 20% by 2030 and 50% by 2050 to multimodal options (City of Commerce City, 2023).

In March 2026, the City of Thornton adopted its first Environmental Sustainability Master Plan. Within this plan, Thornton adopted community-wide GHG reduction targets to guide long-

term climate action and align local efforts with broader state climate goals: a 50% reduction in emissions by 2035 and an 80% reduction in emissions by 2045, relative to 2024 emissions. The city also set the goal of net zero emissions by 2050 (City of Thornton, 2026).

In 2025, the City Council of Northglenn adopted a Climate Action and Resilience Plan. Through strategic implementation of climate solutions, Northglenn seeks to reduce GHG emissions 25% by 2030, 75% by 2040, and net zero by 2050, compared to a 2016 baseline (City of Northglenn, 2025).

5.0 Applicable Guidance

The methodology for the GHG analysis was conducted in accordance with all applicable state regulations and CDOT guidance. It was also informed by federal guidance from EPA and FHWA. The following relevant guidance was applied to the methodology for the analysis, where appropriate, as described in **Section 7.0** and **Attachment B**:

- **NEPA Manual, Version 7** (CDOT, 2024)
- **CDOT Regionally Significant and Transportation Capacity Interpretation and Examples for CDOT Projects** (CDOT, 2022a)
- **CDOT Interim Guidance for Project Level Compliance of CRS 43-1-128 (NEPA and Construction)** DRAFT (CDOT, 2023)
- **Air Quality Project-Level Analysis Guidance, Version 1** (CDOT, 2019)
- **MOVES4 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity** (EPA, 2023)
- **MOVES Greenhouse Gas Guidance: Using MOVES for Estimating State and Local Inventories of Onroad Greenhouse Gas Emissions and Energy Consumption** (EPA, 2024a)
- **Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide** (Interagency Working Group on Social Cost of Greenhouse Gases [IWG SC-GHG], 2016)

6.0 Project Scoping and Interagency Consultation

An environmental scoping meeting was held for the project on February 14, 2024. FHWA, CDOT resource specialists and project staff, and consultant team members were invited to the meeting. The meeting included the topics of project overview and status; roles, responsibilities, and expectations; agency coordination; and a review of the environmental resources and scoping form.

Technical Working Group and FHWA coordination meetings were held monthly starting February 2024 throughout the project to discuss analysis needs, develop the Greenhouse Gas Analysis Work Plan (formally reviewed by FHWA in January 2025), develop the project schedule, and review the analysis results. Invitees included FHWA, CDOT, and the consultant team. FHWA's involvement in the GHG analysis was primarily focused on supporting the MOVES model runs, the outputs of which were used to quantify direct operational GHG emissions for the project, consistent with the requirements of CRS 43-1-128(4)(a).

CDOT GHG specialists were also engaged throughout the analysis, providing guidance on key assumptions and reviewing the final analysis to ensure consistency with state requirements under CRS 43-1-128 and CDOT's Interim Guidance (CDOT, 2023).

Input data for the GHG analysis, including traffic information and MOVES emissions factors, were submitted to the Technical Working Group for review, and comments were discussed during Working Group meetings. Inputs were revised as necessary based on decisions made by the Technical Working Group. Once analysis results were available and quality checked, they were presented to and discussed with the Technical Working Group participants. The analysis was updated as necessary to address questions and comments from the participants.

7.0 Methodology

This section of the report provides details of the methodology used for each element of the GHG analysis, and **Section 8.0** summarizes the results of the analysis.

7.1 Overview

The GHG analysis conducted for the project included:

- An assessment of lifetime operational emissions from vehicles traveling on project and, as described in **Section 7.3.1**, nearby "non-project" roadways for the No Action and Build alternatives.
- An assessment of lifetime construction and maintenance emissions associated with the No Action and Build alternatives.
- A cumulative assessment, considering direct emissions and associated indirect upstream emissions for each project alternative.
- Estimation of the SCC resulting from each project alternative.

7.2 Pollutants Considered

The analysis focused on three GHGs: CO_2, CH_4, and N_2O. CO_2 is the most prevalent GHG, and the largest transportation-related source of this pollutant is motor vehicle exhaust. The production of materials used in roadway construction, such as concrete and steel, also results in CO_2 emissions. CH_4 and N_2O are emitted to a lesser extent, and vehicle exhaust is the main source of these pollutants in the transportation context.

Emissions of these three GHGs can be quantified as emissions of CO_2e, which represents the overall impact of GHG pollutants as if they were all emitted as CO_2. CO_2e is calculated by multiplying the amounts of CH_4 and N_2O by their respective 100-year GWPs. The GWP of CH_4 used in this analysis is 25, meaning that one pound of CH_4 emissions is 25 times as potent as one pound of CO_2 with respect to global warming. The GWP for N_2O used in this analysis is 298. These GWP values are embedded in the MOVES4 and Infrastructure Carbon Estimator (ICE) models used for modeling GHG emissions in the analysis.

7.3 Analysis Approach

7.3.1 Study Area

The analysis encompassed all mainline I-25 roadway links from the US 36/I-270 interchange on the south to 104th Avenue on the north, as well as portions of US 36 and I-270 at the interchanges with I-25. The analysis of operational emissions also encompassed nearby "non-project" links where traffic was determined to be affected by the project:

- Connector ramps at the US 36 and I-270 interchanges with I-25
- Ramps at I-25 and CO-224
- Ramps at I-25 and 84th Avenue
- Ramps at I-25 and Thornton Parkway
- Ramps at I-25 and 104th Avenue

The selection of non-project links to include in the analysis of operational emissions was guided by FHWA recommendations and is discussed in Section 1.0 of **Attachment C**. The complete list of roadway links that were included in this analysis appears in Table 1 through Table 3 of **Attachment C**.

7.3.2 Modeling of Operational, Construction, and Maintenance Emissions

MOVES Modeling of Operational Emissions

For the operational emissions analysis, a lookup table of emission factors for the pollutants considered (i.e., CO_2, CH_4, and N_2O) was generated by running the most recent version of EPA's MOVES[2] available when this analysis was conducted (i.e., MOVES4.0.2) for each analysis year (2024, 2030, 2040, and 2050). For each analysis scenario (i.e., Existing Conditions in 2024, No Action Alternative in 2030, 2040, and 2050, and the Build Alternative in 2030, 2040, and 2050), emission factors from the lookup table were combined with link-level travel activity (traffic) and roadway type data to calculate the link-level emissions. The link-level emissions were then aggregated to the project level for each pollutant. **Attachment C** provides a detailed description of the MOVES model setup and input data.

ICE Modeling for Construction and Maintenance Emissions

The construction and maintenance analysis was conducted using the most recent version of FHWA's ICE tool available when this analysis was conducted (i.e., Version 2.2.8). ICE is a spreadsheet tool that estimates the life-cycle energy use and GHG emissions from the construction and maintenance of transportation facilities. The tool accounts for energy use and emissions associated with transportation infrastructure, including construction/rehabilitation activities and materials, traffic delay, routine maintenance, and facility use.

Multiple types of infrastructure were analyzed to capture the overall impact of the project:

- Roadway construction, realignment, reconstruction, and resurfacing
- Bridges and overpasses
- Culverts
- Pathways (sidewalks and bicycle paths)
- Signs
- Lighting

The amounts of each type of infrastructure associated with each alternative were developed by CDOT and modeled using the ICE tool. All infrastructure types were modeled using ICE in Planning mode, except for culverts, which were analyzed using the ICE project mode to better define the size of the planned culverts. The No Action Alternative includes some activities that generate emissions: the existing roadways need to be maintained, existing

[2] EPA (2023) MOVES: MOVES4. Office of Transportation and Air Quality. US Environmental Protection Agency. Ann Arbor, MI. August 2023. https://www.epa.gov/moves/moves-versions-limited-current-use.

lighting consumes electricity, and some reconstruction and resurfacing is planned for the No Action Alternative, given the age and condition of the highway corridor.

Resurfacing of the I-25 corridor is anticipated to occur some time in the future, estimated between 2040 and 2044, and was included in the ICE modeling for both the No Action Alternative and the Build Alternative. The ICE tool currently contains a limitation whereby the latest construction start year that can be modeled is 2035. As a result, the future resurfacing activity was modeled using a construction start year of 2035, reflecting 2035 emissions factors for the construction activity.

Construction delay emissions for the Build Alternative were not modeled because travel speeds along the corridor are anticipated to remain unchanged during construction.

7.3.3 Lifetime Operational GHG Emissions

Lifetime emissions for each project alternative were calculated as the sum of estimated annual emissions for calendar years 2027 through 2050. The annual emissions for each of those calendar years were interpolated from the MOVES-based GHG operational emissions for 2024, 2030, 2040, and 2050. The interpolation method was based on the MOVES Alternate Vehicle Fuel and Technology (AVFT) input table[3] provided by CDOT and the Colorado vehicle age distribution. MOVES was run with the CDOT-provided AVFT table, the Colorado vehicle age distribution, and defaults for other inputs for each calendar year from 2024 through 2050, and the trend in GHG emissions results over that time period was applied to the project-specific operational emissions for 2024, 2030, 2040, and 2050. This approach yielded an estimate of project-specific GHG emissions for each year in the lifetime of the project.

7.3.4 Life Cycle Assessment and SCC

Life Cycle Assessment

This analysis considers direct emissions from operation, construction, and maintenance of the project alternatives and the indirect (upstream) emissions associated with these activities. Cumulative lifetime emissions are calculated as the sum of direct and indirect emissions. The approach for estimating lifetime operational emissions is described in **Section 7.3.3**; the approaches for estimating lifetime construction and maintenance emissions and upstream emissions are discussed below.

ICE uses a life-cycle approach to estimate GHG emissions associated with construction and maintenance. It accounts for the embodied energy and emissions associated with the extraction, transportation, and production of materials used for construction, including fuel use for transporting materials to the construction site, routine maintenance, rehabilitation and preventative maintenance, as well as ongoing electricity use in roadway lighting and the

[3] The AVFT table contains electric vehicle sales by vehicle type and model year; the age distribution defines the rate of fleet turnover (i.e., the fraction of the vehicle fleet that is represented by new vehicles).

electrical-generation emissions associated with that electricity use.[4] ICE also accounts for emissions associated with vehicles delayed during construction while using the infrastructure.

Upstream emissions from vehicle operation reflect "well-to-pump" emissions. These emissions are associated with producing petroleum fuels and electricity consumed by vehicle operation. CDOT has developed a methodology for estimating these emissions as a function of VMT. For petroleum fuels (gasoline and diesel fuel), CDOT uses projections of fuel sales along with upstream emissions factors from the U.S. Department of Energy's **Greenhouse Gas and Regulated Emissions and Energy use in Transportation** model to estimate upstream emissions per year. To estimate electrical grid emissions from electricity consumed by electric vehicles, CDOT uses a detailed methodology that accounts for changes in electric vehicle usage, vehicle efficiency, and changes in the mix of sources powering the electrical grid to estimate upstream electricity-related emissions per year. Then, annual upstream emissions rates in units of kilograms CO_2e per mile driven are calculated using CDOT projections of VMT.

Social Cost of Carbon

The SCC is an estimate, in dollars, of the economic damage that would result from emitting one additional ton of CO_2 into the atmosphere, putting the effects of climate change into economic terms to help decision makers and the public understand the economic impacts of decisions that would increase or decrease emissions. In this analysis, the SCC for each project alternative was calculated by calendar year using annual estimates of GHG emissions from vehicle operation, construction, and maintenance. Then, for each project alternative, the calculated SCC values were summed across calendar years to calculate the total cost associated with each project alternative over the lifetime of the project (i.e., 2027 through 2050). The costs are expressed in terms of calendar-year 2020 U.S. dollars (USD).

Because GHGs emitted today can cause climate effects many decades into the future, SCC analyses use discount rates to characterize the present-day value of these future impacts. Among other things, the SCC estimates can be used to compare the cost of emissions-mitigation strategies to the value of the impacts avoided via mitigation. Four SCC values are used in this analysis. The first three values are based on the average SCC from three integrated assessment models, at discount rates of 5.0%, 3.0%, and 2.5%. SCC estimates are based on several discount rates because the literature shows that SCC is highly sensitive to the discount rate and because no consensus exists as to the appropriate rate to use for analyses spanning multiple generations (EPA, 2016). In addition, there is extensive evidence in the scientific and economic literature as to the potential for lower-probability, but higher-impact outcomes from climate change, which would be particularly harmful to society (IWG SC-GHG, 2016). The fourth value, corresponding to the 95th percentile of the frequency

[4] Infrastructure Carbon Estimator, version 2.2 Final Report and User's Guide, May 2023, https://www.dot.state.mn.us/sustainability/ghg-analysis.html

distribution of SCC estimates based on a 3.0% discount rate, is used to represent the damages associated with these lower-probability, higher-impact outcomes.[5]

The SCC values used in this analysis were published in 2021 by the federal IWG SC-GHG, in the document "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" (IWG SC-GHG, 2021). The social cost of CO_2 in that document was applied to the vehicle operation, construction, maintenance, and upstream CO_2e emissions estimated for the project alternatives, as described above.

[5] EPA Fact Sheet – Social Cost of Carbon, December 2016b: https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

8.0 Project-Level GHG Analysis Results

The GHG analysis results for direct, indirect, and cumulative annual and lifetime emissions, and calculated SCC for the project alternatives are presented in this section.

8.1 Direct Effects

Table 4 and **Figure 2** summarize the lifetime (2027-2050) direct emissions associated with the project alternatives. Emissions from initial construction, ongoing roadway maintenance, and vehicle operation are included. Emissions are in units of metric tons (MT) CO_2e.

Table 4. Lifetime Direct GHG Emissions (MT CO_2e Over the Project Lifetime)

Phase	No Action	Build	Build – No Action
Construction	3,005	12,416	+9,411 (+313%)
Maintenance	3,655	3,854	+199 (+5%)
Operational	2,230,981	2,233,595	+2,613 (+0.1%)
Total Direct Emissions	**2,237,641**	**2,249,864**	**+12,223 (+0.5%)**

Figure 2. Lifetime Direct GHG Emissions (MT CO_2e Over the Project Lifetime)

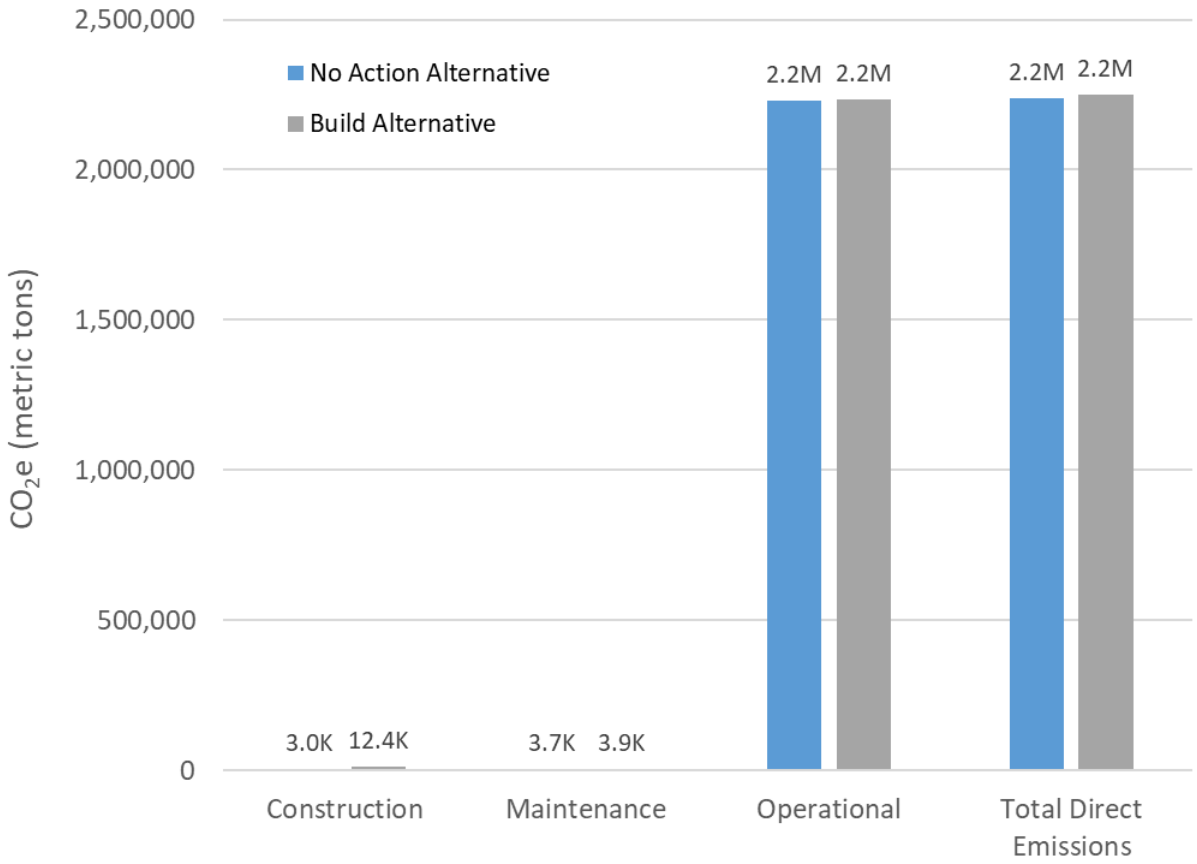
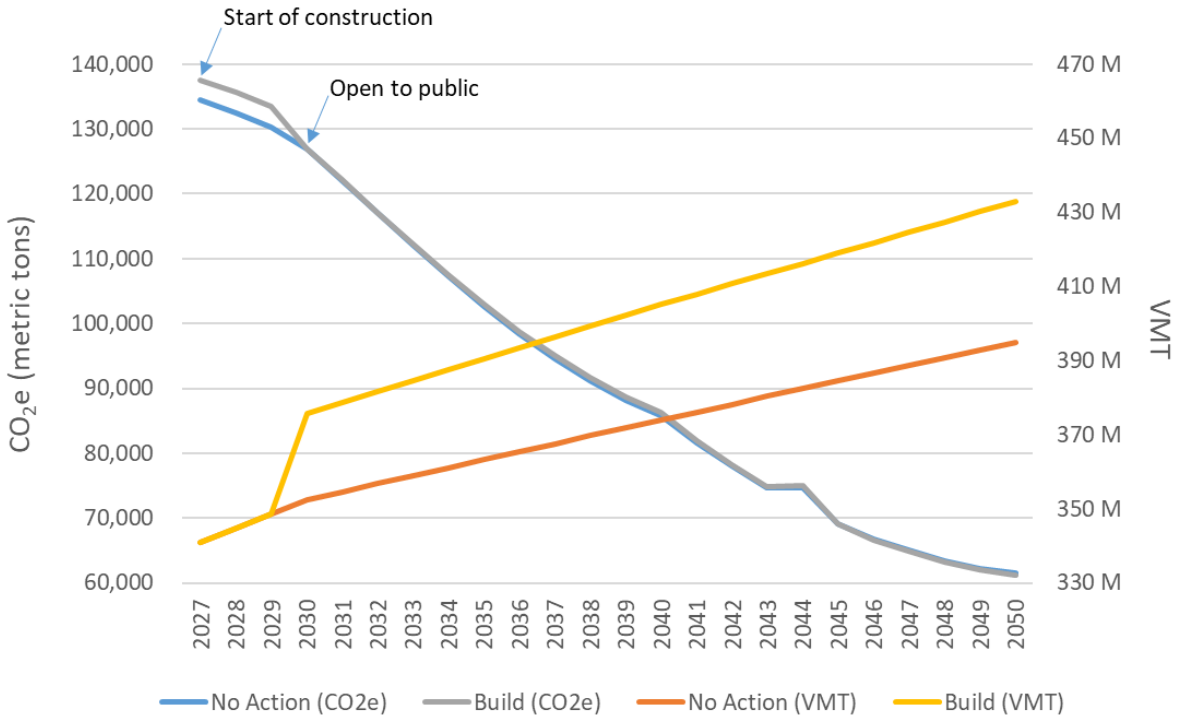


Figure 3 summarizes the **annual** direct emissions and VMT associated with the project alternatives. Emissions from construction, ongoing roadway maintenance, and vehicle operation are included in the figure. Emissions are in units of MT CO_2e, and VMT is in units of miles.

Annual emissions (downward-sloping lines) are the same for both alternatives prior to the start of construction and then increase when construction begins in 2027 (construction begins in 2027 for the Build Alternative and the No Action Alternative, which involves some pavement resurfacing and reconstruction). After construction is complete in 2029, annual emissions decrease again, but each alternative has different emissions due to different levels of traffic (shown on the upward-sloping VMT lines). The annual direct GHG emissions are similar for the two project alternatives.

Figure 3. Annual Direct GHG Emissions and VMT (MT CO_2e and Miles Per Year)



8.2 Indirect Effects

Figure 4 summarizes the annual indirect emissions for the project alternatives. In this analysis, indirect emissions are the upstream emissions associated with producing fuel and electricity consumed by vehicles as they use the project infrastructure. Indirect emissions for this analysis were calculated using the VMT and emission factors provided by CDOT that are based on the upstream fuel cycle. While VMT is projected to increase throughout the project lifetime, the upstream emission factors provided by CDOT generally decrease over the same time period, reflecting anticipated improvements in fuel production efficiency. The net effect of these two trends is an overall decrease in indirect emissions from the year construction starts to the horizon year. **Table 5** summarizes the lifetime indirect emissions for the project alternatives.

Figure 4. Annual Indirect GHG Emissions (MT CO_2e Per Year)

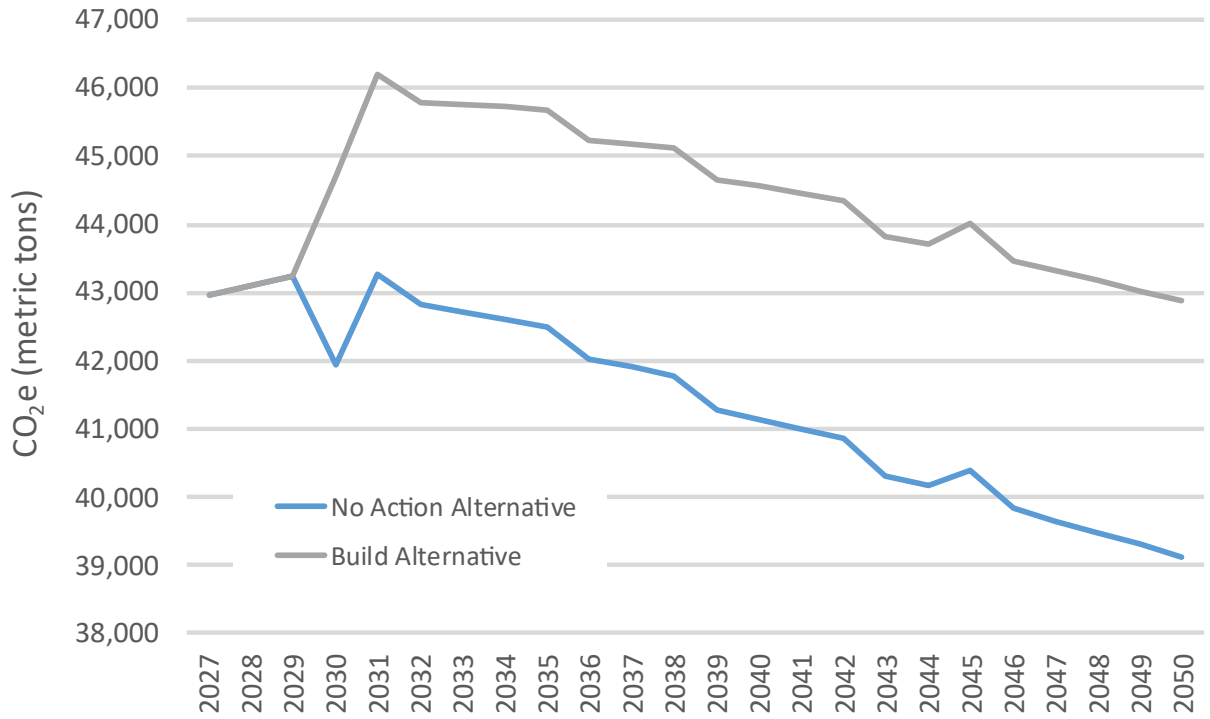


Table 5. Lifetime Indirect Emissions Associated with the Project Alternatives (MT CO_2e)

	No Action	Build	Build - No Action
Upstream Fuel Cycle	993,294	1,064,067	+70,773 (+7%)

8.3 Cumulative Effects

Table 6 summarizes the cumulative (lifetime) emissions (in units of MT of CO_2e) associated with the project alternatives. Cumulative effects for the purpose of this analysis are the summation of direct and indirect effects.

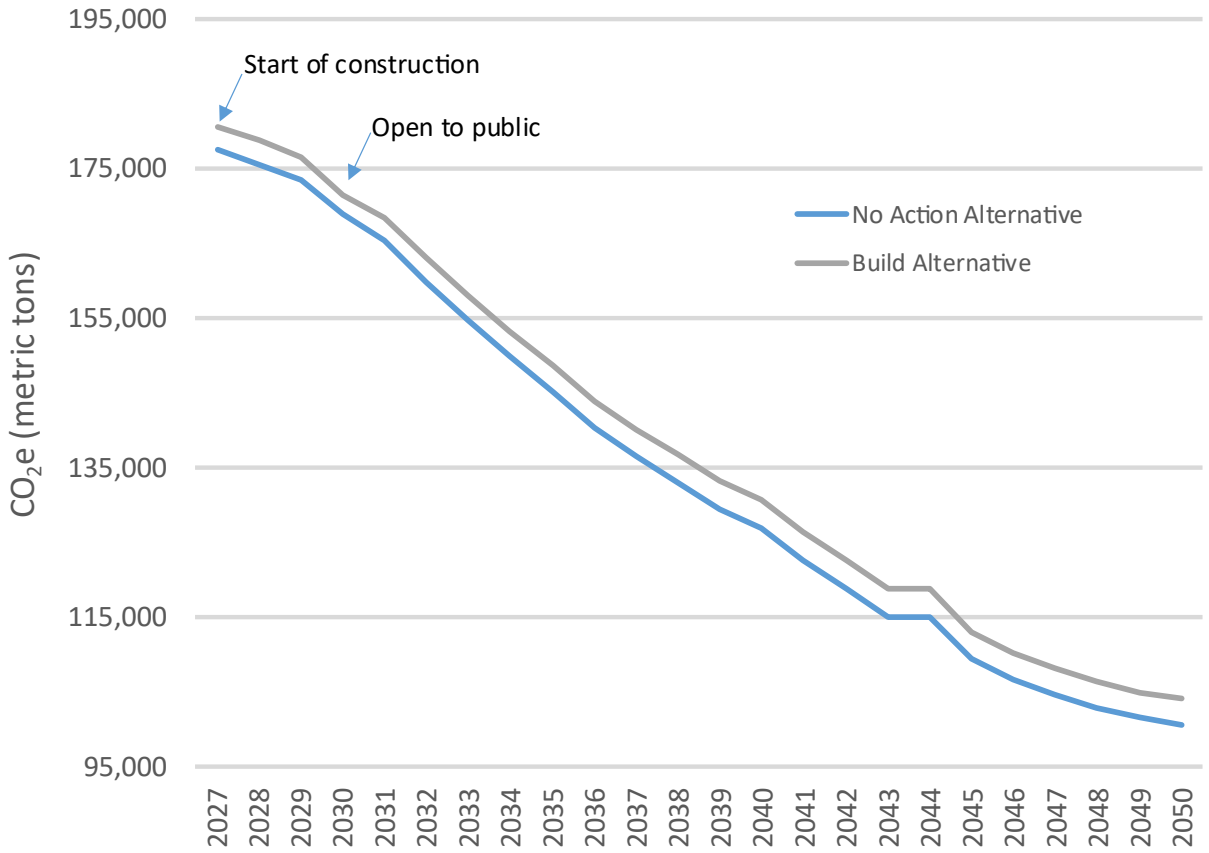
Table 6. Cumulative GHG Emissions (MT CO_2e)

	No Action	Build	Build - No Action
Direct Effects	2,237,641	2,249,864	+12,223 (+1%)
Indirect Effects	993,294	1,064,067	+70,773 (+7%)
Cumulative Effects	3,230,935	3,313,932	+82,996 (+3%)

Figure 5 illustrates the annual cumulative (sum of direct and indirect) emissions during the project lifetime, which are also tabulated in **Attachment D**. The Build Alternative results in higher annual cumulative emissions than the No Action Alternative throughout the project lifetime for two reasons: the Build Alternative involves greater construction activity, resulting

in higher construction emissions during the construction period; and the addition of lanes under the Build Alternative results in higher annual operational emissions, corresponding to an increase in VMT compared with the No Action Alternative that persists through the horizon year. The Build Alternative results in a 9.6% increase in daily VMT compared with the No Action Alternative in 2050. Despite the increase in VMT associated with the Build Alternative, cumulative GHG emissions decrease annually for both alternatives due to improvements in vehicle fuel efficiency and the decreasing carbon intensity of the vehicle fleet, which are reflected in the upstream emissions factors.

Figure 5. Annual Cumulative GHG Emissions (MT CO_2e Per Year)



8.4 Social Cost of Carbon

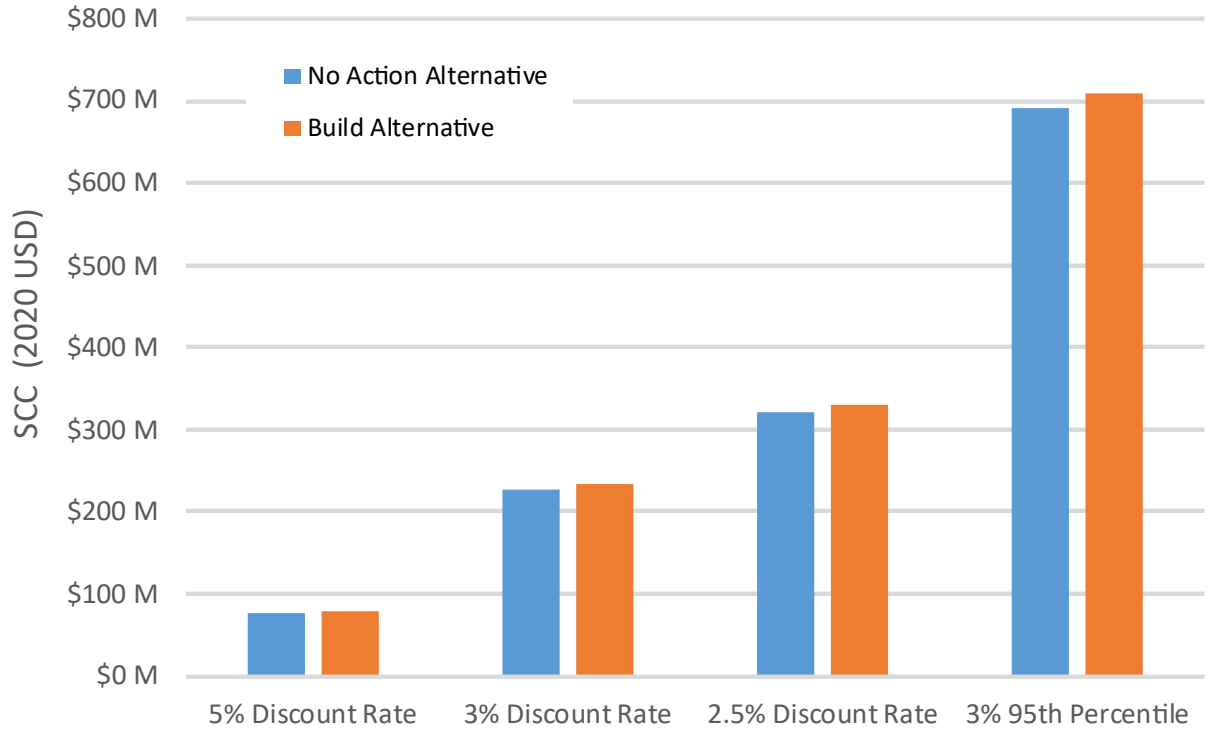
Table 7 and **Figure 6** summarize the SCC associated with the project alternatives. These estimates are in calendar-year 2020 USD and are based on the cumulative emissions from **Table 6**.

Table 7. Total Lifetime SCC (Calendar-Year 2020 USD)

	5.0% Discount Rate	3.0% Discount Rate	2.5% Discount Rate	3.0% Discount Rate 95th Percentile
No Action Alternative	$76,586,851	$226,635,889	$320,903,963	$691,157,406
Build Alternative	$78,642,400	$232,629,738	$329,355,009	$709,470,002
Difference[1]	$2,055,549	$5,993,849	$8,451,047	$18,312,596

[1] Difference between the No Action Alternative and the Build Alternative (Build - No Action)

Figure 6. Total Lifetime SCC by Discount Rate and Alternative (Calendar-Year 2020 USD)



9.0 Project-Level GHG Analysis Effects

This section details the voluntary supplemental emissions analysis conducted by CDOT for the I-25 North US 36 to 104th corridor as of March 2026. The primary objective of this analysis is to qualitatively compare the Build Alternative emissions rates of GHGs to the No Action through analyzing the relative change in emissions rates under the Build Alternative.

9.1 Purpose of Supplemental Analysis

As documented in this technical report under **Section 8.3** (Cumulative Effects) there is a 9.6% increase in predicted annual VMT under the Build Alternative relative to the No Action Alternative; however, the predicted annual increase in operational emissions under the Build Alternative is less than 1% relative to the No Action Alternative. To further evaluate why the predicted change in emissions is not as proportional to the change in VMT between alternatives as would be expected, a voluntary supplemental emissions analysis was conducted by CDOT to provide additional qualitative information on operational GHG emissions changes between alternatives. To do so, CDOT performed a qualitative comparative analysis of the change in link-level GHG emissions rates between the Proposed Build and No Action alternatives in the project location.

9.1.1 Supplemental Analysis Overview

For the supplemental analysis of operational GHG emissions CDOT utilized the EPA's MOVES model with the same assumptions and input files used by the consultant in the emissions inventory for consistency. However, this supplemental analysis did not calculate total mass annual GHG emissions at the individual roadway (link level) as this was already performed for the comparative emissions inventory. Furthermore, no atmospheric modeling was conducted to analyze any potential beneficial or adverse climate change impacts to GHG concentrations between alternatives or quantitative modeling for GHG concentrations as GHGs are global pollutants that do not have regional or localized effects. Rather, the supplemental GHG emissions analysis only evaluated direct motor vehicle emissions (i.e., tailpipe and fuel losses). Indirect emissions (i.e., upstream fuel cycle emissions) of GHGs were not included in the supplemental analysis.

As with the emissions inventory, to ensure an accurate comparison, all assumptions regarding vehicle mix and vehicle fuel types remain consistent across both the Build and No Action scenarios. While all emissions analyses completed for this project under NEPA assume a level of zero emission vehicle (ZEV) adoption, including ZEV adoption by commercial vehicles, these vehicles are only accounted for in MOVES through standard fleet turnover rates as identified by APCD using the Colorado Department of Motor Vehicles statewide vehicle registration database. Furthermore, while the emissions analysis does assume future levels of ZEV adoption for 2050, it is important to remember that by 2050 a significant number of internal combustion vehicles (gasoline and diesel) are forecasted to remain onroad and in use in the region. The most important aspect of an emissions analysis under NEPA for transportation is that assumptions on fleet mix and fuel usage remain consistent between

alternatives, as was performed in this Greenhouse Gas Technical Report. The exception would be if a specific project element under an alternative would change these assumptions, e.g., adding a limited use facility such as an Express Lane, which is not the case for either alternative under consideration for this project. Keeping vehicle assumptions consistent between alternatives in an emissions analysis ensures that predicted changes in emissions or air quality are the result of forecasted changes in travel behavior specific to an alternative.

Rather than a traditional emissions inventory analysis that calculates total mass emissions from a project for a given suite of pollutants, this voluntary supplemental analysis utilizes the MOVES emissions rates model to evaluate the relative change in emissions intensity, measured in grams per mile (gpm) traveled of the Build Alternative in relation to the No Action Alternative. As documented in the Traffic Technical Report (**Appendix D1**)) for the project, there is not a large difference in the level of VMT under the Build Alternative compared to the No Action Alternative due to a lack of alternate routes in the project area.

Predicted differences in VMT between alternatives are expected to remain on the lower range of what would be expected under a typical RS/TC project located on an interstate in an urban area in the country. This is because the increased capacity results in an immediate congestion mitigation following project completion that makes the roadway a more attractive route to drivers. The lack of alternate routes in the project area results in more drivers traveling under congested conditions on I-25 under the No Action Alternative. Similarly, this results in limited travel inducement on the I-25 corridor between the two alternatives with an approximately 9.6% predicted increase in VMT from the roadways used in the emissions analysis and a forecasted 8.8% increase for 2050 under the Build Alternative in comparison to the No Action for all roadways in the traffic study area (refer to **Appendix D1**: Traffic and Safety Technical Report). Therefore, the primary driver for changes in emissions of the Build Alternative as it relates to the No Action Alternative are changes in emissions rates resulting from varying vehicle operating speeds.

9.1.2 The Speed and Emissions Relationship

Table 8 shows a simplified example of the emissions rates (in gpm) for passenger cars and heavy trucks for CO_2e by speed increments in miles per hour (mph). While the MOVES rates illustrated in this table represent only the summer AM peak period, the final emissions inventory accounts for all time-of-day periods and seasonal variations. Note that “Cars” represents all passenger vehicles, including light-duty trucks and SUVs, and is not limited to sedans and coupes. “Trucks” represent larger commercial vehicles (FHWA Vehicle Classification 5 and greater) that are present in the project area and region. Variation in seasons and time shows similar trends in emissions rates by speed, so one period, summer AM peak period, was selected to demonstrate this relationship graphically.

Table 8. Passenger Vehicles Versus Trucks Combined CO_2e Emissions Rates (Tailpipe and Evaporative) by Vehicle Speed in the Project Horizon Year (2050) for Summer AM Conditions

Speed (mph)	Car Emission Rates (gpm)	Truck Emission Rates (gpm)
1	5,930.50	43,695.28
5	1,312.58	10,966.52
10	787.57	7,252.26
15	621.87	6,360.39
20	517.01	5,757.15
25	460.73	5,269.61
30	424.30	5,145.22
35	408.88	4,513.95
40	398.34	4,437.14
45	390.14	4,378.81
50	379.65	4,231.19
55	370.02	**4,069.03**
60	**364.91**	4,090.55
65	371.20	4,287.07
70	385.90	4,460.53
75	407.12	4,664.70

Table 8 demonstrates that emissions rates for CO_2e are significantly higher at lower speeds when engines are less efficient, which occurs from vehicle operations during congestion. Tailpipe emissions rates are lowest per VMT at speeds near 55 mph for trucks and 60 mph for cars, after which they begin to increase. This demonstrates that as vehicle speeds improve and are no longer operating under congested roadway conditions the emissions intensity decreases and results in a higher efficiency form of travel from a strictly operational perspective.

As the predicted increase in VMT under the Build Alternative relative to the No Action Alternative is greater than the predicted increase in GHG emissions (**Section 8.0**), the primary driver for changes in emissions of the Build Alternative as it relates to the No Action Alternative are changes in emissions rates resulting from varying vehicle operating speeds. As shown in **Table 8**, the lowest emissions rates are associated with speeds approaching 55 or 60 mph, or near highway free flow speeds. Under "stop and go" congestion (typical of the No Action Alternative), engines work harder, and more acceleration and deceleration occurs,

resulting in a greater level of fuel consumption and associated GHG emissions on grams per VMT basis at lower vehicle operating speeds.

9.1.3 Analysis Focus: Scenario Year and Season, Travel Time Periods, and Vehicle Types

To reduce the scope of the voluntary supplemental emissions analysis, CDOT evaluated only predicted changes in GHG emissions rates for trucks on this segment of I-25 (heavy-duty trucks FHWA Vehicle Classification 5 and larger). The supplemental analysis focused on commercial trucks because as shown in **Table 8**, emissions rates for these vehicles are much higher than passenger cars. **Table 8** also shows that emission rates for passenger vehicles follow a similar trend with changes in speed for heavy-duty trucks. Therefore, while the supplemental analysis evaluates trucks specifically, the resulting changes in emission rates are representative of the broader relationship between speed and emissions across vehicles on the corridor. To further streamline the qualitative analysis, only rates associated with the 2050 summer AM peak period were utilized as surrogate rates which were kept consistent between alternatives.

9.1.4 Scenario Year and Season

The use of changes in emissions rates only associated with the 2050 summer travel behavior is warranted as the supplemental analysis does not perform air modeling intended to predict future concentrations that would require seasonal emissions rates associated with an entire year as was performed in the emissions inventory. For GHG emissions MOVES is only sensitive to season and temperature changes as they relate to a driver's usage of a vehicle cooling system and resultant decrease in fuel economy. Thus, although emissions of GHGs decrease during colder months of the year, the relative difference between alternatives in emissions intensity due to seasonality would not change if both the summer and winter seasons were analyzed, as was performed in the operational emissions inventory.

9.1.5 Travel Time Periods

As the supplemental analysis is intended to evaluate changes in predicted emissions rates resulting from changes in forecasted speeds under the Build Alternative in relation to the No Action Alternative, only the AM and PM peak periods from the travel demand modeling were analyzed. The AM and PM peak are the times of day when the greatest differences in speeds between alternatives are expected due to high volumes of vehicles traveling on the segment and associated congestion. **Figure 7** and **Figure 8** show the AM and PM peak predicted hourly average speeds on the segment by direction, i.e., northbound and southbound.

Figure 7. Northbound AM and PM Peak Predicted Hourly Average Speeds on GP Lanes in the Project Segment

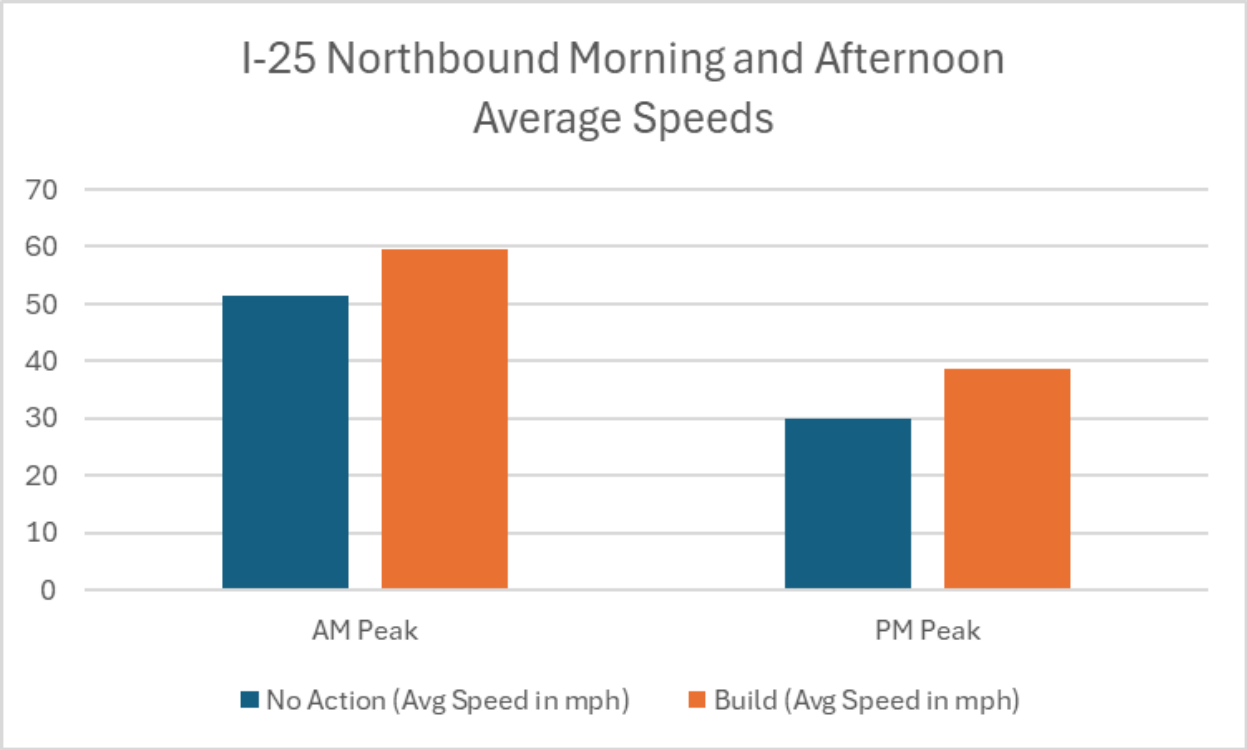
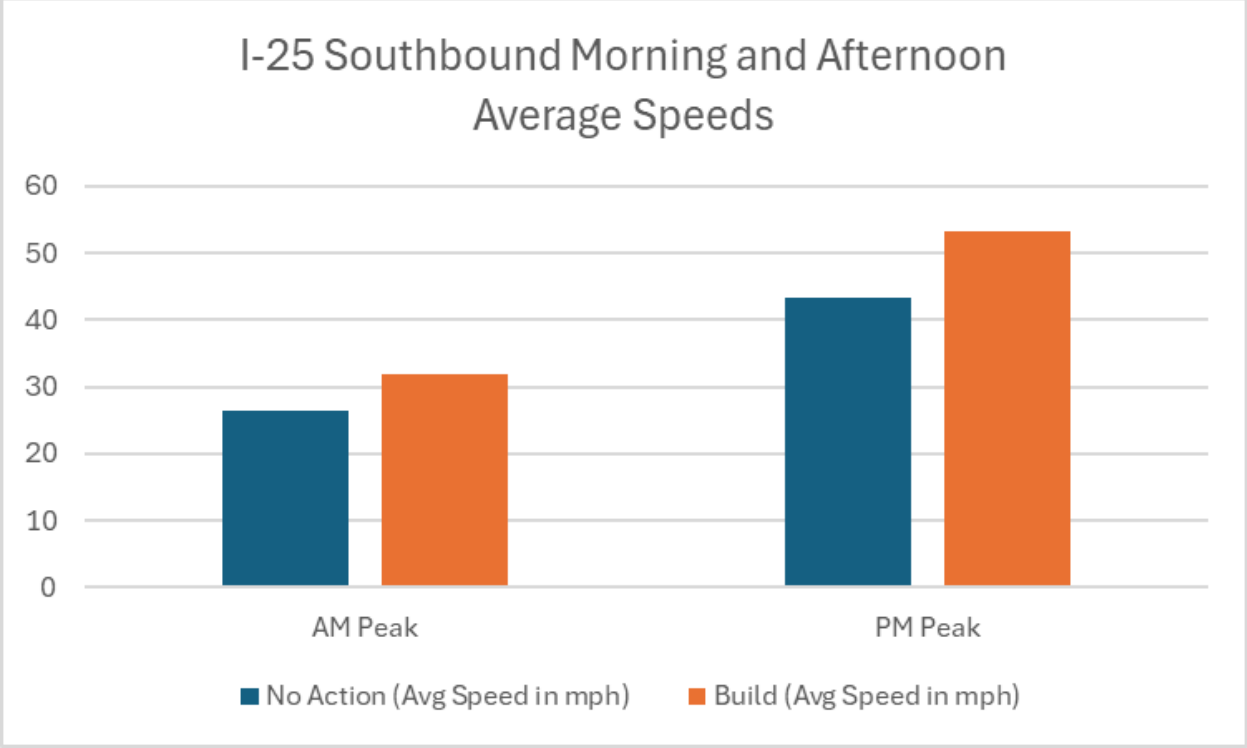


Figure 8. Southbound AM and PM Peak Predicted Hourly Average Speeds on GP Lanes in the Project Segment



This analysis is a qualitative comparison of alternatives as they relate to each other, where the relative changes in emissions rates under the Build Alternative compared to the No Action Alternative can be assumed to be similar during other seasons and peak periods of the day. Conversely, during off-peak travel periods there are a reduced number of vehicles overall and lower levels of congestion predicted under the No Action Alternative relative to the Build Alternative than during peak periods. Therefore, the relative emissions benefits under the Build Alternative due to improved emissions intensity during the off-peak periods will be less than during the peak periods represented in the voluntary supplemental analysis due to less variance in speeds between the alternatives. This results in lower relative level of differences in the GHG emissions rates per vehicle mile traveled during the lower vehicle volume off peak periods, particularly overnight. The operational emissions inventory (**Section 8.1**) provides an analysis of annual GHG emissions between alternatives for all time of day periods in the travel model that accounts for this reduction in the differences between emissions rates by alternative during the off-peak periods.

Commercial trucks were selected for the supplemental emissions analysis because their emission rates per mile are significantly higher than those of passenger cars, and thus, also account for a significant quantity of the total predicted operational GHG emissions. However, it is also reasonable to extrapolate these results to the total onroad vehicle mix since passenger vehicles share a similar speed to emissions profile (**Table 8**). A reduction in truck emission rates due to improved traffic flow is highly likely to correspond with a reduction in passenger vehicle emissions rates, though this relationship may not be a direct one to one comparison.

9.1.6 Qualitative Supplemental Analysis – Link Level Approach

To qualitatively compare the predicted emissions rates of GHGs from the Build Alternative to the No Action Alternative, the small sections of this segment of I-25 referred to as “links” in the travel demand model were mapped to each other so that a given link under the Build Alternative can be compared to the same corresponding link at the same location on I-25 under the No Action Alternative by direction and time of day. The relative percent change in emissions rates under the Build Alternative compared to the No Action Alternative were calculated at the individual link level by direction and peak period. This is consistent with the voluntary supplemental analysis to further evaluate emissions of particulates in the Air Quality Technical Report where at the individual link level the relative percent change in particulate matter emissions rates (gpm) were calculated by pollutant, direction, and peak period and then aggregated into a total value to qualitatively compare the Build Alternative in relation to the No Action Alternative.

The voluntary supplemental GHG emissions analysis deviates in methodology from the emissions inventory by isolating the analysis to the emissions intensity at the individual link level rather than calculating mass total emissions. Calculating the relative percentage changes in emission rates in a side by side comparison between alternatives evaluates whether lower intensity emissions rates under the Build Alternative influence the lack of proportionality between changes in VMT and GHG in relation to the alternatives. In this

analysis a relative percent difference less than 0% indicates a reduction in the emissions intensity, (i.e., a lower emissions rate in gpm) at that physical location under the build alternative. A calculated change in emissions rates greater than 0% indicates an increase in the emissions intensity under the Build Alternative as compared to the No Action Alternative at that physical location.

The voluntary supplemental analysis calculated that in a side-by-side geographic comparison, 29 of the 37 individual links that represent all of the general highway lanes in the emissions inventory study area were predicted to operate at a lower emissions intensity under the Build Alternative in relation to the corresponding link in the No Action Alternative during the AM peak period. During the PM peak period 27 of these same 37 links are predicted to operate at a lower emissions intensity under the Build Alternative. This confirms that lower emissions rates on roadway links under the Build Alternative result from improvements in vehicle speeds. These links are otherwise highly congested under the No Action Alternative. Therefore, GHG emissions intensity will be reduced under the Build Alternative as compared to the No Action Alternative for the GP highway lanes in the segment.

9.1.7 Supplemental Analysis Segment Level Findings

To assess the overall relative percent change in emissions rates at the segment level for the project, the relative percent change in emissions rates at the individual link level were aggregated. However, it would not be accurate to simply take an average value of the relative percentage change in emissions rates because some of the links on the segment have significantly more VMT associated with them than others on the segment. Therefore, the relative percent change in emissions rates under the Build Alternative as compared to the No Action Alternative at the link level values were first weighted by the calculated total VMT on the segment, by direction, before being aggregated. This “VMT weighting” ensures that longer highway segments or those with higher traffic volumes carry more influence in the overall segment level assessment, preventing outliers on short or low volume links from skewing the overall data.

Table 9 below summarizes the predicted 2050 overall relative change in commercial vehicle emissions intensity from the voluntary supplemental analysis under the Build Alternative as compared to the No Action Alternative by direction and peak period. The “Segment Level” column represents the combined change across both directions of travel for each peak period assessed. A value of less than 0% indicates lower overall emissions rate, and therefore a more efficient means of travel under the Build Alternative in comparison to the No Action Alternative.

Table 9. Northbound, Southbound and Total Segment Link-Level Relative Percent Difference for Peak AM and PM CO_2e Emission Rates

Pollutant	Time Period	Northbound Relative Difference	Southbound Relative Difference	Segment Level Relative Difference
CO_2e	AM Peak	-1%	-5%	-2%
CO_2e	PM Peak	-8%	-6%	-7%

Table 9 shows that the MOVES model is predicting lower overall emissions rates for the Build Alternative relative to the No Action Alternative by direction on the segment during both the AM and PM peak periods. The relative differences in GHG emissions rates between alternatives would be much lower during some of the off-peak hours due to lower vehicle volumes and reduced congestion, such as late at night. However, the majority of daily VMT is predicted to occur during the AM and PM peak periods in the travel demand model. This indicates that overall predicted changes in emissions rates due to improved speeds under the Build Alternative relative to the No Action Alternative are likely to be having a meaningful influence on the total calculated operational GHG emissions in the emissions inventory.

9.1.8 Supplemental Analysis Findings and Conclusions

The voluntary supplemental operational GHG emissions analysis indicates that the Build Alternative reduces most emissions rates of GHGs across the project during the AM and PM peak periods. Overall reductions of GHG emissions intensities across the segment are predicted to provide a net benefit in operational emissions rates of GHGs when compared to the No Action Alternative. Although the analysis evaluated the percentage change in emissions rates for commercial trucks, it is also reasonable to assume that emission rates of passenger vehicles are also likely to decrease under the Build Alternative as they follow similar emissions rate and speed profiles as commercial trucks (**Table 8**). CDOT did not focus on passenger vehicle rates in this analysis due to their reduced impact when compared to commercial truck traffic; moreover, providing for improved commercial truck traffic flows and reduced vehicle incidents in the segment are part of the project's Purpose and Need. To reduce the scope and eliminate redundancy from the operational GHG emissions inventory (**Section 8.1**), the voluntary supplemental analysis conducted by CDOT focused on the AM and PM peak periods when vehicle volumes and congestion are higher than in the off-peak periods when the relative differences in GHG emissions rates between alternatives would be reduced. The operational emissions inventory provides an estimate of GHG emissions for all hours of the day over the lifetime of the project in total mass emissions.

Furthermore, under the Build Alternative there is an increase in predicted VMT along the interstate in the project area; however, it is limited due to a lack of good alternate routes for drivers in the area who are still predicted to choose to travel on the interstate under the more congested No Action Alternative. It is likely that increases in VMT along the interstate in the project area are associated with some decreases in VMT on the limited parallel routes that are available to drivers, e.g., Huron Street and Washington Street. These parallel routes have lower speeds and signalized intersections with more braking and acceleration events

that generally lead to higher vehicle emissions rates than those on the interstate in the project area. This is particularly true for commercial vehicles that have overall higher emissions rates and higher emissions per VMT. Under the Build Alternative commercial vehicles would have improved access to the interstate through the auxiliary lane additions that lead to operational benefits and reduced safety incidents in the project location that are associated with lower emissions rates at higher speeds as well as reduced delay in travel times from fewer vehicle collisions (**Section 10.2.1**).

By improving traffic flow and reducing congestion, the Build Alternative emissions analysis shows an increase in average corridor speeds and general smoothing of travel, resulting in lower GHG emission rates when compared to the No Action Alternative.

The reduction in emissions per mile in the Build Alternative represents a more efficient form of travel which supports the critical consideration for this project, where motorists lack adequate alternate route choices and are likely to travel on the segment regardless. Ultimately, these results indicate that due to a lack of alternate routes in the area, the Build Alternative reduces GHG emissions rates to a large degree compared to the No Action Alternative.

The difference in GHG emissions rates between alternatives from improved traffic flows during the AM and PM peak periods in the Build Alternative is predicted to offset some of the predicted increase in VMT associated with the Build Alternative. Consequently, the improved operational efficiency under the Build Alternative, coupled with the lack of alternative routes under the No Action Alternative, is expected to result in a smaller increase in lifetime operational GHG emissions than would typically occur with highway expansions, where changes in VMT are more closely correlated with changes in emissions.

9.2 Related Projects with GHG Impacts

The project Build Alternative, alongside a host of separate but related projects in the area, contain several components which were not included in the GHG quantitative impact analysis but are expected to reduce GHG emissions through transit, bicycle and pedestrian facilities, and other safety and operational roadway improvements.

Build Scenario Alternative Elements

As part of the Build Alternative, the 88th Avenue bridge would be widened to accommodate improved bicycle and pedestrian facilities consistent with the City of Thornton's planned cross-section for 88th Avenue, creating opportunities for safer multimodal travel over I-25 and 88th Avenue. Additionally, the Build Alternative includes a realignment of the I-25-adjacent regional trail and pedestrian network within the Niver Creek Open Space to accommodate highway widening and the replacement of the existing, aging pedestrian and bicycle underpass infrastructure at the Thornton Park-n-Ride facility, to maintain regional trail connectivity and improve safety for nonmotorized users across the I-25 corridor. Further, to eliminate unsafe bus weaving movements at the Thornton Park-n-Ride facilities south of 88th Avenue due to insufficient weave and merge lengths, the Build Alternative will remove

the bus-only slip ramps, which will resolve conflicts with the Niver Creek Trail and improve overall safety and operations in the corridor.

Nearby Related Projects

The following transportation improvements that may affect regional travel in the project area but will occur within an area surrounding the project area are considered under both the No Action and Build Alternative.

Southeast of the project area, the I-270 Express Lane improvements between I-25 and Interstate 70 (I-70), coupled with the I-25/US 36 and I-70 Direct Connect projects, are expected to allow for seamless Express Lane travel across multiple corridors in the regional network and improve congestion and travel speeds on the I-270 corridor. Without these improvements, vehicle trips would continue to occur on the more circuitous route choices of I-70 and I-25, as well as trips through local neighborhoods. It is predicted that as a result of these projects, VMT and emissions are expected to be reduced on these alternative routes, including on the I-25 corridor south of US 36.

10.0 Consideration of Indirect Effects

10.1 Upstream Fuel Cycle Emissions

Upstream fuel cycle GHG emissions are the emissions associated with transportation fuel extraction, production, and distribution prior to entering the vehicle fueling tank. Over the project's estimated lifetime, the upstream fuel cycle emissions are higher under the Build Alternative relative to the No Action Alternative. This is due to the methodology for calculating upstream fuel cycle GHG emissions being only sensitive to the difference in VMT between the project alternatives. Holding the variables constant that represent onroad VMT by vehicle mix (passenger vehicles, light commercial trucks), fuel type (gasoline, diesel, and electricity) provides for an "apples-to-apples" comparison between alternatives of GHG emissions. Furthermore, the methodology for calculating upstream fuel cycle GHG emissions does not consider emissions improvements associated with improved speeds from congestion and reduced fuel consumption and lower emissions rates. This provides for a relative comparison between alternatives of GHG emissions solely associated with increased vehicle travel. This results in a conservative estimate of upstream fuel cycle emissions under the Build Alternative relative to the No Action Alternative on a GHG emissions intensity per VMT basis, but to an unknown extent.

10.2 Indirect Effects Not Quantified in the Analysis

10.2.1 Safety Improvements

As described under the Purpose and Need for the project (Section 12 of the I-25 US 36th to 104th EA), a main need of the project is safety improvements in the segment. Currently this location experiences elevated crash frequencies and patterns in both the northbound and southbound directions based on peak period travel patterns that are commonly associated with congestion, as well as complex merging patterns from closely spaced interchanges. These crashes are currently associated with high recorded levels of fatalities and injuries to the vehicle drivers and passengers involved and represent a significant need for safety improvements in the corridor.

In addition to the direct benefits to public health from reduced injuries and fatalities related to safety improvements, an indirect effect of safety improvements is the beneficial emissions reductions associated with reduced incidents of unanticipated traffic delays and increases in travel time and congestion from vehicle crashes (e.g., lane closures, safety and emergency vehicle movements) to other drivers on the interstate. The travel demand modeling used in the air pollutant and GHG operational emissions analysis predicts an average day of travel in the region and does not capture unpredictable behaviors such as erratic lane movement that can result in vehicle crashes or the crash incident in itself. Therefore, the real-world emissions benefits from reduced crashes and improved traffic flow related to safety improvement elements under the Build Alternative are an indirect effect that was not quantified or reflected in the GHG operational emissions analysis.

The total crash ratio is predicted to increase in 2050 under both the No Action Alternative and the Build Alternative, which is significantly driven by future anticipated growth in total population and VMT. Under the No Action Alternative the total crashes per million VMT basis is predicted to increase by 13% (Section 14.1.2 of the I-25 US 36th to 104th EA). Under the Build Alternative the rate of vehicle crashes per million VMT are predicted to decrease by 12% as compared to the No Action Alternative (Section 14.1.2). This reduction in predicted crash rate indicates that the Build Alternative enhances overall safety with respect to the higher traffic volumes anticipated by 2050 under either alternative. The safety enhancements under the Build Alternative are anticipated to lead to a reduction in safety incidents and real-world traffic delays and congestion that also correspond to a decrease in GHG emissions relative to the No Action Alternative that are not captured in the travel demand modeling and operational emissions analysis.

10.2.2 Land Use

The project represents a single segment within the 5.6-mile-long I-25 North corridor. This segment already contains Express Lanes that are operated by the Colorado Transportation Investment Office (CTIO) and the addition of Express Lanes on other segments of I-25 North have been completed or are being considered for future use on the interstate. A complete buildout of dynamically tolled Express Lanes on the I-25 North corridor paired with future land use changes due to Colorado's strategic growth laws (not yet reflected in DRCOG's travel model) would likely result in lower long-term VMT and GHG emissions, as discussed below.

Highway expansions generally lead to increased VMT, referred to as induced demand, on the corridor. Some elements of induced demand from highway expansions are desirable and intentional, such as having more users choose to travel on the widened and less congested roadway for shorter and more direct trips, which can lead to corresponding decreases in VMT in the region on other indirect routes. A negative example of induced demand is that the reduction in congestion can cause travelers to take more frequent or longer trips (i.e., latent demand), leading to increases in VMT and associated emissions. In some cases, the amount of travel and congestion on the roadway can increase to a level where there are no longer emissions benefits being realized from improved traffic operations. These undesirable elements of induced demand are sensitive to the availability of travel choices and the land use in the project area. CDOT's Express Lane operations on I-25 North improve traffic operations in real-time, encouraging high-occupancy vehicles with three or more occupants (HOV3+) and transit, while limiting induced demand that would otherwise likely occur over time with a new GP Lane. The connection between Express Lane operations that are supportive of improved transit operations is a critical element of providing improved travel choices throughout segments in the corridor that also support more desirable land use development patterns. Improving travel choices, increasing transit service and supporting strategic growth to reduce single occupancy vehicle (SOV) travel in Colorado are all foundational elements considered under the CDOT GHG Transportation Planning Standard during rule development and adoption which are supported by Express Lane operations on the corridor.

CDOT's Express Lanes on I-25 North actively manage congestion through pricing strategies that discourage latent (induced) demand, and allow pricing to change as corridor conditions adjust during peak periods. Given Colorado's recent growth, Express Lanes provide CTIO/CDOT with a real-time tool to manage unexpected growth without requiring additional construction beyond the Express Lane. Express Lanes achieve this by offering drivers a choice: pay a toll for the Express Lane, use the GP Lanes, delay a trip, or not make an unnecessary trip to avoid congestion during peak periods. Expanding the road to include an Express Lane will limit latent (induced) demand.

The Express Lane incentivizes HOV3+ through a toll exemption and supports public transit by allowing buses to bypass congestion, ensuring faster and more reliable service, which effectively reduces overall traffic along the corridor. Through accommodating transit operations on the Express Lanes, the highway infrastructure also functions as supportive transit infrastructure for local service providers and CDOT.

Compared to GP lanes, CDOT's Express Lanes on I-25 North are better designed to limit the undesirable effects of induced demand, especially those that could occur from future land use conditions in the area that may not be represented in the current regional long-range planning year assumptions at the time of NEPA analysis.

CDOT's Express Lane operations on I-25 North provides better travel time reliability for transit riders as well as drivers who elect to pay a toll to travel in the Express Lane based on current congestion levels. Through the I-25 North Express Lane operation, latent demand is discouraged and congestion mitigation benefits such as reduced emissions from improved traffic flow are managed for congestion based on observed real-world conditions in both present and future years. CDOT's Express Lanes as compared to static transportation infrastructure, e.g., GP Lanes, are better designed to limit the undesirable effects of induced demand, especially those that could occur from future conditions in the area that may not be represented in the current regional long-range planning year assumptions at the time of NEPA analysis. This includes future residential development and other land use changes that are unknown at the time of the analysis and are dependent on factors such as population growth and new employment or economic centers whose locations are often controlled by outside factors such as private developers who are predominantly driven by regional markets and other economic conditions. This has resulted in CDOT and regional planning agencies having historically had limited influence over these unknown future changes and how they impact current and future SOV miles traveled within an area. Recently, several new laws and programs have been put into place to support strategic growth and sustainable land use in the project area that are also anticipated to have beneficial effects on reducing SOV VMT in the state. The following subsection discusses the connections between these new strategic growth requirements and travel behavior.

Strategic Growth Measures in Colorado

Future land use changes associated with Colorado's strategic growth laws are not yet reflected in DRCOG's travel model, but are likely to have an important effect on travel behavior along the I-25 North corridor. In 2024 the Colorado Legislature passed HB 24-1313,

Housing in Transit-Oriented Communities, to prioritize sustainable land use policies and increase opportunities to construct housing near transit. Jurisdictions subject to this law are called Transit-Oriented Communities (TOCs). TOCs are required to calculate a Housing Opportunity Goal for their jurisdiction, which is calculated by multiplying the total eligible acreage of their transit areas (areas within one-quarter mile of a public bus route or one-half mile of light rail, commuter rail, or commuter bus rapid transit station, excluding certain exemptions) by 40 units per acre. Then, TOCs must ensure that specific locations within their transit areas, known as "transit centers", have a sufficient combined zoning capacity that is greater than or equal to the jurisdiction's Housing Opportunity Goal. To qualify as a transit center, among other requirements, the area must allow for at least 15 units per acre which is the medium threshold for transit-supportive land use.

There are numerous transit areas in the vicinity of the project area associated with several different TOCs, according to the Department of Local Affairs (DOLA, 2026). In these locations the combined Housing Opportunity Goals total zoning capacity for over 100,000 units. The local governments associated with these transit areas will need to demonstrate that the combined zoning capacity of their transit centers, from either newly adopted zoning changes or the maintenance of existing zoning, supports the opportunity for 100,000 residential units near transit centers. Transit centers have not yet been identified at this time, except in a handful of communities who have complied with the law ahead of the deadline of December 31, 2027. It is important to note that the Housing Opportunity Goal is not a requirement for actual constructed housing units, rather it is a requirement for zoning capacity - which will have an influence on future land use and eventually result in more housing with access to transit or walkable neighborhoods. Notably, in most Colorado communities, only 10-20% of available zoning capacity is constructed as housing.

Increases in infill residential density and mixed-use development have been analyzed in Colorado and are predicted to result in reductions in household VMT (Colorado Energy Office [CEO], 2024). This is due to residents in these areas having improved access to transit, as well as living in walkable and bikeable neighborhoods. These additional travel choices allow for reductions in SOV trips. Moreover, denser residential development patterns are often followed by similar development patterns in or near essential services for residents. Increasing an area's access to essential services and other destinations (e.g., grocery, healthcare, childcare, parks) within a short distance are predicted to have a reduction in average trip lengths at the household level in these locations. This increase in access to essential services within short distances is important as the CDOT state travel demand model (StateFOCUS) has predicted previously that light-duty vehicle travel for commuting purposes only accounts for about 50% of the total daily passenger vehicle VMT occurring statewide indicating that a large portion of VMT are associated with access to essential services beyond employment.

By encouraging new housing units to be developed as part of residential infill development near transit in walkable and bikeable neighborhoods, HB 24-1313 has the potential to decrease the number of new housing units that need to be constructed farther from jobs and

other essential services that lead to longer trips and increased VMT from new development. The combined effect of an Express Lane throughout the I-25 North corridor, alongside transit access in the Express Lane, paired with transit-oriented infill limits long-term VMT and GHG growth on the corridor. Redirecting households and jobs towards compact, transit accessible locations results in shorter average trip lengths, reducing vehicle travel and its associated emissions. CDOT supports Colorado's strategic growth laws and policies by prioritizing areas in compliance with HB 24-1313 for grants and other funding opportunities following Executive Order D 2024 005 and D 2025 011 from Governor Polis.

11.0Mitigation/GHG Commitment Considerations

For the purposes of CRS 43-1-128(4)(a), Colorado has not established a significance threshold for GHGs, and GHG mitigation is not required. However, there are project-level mitigation measures occurring to address air quality that are likely to have GHG co-benefits. The mitigation measures listed for addressing the release of diesel emissions from construction equipment in the I-25 (US 36 to 104th Avenue) Air Quality Technical Report (CDOT, 2026b) will also help to reduce GHG emissions from the construction of the project. These measures include:

- Prohibition of unnecessary idling of construction equipment
- To the extent practical, use heavy construction equipment that has the cleanest available engines or that can be retrofitted with diesel particulate-control technology
- To the extent practical, use alternatives to diesel engines and/or diesel fuels, such as biodiesel, liquefied natural gas, compressed natural gas, fuel cells, and electric engines
- Install engine pre-heater devices to eliminate unnecessary idling for wintertime construction
- Prohibit tampering with equipment to increase horsepower or to defeat an emission control device's effectiveness
- Require construction vehicle engines to be properly tuned and maintained
- Use construction vehicles and equipment with the minimum practical engine size for the intended job

12.0Resilience Considerations

Resilience became a key priority for CDOT after the 2013 Front Range flooding event caused severe damage to the transportation system. The flood impacted roughly 500 miles of roads and 50 bridges, and required more than $700 million in emergency repairs. CDOT, businesses, and the traveling public all felt the financial impact and inconvenience. Recognizing the importance of transportation resiliency, in 2018 the Transportation Commission adopted Policy Directive 1905, "Building Resilience into Transportation Infrastructure and Operations" (CDOT, 2018). The Policy Directive directed CDOT to support state resilience goals by incorporating resilience in strategic decisions about transportation assets and operations and created the Risk and Resilience Program at the agency. The Risk and Resilience Program has created a suite of tools and processes by which resiliency can be integrated into project assessment, design, and decision making.

Building resilience is like an insurance policy; by identifying a threat and implementing a mitigation measure, we can reduce the risk to the transportation system in the future. Proactive management of threats before they occur minimizes the resources needed to rebuild and restore service, minimizes the disruptions to people's lives and to business activity, and lowers the cost to CDOT and the traveling public in the long run. Utilizing the risk and resilience assessment as part of life-cycle planning and life-cycle cost analysis makes good financial sense. For this project, CDOT conducted an initial high-level assessment of risk and resilience in the area to identify areas recommended for further assessment.

Areas Recommended for Further Assessment
Parts of the project are located in the floodplain, as discussed in **Appendix D5**: Floodplains Technical Report. The high-level assessment of risk and resilience focused on flooding as the primary natural hazard impacting the project area, and assets including bridges and major culverts, minor culverts, and culverts less than 48 inches in diameter.

Key areas and potential assets recommended for further assessment are listed in the following section; for each, the application of a Climate-Informed Science Approach would aid the project team in assessing the sensitivity of the proposed infrastructure improvements to future conditions, in the justification of resilience improvements, and to develop benefit-cost analyses for future funding pursuits. This review was conducted using CDOT's Asset Resiliency Mapping Application.

South of Milepost (MP) 221, there is potential for flooding due to the intersection of the 500-year flood plain with I-25. Flooding could result in partial or full closure of the roadway, as well as overtopping of culverts in the area if they are unable to meet expected flow rates.

It is recommended that once scope is clarified, the project team may want to conduct further assessment of structure E-17-FJ south of MP 219. Further, assess whether the additional drainage features north of the western Park-n-Ride facility, part of which are within the 100-

year floodplain, facility would be included in the project area. Potential flooding in this area could impact operability of the bus lanes on the west and east sides of I-25.

The 100-year floodplain intersects with I-25 near MP 218.75, and structures in that area are good candidates for further resilience assessment as project scope is developed.

While just outside the project area, a resilience assessment should be conducted for culverts just north of MP 221.

Considerations for Culverts

- Resilience approaches specific to culverts may include consideration of replacement-in-kind, upsizing, and performance in projected future flood events.
- Consideration of future extreme weather events and potential for different max peak flows.
- Risk and Resilience Assessment Tool - has specific model for culverts and a process for doing a much more detailed assessment of culverts.

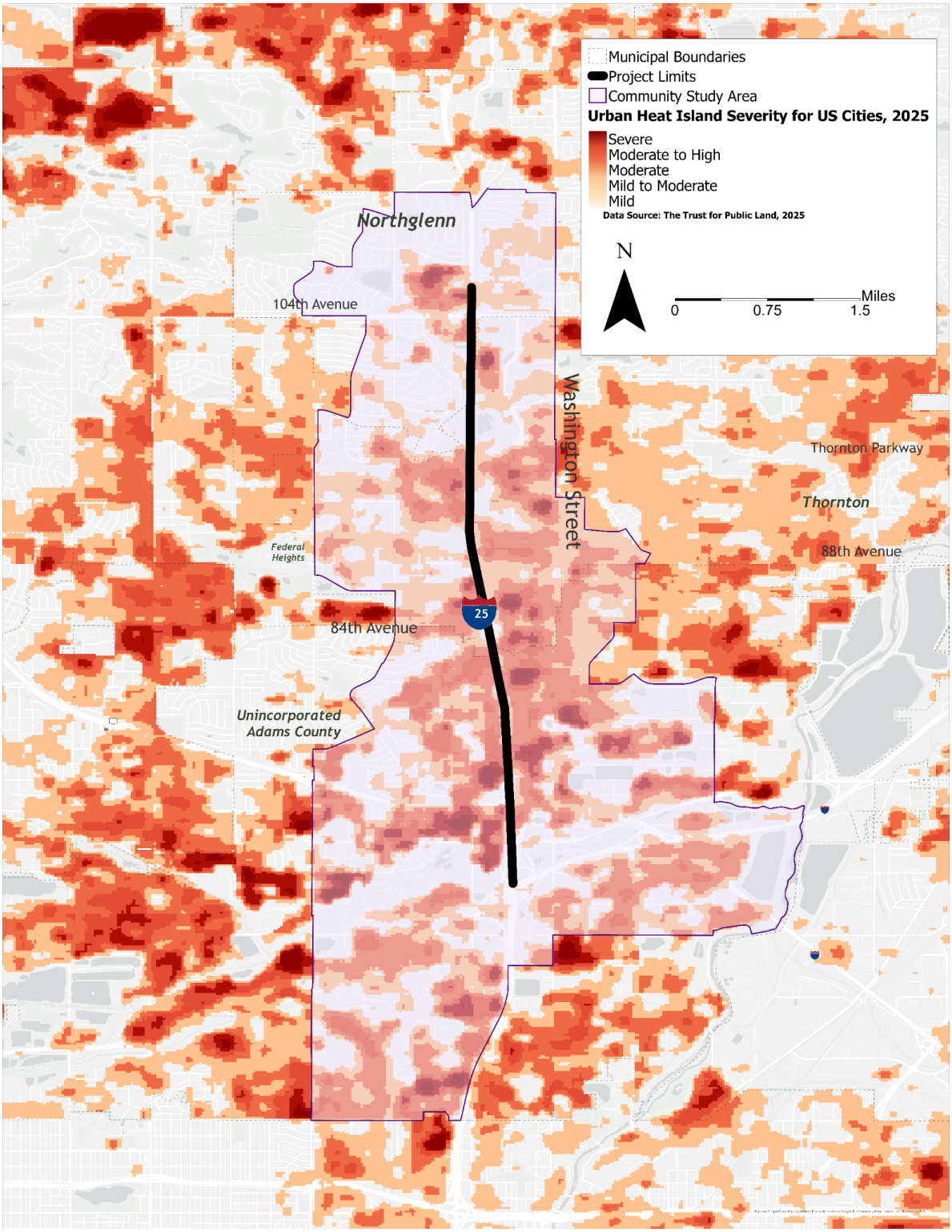
13.0Community Impact Considerations

Components of Colorado Senate Bill 21-260, The Sustainability of the Transportation System, now codified as CRS 43-1-128, require certain projects to use enhanced engagement methods with Disproportionately Impacted Communities (DI Communities) throughout the planning, environmental study, and project delivery phases. The requirement to work with and evaluate effects to Disproportionately Impacted (DI) Communities only applies if the project is an RS/TC project. As an RS/TC project, the US 36th to 104th Avenue project was required to undergo additional analysis and consideration for DI Communities.

To fulfill these state requirements, a community analysis for the US 36 to 104th Avenue project was also conducted in parallel with the NEPA process. As documented in Figure 3 “DI Communities” and Table 1 “DI Communities and EnviroScreen Scores by Census Block Group” of the I-25 (US 36 to 104th Avenue) State Community Analysis Technical Report (CDOT, 2025), DI Communities are present in this study corridor. Section 4.0 of the State Community Analysis Technical Report describes the outreach and engagement efforts conducted by CDOT in the community study area (CSA). During these public engagement efforts, CDOT received comments and questions related to prioritizing safety, congestion relief, smoother traffic operations, and better bicycle and pedestrian connectivity. To incorporate these priorities, CDOT retained bike and pedestrian facility improvements on the 88th Avenue bridge.

One particular climate vulnerability within the CSA relates to the “heat island” effect. Heat islands are urbanized areas that experience higher temperatures than outlying areas. These higher temperatures result in increased energy consumption, elevated emissions of air pollutants and GHGs, and compromised human health and comfort (Santamouris, 2020). Climate change is expected to intensify these heat island impacts. The Trust for Public Land developed and mapped an index that measures heat island severity nationally. Severity is measured on a scale of 1 to 5, with 1 being a relatively mild heat area (slightly above the mean for the city), and 5 being a severe heat area (significantly above the mean for the city) (Trust for Public Land, 2023). **Figure 9** shows that much of the CSA has a high or severe heat severity index.

Figure 9. Heat Island Severity Index



14.0Conclusion

As documented in **Section 8.0** and **Attachment D** of this technical report, the analysis predicts that annual GHG emissions decline over the life of the project regardless of alternative, even though VMT increases over time. The Build Alternative would produce cumulative GHG emissions (lifetime direct and indirect emissions combined) that are 3% higher than the No Action Alternative. There would be a temporary increase in emissions as a result of project construction, and then emissions decrease each year after that. For over 25 years, DRCOG has been actively involved in efforts to reduce the amount of motor fuel burned, VMT, and associated GHG emissions. The task continues to be challenging due to the region's growth. However, DRCOG has remained strongly committed to efforts to reduce GHG emissions through its planning work and project funding allocations. As part of their efforts to reduce emissions of GHGs from transportation in the region, DRCOG has reduced and limited the number of planned roadway expansion projects that were included in previously approved regional planning documents, and furthermore, has formally incorporated these actions into their current long-range planning process through inclusion in their 2050 RTP and GHG Transportation Report. The I-25 US 36 to 104th Build Alternative is included in DRCOG's 2050 RTP and is analyzed as part of the associated GHG Transportation Report. DRCOG's GHG Transportation Report demonstrates a significant regional reduction in GHGs and satisfies the requirements of the GHG Transportation Planning Standard for all compliance demonstration years. It is important to note that the GHG Transportation Planning Standard addresses regional emissions reductions of GHGs from the transportation network as a whole, and not on an individual project-by-project basis. This is appropriate given that individual and commercial travel behavior is highly dynamic with high levels of traveler variability, such as route and mode choice, given the day-to-day conditions of the transportation network in the region. Furthermore, unlike criteria pollutants, GHGs are global pollutants that do not have regional or localized impacts near the source of their emissions. Therefore, it is important to consider each corridor's context within a region, as well as how it relates to a planning area's commitments to reduce GHG emissions as a whole within their transportation network rather than to solely focus on a single action. Although emissions of GHGs may increase through implementation of the Build Alternative in comparison to the No Action Alternative at the corridor level, when considered as part of a holistic transportation plan, the project does not adversely impact DRCOG's regional GHG emissions reduction efforts or compromise the agency's ability to comply with the GHG Transportation Planning Standard.

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Attachment A.

Project Information

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Attachment A: Project Information

October 23, 2026 - Version 15

Subaccount number: 25563

BACKGROUND

The Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) are proposing transportation improvements to Interstate 25 (I-25) between United States Highway 36 (US 36)/I-270/I-76 interchange and 104th Avenue.

Project History

CDOT has previously completed an Environmental Impact Statement (EIS), a Planning and Environmental Linkages (PEL) study, a safety audit, previous National Environmental Policy Act (NEPA)-level planning, and supplemental operational and transit and safety analyses that recommended improvements to this segment of I-25.

Some of the previously recommended improvements have been constructed, like the Express Lanes approved in the **North I-25 Record of Decision 1** (ROD1) (FHWA and CDOT, 2011), while others have not yet been implemented. The current Project evaluates proposed transportation improvements that reflect and build upon previous recommendations.

Because the current Project includes elements that were not evaluated and approved in the **North I-25 ROD1**, this Project is undergoing new evaluation under the National Environmental Policy Act.

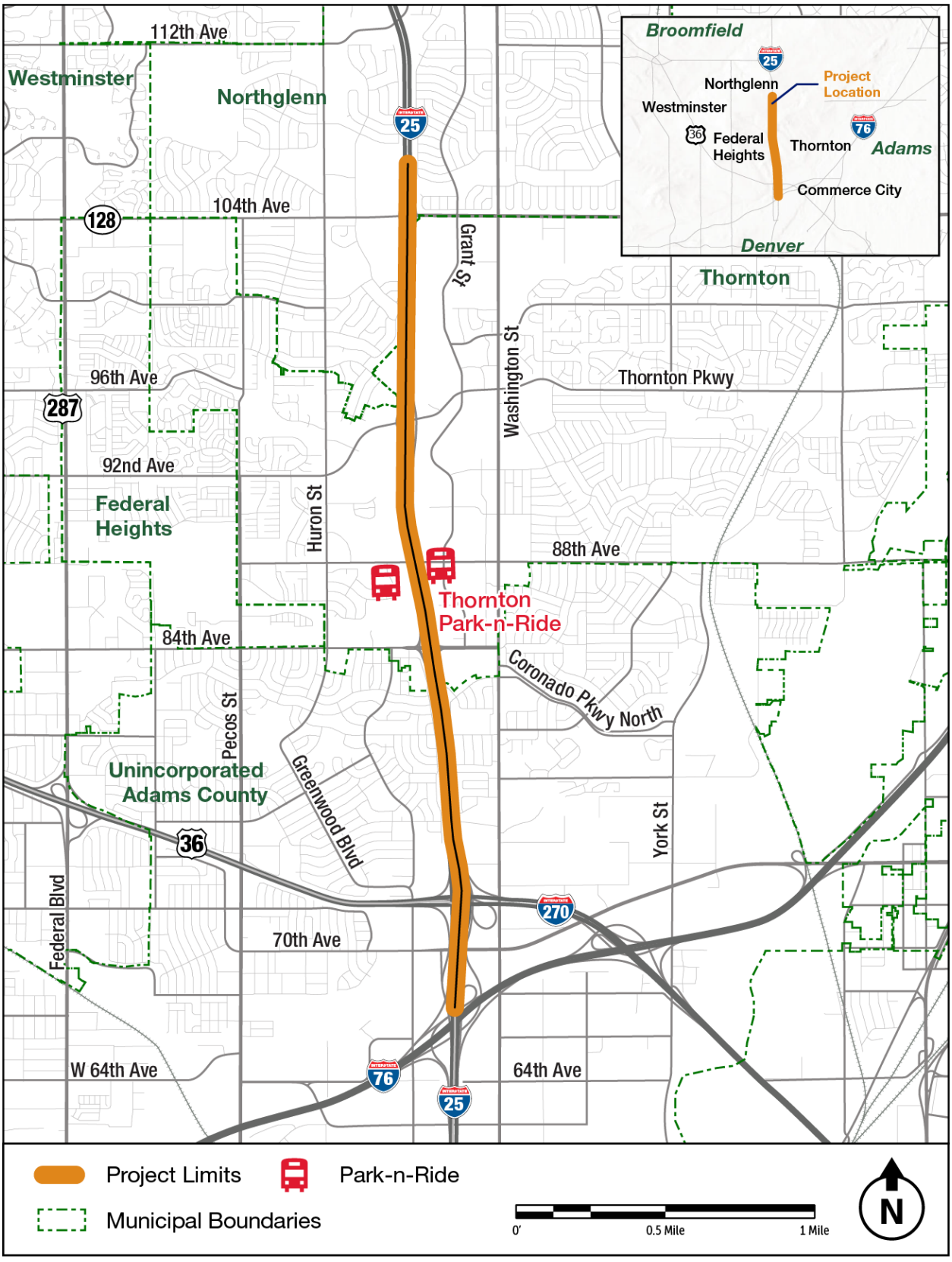
Study Area

The Project limits, illustrated in **Figure 1**, extend along I-25 from the US 36/I-76/I-270 interchange to 104th Avenue. It includes portions of US 36 and I-270, major arterials crossing I-25, and areas of potential drainage improvements. The study area for the Project varies by resource. Each resource's study area is defined within its corresponding technical report or memorandum.

The interchanges included in the Project limits are:

- I-25/US 36/270/I-76
- I-25/84th Avenue
- I-25/88th Transit Slip Ramps
- I-25/Thornton Parkway
- I-25/104th Avenue

Figure 1. Project Limits



PURPOSE AND NEED

The purpose of the Project is to improve I-25 between US 36 and 104th Avenue to address safety concerns and traffic operations.

The Project is needed to:

- Improve safety
- Improve traffic operations

In addition to addressing Project needs, the Project also has the following goal:

- Minimize environmental and community impacts caused by the Project

PROPOSED ACTION

The Project would improve approximately five miles of I-25 between US 36 and 104th Avenue. All lanes are 12 feet in width unless otherwise noted. The current cross-section of this segment of I-25 includes:

- Three general-purpose travel lanes in each direction
- One Express Lane in each direction, along the inside shoulder, separated from the adjacent general-purpose lane by a 2-foot buffer
- A southbound auxiliary lane between the 84th Avenue and US 36 interchanges
- A southbound auxiliary lane between the 88th Avenue transit slip ramp and the 84th Avenue interchange
- A northbound auxiliary lane between the 88th Avenue transit slip ramp and Thornton Parkway interchange
- Inside shoulders varying in width between 2 and 12 feet and outside shoulders varying in width between 6 and 12 feet

The Proposed Action on I-25 between US 36 and 104th Avenue, illustrated in **Figure 2**, includes the general-purpose and Express Lanes listed above and adds the following elements to the existing cross-section:

- A new 12-foot wide southbound general-purpose lane from 104th Avenue to south of 84th Avenue (all new lanes will be 12 feet in width)
- A new northbound climbing lane from the I-76 entrance ramp to 104th Avenue
- An expanded buffer of 4 feet between the Express Lane and the adjacent general-purpose lane
- A new continuous auxiliary lane southbound between the 84th Avenue and Thornton Parkway interchanges
- New continuous northbound auxiliary lanes between the interchanges at I-270 and 84th Avenue, 84th Avenue and Thornton Parkway, and Thornton Parkway and 104th Avenue
- Expanded inside and outside shoulders with typical 10-foot widths, and minimum 6.5-foot inside and 7-foot width in restricted locations

In addition to those changes to the cross-section, the Proposed Action would include the following elements:

- Realignment of the combined I-76 and US 36 on-ramp connection
- Expansion of the I-270 exit to northbound I-25 from one to two lanes; I-270 merge with I-25 shifted farther north (See **Figure 3**)
- Removal of bus-only slip ramps along I-25 at the Thornton Park-n-Ride facilities
- Changes to the Park-n-Ride west parking lot including reduction in size and reconstruction of circulation widths, sidewalks, and median areas to accommodate the proposed open channel of Niver Creek
- Changes to the Park-n-Ride east parking lot including reconstruction of bus bays and relocated shelters and amenities
- Replacement of the 88th Avenue bridge over I-25; wider to accommodate improved bicycle and pedestrian facilities and longer to accommodate I-25 widening

- Realignment of the I-25 adjacent existing trail and pedestrian network within the Niver Creek Open Space and its connections to the Thornton Park-n-Ride facilities (see **Figure 4**)
- Replacement of the aging pedestrian and bikeway underpass at the Thornton Park-n-Ride facility
- Removal of Niver Creek from the existing box culvert at the Thornton Park-n-Ride and conversion of the creek into an open channel
- Relocation of the segment of Niver Creek east of I-25, which currently flows south from the Park-n-Ride east parking lot to the creek's intersection with Tributary L, to the west side of I-25
- New water quality treatment features throughout the project area

Figure 2. Proposed Action

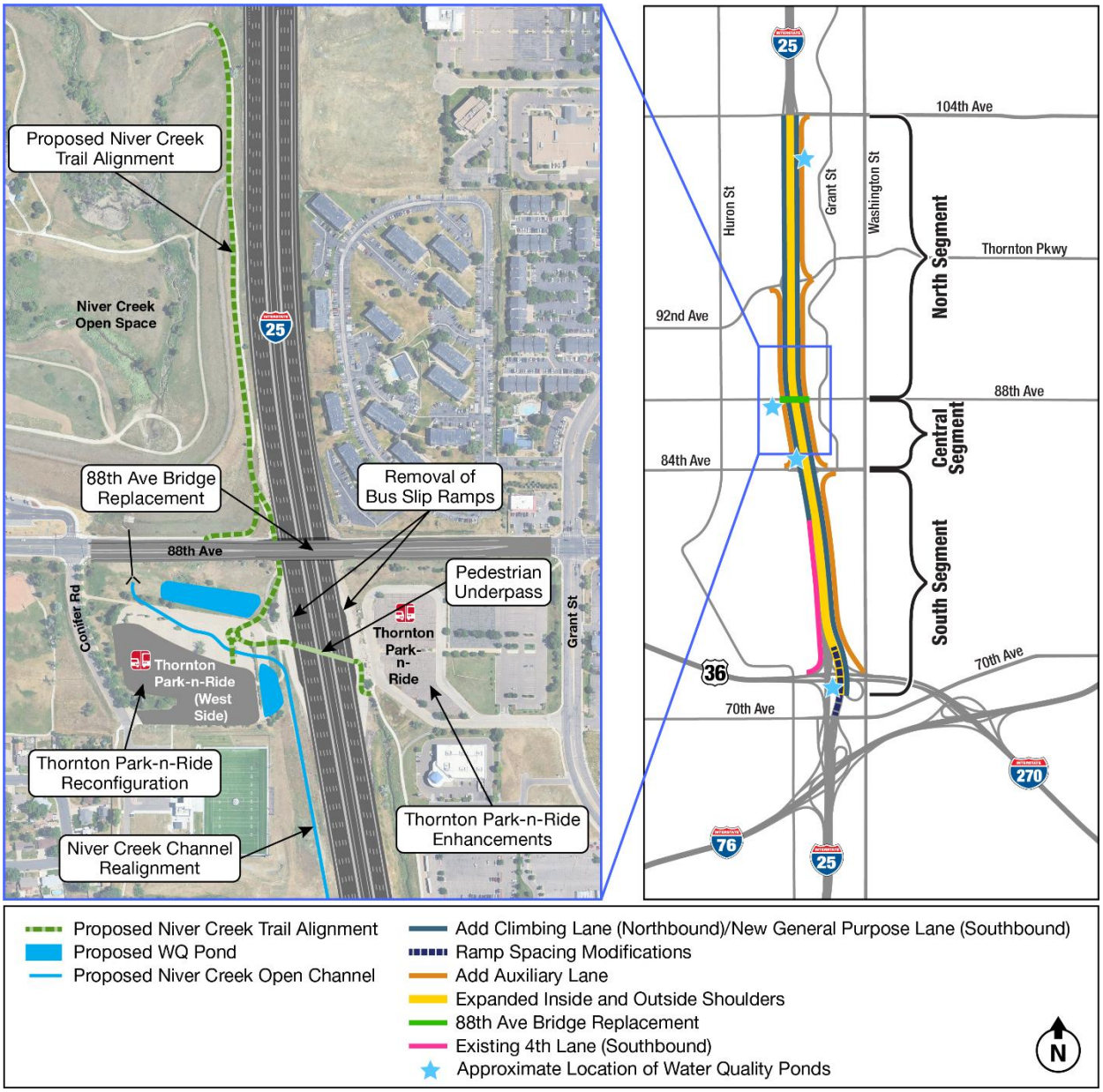


Figure 3. Proposed Improvements to I-270 Exit to NB I-25

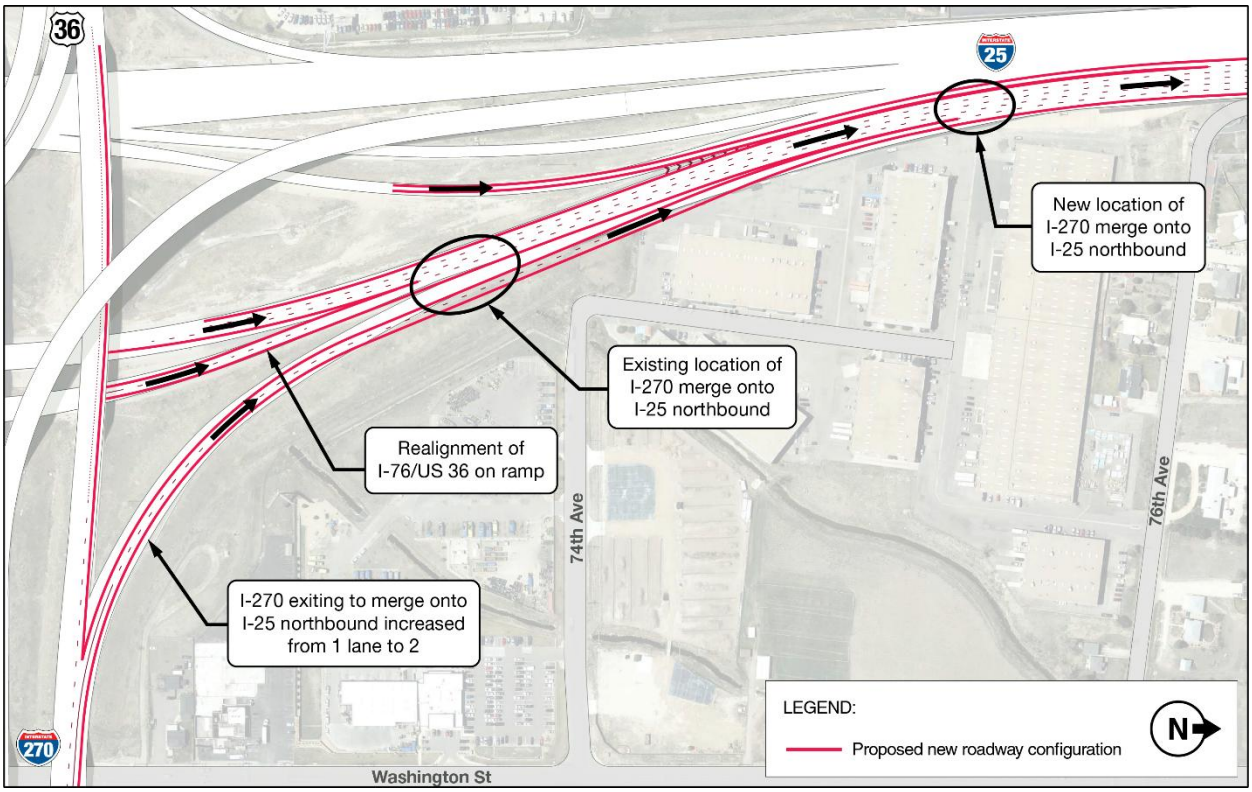
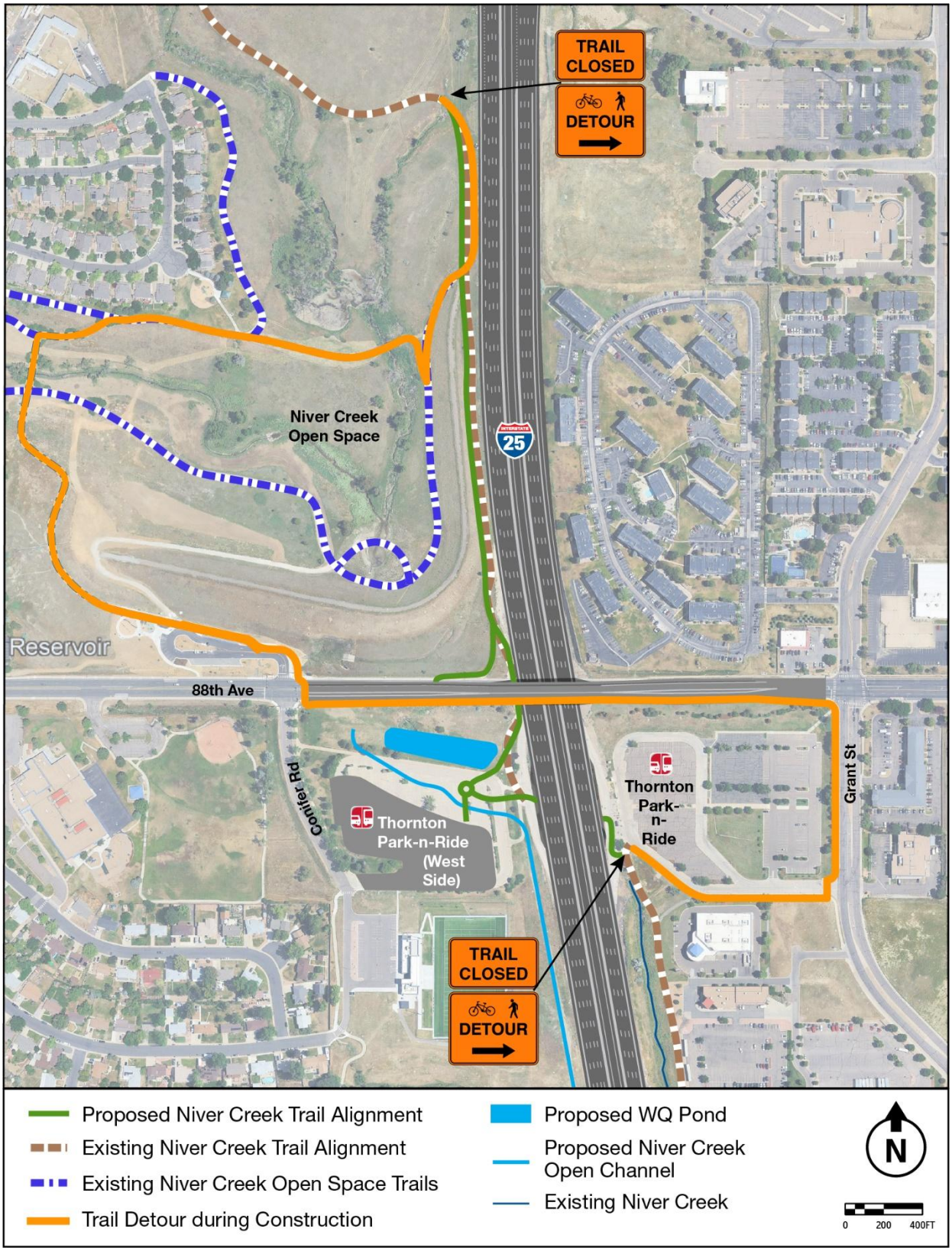


Figure 4. Proposed Realignment of Niver Creek Trail



Attachment B.

Greenhouse Gas Analysis Work Plan

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Greenhouse Gas Analysis: Work Plan

July 18, 2025
Project Number: PM 0253-299
Subaccount Number: 25563

Table of Contents

Page No.

Acronyms and Abbreviations ..... B-ii

1.0 Introduction and Background B-1

2.0 Regulatory Setting B-2

3.0 Methodology for Quantitative GHG Analysis B-3
3.1 Operational Emissions B-3
3.1.1 MOVES Runs – Overview of Approach B-4
3.1.2 MOVES Run Specification Inputs B-5
3.1.3 MOVES Project Data Manager Inputs B-5
3.1.4 Calculation of Project-Level Emissions B-7
3.2 Construction and Maintenance Emissions B-8
3.3 Upstream Emissions from Vehicle Operation B-8
3.4 Life Cycle Assessment of GHGs and Social Cost of Carbon B-9

4.0 Reporting B-10

5.0 References B-11

Tables

Table 1. Time periods for traffic and emissions modeling B-4

Table 2. MOVES RunSpec options B-4

Table 3. MOVES Project Data Manager inputs B-5

Acronyms and Abbreviations

Acronym	Definition
APCD	Air Pollution Control Division
AQ-PLAG	Air Quality Project-Level Analysis Guidance
ATR	Automated Traffic Recorder
AVFT	Alternate Vehicle Fuel and Technology
CDOT	Colorado Department of Transportation
CH_4	methane
CO_2	carbon dioxide
CO_2e	CO_2-equivalent
C.R.S	Colorado Revised Statutes
DRCOG	Denver Regional Council of Governments
EF	emission factor
EPA	U.S. Environmental Protection Agency
EPB	Environmental Program Branch
FHWA	Federal Highway Administration
GHG	greenhouse gas
GREET	Greenhouse Gas and Regulated Emissions and Energy use in Transportation model
HPMS	Highway Performance Monitoring System
I-25	Interstate 25
I-270	Interstate 270
I/M	inspection and maintenance
ICE	Infrastructure Carbon Estimator
LCA	life cycle assessment
MOVES	Motor Vehicle Emissions Simulator
mph	miles per hour
MPO	metropolitan planning organization
N_2O	nitrous oxide
NEPA	National Environmental Policy Act
OTIS	Online Transportation Information System
RS/TC	Regionally Significant Transportation Capacity
RTD	Regional Transportation District
RunSpecs	run specifications
SB	Senate Bill
TDM	travel demand model
TP	time period
US 36	U.S. Highway 36
V/C	volume to capacity
VMT	vehicle miles traveled
ZEV	zero emission vehicle

1.0 Introduction and Background

The Colorado Department of Transportation (CDOT) and Federal Highway Administration (FHWA) are proposing transportation improvements to Interstate 25 (I-25) from U.S. Highway 36 (US 36) to 104th Avenue (the Project).[1] This document presents the work plan for the proposed analysis of greenhouse gas (GHG) impacts from the Project. The analysis is based on the latest planning assumptions for the Project. The scope was developed through consultation with CDOT Environmental Program Branch (EPB) Air Quality and Greenhouse Gas Specialists.[2] A separate workplan covers the air quality analysis proposed for the Project under Federal and State air quality analysis requirements.

The overall proposed GHG analysis described in this work plan covers state requirements (described in **Section 2.0**) for evaluating GHG impacts and includes the analysis elements summarized below.

A quantitative analysis of GHG emissions based on a life cycle assessment (LCA) approach and the social cost of carbon related to GHG emissions over the lifetime of the Project will be conducted to account for energy use and GHG emissions associated with (1) construction and maintenance of the Project, and (2) cumulative operational GHG emissions based on annual emissions from the start of construction (2027) through the horizon year (2050). An interim analysis year of 2040 was also selected for interpolation of GHG emissions across the project years and will be modeled to better reflect substantial changes in climate pollutant emissions from the modeled vehicle fleet that are expected to occur between the opening and horizon years. The social cost of carbon calculation will be conducted with a discount rate of 2.5% per the requirements of Senate Bill (SB) 21-260 (CDOT 2023a), as well as three other discount rates (5%, 3%, and 3% at the 95th percentile) to ensure a comprehensive analysis.

The remainder of this work plan provides a brief overview of the regulatory context for the analysis of the Project's GHG impacts (**Section 2.0**); describes the methods to be used for each element of the analysis and relevant state guidance that will be followed (**Section 3.0**); and discusses plans for technical reporting of the analysis (**Section 4.0**).

[1] The purpose of the Project is to improve I-25 between US 36 and 104th Avenue to address traffic and transit operations, and safety concerns.
[2] Pre-scoping and scoping meetings were held on January 23 and February 14, 2024.

2.0 Regulatory Setting

The purpose of the GHG analysis is to evaluate potential impacts associated with the Project in accordance with applicable state requirements and guidance. These are described in the subsections below and include the following.

- Colorado Revised Statutes (C.R.S.) 43-1-128(4)(a) for this project analysis.
- CDOT Interim Guidance for Project Level Compliance of CRS 43-1-128 (National Environmental Policy Act [NEPA] and Construction) DRAFT (CDOT 2023)
- CDOT Regionally Significant and Transportation Capacity Interpretation and Examples for CDOT Projects (CDOT 2022a)

C.R.S. 43-1-128 requires an enhanced level of modeling and analysis of GHG emissions from regionally significant transportation capacity (RS/TC) projects. The Project is considered regionally significant by the Denver Regional Council of Governments (DRCOG)[3] and is considered a planned RS/TC project for CDOT purposes, as it is contained in the CDOT 10-year plan (CDOT 2022b). The RS/TC determination for the Project is based on the following definition in CDOT guidance (CDOT 2022a): "A roadway-widening project (via construction or restriping) adding at least one General Purpose through lane of one lane-mile or more in length (or two miles in length if in a Rural area with a [volume to capacity] V/C ratio less than 85%)."

To meet the state requirements, GHG emissions will be quantified over the Project lifetime for the No Action Alternative and the Proposed Action. The Project lifetime is defined as the period beginning with the commencement of construction through the project horizon year (2050). The GHGs from on-road mobile sources that will be quantified in the analysis include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and CO_2-equivalent (CO_2e). Emissions of these GHGs will be analyzed from the perspective of an LCA. The LCA analysis provides an estimate of cumulative CO_2e emissions over the lifetime of the Project, including (1) operational emissions of vehicles traveling on the Project once opened, (2) emissions from the upstream creation of fuel for those vehicles, and (3) construction and maintenance for the Project. The social cost of carbon due to GHG emissions from the Project will also be calculated consistent with state requirements.

[3] DRCOG is the federally designated metropolitan planning organization (MPO) responsible for transportation planning for the Denver metropolitan region, where the Project is located.

3.0 Methodology for Quantitative GHG Analysis

The methodology for the proposed analysis will be conducted in accordance with all applicable state regulations, and it will be based upon guidance from the U.S. Environmental Protection Agency (EPA) and CDOT. The following relevant guidance will be applied to the methodology for each element of the proposed analysis, where appropriate, as described in this section of the work plan and agreed upon by CDOT and FHWA:

- **NEPA Manual, Version 7** (CDOT 2023a)
- **Interim Guidance for Project Level Compliance of CRS 43-1-128 (NEPA and Construction)** DRAFT (CDOT 2023b)
- **Air Quality Project-Level Analysis Guidance (AQ-PLAG), Version 1** (CDOT 2019)
- **MOVES4 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity** (EPA 2023)
- **MOVES Greenhouse Gas Guidance: Using MOVES for Estimating State and Local Inventories of Onroad Greenhouse Gas Emissions and Energy Consumption** (EPA 2024)

3.1 Operational Emissions

For the proposed quantitative project-level analysis of GHG emissions from vehicle operation, a lookup table of emission factors (EFs) for all GHGs listed in **Section 2.0** will be generated for each analysis year by running the most recent version of EPA's Motor Vehicle Emissions Simulator (MOVES) available when this work plan was developed (i.e., MOVES4.0.2).[4] The lookup table, along with the underlying MOVES input/output files, will be provided to CDOT for review before the data are used in calculating project-level emissions for the analysis. For each analysis scenario (i.e., a baseline year of 2024, No Action Alternative in 2030, Proposed Action in 2030, No Action Alternative in 2040, Proposed Action in 2040, No Action Alternative in 2050, and Proposed Action in 2050), EFs from the lookup table will be combined with the link-level travel activity (traffic) and roadway type data provided by CDOT to calculate the link-level emissions, which will be aggregated to the Project level for each pollutant. The traffic data prepared by CDOT will be based on travel demand model (TDM) results for the proposed operational emissions analysis using DRCOG's Focus 2.3.3 model. The methodology details for this process are described below.

Lifetime operational emissions will be estimated as a sum of annual emissions in the year that construction begins through the horizon year (2050). The emissions for each year during the lifetime of the Project (from the commencement of construction through 2050) that are not modeled explicitly with MOVES will be interpolated between the modeled analysis years: (1) the baseline year of 2024 and the interim year of 2030 will be used to interpolate annual emissions in the year that construction begins through 2029; (2) the interim years of 2030 and 2040 will be used to interpolate annual emissions in 2031 through 2039; and (3) the interim

[4] Note that using MOVES to generate a project-scale lookup table of EFs eliminates the need to use project-specific traffic data as part of the MOVES inputs and adds flexibility to the analysis. If traffic data change or new links are later added to the analysis, updated emissions can be calculated without needing to revise MOVES inputs and re-run the MOVES model.

year of 2040 and horizon year of 2050 will be used to interpolate annual emissions in 2041 through 2049.

3.1.1 MOVES Runs – Overview of Approach

MOVES will be run with the Project Scale setting to estimate running exhaust and crankcase running exhaust emissions for all pollutants. The MOVES runs will produce EFs for the lookup table. Data for Links input for MOVES will be developed based on hypothetical link-level traffic and roadway data that will cover the range of actual link-level traffic for all analysis scenarios. Inputs to prepare Link Source Types inputs for MOVES will be provided by CDOT.

Mainline and ramp roadway segments will be modeled as urban restricted roadways. A series of hypothetical links with traffic volume of 1 vehicle per hour traveling one mile will be created, with average vehicle speed ranging from 0 to 75 miles per hour (mph) in 1 mph speed bins. Modeling a single road grade of 0% in MOVES is consistent with normal practices for comparative project-level emissions analysis. EFs will be developed for both passenger ("non-truck") vehicle and truck vehicle categories, with appropriate mapping of MOVES source types to non-truck and truck categories based on the best available data available when the modeling begins.[5]

For the proposed analysis, the winter season (represented by the month of January) and summer season (represented by July) will be modeled using appropriate fuels inputs for each season, including updated Alternate Vehicle Fuel and Technology (AVFT) fuels inputs recommended by CDOT. This seasonal approach allows the modeling analysis to capture representative annual conditions.

EFs from the lookup table will be applied (outside of MOVES) to Project-specific link-level traffic data in order to calculate link-level emissions, which will be aggregated to the project level, for each inventory analysis scenario. The EFs in the lookup table by vehicle type and speed will be applied to the link-level traffic data to calculate the emissions for each link by traffic time period. The traffic data are anticipated to vary across the four time periods during the day (AM Peak, Midday, PM Peak, and Evening) summarized in **Table 1**, consistent with CDOT's intended use of default time periods in the Focus 2.3.3 TDM.

Table 1. Time periods for traffic and emissions modeling

Time Period	Hours
AM Peak	6 AM – 9 AM
Midday	9 AM – 3 PM
PM Peak	3 PM – 7 PM
Evening	7 PM – 6 AM

[5] The timing for MOVES modeling may be considered as independent of the travel demand modeling and availability of traffic data for any of the proposed analysis scenarios. The lookup table of EFs developed with the MOVES outputs will be combined in post-processing with traffic data, when available, for the analyses.

3.1.2 MOVES Run Specification Inputs

MOVES run specifications (RunSpecs) will be created to specify the parameter options for the MOVES model. **Table 2** summarizes the MOVES inputs for the RunSpecs as defined in the navigation panel of the MOVES interface. The following subsections describe the input options needed for the RunSpecs.

Table 2. MOVES RunSpec options

Navigation Panel	Model Selection
Scale	Project scale; inventory calculation type
Time Spans	Hour; weekdays; January/July; calendar years 2024, 2030, 2040 and 2050
Geographic Bounds	Adams County
Vehicles	All MOVES4 vehicle and fuel type combinations
Road Types	Urban restricted access
Pollutants and Processes	GHGs listed in Section 2.0; running exhaust and crankcase running exhaust (all GHGs)
General Output	Units of grams and miles
Output Emissions Detail	Road type

3.1.3 MOVES Project Data Manager Inputs

After the RunSpecs are created, an input database table must be created before running MOVES. This is done using the Project Data Manager to enter project-specific data. **Table 3** summarizes the MOVES Project Data Manager inputs, and they are discussed in more detail below.

Table 3. MOVES Project Data Manager inputs

Project Data Manager Tab	Data Source
Meteorology Data	Provided by CDOT
Age Distribution	Provided by the Air Pollution Control Division (APCD)
Fuel	Fuel Supply, Fuel Formulation and Fuel Usage Fraction inputs provided by APCD; and AVFT[1] data provided by CDOT
Retrofit	No inputs (not applicable)
Inspection and Maintenance (I/M) Program	Provided by APCD
Link Source Type	Generated by the Air Quality Consultant (Sonoma Technology [now Spheros Environmental]) using data provided by CDOT[2]
Links	Generated by the Air Quality Consultant (Sonoma Technology [now Spheros Environmental])

[1] AVFT = Alternate Vehicle Fuel and Technology
[2] CDOT will provide data based on Automated Traffic Recorder (ATR) stations relevant to the roadways included in the emissions analysis.

Meteorology Data

The meteorology data for this analysis will be provided by CDOT in coordination with APCD, as needed, and will be consistent with those used in the regional emissions analysis for transportation conformity. The relevant data provided by CDOT for each modeled season will

be used to calculate average temperature and humidity for each traffic time period in the two seasons.

Vehicle Age Distribution

The vehicle age distribution input for the modeling, which will be provided by APCD, is expected to be based on their latest available composite of vehicle registration data from seven Denver area counties (Adams, Arapaho, Boulder, Broomfield, Denver, Douglas, and Jefferson). These data will be used to represent the age distribution in the MOVES analysis years (2024, 2030, 2040, and 2050).

Fuel

Fuels inputs provided by APCD will be used with the addition of AVFT data provided by CDOT to reflect the future zero emission vehicle (ZEV) fleet resulting from the state's adoption of the Colorado Clean Cars and Advanced Clean Trucks rules that can be accounted for in MOVES4.

Inspection and Maintenance Parameters

Existing and anticipated future vehicle I/M program parameters for the Denver metropolitan area will be provided by APCD.

Link Source Type

Link source type inputs are used to define the fraction of travel on each link by vehicle type. Two separate sets of MOVES runs will be conducted: one for light-duty vehicles and one for (heavy-duty) trucks. Three sets of link source type inputs will be needed for these MOVES runs: one set with fractions for the four types of MOVES light-duty vehicles (MOVES sourcetypes 11, 21, 31, and 32), and one set with fractions for the nine types of heavy-duty vehicles (MOVES sourcetypes 51, 52, 53, 54, 61, and 62), and one set with fractions for buses (MOVES sourcetypes 41, 42, and 43), assuming travel activity for the listed bus sourcetypes are available for the analyses.[6]

The third set of link source type fractions will be developed to represent the vehicle mix on managed lanes in the Proposed Action, including buses using the managed lanes, in addition to light-duty vehicle activity on managed lanes.[7] The number of buses will be added in based on the Regional Transportation District (RTD) and CDOT Bustang schedules to estimate total volumes for the corridor, and not subtracted from some other category (e.g., single-unit trucks) to conserve total modeled traffic volumes. Current RTD and Bustang schedules will be used to estimate daily transit bus volumes in the managed lanes, and DRCOG modeling will provide passenger vehicle volumes in the managed lanes. Regional DRCOG vehicle population data will be used to disaggregate the passenger vehicle volumes into MOVES passenger vehicle

[6] Note that the MOVES sourcetype 41 represents all buses that are not transit buses, represented by sourcetype ID 42, or school buses, represented by sourcetype 43.
[7] It is assumed that MOVES input data and traffic activity data for buses will be provided by CDOT for this modeling.

sourcetypes; these subtotals and the estimated bus volumes will be used to develop the linksourcetype fractions. This approach will assume that no trucks use the managed lanes.

Link source type inputs for the three groups of vehicles (i.e., light-duty, trucks, and vehicles using the managed lanes) will be developed using ATR data by each class defined in the Highway Performance Monitoring System (HPMS) for representative freeway segments. CDOT will select continuous count ATR stations within the TDM validation boundary based on roadways that will be included in the emissions quantification to provide input data needed for the MOVES modeling.[8] Along with MOVES default estimates by vehicle miles traveled (VMT) and source type, vehicle population data provided by CDOT will also be used for developing the link source type inputs.

Links

A links input table will be created that represents all possible speeds on the urban restricted road type to generate the lookup table of EFs applicable to any traffic link in the analysis scenarios.

3.1.4 Calculation of Project-Level Emissions

The project-level emissions for each pollutant and season in each inventory analysis scenario will be calculated from the link-level traffic data for each scenario and appropriate EFs from the lookup table developed using MOVES. The calculation will be performed as follows. First, the link-level emissions will be calculated for each traffic time period (TP) as the product (multiplication) of VMT by all vehicles, number of hours, and applicable fleet-average total EF based on the fleet mix (i.e., fraction of passenger and truck vehicles) and average speed in each traffic time period:

$$E_{link}^{TP} = VMT_{link}^{TP} \times hrs \times \left(f_t^{TP} \times EF_t(v^{TP}) + (1 - f_t^{TP}) \times EF_{pass}(v^{TP})\right) \quad \textbf{Equation 1}$$

where

$$E_{link}^{TP} = link - level\ emissions\ for\ a\ single\ time\ period\ (TP)$$
$$VMT_{link}^{TP} = L_{link} \times V_{tot}^{TP}$$
$$L_{link} = link\ length\ (miles)$$
$$V_{tot}^{TP} = V_{pass}^{TP} + V_t^{TP} = total\ vehicle\ volume\ in\ the\ TP$$
$$V_{pass}^{TP} = passenger\ vehicle\ volume\ in\ the\ TP$$
$$V_t^{TP} = truck\ vehicle\ volume\ in\ the\ TP$$
$$hrs = number\ of\ hours\ in\ the\ TP$$
$$f_t^{TP} = \frac{V_t^{TP}}{V_{tot}^{TP}} = truck\ fraction\ of\ V_{tot}^{TP}$$
$$EF_t(v^{TP}) = EF\ for\ truck\ vehicles\ as\ a\ function\ of\ average\ speed, v, for\ the\ TP\ (g/mile)$$
$$EF_{pass}(v^{TP}) = EF\ for\ passenger\ vehicles\ as\ a\ function\ of\ speed, v, for\ the\ TP\ (g/mile)$$

[8] The two continuous count locations from the CDOT Online Transportation Information System (OTIS) to be used include (1) Station #101018: on I-25 N/O SH 36; and (2) Station #000507: on I-270 SE/O York St. Post-COVID19 pandemic data will be used.

Note that the EFs by vehicle type and speed in **Equation 1** represent the sum over the emission processes modeled in MOVES (i.e., running exhaust and crankcase running exhaust for all GHGs). For each traffic link, the average speed for each time period will be used as key to identify the applicable EFs for passenger and truck vehicles in the lookup table. As the Project traffic volumes represent annual average volumes, CDOT monthly ATR summary data will be used to develop seasonal traffic adjustments.

For each scenario, after the link-level emissions by time period for each link have been calculated, the total link-level emissions will be calculated as the summation of **Equation 1** over all time periods. Finally, the project-level emissions will be calculated by summing the total link-level emission for each link over all links in the traffic data. The project-level emissions inventories for GHGs will be reported in appropriate mass units per day.

3.2 Construction and Maintenance Emissions

In addition to the operational quantitative GHG emissions inventories for the analysis described in Section 3.1, the GHG emissions associated with construction and maintenance activities of the Proposed Action will be estimated and compared to estimated maintenance emissions for the No Action Alternative. These emissions will be calculated using the most recent version of FHWA's Infrastructure Carbon Estimator (ICE) tool when the work begins (version 2.2.8 is the latest version available when this work plan was prepared). ICE applies an LCA approach to account for energy use and emissions associated with the construction and maintenance of transportation infrastructure, including fuel used by equipment during construction, maintenance, and rehabilitation activities, as well as emissions from the production and transportation of construction materials, and emissions associated with traffic delay during construction and facility use.

Construction emissions for the Proposed Action will be estimated based on the expected period of time for construction from 2027 through 2029. Maintenance emissions for the No Action alternative will be modeled for 2027 through 2050; maintenance emissions for the Proposed Action, which includes more infrastructure than No Action, will be estimated over the time period from 2030 (project opening) through 2050, with No Action maintenance emissions estimates used for 2027 through 2029. Construction and maintenance emissions by year over these respective time periods will be included in the lifetime cumulative emissions analysis for the No Action and Proposed Alternative.

3.3 Upstream Emissions from Vehicle Operation

Upstream emissions from vehicle operation reflect "well-to-pump" emissions, or the emissions associated with producing the petroleum fuels or generating the electricity consumed by the vehicles using the Project. CDOT has developed a methodology for estimating these emissions as a function of VMT. For petroleum fuels (gasoline and diesel fuel), CDOT uses projections of fuel sales along with upstream emissions factors from the U.S. Department of Energy's Greenhouse Gas and Regulated Emissions and Energy use in Transportation (GREET) model to estimate upstream emissions per year. To estimate

electrical grid emissions from electricity consumed by electric vehicles, CDOT uses a detailed methodology that accounts for changes in electric vehicle usage, vehicle efficiency, and changes in the mix of sources powering the electrical grid to estimate upstream electricity-related emissions per year. Then, CDOT projections of VMT are used to calculate annual upstream emissions rates in units of kg CO_2e per mile driven. CDOT's kg CO_2e/mile emissions factors will be combined with annual VMT from the No Action and Proposed Action alternatives to estimate upstream emissions associated with those alternatives.

3.4 Life Cycle Assessment of GHGs and Social Cost of Carbon

This quantitative analysis represents a partial LCA approach using MOVES (operational emissions), ICE (construction and maintenance emissions), and CDOT's kg CO_2e/mile emissions factors (upstream fuel production emissions). This LCA approach accounts for materials/fuel production (extraction, processing, manufacturing), construction (equipment operation, materials transport), operation (vehicle fuel consumption, pavement-vehicle interaction), and maintenance (road repair/rehabilitation, equipment operation). The cumulative operational GHG emissions will be estimated by using the MOVES-based emissions in the first year of construction (2027) through the horizon year (2050), which represents the project lifetime. Annual emissions during the project lifetime will be based on emissions modeled directly with MOVES for the baseline year, 2030, 2040, and 2050, and subsequently interpolated emissions between those years. The interpolation between the modeled years will be based on trends generated by MOVES using vehicle age distributions and the AVFT table provided by CDOT (see Section 3.1). The interpolation between years modeled with MOVES will provide greater time-resolution of the rapidly changing vehicle fleet and its annual emissions for analysis years between the modeled years. The cumulative lifetime GHG emissions from the Project will then be calculated as the sum of:

- Estimated annual operational emissions from the year construction commences through the horizon year;
- Estimated upstream fuel creation GHG emissions from creation of the fuel used by the vehicles traveling on the Project;
- Estimated annual construction emissions from the year construction commences through the year construction is completed; and
- Estimated annual maintenance emissions from the year construction commences through the horizon year

Cumulative GHG emissions will be reported as CO_2e. The social cost of carbon from the Project will be calculated using the estimated cumulative Project lifetime GHG emissions and dollar values per metric ton of GHG at a discount rate of 2.5%, as well as 5%, 3%, and 3% at the 95th percentile.

4.0 Reporting

After completion of the proposed GHG analysis described in this work plan, a GHG technical report will be prepared to document the results, along with the analysis methodology, input data, and key assumptions used for each element of the analysis in coordination with CDOT. The reports will include a discussion of the relevant regulations, air pollutants, and climate-related concerns, as well as potential avoidance, minimization, and control strategies. Some aspects of the report, such as any control strategy commitments for the Project, will require contributions from CDOT or other consultants.

5.0 References

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Attachment C.

Greenhouse Gas Operational Emissions Analysis Methods

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This attachment describes the approach for modeling operational emissions from motor vehicles using the Mobile Source Vehicle Emissions Simulator (MOVES) model and development of the quantitative emissions inventory for the Project. This process involves setting up a run specification for the MOVES model, entering Project data using a MOVES tool called the Project Data Manager, running MOVES, exporting the results as an emissions lookup table, and then using Project traffic data combined with the lookup table to calculate operating emissions for each year and project alternative. These steps are described in more detail below.

1.0 Traffic Data

As described in the Traffic and Safety Technical Report for the Project, the project team selected the Denver Regional Council of Governments (DRCOG) Focus version 2.3.3 travel demand model (TDM) for the I-25 traffic analysis. This TDM provides accurate traffic forecasts and detailed simulations and meets the technical requirements established by the Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA). The analysis uses the 2024 base year and 2050 horizon year TDM results for the existing and future traffic condition analyses.

The emissions inventories were developed using lookup tables of emission factors by vehicle type, road type, speed, and traffic time period (described below), and estimates of vehicle miles traveled (VMT) and speeds by vehicle type from the traffic data. The traffic data provide estimates of traffic volume and speed for each modeled roadway segment (link); the traffic volume was combined with the length of each link in miles to estimate VMT. These calculations were performed separately for cars and trucks, as data for these two vehicle types are included in the traffic data.

The emissions inventory includes all Project links and additional roadway links where traffic is affected by the Project. These additional "non-project" links were identified using the criteria contained in FHWA's Mobile Source Air Toxics Frequently Asked Questions,[1] which provides the only available recommendations for identifying links affected by a highway project. FHWA provides several impact criteria that can be considered, including AADT, level of service (LOS), travel time, and intersection delay, but does not specify a distance from project roadways for consideration of impacts. The following streamlined criterion was applied: *A change in AADT of +/- 5% or more for links within a 100-m boundary around the project links*. This criterion was recommended by FHWA and endorsed by CDOT.

This criterion was applied to all roadway links in the traffic modeling for analysis year 2050 to identify the non-project links to be included in the emissions inventory analysis. The final set of project and non-project links included in the emissions inventory analysis are shown in Table 1 (Existing Conditions), Table 2 (No Action Alternative), and Table 3 (Build Alternative).

Table 1. Roadway links included in the GHG analysis for Existing Conditions

Link Description	Link ID	Road Type
SB I-25 GP Mainline	10043	Freeway
SB I-25 Off-Ramp to I-270	10049	Freeway Ramp
SB I-25 Off-Ramp to 76	10051	System Ramp
SB I-25 GP Mainline	10052	Freeway
NB I-25 GP Mainline	10054	Freeway

[1] Frequently Asked Questions (FAQs): FHWA Recommendations for Conducting Quantitative Mobile Source Air Toxics (MSAT) Analysis for FHWA NEPA Documents, https://www.fhwa.dot.gov/environMent/air_quality/air_toxics/policy_and_guidance/msat/fhwa_nepa_msat_faq_moves3_.pdf

Link Description	Link ID	Road Type
NB I-25 GP Mainline	10055	Freeway
SB I-25 GP Mainline	10479	Freeway
SB I-25 Off-Ramp to Thornton Pkwy	10480	Freeway Ramp
SB I-25 GP Mainline	10481	Freeway
SB I-25 GP Mainline	10482	Freeway
SB I-25 Off-Ramp to 84th Ave	10483	Freeway Ramp
SB I-25 GP Mainline	10484	Freeway
NB I-25 GP Mainline	10485	Freeway
NB I-25 GP Mainline	10486	Freeway
NB I-25 Off-Ramp to 84th Ave	10487	Freeway Ramp
NB I-25 GP Mainline	10488	Freeway
NB I-25 GP Mainline	10489	Freeway
NB I-25 Off-Ramp to Thornton Pkwy	10490	Freeway Ramp
84th Ave Ramp to SB I-25	10496	Freeway Ramp
WB 84th Ave Ramp to NB I-25	10498	Freeway Ramp
Thornton Pkwy Ramp to SB I-25	10579	Freeway Ramp
WB Thornton Pkwy Ramp to NB I-25	10581	Freeway Ramp
SB I-25 GP Mainline	10831	Freeway
SB I-25 GP Mainline	10832	Freeway
SB I-25 Off-Ramp to 104th Ave	10833	Freeway Ramp
NB I-25 GP Mainline	10837	Freeway
NB I-25 Off-Ramp to 104th Ave	10838	Freeway Ramp
104th Ave Ramp to SB I-25	10850	Freeway Ramp
WB 104th Ave Ramp to NB I-25	10856	Freeway Ramp
NB I-25 EL	25269	Managed Lane
SB I-25 EL	25270	Managed Lane
SB I-25 EL	25272	Managed Lane
NB I-25 EL	25594	Managed Lane
NB I-25 GP Mainline	25596	Freeway
WB I-270 Ramp to NB I-25	25600	System Ramp
EB I-270 ramp to NB I-25	25602	System Ramp
SB I-25 EL	25603	Managed Lane
SB I-25 GP Mainline	28292	Freeway
SB I-25 Off-Ramp to I-270	28293	System Ramp
NB I-25 EL	28580	Managed Lane
NB I-25 GP Mainline	28709	Freeway
EB I-76 Ramp to NB I-25	28749	System Ramp
I-270 WB Off-Ramp to N Broadway	28755	Freeway Ramp
WB 76 Off-Ramp to NB I-25	29045	System Ramp
NB I-25 Off-Ramp to CO 224	29053	Freeway Ramp
NB I-25 Off-Ramp to 84th Ave	29331	Freeway Ramp
NB I-25 Off-Ramp to 84th Ave	29332	Freeway Ramp
WB 84th Ave Ramp to NB I-25	29334	Freeway Ramp
WB 84th Ave Ramp to NB I-25	29335	Freeway Ramp

Link Description	Link ID	Road Type
SB I-25 Off-Ramp to 84th Ave	29336	Freeway Ramp
SB I-25 Off-Ramp to 84th Ave	29337	Freeway Ramp
84th Ave Ramp to SB I-25	29338	Freeway Ramp
84th Ave Ramp to SB I-25	29339	Freeway Ramp
NB I-25 Off-Ramp to 104th Ave	29340	Freeway Ramp
NB I-25 Off-Ramp to 104th Ave	29342	Freeway Ramp
WB 104th Ave Ramp to NB I-25	29343	Freeway Ramp
WB 104th Ave Ramp to NB I-25	29344	Freeway Ramp
104th Ave Ramp to SB I-25	29346	Freeway Ramp
104th Ave Ramp to SB I-25	29347	Freeway Ramp
SB I-25 Off-Ramp to 104th Ave	29348	Freeway Ramp
SB I-25 Off-Ramp to 104th Ave	29349	Freeway Ramp
SB I-25 GP Mainline	32951	Freeway
NB I-25 EL	40854	Managed Lane
SB I-25 EL	42615	Managed Lane
SB I-25 EL	42619	Managed Lane
NB I-25 EL	42620	Managed Lane
NB I-25 EL	43076	Managed Lane
SB I-25 EL	43077	Managed Lane
SB I-25 EL	43078	Managed Lane
NB I-25 EL	43620	Managed Lane
NB I-25 GP Mainline	43621	Freeway
NB I-25 EL	43622	Managed Lane
NB I-25 EL	43623	Managed Lane
NB I-25 GP Mainline	43624	Freeway
NB I-25 EL	43625	Managed Lane
NB I-25 GP Mainline	43626	Freeway
NB I-25 EL	43627	Managed Lane
NB I-25 EL	43628	Managed Lane
NB I-25 GP Mainline	43629	Freeway
NB I-25 EL	43631	Managed Lane
SB I-25 EL	43634	Managed Lane
NB I-25 GP Mainline	43650	Freeway
SB I-25 EL	43652	Managed Lane
SB I-25 Off-Ramp to I-270	43653	System Ramp
SB I-25 EL	43654	Managed Lane
SB I-25 GP Mainline	43655	Freeway
SB I-25 EL	43656	Managed Lane
SB I-25 GP Mainline	43657	Freeway
SB I-25 EL	43659	Managed Lane
SB I-25 GP Mainline	43660	Freeway
SB I-25 EL	43661	Managed Lane
SB I-25 EL	43662	Managed Lane
SB I-25 GP Mainline	43663	Freeway

Link Description	Link ID	Road Type
SB I-25 EL	43665	Managed Lane
SB I-25 GP Mainline	43666	Freeway
SB I-25 GP Mainline	43667	Freeway
SB I-25 EL	43670	Managed Lane
SB I-25 EL	43671	Managed Lane
SB I-25 EL	43672	Managed Lane
NB I-25 EL	43734	Managed Lane
NB I-25 GP Mainline	43735	Freeway
NB I-25 EL	44007	Managed Lane
SB I-25 EL	44009	Managed Lane
NB I-25 GP Mainline	44036	Freeway
NB I-25 EL	44037	Managed Lane
SB I-25 GP Mainline	44038	Freeway
SB I-25 EL	44039	Managed Lane
NB I-25 GP Mainline	44040	Freeway
NB I-25 EL	44041	Managed Lane
NB I-25 GP Mainline	44042	Freeway
NB I-25 EL	44043	Managed Lane
SB I-25 GP Mainline	44044	Freeway
SB I-25 EL	44045	Managed Lane

Table 2. Roadway links included in the GHG analysis for the No Action Alternative

Link Description	Link ID	Road Type
SB I-25 GP Mainline	10043	Freeway
SB I-25 GP Mainline	10048	Freeway
SB I-25 Off-Ramp to I-76	10051	System Ramp
SB I-25 GP Mainline	10052	Freeway
NB I-25 GP Mainline	10054	Freeway
NB I-25 GP Mainline	10055	Freeway
SB I-25 GP Mainline	10479	Freeway
SB I-25 Off-Ramp to Thornton Pkwy	10480	Freeway Ramp
SB I-25 GP Mainline	10481	Freeway
SB I-25 GP Mainline	10482	Freeway
SB I-25 Off-Ramp to 84th Ave	10483	Freeway Ramp
SB I-25 GP Mainline	10484	Freeway
NB I-25 GP Mainline	10485	Freeway
NB I-25 GP Mainline	10486	Freeway
NB I-25 Off-Ramp to 84th Ave	10487	Freeway Ramp
NB I-25 GP Mainline	10488	Freeway
NB I-25 GP Mainline	10489	Freeway
NB I-25 Off-Ramp to Thornton Pkwy	10490	Freeway Ramp
84th Ave Ramp to SB I-25	10496	Freeway Ramp
WB 84th Ave Ramp to NB I-25	10498	Freeway Ramp
Thornton Pkwy Ramp to SB I-25	10579	Freeway Ramp
WB Thornton Pkwy Ramp to NB I-25	10581	Freeway Ramp
SB I-25 GP Mainline	10831	Freeway
SB I-25 GP Mainline	10832	Freeway
SB I-25 Off-Ramp to 104th Ave	10833	Freeway Ramp
NB I-25 GP Mainline	10837	Freeway
NB I-25 Off-Ramp to 104th Ave	10838	Freeway Ramp
104th Ave Ramp to SB I-25	10850	Freeway Ramp
WB 104th Ave Ramp to NB I-25	10856	Freeway Ramp
NB I-25 EL Off-Ramp to CO 224	25269	Managed Lane
CO 224 On-Ramp to SB I-25 EL	25270	Managed Lane
SB I-25 EL	25272	Managed Lane
SB I-25 EL	25594	Managed Lane
NB I-25 GP Mainline	25596	Freeway
WB I-270 Ramp to NB I-25	25600	System Ramp
EB US 36 Ramp to NB I-25	25602	System Ramp
SB I-25 EL	25603	Managed Lane
SB I-25 GP Mainline	28292	Freeway
SB I-25 Off-Ramp to I-270	28293	System Ramp
NB I-25 EL	28580	Managed Lane
NB I-25 GP Mainline	28709	Freeway
EB 76 Off-Ramp to NB I-25	28749	System Ramp
WB I-270 Off-Ramp to Broadway	28755	Freeway Ramp

Link Description	Link ID	Road Type
EB 76 Off-Ramp to NB I-25	29045	System Ramp
NB I-25 Off-Ramp to CO 224	29053	Freeway Ramp
NB I-25 Off-Ramp to 84th Ave	29331	Freeway Ramp
NB I-25 Off-Ramp to 84th Ave	29332	Freeway Ramp
WB 84th Ave Ramp to NB I-25	29334	Freeway Ramp
WB 84th Ave Ramp to NB I-25	29335	Freeway Ramp
SB I-25 Off-Ramp to 84th Ave	29336	Freeway Ramp
SB I-25 Off-Ramp to 84th Ave	29337	Freeway Ramp
84th Ave Ramp to SB I-25	29338	Freeway Ramp
84th Ave Ramp to SB I-25	29339	Freeway Ramp
NB I-25 Off-Ramp to 104th Ave	29340	Freeway Ramp
NB I-25 Off-Ramp to 104th Ave	29342	Freeway Ramp
WB 104th Ave Ramp to NB I-25	29343	Freeway Ramp
WB 104th Ave Ramp to NB I-25	29344	Freeway Ramp
104th Ave Ramp to SB I-25	29346	Freeway Ramp
104th Ave Ramp to SB I-25	29347	Freeway Ramp
SB I-25 Off-Ramp to 104th Ave	29348	Freeway Ramp
SB I-25 Off-Ramp to 104th Ave	29349	Freeway Ramp
SB I-25 GP Mainline	32951	Freeway
NB I-25 GP Mainline	32952	Freeway
NB I-25 EL	40854	Managed Lane
SB I-25 GP Mainline	41174	Freeway
SB I-25 EL	42615	Managed Lane
NB I-25 EL	42616	Managed Lane
SB I-25 EL	43053	Managed Lane
SB I-25 EL	43055	Managed Lane
SB I-25 GP Mainline	43964	Freeway
SB I-25 GP Mainline	43965	Freeway
SB I-25 Off-Ramp to EB I-270	43967	System Ramp
SB I-25 EL	43968	Managed Lane
SB I-25 GP Mainline	43969	Freeway
SB I-25 EL	43970	Managed Lane
NB I-25 GP Mainline	43971	Freeway
NB I-25 EL	43972	Managed Lane
NB I-25 GP Mainline	43973	Freeway
NB I-25 GP Mainline	43974	Freeway
SB I-25 GP Mainline	43975	Freeway
SB I-25 EL	43976	Managed Lane
NB I-25 EL	43978	Managed Lane
NB I-25 GP Mainline	43980	Freeway
SB I-25 GP Mainline	43981	Freeway
SB I-25 EL	43984	Managed Lane
SB I-25 EL	44002	Managed Lane
SB I-25 EL	44003	Managed Lane

Link Description	Link ID	Road Type
SB I-25 EL	44004	Managed Lane
NB I-25 EL	44006	Managed Lane
SB I-25 EL	44007	Managed Lane
NB I-25 EL	44010	Managed Lane
SB I-25 EL	44012	Managed Lane
NB I-25 EL	44014	Managed Lane
NB I-25 GP Mainline	44112	Freeway
NB I-25 EL	44113	Managed Lane
NB I-25 GP Mainline	44158	Freeway
NB I-25 EL	44159	Managed Lane
SB I-25 EL	44160	Managed Lane
NB I-25 EL	44161	Managed Lane
SB I-25 EL	44162	Managed Lane
NB I-25 EL	44163	Managed Lane
WB I-270 ML Direct Connect Ramp to NB I-25 ML	44655	Managed Lane
I-270 WB ML	44656	Managed Lane
I-270 EB ML	44657	Managed Lane
SB I-25 ML Direct Connect to I-270 EB ML	44672	Managed Lane
I-270 EB ML	45317	Managed Lane
WB I-270 ML Egress to GP Lanes	45318	Managed Lane
SB I-25 Off-Ramp to WB US 36	45403	Freeway Ramp
SB I-25 Off-Ramp to WB US 36	45404	Freeway Ramp

Table 3. Roadway links included in the GHG analysis for the Build Alternative

Link Description	Link ID	Road Type
SB I-25 GP Mainline	10043	Freeway
SB I-25 GP Mainline	10048	Freeway
SB I-25 GP Mainline	10052	Freeway
NB I-25 GP Mainline	10054	Freeway
NB I-25 GP Mainline	10055	Freeway
SB I-25 GP Mainline	10479	Freeway
SB I-25 Off-Ramp to Thornton Pkwy	10480	Freeway Ramp
SB I-25 GP Mainline	10481	Freeway
SB I-25 GP Mainline	10482	Freeway
SB I-25 Off-Ramp to 84th Ave	10483	Freeway Ramp
SB I-25 GP Mainline	10484	Freeway
NB I-25 GP Mainline	10485	Freeway
NB I-25 GP Mainline	10486	Freeway
NB I-25 GP Mainline	10488	Freeway
NB I-25 GP Mainline	10489	Freeway
NB I-25 Off-Ramp to Thornton Pkwy	10490	Freeway Ramp
84th Ave Ramp to SB I-25	10496	Freeway Ramp
WB 84th Ave Ramp to NB I-25	10498	Freeway Ramp
Thornton Pkwy Ramp to SB I-25	10579	Freeway Ramp
WB Thornton Pkwy Ramp to NB I-25	10581	Freeway Ramp
SB I-25 GP Mainline	10831	Freeway
SB I-25 GP Mainline	10832	Freeway
SB I-25 Off-Ramp to 104th Ave	10833	Freeway Ramp
NB I-25 GP Mainline	10837	Freeway
NB I-25 Off-Ramp to 104th Ave	10838	Freeway Ramp
104th Ave Ramp to SB I-25	10850	Freeway Ramp
WB 104th Ave Ramp to NB I-25	10856	Freeway Ramp
NB I-25 EL Off-Ramp to CO 224	25269	Managed Lane
CO 224 On-Ramp to SB I-25 EL	25270	Managed Lane
SB I-25 EL	25272	Managed Lane
NB I-25 GP Mainline	25596	Freeway
WB I-270 Ramp to NB I-25	25600	System Ramp
EB I-270 Ramp to NB I-25	25602	System Ramp
NB I-25 EL	25594	Managed Lane
SB I-25 GP Mainline	28292	Freeway
SB I-25 Off-Ramp to I-270	28293	System Ramp
SB I-25 EL	25603	Managed Lane
NB I-25 GP Mainline	28709	Freeway
WB US 36 Off-Ramp to Broadway	28755	Freeway Ramp
WB 76 Off-Ramp to NB I-25	29045	System Ramp
NB I-25 Off-Ramp to CO 224	29053	Freeway Ramp
NB I-25 Off-Ramp to 84th Ave	29331	Freeway Ramp
NB I-25 Off-Ramp to 84th Ave	29332	Freeway Ramp

Link Description	Link ID	Road Type
WB 84th Ave Ramp to NB I-25	29334	Freeway Ramp
WB 84th Ave Ramp to NB I-25	29335	Freeway Ramp
SB I-25 Off-Ramp to 84th Ave	29336	Freeway Ramp
SB I-25 Off-Ramp to 84th Ave	29337	Freeway Ramp
84th Ave Ramp to SB I-25	29338	Freeway Ramp
84th Ave Ramp to SB I-25	29339	Freeway Ramp
NB I-25 Off-Ramp to 104th Ave	29340	Freeway Ramp
NB I-25 Off-Ramp to 104th Ave	29342	Freeway Ramp
WB 104th Ave Ramp to NB I-25	29343	Freeway Ramp
WB 104th Ave Ramp to NB I-25	29344	Freeway Ramp
104th Ave Ramp to SB I-25	29346	Freeway Ramp
104th Ave Ramp to SB I-25	29347	Freeway Ramp
SB I-25 Off-Ramp to 104th Ave	29348	Freeway Ramp
SB I-25 Off-Ramp to 104th Ave	29349	Freeway Ramp
SB I-25 GP Mainline	32951	Freeway
NB I-25 GP Mainline	32952	Freeway
NB I-25 EL	28580	Managed Lane
SB I-25 GP Mainline	41174	Freeway
NB I-25 EL	40854	Managed Lane
SB I-25 EL	42615	Managed Lane
NB I-25 EL	42616	Managed Lane
SB I-25 EL	43053	Managed Lane
SB I-25 GP Mainline	43964	Freeway
SB I-25 GP Mainline	43965	Freeway
SB I-25 Off-Ramp to I-270	43967	System Ramp
SB I-25 EL	43055	Managed Lane
SB I-25 GP Mainline	43969	Freeway
SB I-25 EL	43968	Managed Lane
NB I-25 GP Mainline	43971	Freeway
SB I-25 EL	43970	Managed Lane
NB I-25 GP Mainline	43973	Freeway
NB I-25 GP Mainline	43974	Freeway
SB I-25 GP Mainline	43975	Freeway
NB I-25 EL	43972	Managed Lane
SB I-25 EL	43976	Managed Lane
NB I-25 GP Mainline	43980	Freeway
SB I-25 GP Mainline	43981	Freeway
NB I-25 EL	43978	Managed Lane
SB I-25 EL	43984	Managed Lane
SB I-25 EL	44002	Managed Lane
SB I-25 EL	44003	Managed Lane
SB I-25 EL	44004	Managed Lane
NB I-25 EL	44006	Managed Lane
SB I-25 EL	44007	Managed Lane

Link Description	Link ID	Road Type
NB I-25 EL	44010	Managed Lane
SB I-25 EL	44012	Managed Lane
NB I-25 GP Mainline	44112	Freeway
NB I-25 EL	44014	Managed Lane
NB I-25 GP Mainline	44158	Freeway
NB I-25 EL	44113	Managed Lane
NB I-25 EL	44159	Managed Lane
SB I-25 EL	44160	Managed Lane
NB I-25 EL	44161	Managed Lane
SB I-25 EL	44162	Managed Lane
NB I-25 EL	44163	Managed Lane
WB I-270 ML Direct Connect Ramp to NB I-25 ML	44655	Managed Lane
I-270 WB ML	44656	Managed Lane
I-270 EB ML	44657	Managed Lane
SB I-25 ML Direct Connect to to I-270 EB ML	44672	Managed Lane
I-270 EB ML	45317	Managed Lane
NB I-25 GP Mainline	45402	Freeway
WB 76 Off-Ramp to NB I-25	45404	System Ramp
NB I-25 GP Mainline	45405	Freeway
EB I-270 Ramp to NB I-25	45407	System Ramp
NB I-25 GP Mainline	45410	Freeway
NB I-25 GP Mainline	45412	Freeway

2.0 MOVES Runs – Overview of Approach

MOVES was run with the Project Scale setting to estimate running exhaust and crankcase running exhaust emissions for all pollutants. The MOVES runs produce emission factors for a lookup table, with emissions by road type, speed, and vehicle type (car or truck). Data for Links input for MOVES were developed based on hypothetical link-level traffic and roadway data that cover the range of actual link-level traffic for all analysis scenarios, as described below. Link Source Type inputs for MOVES, which describe the mix of vehicle types on each link, were developed using data provided by the Colorado Air Pollution Control Division (APCD).

Mainline and ramp roadway segments were modeled as urban restricted roadways. Only on-road links were modeled; no "off-network" links were modeled. "Off-network" links reflect parking facilities, such as park-and-ride lots or truck stops, and no facilities of this type are affected by the Project. A series of hypothetical links with a traffic volume of one vehicle per hour traveling one mile were created, with average vehicle speed ranging from 0 to 75 miles per hour (mph) in 1 mph speed bins.[2] Emission factors were developed for both passenger ("non-truck") vehicle and truck vehicle categories, with appropriate mapping of MOVES source types to non-truck and truck categories.

MOVES modeling was performed for a 2024 base year and a 2050 design year. For the analysis, the winter and summer seasons, represented by the months of January and July, respectively, were modeled using appropriate fuels inputs for each season. This approach allows the modeling to capture wintertime conditions in Denver as well as the peak summertime period when warm-weather conditions impact vehicle air conditioning use.

Emission factors from the lookup table were applied (outside of MOVES) to project-specific link-level traffic data in order to calculate link-level emissions, which were aggregated to the project level for each analysis scenario. The emission factors in the lookup table by vehicle type and speed (from the MOVES runs) were applied to the link-level traffic data to calculate the emissions for each link by traffic time period. The traffic data vary across four time periods during the day (AM Peak, PM Peak, Midday, and Evening).

2.1 Run Specification Inputs

MOVES run specifications (RunSpecs) were created to specify the parameter options for the MOVES model. Table 4 summarizes the MOVES inputs for the RunSpecs, as defined in the navigation panel of the MOVES interface.

[2] Note that only a single road grade (equal to 0 percent) was modeled in MOVES for the quantitative emissions inventory analysis, consistent with normal practices for emissions inventory development using the MOVES model.

Table 4. MOVES Run Specification Selections

Navigation Panel	Model Selection
Scale	Project scale; inventory calculation type
Time Spans	Hour; weekdays; January/July; calendar years 2024 and 2050
Geographic Bounds	Adams County
Vehicles	All MOVES4 vehicle and fuel type combinations
Road Types	Urban restricted access
Pollutants and Processes	Running exhaust and crankcase running exhaust (all GHGs considered)
General Output	Units of grams and miles
Output Emissions Detail	Road type

2.2 Project Data Manager Inputs

After the RunSpecs were created, an input database table for each run was created before running MOVES. This was done using the MOVES Project Data Manager to enter project-specific data. Table 5 summarizes the MOVES Project Data Manager inputs, and they are discussed in more detail below.

Table 5. MOVES Project Data Manager Inputs

Project Data Manager Tab	Data Source
Meteorology Data	Provided by APCD
Age Distribution	Provided by APCD
Fuel	MOVES defaults; and AVFT[1] data provided by CDOT
Retrofit	No inputs (not applicable)
Inspection and Maintenance (I/M) Program	Provided by APCD
Link Source Type	Generated using traffic count data provided by APCD[2]
Links	Generic links designed to produce an emissions lookup table

[1] AVFT = Alternate Vehicle Fuel and Technology

[2] Note that the data provided by APCD are based on local Highway Performance Monitoring System (HPMS) traffic counts and reflect a statewide average for urban freeways, and are only used to define the vehicle type mix for separate "car" and "truck" input files for MOVES. The project-specific fleet mix was represented in the emissions analysis by the DRCOG TDM results for “car” and “truck” traffic volumes.

2.3 Meteorology Data

The meteorology data for this analysis were consistent with those used in the regional emissions analysis for transportation conformity and were provided by APCD. The relevant data provided by APCD for each modeled season were used to calculate average temperature and humidity for each traffic time period in the two seasons.

2.4 Vehicle Age Distribution

The vehicle age distribution input for the modeling, provided by APCD, is based on their latest available composite of vehicle registration data from seven Denver area counties (Adams, Arapaho, Boulder, Broomfield, Denver, Douglas, and Jefferson). These data were used to represent the age distribution in the analysis years (2024 and 2050).

2.5 Fuel

Consistent with APCD's standard practice, the default parameters in MOVES for fuel inputs were used, with the addition of AVFT data from CDOT to reflect the future zero emission vehicle (ZEV) fleet resulting from the state's adoption of the Colorado Clean Cars and Advanced Clean Trucks rules. The AVFT inputs define vehicle sales by fuel type and vehicle type in each past and future model year, and the CDOT-provided file reflects implementation of these Colorado rules.

2.6 Inspection and Maintenance Parameters

Existing and anticipated future vehicle inspection and maintenance (I/M) program parameters for the Denver metropolitan area were provided by APCD.

2.7 Link Source Type

Link source type inputs were used to define the fraction of travel on each link by vehicle type. Two separate sets of MOVES runs were conducted: one for light-duty vehicles and one for (heavy-duty) trucks. Three sets of link source type inputs were needed for these MOVES runs: one set with fractions for the four types of MOVES light-duty vehicles (MOVES sourcetypes 11, 21, 31, and 32), and one set with fractions for the six types of heavy-duty vehicles (MOVES sourcetypes 51, 52, 53, 54, 61, and 62), and one set with fractions for buses (MOVES sourcetypes 41, 42, and 43), assuming travel activity for the listed bus sourcetypes were available for the analyses.[3]

The third set of link source type fractions was developed to represent the vehicle mix on managed lanes in the Proposed Action, including buses using the managed lanes, in addition to light-duty vehicle activity on managed lanes.4 The number of buses was added based on the Regional Transportation District (RTD) and CDOT Bustang schedules to estimate total volumes for the corridor, and not subtracted from some other category (e.g., single-unit trucks) to conserve total modeled traffic volumes. Current RTD and Bustang schedules were used to estimate daily transit bus volumes in the managed lanes, and DRCOG modeling provided passenger vehicle volumes in the managed lanes. Regional DRCOG vehicle population data were used to disaggregate the passenger vehicle volumes into MOVES passenger vehicle sourcetypes; these subtotals and the estimated bus volumes were used to develop the linksourcetype fractions. This approach assumed that no trucks use the managed lanes.

[3] Note that the MOVES sourcetype 41 represents all buses that are not transit buses, represented by sourcetype ID 42, or school buses, represented by sourcetype 43.
[4] MOVES input data and traffic activity data for buses were provided by CDOT for this modeling.

Link source type inputs for the three groups of vehicles (i.e., light-duty vehicles, trucks, and vehicles using the managed lanes) were developed using Automated Traffic Recorder (ATR) data by each class defined in the Highway Performance Monitoring System (HPMS) for representative freeway segments. CDOT selected continuous count ATR stations within the TDM validation boundary based on roadways that were included in the emissions quantification to provide input data needed for the MOVES modeling. Along with MOVES default estimates by vehicle miles traveled (VMT) and source type, vehicle population data provided by CDOT and agreed upon by FHWA were used for developing the link source type inputs.

2.8 Links

A links input table was created that represents all speeds on the urban restricted road type to generate the lookup table of emission factors applicable to any traffic link in the analysis scenarios.

Attachment D.

Greenhouse Gas Analysis Supplemental Tables

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This attachment provides additional details of the GHG analysis results, supplementing the results documented in Section 8 of this report.

Table 1 summarizes the vehicle operating (operational) emissions associated with the Existing Conditions (Baseline) and the No-Action and Build alternatives for the Project. Emissions are reported in units of metric tons per day.

Table 1. Greenhouse Gas Emissions from Vehicle Operation (MT/Day)

GHG	Baseline (2024)	No Action (2030)	No Action (2040)	No Action (2050)	Build (2030)	Build (2040)	Build (2050)	Build – No Action (2050)
CO_2	404.866	371.508	249.351	177.749	371.631	251.014	177.120	0.629
CH_4	0.017	0.015	0.012	0.012	0.013	0.010	0.010	0.002
N_2O	0.009	0.010	0.012	0.011	0.010	0.011	0.011	0.001
Total CO_2e	407.845	374.915	253.216	181.426	374.858	254.691	180.571	0.855

Table 2 summarizes the estimated annual VMT by Project alternative.

Table 2. VMT by Project Alternative (Miles Per Year)

Year	No Action	Build
2024	329,663,492	329,663,492
2025	333,456,738	333,456,738
2026	337,249,984	337,249,984
2027	341,043,230	341,043,230
2028	344,836,476	344,836,476
2029	348,629,722	348,629,722
2030	352,422,968	375,693,074
2031	354,584,702	378,636,572
2032	356,746,436	381,580,070
2033	358,908,170	384,523,568
2034	361,069,903	387,467,066
2035	363,231,637	390,410,565
2036	365,393,371	393,354,063
2037	367,555,104	396,297,561
2038	369,716,838	399,241,059
2039	371,878,572	402,184,557
2040	374,040,306	405,128,056
2041	376,138,927	407,914,743
2042	378,237,548	410,701,430
2043	380,336,170	413,488,118
2044	382,434,791	416,274,805
2045	384,533,413	419,061,492
2046	386,632,034	421,848,180
2047	388,730,655	424,634,867
2048	390,829,277	427,421,554
2049	392,927,898	430,208,242
2050	395,026,520	432,994,929

Table 3 summarizes the total construction emissions associated with each of the Project alternatives. Table 4 summarizes the lifetime (2027-2050) maintenance emissions associated with each of the Project alternatives. Emissions are reported in units of metric tons. The emissions estimates are provided only for CO_2e because this pollutant is the only one reported by the Infrastructure Carbon Estimator (ICE) tool.

Table 3. Lifetime Construction Emissions Associated with the Project Alternatives (MT CO_2e)

No Action	Build	Build – No Action
3,005	12,416	+9,411

Table 4. Lifetime Maintenance Emissions Associated with the Project Alternatives (MT CO_2e)

No Action	Build	Build – No Action
3,655	3,854	+199

Table 5 lists estimates of annual direct emissions, which include emissions from vehicle operation, construction (for calendar years 2027 through 2029), and maintenance, for each of the Project alternatives.

Table 5. Annual Direct Emissions Associated with the Project Alternatives (MT CO_2e Per Year)

Year	No Action	Build
2027	134,445	137,582
2028	132,488	135,625
2029	130,268	133,405
2030	126,873	126,864
2031	122,087	122,138
2032	117,089	117,203
2033	112,096	112,272
2034	107,327	107,564
2035	102,711	103,005
2036	98,388	98,737
2037	94,598	94,994
2038	91,184	91,624
2039	88,233	88,710
2040	85,739	86,247
2041	81,583	81,956
2042	77,969	78,225
2043	74,763	74,914
2044	74,752	75,099
2045	69,095	69,062
2046	66,781	66,674
2047	65,022	64,858
2048	63,397	63,180
2049	62,240	61,985
2050	61,474	61,195

Table 6 lists estimates of annual cumulative emissions for each of the Project alternatives. These emissions include the contributions from vehicle operation, construction and maintenance included in Table 5, plus indirect (upstream) emissions.

Table 6. Annual Cumulative Emissions Associated with the Project Alternatives (MT CO_2e Per Year)

Year	No Action	Build
2027	177,417	180,554
2028	175,593	178,730
2029	173,498	176,635
2030	168,812	171,571
2031	165,346	168,331
2032	159,899	162,992
2033	154,806	158,030
2034	149,934	153,285
2035	145,209	148,683
2036	140,408	143,973
2037	136,499	140,172
2038	132,962	136,738
2039	129,512	133,352
2040	126,884	130,811
2041	122,582	126,419
2042	118,819	122,581
2043	115,078	118,744
2044	114,908	118,808
2045	109,471	113,064
2046	106,604	110,124
2047	104,673	108,171
2048	102,871	106,350
2049	101,533	105,006
2050	100,582	104,061

Table 7 lists the SCC values used in the analysis, by discount rate and calendar year. The SCC values used in the analysis were published in 2021 by the federal Interagency Working Group on Social Cost of Greenhouse Gases in "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990."

Table 7. Annual Social Cost of Carbon Values (Calendar-Year 2020 USD Per MT CO_2e)

Year	5.0% Discount Rate	3.0% Discount Rate	2.5% Discount Rate	3.0% Discount Rate 95th Percentile
2020	14	51	76	152
2021	15	52	78	155
2022	15	53	79	159
2023	16	54	80	162
2024	16	55	82	166
2025	17	56	83	169
2026	17	57	84	173
2027	18	59	86	176
2028	18	60	87	180
2029	19	61	88	183
2030	19	62	89	187
2031	20	63	91	191
2032	21	64	92	194
2033	21	65	94	198
2034	22	66	95	202
2035	22	67	96	206
2036	23	69	98	210
2037	23	70	99	213
2038	24	71	100	217
2039	25	72	102	221
2040	25	73	103	225
2041	26	74	104	228
2042	26	75	106	232
2043	27	77	107	235
2044	28	78	108	239
2045	28	79	110	242
2046	29	80	111	246
2047	30	81	112	249
2048	30	82	114	253
2049	31	84	115	256
2050	32	85	116	260

Tables 8 and 9 list the SCC estimates by Project alternative and calendar year. The SCC is calculated using the cumulative CO_2e emissions by Project alternative and calendar year (Table 6) and the SCC values by calendar year (Table 7).

Table 8. Annual SCC Estimates for the No Action Alternative (Calendar-Year 2020 USD Per Year)

Year	5.0% Discount Rate	3.0% Discount Rate	2.5% Discount Rate	3.0% Discount Rate 95th Percentile
2027	$3,193,501	$10,467,585	$15,257,836	$31,225,339
2028	$3,160,667	$10,535,558	$15,276,559	$31,606,673
2029	$3,296,469	$10,583,399	$15,267,854	$31,750,197
2030	$3,207,423	$10,466,327	$15,024,244	$31,567,794
2031	$3,306,922	$10,416,804	$15,046,494	$31,581,103
2032	$3,357,875	$10,233,525	$14,710,692	$31,020,372
2033	$3,250,921	$10,062,375	$14,551,742	$30,651,543
2034	$3,298,539	$9,895,616	$14,243,690	$30,286,583
2035	$3,194,591	$9,728,981	$13,940,032	$29,912,985
2036	$3,229,392	$9,688,176	$13,760,019	$29,485,754
2037	$3,139,472	$9,554,916	$13,513,381	$29,074,245
2038	$3,191,093	$9,440,317	$13,296,221	$28,852,799
2039	$3,237,791	$9,324,837	$13,210,186	$28,622,070
2040	$3,172,093	$9,262,512	$13,069,024	$28,548,839
2041	$3,187,130	$9,071,062	$12,748,520	$27,948,678
2042	$3,089,288	$8,911,408	$12,594,789	$27,565,954
2043	$3,107,112	$8,861,023	$12,313,369	$27,043,381
2044	$3,217,415	$8,962,799	$12,410,029	$27,462,934
2045	$3,065,177	$8,648,179	$12,041,768	$26,491,889
2046	$3,091,527	$8,528,351	$11,833,087	$26,224,680
2047	$3,140,186	$8,478,503	$11,723,363	$26,063,548
2048	$3,086,133	$8,435,431	$11,727,307	$26,026,392
2049	$3,147,511	$8,528,739	$11,676,249	$25,992,347
2050	$3,218,622	$8,549,466	$11,667,507	$26,151,308
Total	**$76,586,851**	**$226,635,889**	**$320,903,963**	**$691,157,406**

Table 9. Annual SCC Estimates for the Build Alternative (Calendar-Year 2020 USD Per Year)

Year	5.0% Discount Rate	3.0% Discount Rate	2.5% Discount Rate	3.0% Discount Rate 95th Percentile
2027	$3,249,964	$10,652,661	$15,527,607	$31,777,429
2028	$3,217,131	$10,723,770	$15,549,467	$32,171,311
2029	$3,356,069	$10,774,748	$15,543,899	$32,324,245
2030	$3,259,857	$10,637,427	$15,269,854	$32,083,851
2031	$3,366,623	$10,604,864	$15,318,137	$32,151,254
2032	$3,422,842	$10,431,520	$14,995,310	$31,620,544
2033	$3,318,640	$10,271,980	$14,854,864	$31,290,033
2034	$3,372,268	$10,116,804	$14,562,066	$30,963,551
2035	$3,271,029	$9,961,771	$14,273,583	$30,628,730
2036	$3,311,374	$9,934,122	$14,109,332	$30,234,283
2037	$3,223,958	$9,812,046	$13,877,036	$29,856,653
2038	$3,281,713	$9,708,400	$13,673,803	$29,672,152
2039	$3,333,808	$9,601,367	$13,601,936	$29,470,861
2040	$3,270,287	$9,549,238	$13,473,582	$29,432,582
2041	$3,286,885	$9,354,980	$13,147,539	$28,823,450
2042	$3,187,098	$9,193,553	$12,993,555	$28,438,724
2043	$3,206,090	$9,143,293	$12,705,615	$27,904,854
2044	$3,326,625	$9,267,028	$12,831,270	$28,395,125
2045	$3,165,786	$8,932,040	$12,437,017	$27,361,438
2046	$3,193,604	$8,809,943	$12,223,795	$27,090,573
2047	$3,245,119	$8,761,822	$12,115,111	$26,934,489
2048	$3,190,491	$8,720,676	$12,123,866	$26,906,475
2049	$3,255,181	$8,820,490	$12,075,670	$26,881,492
2050	$3,329,957	$8,845,199	$12,071,095	$27,055,903
Total	**$78,642,400**	**$232,629,738**	**$329,355,009**	**$709,470,002**