



North Front Range
**Metropolitan
Planning
Organization**

NFRMPO GHG Transportation Report

Determining Compliance with the GHG Transportation Planning Standard

for the

North Front Range Metropolitan Planning Area

2050 Regional Transportation Plan Amendment

and

FY2026-2029 Transportation Improvement Program

Adopted July 2, 2026

Preparation of this report has been financed in part through grants from the Colorado Department of Public Health and Environment and local government contributions.

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List of Acronyms

Acronym	Meaning/Context
AADT	Average Annual Daily Traffic
APCD	Air Pollution Control Division
ATP	Active Transportation Plan
BRT	Bus Rapid Transit
BY	Base Year
CCR	Code of Colorado Regulations
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
COLT	City of Loveland Transit
CSU	Colorado State University
DRCOG	Denver Regional Council of Governments
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GET	Greeley-Evans Transit
GHG	Greenhouse Gas
HHTS	Household Travel Survey
IACT	State Interagency Consultation Team
IGA	Intergovernmental Agreement
LUAM	Land Use Allocation Model
MAP	Mitigation Action Plan
MMT	Million Metric Tons
MOVES4	MOtor Vehicle Emission Simulator Model
MPA	Metropolitan Planning Area
MPO	Metropolitan Planning Organization
MT	Metric Tons
NFRMPO	North Front Range Metropolitan Planning Organization
NFRT&AQPC	North Front Range Transportation and Air Quality Planning Council
OBTS	On-Board Transit Survey
PD	Policy Directive
PIP	Public Involvement Plan
PMT	Person Miles Traveled
RTDM	Regional Travel Demand Model
RTE	Regional Transit Element
RTP	Regional Transportation Plan
SDO	State Demography Office
SIP	State Implementation Plan

SRTS	Safe Routes to School
TAZ	Traffic Analysis Zone
TC	Transportation Commission
TDM	Transportation Demand Management
TIP	Transportation Improvement Program
TMA	Transportation Management Area
TMO	Transportation Management Organization
UNC	University of Northern Colorado
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled

NFRMPO GHG Transportation Report

Purpose

This report demonstrates the 2050 Regional Transportation Plan (RTP) Amendment and the FY2026-2029 Transportation Improvement Program (TIP) complies with Colorado's greenhouse gas (GHG) Transportation Planning Standard ("GHG Planning Standard") specified in the Code of Colorado Regulations ([2 CCR 601-22](#)).

The demonstration is based on analysis of all trips conducted using the NFRMPO's 2019 Base Year (BY) Regional Travel Demand Model (RTDM) and the Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES3) air quality model. The NFRMPO is not relying on GHG Mitigation Measures to demonstrate compliance with the GHG Planning Standard, and as such, this report does not include a Mitigation Action Plan (MAP).

The North Front Range Transportation and Air Quality Planning Council (NFRT&AQPC) will adopt this GHG Transportation Report at their regular monthly meeting on July 2, 2026. Subsequently, at the same meeting the NFRT&AQPC will adopt the 2050 RTP Amendment and FY2026-2029 TIP. The NFRT&AQPC adopted the ozone and carbon monoxide (CO) air quality conformity determination at their regular monthly meeting on December 4, 2025.

Background

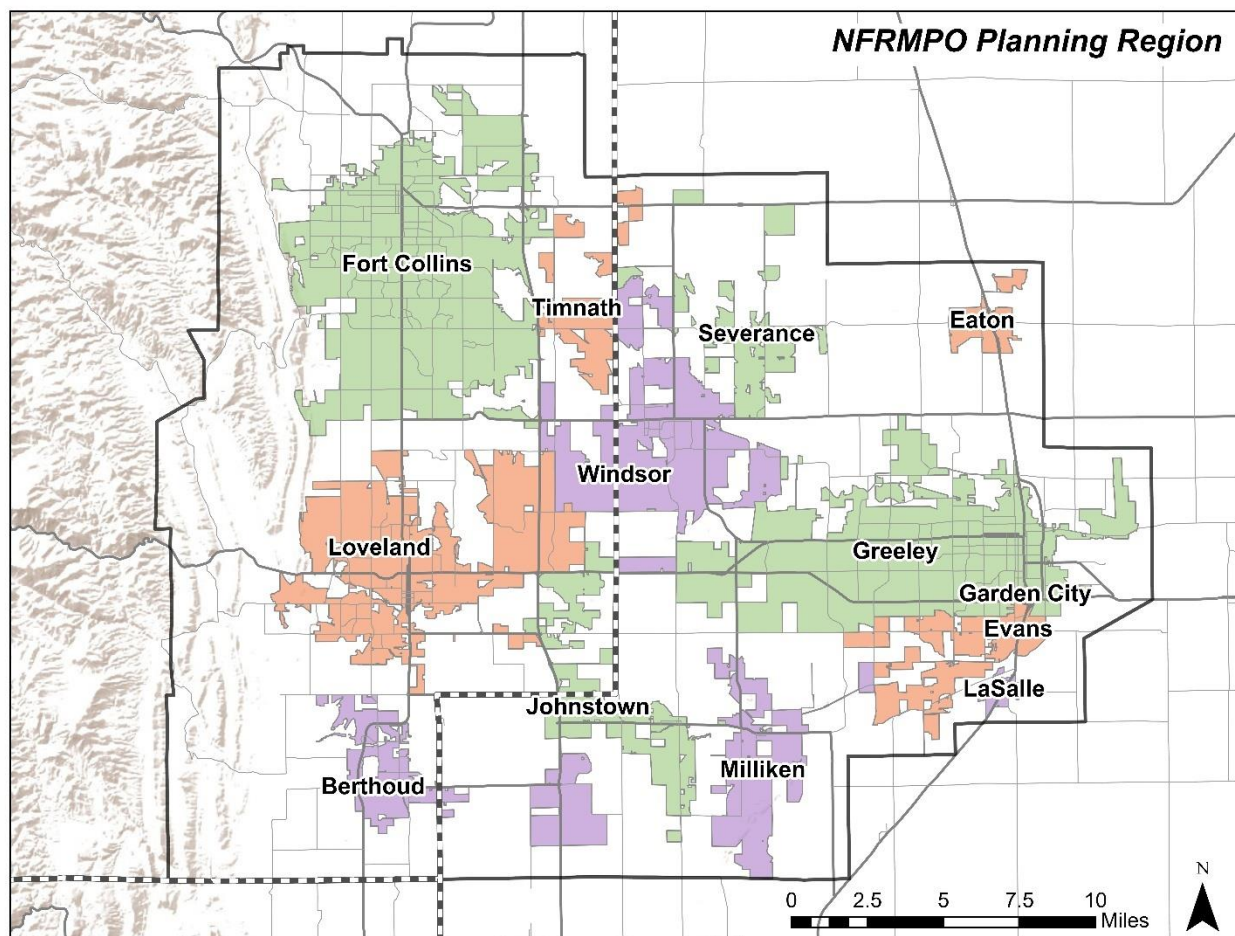
In 2021, Senate Bill (SB) 21-260: Sustainability of the Transportation System was enacted in Colorado. The bill, which created new sources of funding for transportation, also required the Colorado Transportation Commission (TC) to adopt implementing guidelines and procedures for addressing GHG emissions in transportation planning. In December 2021, the TC adopted revisions to the statewide transportation planning rules to incorporate a new GHG Planning Standard to address the GHG requirements in SB21-260.

The GHG Planning Standard requires the Colorado Department of Transportation (CDOT) and the Metropolitan Planning Organizations (MPOs) in Colorado to determine the amount of GHG emissions from transportation projects included in transportation plans and take steps to reduce GHG emissions relative to estimated emissions resulting from Baseline Plans. Baseline Plans are the plans in place at the time the GHG Planning Standard became effective on January 30, 2022.

The NFRMPO is the MPO for the Fort Collins Transportation Management Area (TMA), which includes Berthoud, Fort Collins, Loveland, and portions of Johnstown, Timnath, and Windsor,

and the Greeley Urban Area, which includes Greeley, Evans, and LaSalle. The NFRMPO has 15 local government members, including 13 municipalities and the urbanized portions of Larimer and Weld counties. The NFRMPO Planning Boundary is shown in **Figure 1**.

Figure 1: NFRMPO Planning Area



Legend

- NFR Region
- County Line

April 2026
Sources: CDOT, NFRMPO
 North Front Range
Metropolitan
Planning
Organization

The Baseline Plan for the NFRMPO is the 2045 RTP, which was adopted by the NFRT&AQPC on September 5, 2019, and was in effect as of January 30, 2022. For this GHG Transportation Report, the 2045 RTP will be referred to as the Baseline Plan and the 2050 RTP Amendment will be referred to as the Updated Plan. The FY2026-2029 TIP, which is consistent with the 2050 RTP Amendment, is assessed as part of the analysis for the Updated Plan.

An Intergovernmental Agreement (IGA) is in place between the Air Pollution Control Division (APCD) of the Colorado Department of Public Health and Environment (CDPHE), CDOT, and the

NFRMPO and included in **Appendix A**. The IGA identifies the roles and responsibilities of each agency for model execution and address modeling assumptions for compliance demonstrations for the GHG Planning Standard.

The NFRMPO is also responsible for determining conformity with the State Implementation Plan (SIP) for ozone precursors Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOC) and carbon monoxide (CO) per the federally prescribed transportation conformity process for nonattainment areas. The conformity determination for the 2050 RTP Amendment and the FY2026-2029 TIP, which demonstrates conformity with the SIP, was available for review during the public comment period of October 6, 2025 to November 4, 2025 at <https://nfrmpo.org/public-comment/>.

Greenhouse Gas (GHG) Emissions Analysis

For this report, GHG analysis is required in four compliance years: 2029, 2030, 2040, and 2050. The 2029 compliance year is required because it is the last year of the TIP, while the other three years are explicitly identified as required compliance years in the GHG Planning Standard.

Annual GHG emissions that can be modeled for the Baseline Plan and Updated Plan are shown in **Table 1** for each compliance year. The “Reduction” row of **Table 1** displays the modeled amount of reduced GHG emissions in million metric tons (MMT) for each compliance year and reflects the difference between the Baseline Plan and the Updated Plan. **Table 1** also shows the GHG Reduction Levels established for the NFRMPO in the GHG Planning Standard for each compliance year, with the values for 2029 interpolated. 2029 is interpolated due to the 2019 BY RTDM including modeled years of 2019, 2026, 2030, 2040, and 2050.

Table 1: GHG Emissions Results Before Off-Model Calculations, Million Metric Tons (MMT) per Year

	2029*	2030	2040	2050
Baseline Plan: 2045 RTP	1.55	1.53	1.08	0.78
Updated Plan: 2050 RTP Amendment	1.44	1.42	0.97	0.71
Modeled Reduction	0.11	0.11	0.11	0.07
Required GHG Reduction Level	0.10	0.12	0.11	0.07

* All values for 2029 are interpolated.

As shown in **Table 1**, the 2050 RTP Amendment and FY2026-2029 TIP meets or exceeds the required GHG Reduction Levels in three of the four compliance years. Therefore, additional programmatic investments in GHG reduction measures are being made in the NFRMPO region, which were calculated off-model.

Programmatic Investments

For the 2050 RTP Amendment and FY2026-2029 TIP, the required GHG reduction was not met in compliance year 2030 with modeling alone. Therefore, off-model calculations of additional programmatic investments were used to meet compliance in 2030. The following additional programmatic investments in GHG reduction measures are being made in the NFRMPO region:

- Bike Lanes/Facilities;
- Sidewalks/Pedestrian Facilities;
- Shared-Use Paths;
- Complete Streets Reconstruction;
- Waive Transit Fares 100%;
- Trip Reduction Program – Voluntary;
- Broadband Expansion;
- Replace Signalized Intersections with Roundabouts;
- Replace Diesel Transit Buses with Battery-Electric Buses; and
- Replace Diesel Transit Buses with Hybrid Diesel-Electric Buses.

When accounting for these off-model calculations, the 2050 RTP Amendment and FY2026-2029 TIP meets or exceeds the required GHG Reduction Levels in all four compliance years as shown in **Table 2**.

Table 2: Final GHG Emissions Results, Million Metric Tons (MMT) per Year

	2029*	2030	2040	2050
Baseline Plan: 2045 RTP	1.55	1.53	1.08	0.78
Updated Plan: 2050 RTP Amendment with Only Modeled Reductions	1.44	1.42	0.97	0.71
Updated Plan: 2050 RTP Amendment Reductions for Off-Model Calculations	N/A	0.02	N/A	N/A
Total GHG Reduction	0.11	0.13	0.11	0.07
Required GHG Reduction Level	0.10	0.12	0.11	0.07
Pass/Fail	Pass	Pass	Pass	Pass

* All values for 2029 are interpolated.

Each Policy Directive (PD) 1610 measure calculated off-model as a programmatic investment is described in the following sections.

Bike Lanes/Facilities

When the NFRMPO updates its Active Transportation Plan (ATP), an inventory of bicycle lanes and facilities is included. The NFRMPO's 2025 ATP was adopted in May 2026.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for each mile of two-way facility built, with tons reduced varying depending on the surrounding land use and additional multipliers. Since the base year, 83.26 miles of additional bike lanes or facilities have been completed in the NFRMPO region.

Table 3 shows the calculated GHG emission reduction for 2030 based on 83.26 miles of bike lanes or facilities added.

Table 3: Bike Lanes/Facilities 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Bike Lanes/Facilities	482.360

Sidewalks/Pedestrian Facilities

When the NFRMPO updates its Active Transportation Plan (ATP), an inventory of sidewalk and pedestrian facilities is included and was documented in the adopted 2025 ATP.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for each mile of two-way facility built, with tons reduced varying depending on the surrounding land use and additional multipliers. Since the base year, 661.17 miles of additional sidewalk or pedestrian facilities have been completed in the NFRMPO region.

Table 4 shows the calculated GHG emission reduction for 2030 based on 661.17 miles of sidewalk or pedestrian facilities added.

Table 4: Sidewalks/Pedestrian Facilities 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Sidewalks/Pedestrian Facilities	3,012.955

Shared-Use Paths

When the NFRMPO updates its Active Transportation Plan (ATP), an inventory of shared-use paths is included and was documented in the adopted 2025 ATP.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for each mile of two-way facility built, with tons reduced varying depending on the surrounding land use and additional multipliers. Since the base year, 272.3 miles of additional shared-use paths have been completed in the NFRMPO region.

Table 5 shows the calculated GHG emission reduction for 2030 based on 272.3 miles of shared-use paths added.

Table 5: Shared-Use Paths 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Shared Use Paths	1,473.140

Complete Streets Reconstruction

A portion of Shields Street in Fort Collins is currently undergoing a Complete Streets reconstruction, and the project will be finished before 2030.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for each mile of two-way facility built, with tons reduced varying depending on the surrounding land use and additional multipliers. Since the base year, 0.35 miles of complete streets reconstruction have been completed in the NFRMPO region.

Table 6 shows the calculated GHG emission reduction for 2030 based on 0.35 miles of complete streets reconstruction.

Table 6: Complete Streets Reconstruction 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Shared Use Paths	18.900

Waive Transit Fares 100%

In 2020, the City of Fort Collin's transit service, Transfort, announced it would change to 100% fare free. Transfort's fare free transit service is expected to continue, with Transfort announcing they intend to be fare free indefinitely and documenting commitment of fare free transit service operations in their recently updated Transfort Optimization Plan.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated per million annual trips based on the current ridership base. As of 2024, Transfort had 2,651,954 annual unlinked trips.

Table 7 shows the calculated GHG emission reduction for 2030 based on 2,651,954 annual unlinked trips.

Table 7: Waive Transit Fares 100% 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Waive Transit Fares 100%	607.297

Trip Reduction Program – Voluntary

Developing a Transportation Management Organization (TMO) was a strategy outlined in the NFRMPO’s 2022 Transportation Demand Management (TDM) Action Plan, and the NFRMPO Planning Council has approved setting aside \$100,000 per year in Carbon Reduction Program (CRP) funds between 2024 and 2027 for TMO Incubator funding, with \$399,480 allocated towards a Call for Projects.

The GoNoCo34 TMO was launched in 2024 and is dedicated to improving mobility, reducing congestion, and promoting sustainable transportation options along the US 34 corridor in Northern Colorado. They collaborate with local businesses, public agencies, and the broader community to create innovative solutions that meet the region’s growing transportation needs. The TMO’s mission is to provide resources and tools to reduce single-occupancy vehicle (SOV) trips, enhance transportation choices, and improve air quality while promoting active and shared modes of transportation like carpooling, vanpooling, biking, walking, and public transit. The GoNoCo34 TMO was awarded all \$399,480 of available funding from the CRP TMO Incubator Call for Projects. This funding will improve upon the GoNoCo34 TMO’s programs and outreach efforts and is expected to increase TMO membership year-over-year.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated per 1,000 covered employees. For the 2025-2026 TMO membership year, 9,700 employees are covered in the NFRMPO region.

Table 8 shows the calculated GHG emission reduction for 2030 based on 9,700 covered employees.

Table 8: Trip Reduction Program – Voluntary 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Trip Reduction Program – Voluntary	863.300

Broadband Expansion

The expansion of municipal broadband has been happening in the region since the base year. Connexion began service to Fort Collins residential customers in late 2019. Pulse began service to Loveland residential customers in 2020 and expanded to Timnath and Larimer County residential customers in more recent years.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated per 100 new households served. Since the base year, 38,580 new residential households have been served by Connexion and Pulse within the NFRMPO boundary.

Table 9 shows the calculated GHG emission reduction for 2030 based on 38,580 new households served.

Table 9: Broadband Expansion 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Broadband Expansion	14,274.600

Replace Signalized Intersections with Roundabouts

Since the base year, the region will have replaced four signalized intersections with roundabouts to improve traffic operations and decrease congestion by 2030. The NFRMPO confirmed with its member agencies which signalized intersections will be replaced with roundabouts, including their annual average daily traffic (AADT), in the region since the base year. These intersections can be seen in **Table 10**.

Table 10: Signalized Intersections Replaced by Roundabouts

Locations		4-Leg AADT's				Status
		Northbound	Southbound	Eastbound	Westbound	
37th Ave and 47th Ave Roundabout	City of Evans	6,222	685	10,329	8,752	Constructed
Timberline Rd and Carpenter Rd Roundabout	City of Fort Collins	8,489	5,829	6,795	7,213	Construction will start by Summer 2027
23rd Ave and 4th/ 5th St Roundabout	City of Greeley	5,980	8,061	6,506	3,530	Construction starting in May 2026
Colorado Blvd and Crossroads Blvd Roundabout	Town of Windsor	5,435	4,348	7,971	11,957	Construction will start Summer or Fall 2026

AADT Data Sources: City of Evans, City of Fort Collins, City of Greeley, Town of Windsor

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. Greenhouse gas emission reductions are calculated per 10,000 AADT per roundabout replacing a signalized intersection. Since the base year, four signalized intersections will be replaced by a roundabout by 2030 with a total AADT of 108,102.

Table 11 shows the calculated GHG emission reduction for 2030 based on 108,102 AADT.

Table 11: Replace Signalized Intersections with Roundabouts 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Replace Signalized Intersections with Roundabouts	2,389.066

Replace Diesel Transit Buses with Battery-Electric Buses

Transit agencies in the region have been replacing their diesel buses with battery-electric buses since 2019, the NFRMPO's model base year. Transfort is the only transit agency in the NFRMPO region that has replaced their buses with battery-electric buses during this time period.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for each number of new

vehicles introduced between the base year and the evaluation year. Since 2019, Transfort has replaced eleven diesel buses with battery-electric buses.

Table 12 shows the calculated GHG emission reduction for 2030 based on the replacement of eleven diesel buses with battery-electric buses.

Table 12: Replace Diesel Transit Buses with Battery-Electric Buses 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Replace Diesel Transit Buses with Battery-Electric Buses	935.000

Replace Diesel Transit Buses with Hybrid Diesel-Electric Buses

Transit agencies in the region have been replacing their diesel buses with hybrid diesel-electric buses since 2019, the NFRMPO's model base year. COLT is the only transit agency within the NFRMPO region that has replaced their buses with hybrid diesel-electric buses during this time period.

Calculations for GHGs emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for each number of new vehicles introduced between the base year and the evaluation year. Since 2019, COLT has replaced two diesel buses with battery-electric buses.

Table 13 shows the calculated GHG emission reduction for 2030 based on the replacement of two diesel buses with hybrid diesel-electric buses.

Table 13: Replace Diesel Transit Buses with Hybrid Diesel-Electric Buses 2030 GHG Reduction, Metric Tons (MT) per Year

Policy Directive 1610 Measure	2030 GHG Reduction
Replace Diesel Transit Buses with Hybrid Diesel-Electric Buses	28.000

Baseline Plan and Updated Plan

The following sections provide details of the Baseline Plan and Updated Plan as well as modeling summaries for the NFRMPO's GHG emissions analysis.

Baseline Plan Description

The GHG analysis of the Baseline Plan includes the roadway, transit, and non-motorized facility improvements identified in the 2045 RTP as modeled using the 2019 BY RTDM.

The 2045 RTP identifies the major capacity projects, including regionally significant roadway and transit capacity expansion, that are fiscally constrained and planned for the region through 2045. Each of these major capacity projects is identified in the maps and tables included in [Chapter 3, Section 5](#) of the 2045 RTP. Projects are assigned to one of four staging periods based on anticipated year of completion, including 2020, 2021-2030, 2031-2040, and 2041-2045.

Transit projects are explicitly identified in the 2045 RTP only if they are regional transit projects between jurisdictions, if they are on fixed guideways, and/or if they serve at least 3,000 riders per day. There are five fiscally constrained transit capacity projects included in the Plan, which includes the routes recommended for investment in the NFRMPO's 2045 Regional Transit Element (2045 RTE). In addition to the major transit projects, the fiscally constrained plan of the 2045 RTP includes commitments to local transit system expansion planned as of 2019, as specified in the 2019 Transfort Transit Master Plan and the 2017 Greeley Evans Transit 5-10 Year Strategic Plan, and these local system expansions are included in the modeling of the Baseline Plan. The City of Loveland Transit (COLT) system did not have any planned expansion at the time the 2045 RTP was developed and therefore the 2045 RTP did not assume any expansion of the COLT system.

For non-motorized facility investment, the 2045 RTP includes the buildout of the 12 Regional Non-Motorized Corridors (RNMC) identified in the NFRMPO's 2016 Non-Motorized Plan. The 2045 RTP does not include any commitments for the expansion of the local non-motorized system.

Updated Plan Description

The GHG analysis of the Updated Plan includes the roadway, transit, and non-motorized facility improvements, specifically:

- The expansion of Weld County Road (WCR) 66 from US 85 to WCR 47 (4 miles) from 2-through lanes to 4-through lanes;
- Updates to the alignment and stops for the West Elizabeth BRT;
- Addition of MMOF projects selected in the NFRMPO's 2024 MMOF Call for Projects;
- Increased Safe Routes to School (SRTS) programming and implementation since 2023; and
- Additional GHG-reducing strategies, identified in **Appendix B** and in the 2050 RTP Amendment as modeled using the 2019 BY RTDM.

The 2050 RTP Amendment relies on four categories of strategies for achieving GHG Reductions. **Table 14** describes improvements based on categories and funding sources. How these projects are incorporated into the modeling is explained throughout this document. Additional details on these strategies is also available in the 2050 RTP Amendment.

Table 14: Modeled Improvements and Funding Sources

Category	Improvements	Funding Sources
Transit	- Updated transit network to match local plans and efforts - Acknowledgement of additional funding opportunities - LinkNoCo recommendations	CDOT 10-Year Plan, FTA, MMOF
TDM	- TDM and SRTS programs based on local plans and efforts - Impact of Council setting aside TMO funding - Increase in work from home in all compliance years	MMOF, IIJA, Local funds
Operations	Arterial signal timing improvements by 2030 and additional signal timing improvements through 2050	CDOT 10-Year Plan, IIJA, Local funds
Active Transportation	- Expansion of the local bicycle and pedestrian network by 2030 and increasing to 2050 - Completion of Regional Active Transportation corridors (RATCs) by 2050	IIJA, MMOF, Local funds

Modeling Summary

Key inputs and outputs from the travel model runs for four of the compliance years for the Baseline Plan and the Updated Plan are provided in **Table 15** and **Table 16**. The tables identify demographic data and travel forecasts for the NFRMPO region, which is a subset of a larger modeling area represented in the NFRMPO's 2019 BY RTDM. The forecasted demographic data is from the NFRMPO 2019 BY Land Use Allocation Model (LUAM), which allocates households and jobs forecasted for the entire modeling area by the Colorado State Demography Office (SDO) to smaller geographies throughout the region. The same land use dataset was used to model the

Baseline Plan and the Updated Plan, which means all differences in the emissions results are due to changes in transportation strategies instead of also reflecting any changes in land use planning or population forecasts.

Table 15: NFRMPO Modeling Summary, Baseline Plan

	Model Category	2026	2030	2040	2050
Socio-economic Data	Population	578,923	628,062	738,762	834,360
	Households	229,263	250,964	296,698	343,158
	Employment	272,192	287,249	327,024	361,508
Lane Miles by Roadway Type	Interstate	150	150	158	158
	Expressway	207	207	207	207
	Principal Arterial	680	704	759	759
	Minor Arterial	776	785	839	849
	Collector	1,234	1,245	1,273	1,275
	Ramp	18	18	18	18
	Frontage Road	46	48	48	48
	Centroid Connector	1,349	1,348	1,347	1,347
	Total Lane Miles	4,460	4,505	4,649	4,661
Person Trip Mode Share	Single Occupancy in Auto	48.1%	48.5%	48.9%	49.1%
	Shared Ride in Auto	38.1%	38.5%	38.6%	38.8%
	Walk	9.1%	8.5%	8.2%	8.0%
	Bicycle	4.1%	3.8%	3.6%	3.5%
	Transit	0.6%	0.6%	0.7%	0.6%
	Other Non-Vehicle*	0.0%	0.0%	0.0%	0.0%
	Total Daily Trips	2,722,863	2,997,134	3,464,354	3,885,123
Vehicle and Transit Data – Typical Weekday	Vehicle Miles Traveled (VMT)	12,895,810	14,463,906	17,247,089	19,498,069
	VMT per Capita	22.8	23.0	23.4	23.4
	Average Vehicle Speed (mph)	38	37	35	33
	Average Vehicle Trip Length (mi)	6.7	6.9	7.0	7.1
	Vehicle Hours Traveled (VHT)	342,573	395,715	496,478	589,434
	Transit Trips (Linked)	18,573	19,532	23,618	25,280

Sources: NFRMPO 2019 RTDM, NFRMPO 2019 LUAM

* Other Non-Vehicle includes Reduced Drive Alone trips using the TDM tool in the NFRMPO 2019 RTDM. This tool is not used in the Baseline Plan.

Table 16: NFRMPO Modeling Summary, Updated Plan

	Model Category	2026	2030	2040	2050
Socio-economic Data	Population	578,923	628,062	738,762	834,360
	Households	228,263	254,173	299,111	347,089
	Employment	272,192	291,939	331,713	367,686
Lane Miles by Roadway Type	Interstate	157	158	158	158
	Expressway	207	207	207	207
	Principal Arterial	666	701	745	745
	Minor Arterial	796	825	872	894
	Collector	1,242	1,250	1,277	1,277
	Ramp	18	18	18	18
	Frontage Road	46	46	46	46
	Centroid Connector	1,370	1,371	1,368	1,368
	Total Lane Miles	4,502	4,576	4,691	4,713
Person Trip Mode Share	Single Occupancy in Auto	46.2%	44.8%	44.0%	44.5%
	Shared Ride in Auto	37.3%	35.4%	34.5%	34.7%
	Walk	11.5%	11.8%	12.2%	11.8%
	Bicycle	4.3%	2.2%	3.5%	3.7%
	Transit	0.7%	0.6%	0.6%	0.6%
	Other Non-Vehicle*	0.0%	5.0%	5.1%	4.6%
	Total Daily Trips	3,121,321	3,375,658	3,933,419	4,406,803
Vehicle and Transit Data – Typical Weekday	Vehicle Miles Traveled (VMT)	11,723,198	13,140,624	15,353,535	17,497,996
	VMT per Capita	20.3	20.9	20.8	21.0
	Average Vehicle Speed (mph)	38	38	36	35
	Average Vehicle Trip Length (mi)	6.0	6.3	6.4	6.5
	Vehicle Hours Traveled (VHT)	304,947	349,240	422,269	502,109
	Transit Trips (Linked)	20,182	22,869	27,520	29,896

Sources: NFRMPO 2019 RTDM, NFRMPO 2019 LUAM

* Other Non-Vehicle includes Reduced Drive Alone trips using the TDM tool in the NFRMPO 2019 RTDM.

The NFRMPO 2019 BY RTDM forecasts travel demand for a typical weekday when school is in session. The vehicle and transit data shown in both preceding tables is for a typical weekday. To account for lower traffic volumes on weekends and most holidays, a factor of 338 is used to convert daily VMT forecasts from the travel model into annual estimates used in the GHG emissions analysis. Additional details on the NFRMPO 2019 BY RTDM is available in **Appendix B**.

NFRMPO staff evaluated each GHG strategy for reasonableness, appropriateness, and fundability through existing and expected funding sources. It is important to note this report estimates total GHG emissions for the Updated Plan instead of attempting to identify the GHG emissions reductions from each strategy. This is because the effect of each strategy is nonadditive in the model, as they are in real life: implementing two or more strategies may create a larger impact than the sum of impact from each individual strategy due to synergies, or it may create a reduced impact compared to the sum of each strategy due to overlaps in how the strategies are reducing GHG.

Compared to the Baseline Plan, the Updated Plan has a large increase in walk trips and bike trips and a moderate increase in transit trips. Better connectivity and accessibility on the bicycle and pedestrian network and better frequency and more regional transit service account for the trip increases. In addition, congestion is expected to grow into the future because of increased population and job growth, making walking, bicycling, and transit more attractive than they otherwise would be.

CDPHE staff ran the MOVES4 version of the MOVES tool and provided NFRMPO staff with Microsoft Access databases for each compliance year. After completing an RTDM model run, NFRMPO staff exported that run's network shapefile to update for county designation and more accurate segment lengths. During shapefile processing, staff confirmed county designation by checking if each network link's centroid was located in the correct county. After confirming the county designation, staff added a new field to the shapefile named cntyMiles and calculated the geometry to get the network length in miles. After completing these steps, staff exported the network shapefile to link to the corresponding Microsoft Access database. Once the text file was linked, staff adjusted the "speedMOVESvmt" or "speedMOVESvmt2030" query so that it referred to the new .txt file. Once done, NFRMPO staff ran the query and exported the results to corresponding Excel documents for post-processing if needed.

Public Participation

The NFRT&AQPC will entertain adoption of the 2050 RTP Amendment, the FY2026-2029 TIP, and this GHG Transportation Report at their regular monthly meeting on July 2, 2026. All public comments submitted during the public comment period will be presented and the public is encouraged to attend. Minutes of the NFRMPO Planning Council's meeting will be available on the NFRMPO website at <https://nfrmpo.org/meeting-materials/>.

Impact

Based on the commitment to GHG strategies identified in the 2050 RTP Amendment, the NFRMPO region expects to see a decrease in overall trips taken and miles driven, increase in active transportation and transit usage, and a decrease in VMT. An overall explanation for the increase in non-SOV trips is a compounding of strategies that ramp up with each modeling year.

- **Active Transportation** – Speeds and bicycle/walking attractiveness were increased in the RTDM to represent better connectivity, safer facilities and crossings, adding bicycle lanes and additional protections, and the introduction of more regional e-bike and e-scooter options. These changes made active transportation modes more attractive for shorter and medium-length trips. Currently many of these bicycle and pedestrian options are available in Fort Collins and in pockets across the region, but it is expected these strategies will expand throughout the region in the future.
 - **Model impact:** Person-trip mode share for walking and bicycling shows consistent increases in 2030, 2040, and 2050, but little change in 2025. No bicycle and walking improvements were incorporated into the 2025 scenario.
 - **Context:** The [California Air Resource Board](#) found that increasing bicycle lanes on city streets led to a small increase in the percent of individuals commuting by bicycle and a reduction in the percent of individuals commuting by driving. NFRMPO staff extrapolated increases in bicycle network connectivity, safety, and accessibility.
- **TDM** – Investments in TDM will reduce the number of commuting trips taken by SOVs and will translate into fewer overall trips. TDM strategies like telework, SRTS, carpooling, transit subsidies, and vanpooling redistribute trips across the transportation system. The 2045 RTP was adopted prior to the COVID-19 pandemic, so expected trend changes in teleworking are represented in the 2050 RTP Amendment. Existing vanpooling rates are already incorporated into the RTDM, but the NFRMPO's TDM Action Plan and efforts by

the City of Fort Collins and Colorado State University (CSU) will increase the impact of TDM strategies in the region. In addition, more communities around the region are identifying the need for investments in TDM in their Transportation Master Plans. Additionally, more communities around the region are either expanding or creating their Safe Routes to School programs, which is reflected in the 'Other Non-Vehicle' portion of the model outputs using the model's TDM Tool. The NFRMPO is partnering with local agencies to develop a regional Safe Routes to School program that will be a resource to the local programs. The effectiveness of TDM strategies is expected to increase in each year as more communities implement TDM programs.

- **Model impact:** The NFRMPO anticipates a light-impact in 2030 and growing to a more successful program in 2040 and beyond.
- **Context:** According to the [California Air Pollution Control Officers Association](#), investments in TDM programs can result in a five percent reduction in SOV mode share and a four to six percent reduction in VMT. The NFRMPO chose to be conservative in the impacts of a TDM program but expects a program to grow in success over time.
- **Operations** – Fuel-burning vehicles emit GHG emissions when operating, so strategies that reduce the operation time of vehicles will also reduce GHG emissions. Operations strategies include reducing congestion and reducing delays at traffic signals or other obstacles. The impact of operations strategies is accounted for in the modeling by considering both vehicle miles traveled and vehicle speed by time of day.
 - **Model impact:** Traffic signal and operational improvements result in a reduction in hours of vehicle delay in the Updated Plan as compared with the Baseline Plan. The reductions in delay increase over time, as do the reductions in VHT.
 - **Context:** Research by the [California Air Resource Board](#) shows that traffic signal coordination can reduce GHG emissions between one (1) and ten (10) percent without accounting for induced demand.
- **Transit** – Since the 2019 adoption of the 2045 RTP, the NFRMPO held multiple Calls for Projects and new legislation has been passed at the State and federal levels. New funding for Bustang and local transit has been identified which will support the increases in transit service in future years. In addition, CDOT and Greeley have invested in mobility hubs, which will grow in usefulness over time.

- **Model impact:** The number of transit trips are higher in the Updated Plan compared to the Baseline Plan, with the greatest difference in 2050. Despite these notable increases in transit trips, mode share for transit trips remains about the same (0.5 percent to 0.7 percent) in both the Updated Plan and Baseline Plan. The increase in transit trips reduced VMT, VMT per capita, and VHT.
- **Context:** The Federal Transit Administration estimates that a quarter-full bus emits 33 percent less greenhouse gas emissions per passenger mile than the average single-occupancy vehicle. At-capacity buses can reduce emissions by up to 82 percent compared to SOV on a per-passenger-mile basis.

Appendix A: GHG Modeling Assumptions and Model Execution Intergovernmental Agreement (2023)

**INTERGOVERNMENTAL AGREEMENT BETWEEN THE COLORADO
DEPARTMENT OF TRANSPORTATION, COLORADO DEPARTMENT OF PUBLIC
HEALTH & ENVIRONMENT, AND THE NORTH FRONT RANGE
TRANSPORTATION & AIR QUALITY PLANNING COUNCIL REGARDING THE
EXECUTION OF MPO TRAVEL DEMAND MODEL AND MOVES EMISSIONS
MODEL**

5/30/2023

THIS AGREEMENT is made effective and entered into this ____ day of _____, 2023, by and between the North Front Range Transportation & Air Quality Planning Council, also known as the North Front Range Metropolitan Planning Organization (NFRMPO), the Colorado Department of Transportation (CDOT), and the Colorado Department of Public Health & Environment (CDPHE).

I. APPLICABILITY

This intergovernmental agreement (IGA) applies to the continuing, cooperative, and comprehensive transportation planning and emissions modeling processes required to be carried out pursuant to 2 CCR 601-22, the Rules Governing Statewide Transportation Planning Process and Transportation Planning Regions, as implemented by CDOT and the state's Metropolitan Planning Organizations (MPOs) in order to meet state transportation planning requirements and ensure progress towards reducing greenhouse gas (GHG) emissions from the transportation sector.

II. DEFINITIONS

All defined terms provided in 2 CCR 601-22 have the same definition in this Intergovernmental Agreement.

“Modeling Requirements to Estimate Greenhouse Gas Emissions” - a living document summarizing the most appropriate model structure and design standards for modeling GHG emissions and the transportation system as it relates to the requirements of 2 CCR 601-22. This document is developed and periodically updated through the Statewide Modeling Coordination Group.

“Statewide Modeling Coordination Group (SMCG)” - composed of travel and air pollutant modeling professionals designated by the State Interagency Consultation Team (IACT), with representatives from all the state's MPOs, CDOT, and the APCD.

III. PURPOSE

This IGA is established to define the roles and responsibilities of the Air Pollution Control Division of the CDPHE (APCD), the Division of Transportation Development of CDOT, and NFRMPO (hereafter referred to as “parties”) related to the development and execution of NFRMPO’s MPO Model and the MOVES Model to address the requirements of the GHG Planning Standard in 2 CCR 601-22. Further, this IGA ensures coordination between all parties in carrying out these responsibilities and sets common and shared standards, assumptions, and verification procedures for GHG analysis.

IV. COORDINATION AND COMMUNICATION

Staff from each party will work in partnership to ensure the successful implementation of 2 CCR 601-22 - Rules Governing Statewide Transportation Planning Process (“GHG Planning Rules”). Staff will communicate frequently and make every attempt to resolve differences at the lowest staff level possible and in a timely manner.

Each party will provide one or more representatives to serve on the following committees established by CDOT.

- The State Interagency Consultation Team (IACT), and
- The Statewide Modeling Coordination Group (SMCG).

The IACT works collaboratively and consults appropriately to approve modifications to Regionally Significant definitions, address classification of projects as Regionally Significant, review modeling assumptions and address other issues raised by the parties.

The SMCG works collaboratively to discuss, advise, and agree on analysis approaches and the inputs, content, and timing of work products and outputs related to travel demand modeling, MOVES modeling, and the interrelationships between these tools. The SMCG will make every attempt to resolve technical issues among the parties and to do so in a timeframe that does not delay submission of NFRMPO’s GHG Transportation Report. Disagreements among the SMCG will be elevated to the IACT.

It is expected that all parties will actively participate in the IACT and the SMCG along with any other groups as determined by the IACT.

Any protracted disagreements between parties shall be elevated to the Executive Director of each party.

V. ANALYSIS, DOCUMENTATION, REVIEW & VERIFICATION RESPONSIBILITIES

NFRMPO RESPONSIBILITIES - two (2) areas of responsibility are identified:

1-Modeling and Analysis

1. Notify CDOT's Director of Transportation Development and APCD's Director via email when initiating a transportation planning process that requires a GHG analysis under the GHG Planning Rules to ensure early coordination on MOVES analysis and other relevant technical issues. Such coordination will include de and format of data and reporting information to be shared between the NFRMPO, APC
2. Conduct travel modeling for the NFRMPO MPO area. Develop and report results of NFRMPO's Travel Demand Model and the MOVES Model to the standard described in the "Modeling Requirements to Estimate Greenhouse Gas Emissions" document. Operate these models as described in each submitted NFR
3. Ensure that results contained within the GHG Transportation Report submitted to APCD and CDOT are complete and comprehensive enough to allow for review and verification.

2-Documentation

1. Prepare the GHG Transportation Report in compliance with the requirements of 2 CCR 601-22, 8.02.6. Per the requirements of section 8.04.1, the GHG Transportation Report constitutes the technical data supporting NFRMPO's compliance demonstration. The GHG Transportation Report will also include, if applicable, a GHG Mitigation Action Plan.
2. Prepare a calibration and validation report per the requirements of 2 CCR 601-22, 8.02.2.1. This report may be included in the GHG Transportation Report.
3. Document any substantial changes or modifications made to the technical data provided by APCD, for review during the APCD verification process.
4. When appropriate, provide documentation as described in Section VI of this Agreement.

APCD RESPONSIBILITIES - two (2) areas of responsibility are identified

1-Modeling and Documentation

1. Prepare, and provide to the SMCG and NFRMPO's Transportation Planning Division Director, documentation of the MOVES modeling process, assumptions and inputs utilized by APCD for the NFRMPO MPO area, for inclusion in the GHG Transportation Report. Unless otherwise agreed to by the parties to this Intergovernmental Agreement, this modeling process and documentation will be

considered final for the duration of a given compliance period which begins when a GHG analysis is initiated as determined through SMCG consultation and concludes when the Transportation Commission has approved a NFRMPO GHG Report for a plan update or amendment.

2. Provide NFRMPO with GHG emission factor outputs from the MOVES model and any necessary tools for GHG emissions analysis for each of the required compliance years. Changes to GHG emission methodology that become available after a GHG emission analysis is initiated will only be used if agreed to by the parties to this Intergovernmental Agreement.

2-Review and Verification

1. Perform an overall review of the technical data provided in the draft GHG Transportation Report for obvious calculation errors, and/or results that appear inaccurate, unreasonable, inconsistent, or unsubstantiated; and assess the methods used to estimate future emissions projections

2. Provide timely feedback via a letter or email to NFRMPO's Transportation Planning Division Director on the submitted draft GHG Transportation Report recognizing that Reports will be considered acceptable if no written comments are received by NFRMPO within 30 days of submission. APCD will notify NFRMPO as early as possible of any potential issues to allow time for consultation and consideration of adjustments.

CDOT RESPONSIBILITIES - two (2) areas of responsibility are identified:

1-SMCG and IACT Coordination and Management

1. Convene, organize, and provide non-financial support to the IACT. Schedule a minimum of (3) meetings per year, with additional meetings as needed.

2. Convene, organize, and provide non-financial support to the SMCG. Schedule a minimum of (3) meetings per year, with additional meetings as needed, to evaluate the state of modeling throughout the duration of the rule and cooperatively review at least annually, the need for specific updates to the "Modeling Requirements to Estimate Greenhouse Gas Emissions".

3. Ensure that the "Modeling Requirements to Estimate Greenhouse Gas Emissions" document is updated to reflect new information and decisions made by the SMCG and that all changes receive concurrence from the SMCG before finalizing. Serve as document custodian and ensure all parties have access to the most recent version.

4. As a member of the SMCG, CDOT will provide technical support and advice on modeling issues as needed, including defining assumptions regarding zero emission vehicles by vehicle class and staging year to be used in the MOVES model.

2-GHG Transportation Reports - Facilitation and Review

1. Ensure timely exchanges of the tools, data inputs and outputs, and documentation between parties to this IGA.
2. Facilitate coordination of parties during the review process by helping to schedule meetings as needed and provide technical assistance as needed.
3. Support the Transportation Commission's review of each submitted GHG Transportation Report and prepare filing of all necessary information.

VI. RELIANCE ON PREVIOUS GHG EMISSIONS ANALYSIS

Applicable planning documents, as defined in 2 CCR 601-22, may rely on the previous GHG emissions analysis if the criteria listed below can be demonstrated. This demonstration must be described in writing and presented to the IACT and SMCG for their concurrence.

1. The new applicable planning document contains all projects which must be completed in the document's covered timeframe to achieve the transportation system defined by the applicable planning document for which the previous GHG emissions analysis was conducted;
2. The scope of each project in the new applicable planning document is not significantly different from that described in the previous applicable planning document; and
3. The previous GHG emissions analysis and Mitigation Action Plan, if any, demonstrates compliance with all applicable GHG Reduction Levels required in 2 CCR 601-22.

VII. AMENDMENT, TERMINATION, AND SUPERSESSION OF AGREEMENT

This IGA will be reviewed at least every four (4) years from its effective date. It may be amended, whenever deemed appropriate, by written agreement of all parties.

Any party to this IGA may terminate it by a 60-day written notice to the other parties. If this occurs, the parties agree to consult further to determine whether the issues can be resolved, and the agreement re-implemented in an amended form.

THE COLORADO DEPARTMENT OF TRANSPORTATION

By: DocuSigned by:

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Name: Darius Pakbaz

Title: Director, Division of Transportation Development

Date: 5/30/2023

THE COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

By: DocuSigned by:

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Name: Michael Ogletree

Title: APCD Director

Date: 5/26/2023

THE NORTH FRONT RANGE TRANSPORTION & AIR QUALITY PLANNING COUNCIL

By: DocuSigned by:

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Name: Suzette Mallette

Title: Executive Director

Date: 5/30/2023

Appendix B: NFRMPO 2019 Base Year Regional Travel Demand Model Description

Introduction

The NFRMPO 2019 Base Year (BY) Regional Travel Demand Model (RTDM) is a four-step travel model incorporating trip generation, trip distribution, mode choice, and trip assignment. The model was developed in 2023 and replaces the 2015 BY RTDM developed in 2019. Major improvements to the 2019 BY RTDM compared to the 2015 BY RTDM include updated traffic counts, land use data, and various modeling improvements. The NFRMPO's GHG emissions analysis for the 2050 RTP Amendment uses the NFRMPO 2019 BY RTDM Version 6.3 in TransCAD Version 9.0.

This document provides an overview of the 2019 BY RTDM. More detailed information on the modeling process, inputs, and procedures are available in the [North Front Range Regional Travel Demand Model 2019 Base Year: Technical Report](#). The Technical Report reflects the model as it was developed in 2023.

The remainder of this document is organized into the following sections:

- Model area and Forecast Years
- Demographic Development Estimation
- Roadway and Transit Systems
- The Four-Step Model
- Speed Feedback
- GHG Strategy Methodologies
- Induced Demand
- Model Calibration
- Model Validation

Model Area and Forecast Years

To enable modeling for ozone analysis, the RTDM covers additional portions of Larimer and Weld counties not within the NFRMPO boundary. The expanded area of the model, along with portions of the unexpanded modeling area that are outside of the NFRMPO Metropolitan Planning Area (MPA), are not included in the GHG analysis as the GHG Planning Standard applies to the MPA for the NFRMPO.

The model uses a traffic analysis zone (TAZ) structure developed based on existing land use and roadway conditions, future land use, and staff comments from member governments. Within

the NFRMPO region, the RTDM has 1,123 TAZs. The RTDM has a base year of 2019 and forecast years of 2026, 2030, 2040, and 2050.

Demographic Development Estimation

Socio-economic data provides the foundation for trip-making in the RTDM. Employment data is prepared for basic, retail, medical, and service employment types. Population and household data are developed using a population synthesizer. The population synthesizer generates a record for each person living in the model area, having information such as the person's worker status, student status, and age. Each person is associated with a household record. Household records include information such as household size, household income, and number of autos.

Employment data is used in the RTDM primarily as generators of trip attractions. Person and household data is used in the RTDM primarily as a generator of trip productions. The NFRMPO develops and maintains a Census Block-based land use allocation model (LUAM) which distributes total households and employment at the Block level in the base year and forecast years using a location-choice model. The land use model for the 2019 BY RTDM is the 2019 BY LUAM. Additional information on the 2010 BY LUAM is available in the "NFRMPO 2019 Land Use Allocation Model: Technical Documentation". The model uses forecasted growth in employment and households from the Colorado State Demography Office (SDO).

Roadway and Transit Systems

Roadway and transit networks contain basic input information for use in the model and represents real-world conditions to the greatest extent possible. The roadway network contains over 8,100 links within the MPO boundary defined according to facility type, area type, speeds, capacities, etc. The roadway network is used to distribute trips and route transit and automobile trips. The roadway network was prepared based on data from the NFRMPO and from scheduling/phasing of projects in the Regional Transportation Plan (RTP) and Transportation Improvement Program (TIP). The NFRMPO also collaborated with local jurisdictions as necessary to verify construction and opening dates. The model contains base year, interim year, and forecast year transit route systems based on information provided by Transfort, City of Loveland Transit (COLT), Greeley Evans Transit (GET), and CDOT. Transit networks are categorized into local, express, and Bus Rapid Transit (BRT) service.

The Four-Step Model

The four steps of the 2019 BY RTDM are illustrated in **Figure 2**. Key inputs to the travel model include the roadway and transit system networks and TAZ-level data including population and

jobs. Each step of the travel model answers a different question; see sections below for detail on each step. Key outputs of the travel model include roadway volume and speed by time of day, transit boardings by route, and trip share by mode.

Figure 2: The Four-Step Travel Model

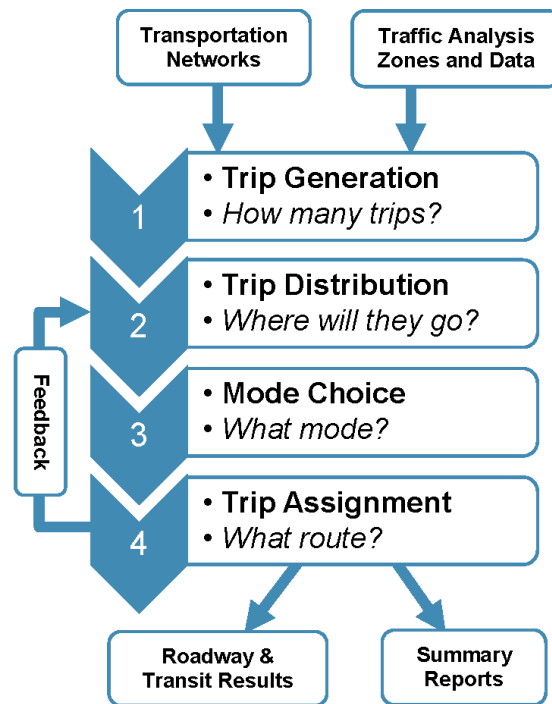


Figure 2 Additional Context: Key inputs to the four-step travel model include the transportation network and TAZs and data. The first step of the travel model is trip generation, which figures out how many trips there are. The second step is trip distribution, which figures out where people will go. The third step is mode choice, which determines what mode people will use. The fourth step is trip assignment, which figures out what route will be taken. The result of this model is roadway and transit results as well as summary reports.

Trip Generation

The trip generation module estimates trip productions and attractions based on zonal attributes (e.g. population, households, income, employment, etc.). Productions and attractions are generated for each TAZ and balanced by trip purpose at the regional level. Person trip productions are generated using a disaggregate choice model estimated from the 2010 household travel survey. This model distinguishes between workers who commute and those who do not commute because they are either working from home or taking the day off. Truck

trips and trip attractions are generated using a regression model. The unexpanded model includes the following trip purposes:

- **Home-Based Work (HBW):** Commute trips between home and work.
- **Home-Based University (HBU):** Trips between home and university locations (e.g., CSU, UNC) for school related purposes by people not employed by the university.
- **Home-Based Shop (HBS):** Trips between home and retail locations for the purpose of shopping.
- **Home-Based School (HBSc):** Trips between home and K-12 school locations for students in these schools.
- **Home-Based Other (HBO):** All other trips with one end at home.
- **Work-Based Other (WBO):** Work-related trips without an end at home.
- **Other-Based Other (OBO):** Trips with neither an end at home nor a work-related purpose.
- **Lodging-Based Other (LBO):** Trips made by visitors, based at a lodging establishment (Estes Park area only, not included in the household travel survey).
- **Medium Truck (MTRK):** Medium-heavy truck trips (FHWA Vehicle classes 5-7).
- **Heavy Truck (HTRK):** Heavy truck trips (FHWA Vehicle classes 8-13).

Some TAZs have unique land uses and generate a significantly different number of trips in comparison to the model's estimation. For these locations, special generator values are applied in the model to define the number of trips produced and attracted to the locations. The main Colorado State University (CSU) campus in Fort Collins and the University of Northern Colorado (UNC) campus in Greeley are the two University special generators used in the NFRMPO model area. Additionally, Rocky Mountain National Park is treated as a special generator in the expanded model area.

The model represents two types of external travel. Through trips are represented by the external-external (EE) trip purpose. Trips with one end inside the modeling area and another outside of the modeling area are referred to as Internal-External/External-Internal (IE/EI) trips. These trips are included in the primary model trip purposes described previously. At external stations, the number of IE/EI trips by purpose is based on traffic count data. Distributions of both EE and IE/EI trips have been calibrated based on analysis of LOCUS location-based services (LBS) data. Growth in external travel is based on analysis of the Colorado Statewide Travel Model.

Trip Distribution

Trip distribution is the process used to apportion person trip productions and attractions from the trip generation model among all zone pairs by trip purpose. The resulting trip table matrix contains both intrazonal trips (trips that do not leave the zone) on the diagonal and interzonal trips in all other zone interchange cells. The NFRMPO model uses a destination choice model for most trip purposes and a standard gravity model for HBU and HBSc trip purposes. The trip distribution model is validated to average trip lengths and trip length frequency distributions observed in the HHTS and developed from LOCUS LBS data.

Mode Choice

The RTDM uses a nested logit model to determine travel modes. The first step in the mode analysis process is the split among primary modes: auto, transit, and non-motorized. The second step provides a choice between drive alone and shared ride 2 and shared ride 3+. The next model provides a choice between walk and drive access to transit, followed by a choice between walk or drive access and then local, express, and BRT. The drive access mode only considers express and BRT transit, as on-board data shows that drive access to local transit is minimal in the region. Lastly, the model provides a choice between walk and bike.

Trip Assignment/Time-of-Day Analysis

The traffic assignment module loads vehicle trips onto the roadway network to estimate link-specific traffic volumes. This is done for three time periods which cover the entire day: the PM peak period, AM peak period, and off-peak. Each of these trip tables is further segmented into peak and shoulder periods, for a total of eight time periods: AM peak, one AM shoulder hour, midday peak period, PM peak, three PM shoulder hours, and an off-peak period representing the remainder of the day. These eight vehicle trip tables are assigned to the roadway network using a capacity constrained equilibrium assignment procedure. The resulting traffic volumes from the four assignments are summed to estimate a 24-hour volume for each link in the network. The mid-day and off-peak periods can be further divided into hourly volumes using percentages identified in the RTDM Technical Report.

Speed Feedback

A speed feedback loop is incorporated into the modeling process to ensure consistency of speeds. This corrects a fundamental problem with travel demand models when estimated speeds used in the trip distribution process are not the same as those which result from the traffic assignment/speed estimation process.

GHG Strategy Methodologies

Transportation Demand Management (TDM)

To reflect the TDM program being developed by the NFRMPO along with other TDM programs across the region, the RTDM was updated to account for a reduction in drive alone trips within specific areas using the NFRMPO's TDM processor. Reduction factors are applied to specific trip purposes based on anticipated effects of the TDM efforts, with reductions varying spatially and over time. Drive alone trips reduced through the TDM processor are assumed to be replaced by locally specific tele-travel (regional increases in work from home shares are addressed directly in trip generation), non-motorized travel, transit, or rideshare; however, the RTDM does not assign a specific mode to the reduced drive alone trips. This is shown in **Figure 3** and **Table 17**. The reduced drive alone trips are identified as “other non-vehicle” trips in the model summary tables included in the GHG Transportation Report.

Figure 3: TDM in the Model

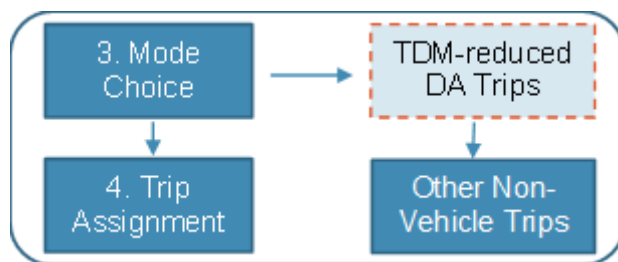


Figure 3 Additional Context: TDM in the model accounts for the development of Transportation Management Organizations (TMOs), increased outreach and marketing, expanded vanpooling and carpooling options, the development of Safe Routes to School (SRTS) programs, and development of regional resources and tools. TDM in the model is further explained in the preceding paragraph.

Table 17: TDM Improvements and Funding Sources

Category	Improvement	Funding Source
TDM	Transportation Management Organization (TMO) to conduct business outreach and develop resources	MMOF, CDOT 10-Year Plan, CDOT, IIJA
TDM	Expansion of RideNoCo program for trip planning, ridesharing, and vanpooling	MMOF, FTA, CDOT, IIJA
TDM	Schoolpooling and SRTS programming	MMOF, CDOT 10-Year Plan, IIJA, Local Funds
TDM	Marketing and promotion of expanded transit, bicycle, and pedestrian options	MMOF, IIJA

Due to the time needed to establish regional TDM programs, the 2029 compliance year for the Updated Plan does not account for any benefits of TDM. **Table 18** displays the reduction factors assumed for 2030, 2040, and 2050 in the Updated Plan. Model runs for the Baseline Plan do not account for TDM programs. Nearby communities have seen up to a [40% reduction in traffic near schools](#) with SRTS programming. After discussing with the NFRMPO's model consultant, the NFRMPO has determined a 15% reduction factor in 2030 and a 25% reduction factor in 2040 and 2050 for Trips to School is a reasonable assumption. Due to the time needed to establish and expand SRTS programs, the 2029 compliance year for the Updated Plan does not account for any additional SRTS benefits.

Table 18: TDM Reduction Factor in the Updated Plan by Location and Trip Purpose, 2030, 2040 and 2050

Locations	Year(s)	Home Based Work and Work Based Trips	Home Based Shopping/ Other Trips	Trips to School	Trips to Universities	All Other Trips
Fort Collins	2030	3%	2%	15%	5.5%	1.5%
	2040	3%	2%	25%	5.5%	1.5%
	2050	3%	2%	25%	5.5%	1.5%
Greeley, Loveland, Windsor	2030	1.5%	1.5%	15%	5%	1.5%
	2040	1.5%	1.5%	25%	5%	1.5%
	2050	1.5%	1.5%	25%	5%	1.5%
Timnath, Severance	2030	0.5%	0.5%	15%	5%	1.5%
	2040	0.5%	0.5%	25%	5%	1.5%
	2050	0.5%	0.5%	25%	5%	1.5%
Remaining NFRMPO Areas	2030	0.5%	0.5%	3%	5%	1.5%
	2040	0.5%	0.5%	3%	5%	1.5%
	2050	0.5%	0.5%	3%	5%	1.5%

Bicycle and Pedestrian Improvements

To account for the expansion of the bicycle and pedestrian network that is forecasted to occur over the lifetime of the RTP, along with the increasing availability of e-bikes and scooters, the RTDM was updated by increasing the average speed of walk trips and bicycle trips and reducing the alternative specific constant of bicycle and pedestrian trips for most trip purposes.

While the RTDM includes a bicycle network, there are three reasons for not reflecting bicycle improvements through the model network. First, the location of bicycle facility improvements through 2050 is not known. Second, extensive bicycle network improvements that reduce level of traffic stress on a regional scale are significantly different than the bicycle facilities included in the calibrated base year model. Finally, expansion of the modeled bicycle network would not account for new technologies such as e-bikes and scooters.

To equate improvements in bicycle and pedestrian infrastructure, the walk and bicycle speed assumptions were updated. These were updated to be representative of improvements to connectivity and accessibility. Modeling completed for the Baseline Plan and the 2025 compliance year for the Updated Plan use the unadjusted values shown in **Table 19**. The 2025 compliance year in the Updated Plan uses unadjusted values due to the time needed to

implement expansions to the bicycle and pedestrian network. Modeling completed for 2030 and beyond for the Updated Plan use the adjusted values shown in that table.

Table 19: Walk and Bicycle Speed Assumptions

	Unadjusted Values	Adjusted Values
Walk Speed	3 mph	4.5 mph
Bicycle Speed	12 mph	17 mph

Table 21 converts the Bicycle and Pedestrian Alternative Specific Constants (ASCs) developed by Cambridge Systematics from **Table 20** into equivalent minutes of In-Vehicle Travel Time (IVTT). In essence, the model assumes a penalty for choosing an alternative mode of transportation based on attractiveness for trip types. Expected improvements to the bicycle and pedestrian network could reduce barriers to making these options more attractive for people to use. The NFRMPO asserted a 25 percent reduction to ASCs for all trips except HBSc, which already had a positive constant. The results were tested and showed a 1.0 percentage point increase in non-motorized trips in 2050 between the Baseline Plan and Updated Plan, which was deemed reasonable based on expected investments in network connectivity, accessibility, and improvement projects. These investments include safer bicycle lanes, better connectivity and protection, more marketing, improved wayfinding, and better bicycle parking, among other improvements.

Table 20: Bicycle and Pedestrian Alternative Specific Constants

Trip Purpose	Unadjusted Values		Adjusted Values	
	Bicycle	Pedestrian	Bicycle	Pedestrian
HBW	-0.336566	-0.560631	-0.25242	-0.42047
HBU	-0.853826	-0.546834	-0.64037	-0.41013
HBS	-1.452584	-0.467941	-1.08944	-0.35096
HBO	-0.311467	0.925648	-0.2336	0.694236
HBSc	0.366699	1.299213	0.366699	1.299213
WBO	-1.586597	-0.332458	-1.18995	-0.24934
OBO	-1.888487	-0.072737	-1.41637	-0.05455
LBO	-1	-1	-0.75	-0.75

Table 21: Bicycle and Pedestrian Alternative Specific Constants, Equivalent Minutes of In-Vehicle Travel Time (IVTT)

Trip Purpose	Unadjusted Values		Adjusted Values	
	Bicycle	Pedestrian	Bicycle	Pedestrian
HBW	13.46	22.43	10.1	16.82
HBU	34.15	21.87	25.61	16.41
HBS	58.1	18.72	43.58	14.04
HBO	12.46	-37.03	9.34	-27.77
HBSc	-14.67	-51.97	-14.67	-51.97
WBO	63.46	13.3	47.6	9.97
OBO	75.54	2.91	56.65	2.18
LBO	40	40	30	30

Work From Home

The RTDM makes assumptions about the rate of workers not commuting on a specific day. This non-commute share reflects the rate of telework along with the workers at self-employed small home businesses; those regularly working from home offices; and a share of workers not working on a typical day due to absenteeism, part time work, and alternative schedules such as weekend work or three 12 hour shifts a week.

For the base year, the work from home rate is assumed to be 11 percent based on analysis of the HHTS and coordination with CDOT and DRCOG. Under a standard future condition without increased work from home, the rate is assumed to stay at 11 percent. With the Updated Plan, a higher share of work from home is anticipated. The model assumptions for the Updated Plan include slightly more than doubling the work from home rate from 11 percent to 25 percent.

The NFRMPO, The City of Fort Collins, and CSU developed TDM Plans, which addresses investments in TDM resources, strategies, and programming throughout the region. These Plans built on shifts during the COVID-19 pandemic, which increased telework policies and strategies. In addition, CDOT has developed new funding to invest in TDM strategies, including creating WFH policies.

Analysis of HHTS data shows that reductions in commute trips are linked to an increase in the amount of home-based shopping (HBS), home-based other (HBO), and other-based other (OBO) trips as workers make additional trips in place of their commute trips. The disaggregate trip

generation model estimated using the 2010 HHTS accounts for the increase in other trip types resulting from decreased commute trips through interaction between the trip generation models for each trip purpose. For the Baseline Plan, the work from home share remains at 11 percent.

Improved Transit Service, Mobility Hubs, Transit Signal Priority, and Real-Time Transit Information

Modeling conducted for the Updated Plan includes additional transit service, mobility hubs, transit stations, and park-n-rides as identified in the Updated Plan. Transit service and improved park-n-rides were incorporated directly into the model. In addition to these improvements, two adjustments were made to modeling conducted for the Updated Plan to reflect transit signal priority for certain transit routes and the availability of real-time transit service information.

The Transit Speed/Congested Speed Factor reflects the travel speed of the transit route relative to the congested speed of traffic. Without transit signal priority and given the need to make stops along the route, the default assumption in the RTDM is a factor of 0.5, which means transit service operates at half the speed of traffic. The adjusted value is used for routes planned to have transit signal priority in future compliance years, starting in 2040.

The model’s unadjusted transfer penalty factor of 3.5 minutes reflects the uncertainty of making a transfer between transit routes and is used in the Baseline Plan and 2025 compliance year. Modeling conducted for the Updated Plan for 2030 and beyond uses the adjusted transfer penalty factor of 0.0 which reflects the increased certainty provided to transit users through real-time transit service information.

Table 22 identifies the unadjusted and adjusted transit assumptions for transit speeds and the transfer penalty.

Table 22: Unadjusted and Adjusted Transit Assumptions

Assumption	Unadjusted Value	Adjusted Value
Transit Speed/Congested Speed Factor	0.5	1.0
Transfer Penalty	3.5	0.0

Arterial Signal Timing Improvements

To account for planned improvements to arterial signal timing identified in the Updated Plan, the RTDM was adjusted to reflect reduced delay along major corridors with traffic signals and increased demand due to improvements in speed, as shown in **Table 23**. The arterial signal

timing adjustments are applied in 2030 and beyond based on the forecasted number of traffic signals adjusted, the forecasted volume on major corridors, and delay reduction and induced travel elasticity factors identified in CDOT's [Policy Directive \(PD\) 1610: Greenhouse Gas Mitigation Measures](#). Specifically, PD 1610 identifies the following factors for arterial signal timing improvements:

- Hours of delay reduction per vehicle per mile: 0.006
- Induced travel elasticity (defined as percent change in VMT with respect to percent change in travel time): -0.3

Table 23: Arterial Signal Timing Assumptions, Updated Plan

	2030	2040	2050
Number of Signals	126	126	126
Average Forecasted Volume Before Signal Timing	20,002	24,693	29,352
Delay Reduction (Hours)	45,555	56,019	66,589
Average Forecasted Volume After Induced Travel Adjustment	20,722	25,582	30,409

Induced Demand

Induced demand is the increase in the overall amount of travel such as person-miles traveled (PMT) or VMT in response to improvements in transportation capacity/level of service. There are five possible elements of induced demand:

1. **Route shifts:** Travelers choosing a different route, which changes volumes on particular facilities and has the potential to slightly increase or decrease overall VMT.
2. **Mode shifts:** Travelers choosing a different mode, which changes overall VMT but does not significantly change PMT.
3. **Destination shifts:** Travelers choosing to visit different destinations or choosing to live further or closer to their frequent destinations.
4. **Additional trips:** Travelers choosing to make a trip they would otherwise forgo.
5. **New development:** In the long term, transportation capacity can influence the location of new development, which may affect overall VMT.

Another type of change that may occur as a result of increases in transportation capacity is shifts in the time of day trips are made. This change does not significantly increase the amount of PMT or VMT, but it can impact congested speeds.

The 2019 BY RTDM addresses three of the five elements of induced demand:

- The traffic assignment model is sensitive to travel time and capacity and assigns higher volumes to improved facilities.
- The mode choice model is sensitive to level of service by mode and allocates travel demand to improved modes.
- The trip distribution model is sensitive to travel impedance and adjusts destinations in response to new capacity.

The trip generation model of the 2019 BY RTDM includes limited consideration of destination accessibility, but model estimation exercises did not uncover a significant relationship between accessibility and trip generation rates. Therefore, the model does not forecast significant changes in trip generation resulting from transportation system improvements. Lastly, the 2019 BY RTDM does not directly address the new development element of induced demand, as changes to forecast year land use patterns related to transportation improvements would require additional updates to the land use allocation model as well as coordination with local jurisdictions. Future updates to the NFRMPO's RTDM will continue to explore data sources and potential model improvements related to these two elements of induced demand.

Model Calibration

The 2019 BY RTDM was calibrated using data from the 2010 *NFRMPO Household Survey*, LOCUS LBS data, and the *NFRMPO On-Board Transit Survey, 2009 (OBTS)*. The household survey was used to develop the trip generation model and auto occupancy rates. The household survey combined with LOCUS LBS data was used to develop trip length frequency distributions and average trip lengths by purpose and time of day. The OBTS was used in combination with the household survey and 2019 transit boarding counts to produce mode share targets. Additional detail on model calibration is available in Section 12 of the NFRMPO's RTDM Technical Report.

Model Validation

Validation involves testing the RTDM's predictive capabilities. Validation tests include quantifying the model's ability to replicate observed conditions and performing sensitivity tests.

The base year validation effort was conducted by comparing model results to observed traffic count data representative of 2019 (collected between 2017 and 2019). Transit ridership was validated to boarding counts on the transit systems in the region at the system level. The overall sum of model volumes is within two percent of the traffic counts on the same links. Model volume totals by facility type are within ten percent of the sum of traffic counts for arterials and

freeways and within 15 percent for collectors. The overall percent root mean square error (percent RMSE) is 41.5 percent. Additional detail on model validation is available in Section 12 of the NFRMPO's RTDM Technical Report.

Table 24 shows validation data for the NFRMPO's 2019 BY RTDM to use as a comparison to data shown in the GHG Transportation Report.

Table 24: NFRMPO Updated Plan Modeling Summary, Validation

	Model Categories	2019
Socioeconomic Data	Household Population	549,037
	Households	210,824
	Employment	240,483
Person Trip Mode Share	Single occupancy in auto	49.7%
	Shared ride in auto	37.8%
	Walk	8.2%
	Bicycle	3.7%
	Transit	0.5%
	Other Non-Vehicle	0.0%
	Total Daily Trips	2,759,292
Vehicle and Transit Data – Typical Weekday	Vehicle Miles Traveled (VMT)	15,139,122
	VMT per capita	27.6
	Average vehicle speed (mph)	38
	Average vehicle trip length (mi)	6.6
	Vehicle Hours Traveled (VHT)	367,546
	Transit trips (linked)	13,976

* Other Non-Vehicle includes Reduced Drive Alone trips using the TDM tool in the NFRMPO 2019 RTDM. This tool is not used in the 2019 model run.

Appendix C: MOVES4 Modeling and GHG Emissions Calculation Methodology Memorandum



COLORADO

Department of Transportation

Division of Transportation Development

2025 MOVES4 Modeling and Greenhouse Gas Emissions Calculation Methodology

To: Transportation Commission

From: Sabrina Williams - CDOT and Dale Wells - CDPHE

Date: December 22, 2025

Subject: CDOT Greenhouse Gas Transportation Planning Standard —
2025 MOVES4 Modeling and Greenhouse Gas Emissions
Calculations Methodology Documentation.

Appendix C.1 - Introduction:

This document summarizes the methodology used to calculate greenhouse gas (GHG) emissions for demonstrating compliance with the CDOT Greenhouse Gas (GHG) Transportation Planning Standard (Standard). Previous GHG emissions calculations to support CDOT were conducted by the Air Pollution Control Division (APCD). This methodology represents a coordinated approach between CDOT and APCD's modeling teams to represent likely future on-road GHG emissions as accurately as possible. The approach was also agreed upon by the Statewide Model Coordination Group (SMCG). Several refinements and improvements were made compared to the previous methodology for calculating GHG emissions due to the availability of new models, data and assumptions. All data and files utilized in the GHG emissions analysis methodology were reviewed by an individual other than the person who developed the data and/or performed the modeling as documented throughout.

The process for calculating GHG emissions begins with generating emission rates using the EPA's Motor Vehicle Emissions Simulator Model (MOVES). The GHG emissions rates developed in MOVES are the same statewide and applied consistently between all agencies to calculate mass total GHG emissions for a compliance area. The emission rates are multiplied by the vehicle miles traveled (VMT) from the Travel Demand Model (travel model) at the link level for individual hours of the days based on the observed vehicle mix from CDOT's statewide Automated Traffic Recorder (ATR) station network within a Microsoft (MS) Access relational database. The result of querying the database is the predicted total mass emissions of GHGs for the roadways represented in the travel model for an average weekday. This requires a series of data analysis and post-processing steps

to correctly compile these three main parameters (emissions rates, travel behavior, vehicle mix) into compatible formats within the database.

In 2025 the three significant new considerations for how GHG emissions are calculated for the purposes of an agency demonstrating compliance with the Standard were adopted by consensus through the Statewide Model Coordination Group (SMCG). These considerations involve updates to (1) vehicle emissions rates, (2) vehicle mix assumptions, and (3) the number of vehicle classes considered.

Each step in the emissions calculation process results in standalone datasets (emissions rates, vehicle mix, travel modeling) that are created independently, but compiled in a manner that allows this data to interface with each other through relational database software (MS Access) that calculate total GHG mass emissions for a compliance agency. All data used in the emissions analysis developed by an individual (or agency) was then independently reviewed by another individual (or agency) for data validity and accuracy prior to incorporation into the final GHG emissions calculations methodology. In addition to the analysts and reviewers noted throughout, all SMCG member agencies were extended the opportunity to perform additional data review at each step in development of the emissions calculations, including contributing to the underlying framework that established the methodology and resultant procedures.

Appendix C.2 - Vehicle Emissions Rates

Performed by: Sabrina Williams-CDOT

Reviewed by: Dale Wells-CDOT

New GHG Rates were required to incorporate the State Interagency Coordination Team (IACT) determination, as defined under 2 CCR 601-22 Section 1.44, May 5, 2025 that the CDOT Department of Accounting and Finance (DAF) projections on future EV adoption be used in the GHG emissions rates development. The previous GHG emissions rates were developed using asserted adoption curves of early, mid and late term EV adopters annually with individual forecasts for passenger vehicles and SUVs/light-duty trucks through 2050. CDOT DAF, as part of CDOT's 10-Year Plan development, created a forecast of expected revenue through the year 2050. As part of their revenue forecasting effort, DAF also generated a forecast of light-duty EV fleet growth in Colorado (since revenue from EVs is different from revenue from fossil-fueled vehicles). DAF's forecast estimated 950,000 light-duty EVs in Colorado in 2031, with an estimate of 95% of light-duty vehicles being EVs in 2050.

Separate EV adoption rates were initially developed for passenger cars and SUVs/light-duty trucks as at that time very few EV SUVs/light-duty trucks were available for purchase and it was unknown when additional electrified SUVs/light-duty trucks would be commercially available. Since the time the initial EV planning assumptions were used to develop the original GHG rates, numerous electrified SUV make and models are now

commercially available and auto manufacturers continue to release additional EV SUVs for sale. Furthermore, manufacturers have indicated that electrified light-duty trucks will become more broadly available in future years. The Colorado Energy Office (CEO) has completed numerous studies on likely future EV adoption for planning purposes such as EV charging infrastructure needs. These studies also project greater levels of electrification of these larger passenger vehicles within the next five years. Given that a significant percentage of passenger vehicles registered in the state are classified as SUVs and light-duty trucks, the earlier SUV/light-duty truck EV adoption rates was adjusted to reflect the quicker levels of EV adoption now expected. Therefore, in future years the rate of EV adoption is assumed to be the same between passenger cars and SUVs/light-duty trucks in developing the new GHG rates whereas previously they differed.

Appendix C.3 - Vehicle Mix Assumptions

Performed by: Juan Robles-CDOT

Reviewed by: Sabrina Williams-CDOT, Dale Wells-CDPHE

Overview

The vehicle mix represents the type (i.e. motorcycles, passenger cars, SUVs, vans, trucks, etc.) of vehicles operating on a roadway. The GHG emissions rates are highly variable by vehicle class and generally increase with the size of the vehicle. For example, passenger cars emit significantly less GHGs per vehicle mile traveled (VMT) than heavy-duty trucks. While travel demand models forecast total on-road travel behavior, including trips from commercial vehicles, no travel demand model in the state is calibrated for commercial travel accurately enough to properly assign the on-road vehicle mix. Therefore, the real-world observed vehicle mix used to calculate GHG emissions for the Standard is developed from traffic observations (counts) collected by CDOT's vehicle count stations.

Vehicle mix is assigned from ATR data using both continuous and short-duration counts stratified by hour of the day, the [13 Federal Highway Administration \(FHWA\) vehicle classifications](#) as well as roadway and urban or rural area type updated for more recently observed years. Each ATR station's counts were used in conjunction with VMT weighting for the roadway to develop a ratio of vehicle types by hour for all of the major roadway types in Colorado. The VMT-weighting of the counts is a refinement of the previous vehicle mix assignment that used unweighted (straight) counts in the previous emissions calculations. The VMT-weighting method was developed by CDOT and APCD in order to better reflect the vehicle mix outside the Front Range where the majority of ATR stations are located. Furthermore, for the 2025 vehicle mix used to calculate GHG emissions rates, post-pandemic (2023) vehicle classification counts were used. In the previous GHG emissions calculations methodology, pre-pandemic (2017-2019) vehicle classification counts were used. SMCG determined that an update to post-pandemic vehicle

classification counts should be made statewide to the emissions calculation methodology in order to more accurately reflect the vehicle mix that is currently present on roadways in the state as transportation behavior has altered since COVID due to factors including increased remote employment and land use changes.

ATR Count Data Methodology

To assign the vehicle mix percentages by roadway functional category, a total of 316 statewide count stations that collect hourly classification data were used. Of these count locations, 75 of them are permanent traffic recorders (ATRs), and 241 were short-term counts for the years 2022 and 2023. The 13-bin FHWA hourly counts were then grouped into the five Highway Performance Monitoring System (HPMS) class groups used in MOVES to calculate emission rates (passenger vehicles [including SUVs and light-duty trucks], motorcycles, buses, single unit heavy-duty trucks and combination heavy-duty trucks)

To calculate the vehicle mix fractions or percentages for each functional class by individual hours, the VMT-weighted sum of all hourly volumes from each class was divided by the total number of counts for each class. This means that ATR stations have a larger weight than short-term count locations because there are many more hourly counts available from ATRs, and that count stations with higher volumes or VMT have a higher weight than stations with low volumes or VMT.

A simplified example would be if the number of total individual hourly volumes at an ATR station were 20,000 vehicles and 17,000 vehicles were observed to be passenger vehicles and 1,000 vehicles were single unit (SU) trucks. In this case, the percentage of passenger vehicles for that station in that individual hour is assigned to be 85% and the fraction of SU trucks would be 15%.

[Figure C-1](#) below shows percentages for the Urban Freeways and Expressways functional category with reliance on 11 ATRs. The average percentages for this class are shown in green and the percentages for each of the ATRs are below the green bar. Only the aggregated values for the entire area type and roadway functional classification are used to calculate emissions for the state, the individual data shown for each ATR station is used in the calculation of average vehicle mix percentages.

Figure C-1. Example illustrating calculation of vehicle mix percentages as a weighted average of count data from multiple locations

Sta_ID	Rural_Urban	Func_Class	Average VMT	M-cycles	Pass_veh	Buses	SU	Combo
	Urban	(2) Freeway & Expr	109,926	0.17%	97.37%	0.13%	1.25%	1.09%
000003	Urban	(2) Freeway & Expr	134,451	0.19%	97.38%	0.06%	1.12%	1.25%
000004	Urban	(2) Freeway & Expr	168,873	0.07%	98.27%	0.29%	0.76%	0.61%
000503	Urban	(2) Freeway & Expr	57,247	0.10%	98.96%	0.07%	0.50%	0.37%
000504	Urban	(2) Freeway & Expr	246,762	0.18%	97.05%	0.23%	1.53%	1.02%
000506	Urban	(2) Freeway & Expr	91,498	0.13%	97.97%	0.10%	1.24%	0.56%
100331	Urban	(2) Freeway & Expr	131,878	0.20%	98.27%	0.20%	0.85%	0.48%
103608	Urban	(2) Freeway & Expr	104,847	0.11%	98.44%	0.09%	0.72%	0.64%
103684	Urban	(2) Freeway & Expr	81,433	0.12%	89.91%	0.25%	3.38%	6.34%
103712	Urban	(2) Freeway & Expr	11,012	0.10%	89.71%	0.11%	3.29%	6.78%
105548	Urban	(2) Freeway & Expr	164,048	0.19%	97.45%	0.07%	1.22%	1.08%
107556	Urban	(2) Freeway & Expr	121,040	0.13%	96.99%	0.10%	1.77%	1.02%

Of the seven roadway functional categories:

- (1) Interstate
- (2) Freeway & Expressway
- (3) Other Principal Arterial
- (4) Minor Arterial
- (5) Major Collector
- (6) Minor Collector
- (7) Local

CDOT does not collect classification data on Minor Collectors, Ramps or Local roads that would permit the calculation of accurate mix percentages for these roadways. Thus, there is no vehicle classification count data available at a statewide level for these roads. However, travel models must account for vehicle travel for all road types in the state to accurately predict passenger trips and associated VMT whose emissions need to be accounted for. CDOT and APCD determined the most suitable approach for assigning the vehicle mix on these access roads for the purposes of calculating GHG emissions was to assign the same vehicle mix as the most similar roadway functional classification for which vehicle classification was available. In this case, functional classes six and seven would use the rates from Major Collectors.

The result is a compiled table of the observed individual hourly vehicle mix by HPMS category for the seven roadway functional classifications that are represented in the travel modeling for a GHG compliance area.

The vehicle mix is applied to the travel model run data in the MS Access database that calculates the mass total emissions and is not considered directly within the MOVES modeling to develop the GHG emissions rates as discussed later in the documentation of the GHG emissions analysis methodology.

Appendix C.4 - Vehicle Classes Considered

Performed by: Mobility Analysis Section-CDOT

Reviewed by: Sabrina Williams-CDOT, Juan Robles-CDOT

The original GHG rates developed in MOVES for use in prior analyses to demonstrate compliance with the standard had unique rates for six HPMS vehicle categories: motorcycle, passenger cars, passenger trucks, buses, single unit heavy trucks, and combination heavy trucks. These GHG emissions rates by HPMS category are applied to the travel model data in the MS Access database in conjunction with the observed vehicle mix fractions (observed vehicle classification counts) to calculate total mass GHG emissions for a compliance area. However, Division of Transportation Development Mobility Analysis Section staff realized that because vehicle classification counts are recorded by the number of axles and length of a given vehicle, the CDOT count network often records SUVs and light-duty trucks as passenger cars. Furthermore, in MOVES the type of vehicles are not grouped by the body style of a vehicle, rather by similar characteristics of the engines and associated emissions profiles. This results in many vehicles that are commonly thought of as passenger vehicles, such as wagons and crossovers, being considered to be passenger trucks in the MOVES model.

To more accurately account for the number of larger passenger vehicles and to minimize the discrepancy between the CDOT count network's data collection mechanism and the MOVES model vehicle source types, a refinement was made to the number of vehicle classes considered in the GHG emissions calculations to combine passenger cars and SUVs/light-duty trucks to reflect total passenger vehicles. This was performed by aggregating the observed vehicle classification counts to a new HPMS25 vehicle category representing all passenger vehicles instead of differentiating between passenger cars and SUVs/light-duty trucks. This resulted in reducing the number of HPMS classes considered in the MOVES model to develop the updated GHG emissions rates from six to five categories of vehicles: motorcycles, passenger vehicles, buses, single-unit heavy trucks, and combination heavy trucks.

The refinements to the number of vehicle classes considered results in an increased representation of SUVs/light-duty trucks and their associated GHG emissions in the state that more accurately depicts present real-world observed conditions. Furthermore, the

approach of representing all passenger vehicles as a single HPMS category is now consistent with the manner in which CDOT reports HPMS data for the state.

Appendix C.5 - MOVES4 GHG Emissions Rates

Performed by: Sabrina Williams, CDOT

Reviewed by: Dale Wells, APCD-CDPHE

Overview

Incorporating the DAF future EV planning assumptions required new emissions rates to be developed in MOVES. Emissions rates were generated using the MOVES version 4.1.2 (MOVES4). Previously MOVES version 3.0.1 (MOVES3) was used to generate the original GHG emissions rates. The change in GHG emissions rates specific to changing to model versions is minimal due to the previous and continued high levels of EV/ZEV adoption assumed in future years, which is discussed in later sections. For more information about GHG modeling using MOVES, see the [Using MOVES for Estimating State and Local Inventories of On-road Greenhouse Gas Emissions and Energy Consumption](#) guidance document. The MOVES4 Run Specifications used to generate the GHG emissions rates may also be found in later sections.

MOVES4 Run Specifications

The run specification (RunSpec) parameters outlined below were used to calculate GHG emission rates with MOVES. CDOT performed the MOVES4 modeling to develop the new GHG emissions rates and model results and inputs were reviewed and verified by APCD for accuracy. The MOVES modeling methodology is largely consistent with APCD's previous process to calculate GHG emissions except where noted.

The three modeled years: 2030, 2040, and 2050, used the same run specifications except for where specified (e.g., the year being modeled). Each of the three modeled years has five related run specifications to separate the emission rates by vehicle type, as described in the On-road Vehicles section, i.e., five MOVES runs per compliance year. This denotes a change from the previous GHG emissions rates that were generated using six model runs to represent vehicle types by aggregating passenger cars with SUVs and light-duty trucks into a single MOVES run. When used for modeling compliance with the Standard the GHG emissions rates are applied identically between an agency(s) baseline plan and compliance plan demonstrations, e.g., there is no emissions benefit given to a compliance demonstration for future EV/ZEV adoption. If an MPO or CDOT were to develop a project in a long-range transportation plan specific to switching vehicle types or vehicle fuel types in a future year, this will be revisited by SMCG for consideration on how to best represent these types of planning actions.

Scale

The "Scale" parameters define the model type (on-road or non-road), domain/scale, and calculation type.

Model Type

On-road was the model type selected. This estimates emissions from motorcycles, cars, buses, and trucks that operate on roads.

Non-road/off-network emissions were not included. These emissions are from equipment used in applications such as recreation, construction, lawn and garden, agriculture, mining, etc. and are outside of the scope of this analysis.

Domain/Scale

MOVES allows users to analyze mobile emissions at various scales: National, County, and Project. While the County scale is necessary to meet statutory and regulatory requirements for State Implementation Plans (SIPs) and transportation conformity, either the County or National scale can be used for GHG inventories at the federal level. EPA recommends using the County scale for GHG analysis.

The County scale allows the user to enter locally-specific data through the County Data Manager whereas under the National Scale only MOVES default values are used. Providing local data significantly improves the precision of the modeling results and allows the MOVES users to better evaluate future planning scenarios. Therefore, the County Scale was used.

County Scale in MOVES can be used to model a single county, or a larger representative group of counties such as a nonattainment area or entire state that share common emissions characteristics such as fuel types and blends, emissions testing programs, vehicle age and other considerations. For this modeling, Adams County was used as the representative county on MOVES to develop the statewide GHG emissions rates. All non-default inputs in MOVES4 used in the County Data Manager are representative of the most currently available statewide vehicle data compiled by APCD for EPA's National Emissions Inventory (NEI) Reporting, with the exception of future EV/ZEV adoptions rates at the direction of IACT.

Calculation Type

MOVES has two calculation types - Inventory (total emissions in units of mass) or Emissions Rates (emissions per unit of distance for running emissions or per vehicle for starts and hotelling emissions) in a look-up table format that must be post-processed to produce an inventory. Either may be used to develop emissions estimates for GHGs.

The Emission Rates calculation type was used. Emissions Rates calculation type requires more post-processing; however, this also allows for a consolidated set of GHG emissions rates that can be used statewide by any GHG compliance agency with minimal emissions modeling required from an MPO. Furthermore, this method provides for not needing to rerun MOVES if there is a change to an agency's travel model.

Time Span

The “Time Span” parameters define the years, months, days, and hours that emissions are calculated.

When Emission Rates is specified in the RunSpec, users may choose to approach the selection of options in the Time Spans Panel differently than when running MOVES in Inventory mode. For example, when modeling running emission rates, instead of entering a diurnal temperature profile for 24 hours, users can enter a range of 24 temperatures in increments that represent the temperatures over a period of time. By selecting more than one month and using a different set of incremental temperatures for each month, users could create a table of running emission rates by all the possible temperatures over an entire season or year.

When using Emission Rates instead of Inventory, the time aggregation level is automatically set to Hour and no other selections are available. Pre-aggregating time does not make sense when using Emission Rates and would produce emission rates that are not meaningful. However, the year, month, and day must still be specified and will affect the emission rates calculated.

The time span parameters specified in the following subsections were also used because the travel model outputs represent an average weekday. These daily emissions are then translated into annual emissions in the final step of the emissions calculation process.

Years

The County scale in MOVES allows only a single calendar year in a RunSpec. Users who want to model multiple calendar years using the County scale will need to create multiple RunSpecs, with local data specific to each calendar year, and run MOVES multiple times.

The years used were 2030, 2040, and 2050. Emission rates for each of these years were calculated separately. This accounts for information such as a changing age distribution of vehicles, fleet turnover and their corresponding fuel types and fuel efficiencies.

Months

MOVES allows users to calculate emissions for any or all months of the year. If the user has selected the Emission Rates option, the Month can be used to input groups of temperatures as a shortcut for generating rate tables for use in creating inventories for large geographic areas.

The months used were January and July to match the previous modeling by APCD. These represent winter and summer months and generally the extremes in annual weather conditions. This accounts for changes in fuel efficiency between warm and cold temperatures throughout the year. The arithmetic averages of emission rates from January and July were used for the final emissions inventory to represent an annual average GHG emissions rate.

Days

Weekdays and weekend days can be modeled separately in MOVES. MOVES provides the option of supplying different speed and VMT information for weekdays and weekend days to allow the calculation of separate emissions estimates by type of day.

The days used were weekdays to match the TDM output data. These represented the emission rates for an average weekday. The results are annualized in one of the final steps for calculating the GHG emissions to approximate a full year.

Hours

The hours used were all 24 hours of the day (i.e., clock hours ending at 1:00 AM, 2:00 AM, 3:00 AM, etc.). These represent the emission rates for individual hours of a day. This accounts for changes in fuel efficiency between warm and cold temperatures throughout the day.

Geographic Bounds

The “Geographic Bounds” parameter defines the county(s) used. For a county-scale run, only one county can be selected per RunSpec. The county used was Adams County, Colorado; however, any county in Colorado could have been selected as the MOVES modeling defined input parameters such as the vehicle age used to estimate emission rates using statewide data.

On-Road Vehicles

MOVES describes vehicles by a combination of vehicle characteristics (e.g., passenger car, passenger truck, light commercial truck, etc.) and the fuel that the vehicle is capable of using (gasoline, diesel, etc.). This is required to specify the vehicle types included in the MOVES run.

The “On-road Vehicles” parameter defines the source types (i.e., vehicle types) and their fuels (gasoline, diesel, electricity, etc.). All combinations of vehicle types and fuels available in MOVES4 were used to calculate the emission rates; except that no EV/ZEVs are assumed for buses or commercial vehicles. The process for assigning what vehicle types are represented in the model run has been refined from the previous method that used separate MOVES runs to represent passenger cars vs. SUVs and light-duty trucks. The MOVES model runs used in the GHG rates update now match the MOVES HPMS types defined in the model that aggregates all passenger vehicles into a single category (HPMS=25).

[Table C-1](#) illustrates the HPMS categories.

Table C-1. Composition of vehicle types used for MOVES emissions modeling

MOVES Vehicle Source Type	HPMS Name	HPMS (Current)	HPMS (Previous)
Motorcycle	Motorcycles	10	10
Passenger Car	Light-Duty Vehicles	25	20
Passenger Truck	Light-Duty Vehicles	25	30
Light-Commercial Truck	Light-Duty Vehicles	25	30
Other Buses	Buses	40	40
Transit Bus	Buses	40	40
School Bus	Buses	40	40
Refuse Truck	Single Unit Trucks	50	50
Single Unit Short-Haul Truck	Single Unit Trucks	50	50
Single Unit Long-Haul Truck	Single Unit Trucks	50	50
Motor Home	Single Unit Trucks	50	50
Combination Short-Haul Truck	Combination Trucks	60	60
Combination Long-Haul Truck	Combination Trucks	60	60

Road Type

The Road Type in MOVES is used to define the types of roads that are included in the run. There are four categories of road types in MOVES used to represent onroad emissions and they are separated between urban vs. rural and ramp-controlled (Interstates) vs. non ramp-controlled (local roads). Assignment of the correct road type when calculating emissions is important because in MOVES the vehicle drive cycles assumed in the model are variable by road type, e.g., MOVES assumed more stop and go traffic on local roads associated with intersection controls than interstates, as well as area type, e.g., MOVES assumes a greater level of congestion on local roads in urban areas than rural areas. MOVES also has an option for Off-Network road types which would be associated with vehicle emissions not occurring in traffic, e.g., idling vehicles at a large transit station. All road types were selected in MOVES. The Off-Network road type must be selected for MOVES to execute in Emissions Rate mode, but was not used in the emissions calculations as they are not on-road emissions.

Pollutants and Processes

The Pollutants and Processes Panel allows users to select from various pollutants, types of energy consumption, and associated processes of interest. In MOVES, a pollutant refers to particular types of pollutants or precursors of a pollutant but also includes energy consumption choices. Processes refer to the vehicle mechanism by which emissions are released, such as running exhaust or start exhaust. Users should select all relevant processes associated with a particular pollutant to account for all emissions of that pollutant. Generally, for this project, that includes running emissions, e.g. emissions processes associated with vehicle start-ups, extended idling and refueling occur on Off-Network road types in MOVES.

The CO₂ Equivalent pollutant is the sum of the global warming potential of Carbon Dioxide (CO₂) and all other greenhouse gases expressed as a unit CO₂ Equivalents. (CO₂e) is the pollutant of interest in MOVES as it accounts for all greenhouse gas emissions considered in MOVES. MOVES requires several other prerequisite pollutants for CO₂e, e.g., methane; whose individual global warming potentials are calculated within the model and appropriately summed with CO₂ and reported as CO₂e.

General Output

The General Output parameters define the output database, units, and activity.

Output Database

Results from the five related HPMS RunSpecs for a given analysis year (2030, 2040, 2050) can be stored together in a single output database for convenience, or separate databases can be created for each run. The RunSpecs must have the same units and aggregation or MOVES will not execute. A different output database is required for each year and varying MOVES RunSpec. A consistent and informative naming convention for the output database assists in file housekeeping. Five output databases were used for each year modeled representing a single HPMS category for that year. Each output database contained results for the modeled year and vehicle HPMS category.

Units

Users can select from any of the mass unit selection options but should generally choose a unit whose magnitude is appropriate for the parameters being analyzed.

The units selected in the MOVES RunSpecs are grams for mass, joules for energy, and miles for distance.

Activity

MOVES allows the user to select multiple activity output options. As Emissions Rates were selected MOVES automatically reports emissions in mass units per distance traveled (grams/VMT) for each month and hour selected in the MOVES Time Spans panel for each Road Type selected in MOVES.

Output Emissions Detail

This panel allows the users to make selections that will additionally disaggregate the data beyond what is automatically reported by MOVES. Certain selections are automatically made by MOVES based on the RunSpec definition and cannot be unselected.

No optional details were selected in this panel as the outputs automatically reported by MOVES for these RunSpecs contain sufficient detail for calculating GHG emissions in this manner.

Input Database (Formerly the County Data Manager)

The previous panels in MOVES defined the RunSpec and the format of the output data. The next step is to create the input database where files with local data are imported.

The RunSpec parameters selected in the other panels in MOVES define the file structure and required data for the input database and constrain all files imported into MOVES to this structure or errors are generated and the model will not execute. Therefore, it is recommended that the MOVES user make this Input Database the last panel used in the MOVES graphical user interface (GUI) as any alterations to the RunSpec can result in needing to recreate its settings.

One input database was created for each model year for each vehicle HPMS category; a total of 15 MOVES model runs. Data is imported into the input database for each MOVES run, as specified below.

Age Distribution

The Age Distribution in MOVES represents the distribution of the age of each vehicle type in MOVES from 0-30 years old (vehicles whose model years are 31 years and older). The age distribution is a critical input in MOVES as this directly assigns the specific vehicle model years and vehicle characteristics, e.g., fuel types and associated emissions rates. MOVES allows the user to import locally specific data as was performed in this analysis. APCD develops locally specific age distributions from all vehicles registered in the state every three years for the EPA's National Emissions Inventory (NEI) reporting at the county and statewide level, as well as for the Denver Metro/North Front Range 8-hr Ozone Nonattainment Area. For this analysis, the statewide age distribution for the 2024 NEI reporting was imported into MOVES4 except for long-haul commercial vehicles. National default values were used for long-haul commercial vehicles as a significant portion of these vehicles in the state are registered elsewhere in the country.

Average Speed Distribution

Vehicle tailpipe emissions rates are highly affected by the speed the vehicle is traveling. At lower speeds associated with congestion emissions rates are higher and rates decrease until vehicles are traveling at speeds of approximately 55 miles per hour (mph) where at that point emissions rates begin to increase again. MOVES requires an Average Speed

Distribution be imported to perform a model run. This distribution is an important input in Inventory Mode as it represents the detailed information concerning the on-road speeds of vehicles and related emissions rates by road type, hour of the day, day of the week, and month of the year. In Emissions Rates mode, however, the average speed distribution is not used and for this analysis national default values were used.

Fuel

The fuels data in MOVES assigns the specific fuel formulations, including chemical properties, for all petroleum vehicles as well as the fuel types for each vehicle type by model year including representation of EV/ZEVs in the model through the Alternative Vehicles Fuels and Technologies (AVFT) file. For the GHG analysis, default fuel values were used with the exception of the AVFT data.

The AVFT file specifies the fraction of each fuel used by a vehicle type, e.g., gas, diesel, ethanol and electricity, for vehicle model years 1960-2060. It is important to specify these fractions by model year as this provides a more accurate estimate of the fuel economy standards and emissions improvements associated with fleet turnover as older higher emitting vehicles are retired and replaced with lower emitting vehicles than assuming an average fuel mix for an entire vehicle type in MOVES.

In a MOVES run, vehicle data is only considered for the same vehicle model year as the analysis year selected in the RunSpec and the previous 30 vehicle model years, i.e., the fuel mix considered in a specific run is assigned from the Age Distribution in MOVES.

Although EV/ZEVs have zero GHG emissions, these vehicles do have emissions of other pollutants, such as particulate matter, and should be represented within MOVES. Therefore, future EV/ZEV planning assumptions are directly considered within MOVES and there is no “zeroing” out of EV/ZEV VMT, because that VMT corresponds to a GHG tailpipe emissions rate of zero. For this analysis the AVFT file used the same motor vehicle registration data for the 2024 NEI as the Age Distribution through vehicle model year 2024 after which the DAF EV planning assumptions for light-duty vehicles were incorporated to represent future EV adoption levels. MOVES4 contains default values for future EV adoption for commercial vehicles; however, this data was not used in the model and no EV/ZEVs were considered for commercial vehicles.

Meteorology

Vehicle emissions rates can vary by temperature and humidity, particularly for criteria pollutants and mobile source air toxics. However, GHG emissions from vehicles relate to atmospheric conditions solely based on a driver’s comfort and their likely usage of air conditioning in a vehicle and resultant impacts to fuel economy. The default values for Meteorology in MOVES represent actual climate data for all individual counties in the nation as collected from the National Climate Data Center. MOVES default data for Adams County, Colorado was used for the months of January and July in the analysis, which is consistent with the RunSpec.

Road Type Distribution

MOVES does not have default data for the Road Type Distribution and it must be created and imported by the user. In Emissions Rates the Road Type Distribution data in a MOVES run does not impact the results and is not an important file in the analysis, but must be present and correctly compiled for the model to run. A Road Type Distribution file was provided by APCD imported in MOVES for the analysis.

Source Type Population

MOVES requires the Source Type Population file to be present in MOVES and there is no national default data available in MOVES. However, this file does not change the results in Emissions Rates as this data is used for calculating vehicle emissions associated with off-network activity, e.g., extended periods of idling at a truckstop or a large number of vehicles congregating at a transit station. As these vehicle emissions are not truly occurring “on-road” they are not accounted for in the analysis or present in the Emissions Rates output files. The Source Type Population was provided by APCD from the 2024 NEI and used in the analysis.

Vehicle Type VMT

The Vehicle Type VMT is required to run MOVES and is very important if Inventory is selected in the RunSpec. However, in Emissions Rates mode this data does not change the results; moreover, a single vehicle classification is considered in this analysis so the VMT considered in MOVES does not vary by vehicle category. Default Vehicle Type VMT data was imported in MOVES for all runs with the exception of the annual HPMS file that was provided by APCD from the 2024 NEI in order for MOVES to run.

Inspection and Maintenance Program

The Denver Metro/North Front Range Ozone Nonattainment Area has a vehicle inspection and maintenance (I/M); i.e., emissions testing program as an emissions reduction strategy in the state implementation plan (SIP) for all or a portion of these nine counties in the state. However, in MOVES there is no GHG tailpipe emissions benefit associated with I/M programs as emissions control devices such as catalytic converters and diesel particulate filters do not reduce emissions of GHGs. In MOVES there is a slight methane credit given to I/M programs associated with evaporative emissions; however, these emissions reductions are insignificant compared to net GHG emissions that are dominated by tailpipe exhaust. The check box for “No I/M Program” was selected since there is not a statewide I/M program and accounting for the minimal GHG emissions credit within the ozone nonattainment area would result in no meaningful change to the results.

MOVES Output Data and Post-processing

Output Database (HeidiSQL)

After MOVES has successfully completed a model run the results are stored in the output database that was created in the RunSpec. The MOVES install package includes HeidiSQL

which is an open source database software and results are automatically stored here as well as the data that was imported into the input database for that RunSpec.

The main output file of interest in MOVES for this analysis is the “Rate Per Distance” table. The file associated with each MOVES run contains the emissions rates for the HPMS category being analyzed for the months, road types and pollutants specified in the RunSpec for every individual hour of the day by speed bin. This table was queried in HeidiSQL to select only emissions of CO₂eq as that is the pollutant of interest in the analysis and those results were exported from the HeidiSQL as a .csv file for each MOVES run.

Post-Processing Emissions Rates by Speed and Month

Emissions Rates mode in MOVES does not produce emissions rates associated with speed changes at the level of rates at individual integer speeds in miles per hour values. Rather MOVES aggregates emissions by speed into groups of 16 speed bins with each bin corresponding to a five mile per hour maximum and minimum range of vehicle speeds, e.g., 42.5 mph to 47.5 mph. This results in faster model run times and smaller output files, and could be appropriate in instances where only a qualitative analysis is needed. However, for the purposes of this quantitative analysis a greater level of granularity concerning emissions rates by speeds is needed for GHG emissions results precise enough for accurate comparison to the absolute standards associated with each compliance year.

Previously the emissions rates were post-processed to produce emissions rates in grams per mile at individual integer speeds through interpolation in an additional MS Access database that was separate from the database utilized to calculate total mass GHG emissions for a compliance area. In revising the analysis, the interpolation methodology to develop GHG emissions rates in individual integer mph values remains unchanged, but APCD has consolidated this step into the same MS Access database used by an agency to calculate the total GHG emissions for a compliance area. Average annual emissions rates were similarly generated from a straight average of the emissions rates from the representative months of January and July in MOVES output data in the MS Access database.

Appendix C.6 - Calculation of Mass GHG Emissions

Performed by: Dale Wells-ACPD

Reviewed by: Sabrina Williams-CDOT

Total mass GHG emissions for a compliance area are calculated in MS Access databases for 2030, 2040 and 2050 that are developed by APCD and are unique for each MPO/non-MPO area based on the design and structure of each compliance agency’s travel modeling platform as well as the format the travel model runs data is provided.

Each database contains lookup tables for the GHG emissions rates and vehicle mix ratios that are consistent statewide, and the travel model run files specific to each individual

agency. There are additional tables in each database that appropriately assign each link a road type from MOVES based on the area type and roadway functional classification based on an agency's travel modeling metadata.

Travel Model Data Considerations

Prior to calculating GHG emissions an agency must remove all links extending outside of their GHG compliance area that are represented in the travel model run. This is performed by a compliance agency splitting any sections of links that may go outside a compliance area in comparison to their boundary in appropriate spatial software, e.g., ESRI geographic information system (GIS) or TransCAD, so that only the portions of the link within a compliance area boundary are considered in the GHG emissions calculations for the agency. Following the splitting of links, the length of those split links must be recalculated. Whether this calculation is done automatically or manually depends on the particular software platform in use. Once the lengths of any split links are calculated, the VMT for the split links can be calculated by multiplying the recently-calculated link length by the predicted travel volumes.

GHG emissions rates are highly variable by vehicle speeds, and to a much lesser extent individual hours of the day based on temperature and use of cooling in the cab of the vehicle. Ideally, some form of dynamic traffic assignment would be used (such as the Simulation-Based Assignment of PTV VISUM) to estimate such within-day variation in travel speed. Static assignment of 24 individual hours would produce similar output data for GHG emissions calculations. Conversely, if an agency's travel model has less than 24 time periods, coordination is required between CDOT, APCD and individual MPOs on an agreed upon process for disaggregating travel model data with predicted vehicle volumes and speeds from time periods representing multiple hours to discrete individual hours. This is particularly important for agencies with a traffic assignment process that contains a single off-peak period representing 22 hours travel behavior in a day. In this instance simply dividing the predicted volumes on a link by the number of hours in the period is likely to greatly underestimate travel volumes during the AM and PM peak shoulders and midday hours, while overestimating travel volumes in nighttime hours. Furthermore, the use of the predicted speed for a link from a four-step model during an off-peak hours is likely to overestimate speeds during the AM and PM peak shoulders and midday hours which results in underestimating emissions during this time of day.

Querying the Database

The MS Access databases developed by APCD each contain numerous queries that run in sequence. These queries assign the correct GHG emissions rates and vehicle mix ratios at the link level through a series of joins. The length of each link is multiplied by the predicted hourly volume to calculate the VMT for that hour that then is multiplied by the vehicle mix ratio and appropriate GHG emissions rate for that vehicle class to calculate the emissions. Emissions for the links are then summed together to calculate the final

database output which is daily GHG emissions in short-tonnes for each travel model scenario.

Calculation of Annual Emissions and Modeled Reductions

The emissions in GHG short-tons/day from the MS Access database are extracted into spreadsheet workbooks, e.g., MS Excel, and annualized through multiplying the weekday emissions by 338 to get annual emissions. Standard unit conversions (one US short ton = 0.907185 metric tons) are applied to calculate the GHG emissions in million metric tons (MMT) per year for each agency's baseline and compliance travel model scenarios for 2030, 2040, and 2050. The modeled emissions reduction for each year is simply calculated by subtracting the compliance emissions from the baseline emissions. The modeled emissions reduction is then compared to the agency's reduction target for that compliance year to determine if compliance with the Standard has been demonstrated through modeling or if mitigation is required.

Appendix D: CDOT Boundary and Links Verification Memo



COLORADO

Department of Transportation

Division of Transportation Development

North Front Range Metropolitan Planning Organization
C/O **Elizabeth Relford**, Executive Director
419 Canyon Ave.
Suite 300
Fort Collins, CO 80521
June 9, 2026

RE: Discrepancies with the MPO boundary shapefiles

Dear Elizabeth Relford,

The North Front Range Metropolitan Planning Organization (NFRMPO) model area includes areas outside of the MPO boundary; however, the NFRMPO is only responsible for modeling GHG emissions within the MPO boundary in order to comply with the CDOT GHG Transportation Planning Standard (GHG Rule). Doing so requires the creation of a subset of the model area unified network, including all regionally significant roadways within the MPO boundary by splitting roadways that cross outside the MPO boundary as represented in a digital mapping file within the travel demand modeling software. Per the IGA between CDOT and APCD, the Statewide Model Coordination Group's Memorandum on the "Process for GHG Emissions Calculations and APCD Verification" must be followed by each agency subject to the GHG Rule and associated compliance demonstration. To ensure that only roadways within the MPO boundary are accounted for in demonstrating compliance with the GHG Rule, the process established by the memorandum directs CDOT modeling staff to review the MPO regional roadway network in relation to the MPO boundary file retained by the CDOT GIS Section prior to APCD beginning the formal GHG emissions verification process.

In reviewing the roadway network splits at the MPO boundary, the CDOT modeling staff discovered discrepancies with the MPO boundary shapefile used by NFRMPO and the MPO boundary shapefile retained by CDOT. The areas where the boundary files did not agree are occurring on small subsections of regional roadways that border the NFRMPO and the non-MPO area as well as the border between the NFRMPO and the Denver Regional Council of Governments (DRCOG). This is resulting in minor overlapping of sections of regional roadways between agencies that is resulting in an overestimation of emissions at the statewide level. However, as the MPO boundary is defined between an MPO and the Governor, and furthermore, that this also relates to NFRMPO and DRCOG as well as NFRMPO and the non-MPO area, it is unclear to the CDOT modeling staff and the CDOT GIS staff which file most accurately meets the legal definitions of the two MPO boundaries and is precise enough for the purposes of calculating emissions.

Given that the MPO boundary file provided by NFRMPO for the purposes of this updated GHG Report is consistent with their prior GHG Reports and that this GHG Report is not part of a regular Regional Transportation Plan planning cycle but rather reflects the addition of a single Regionally Significant project of 4 new lane miles, CDOT has approved the use of the MPO boundary file NFRMPO has provided for the purposes of their 2026 GHG Report with no refinements for the purposes of creating the roadway network subarea that is used to calculate GHG emissions and demonstrate compliance with the GHG Rule.





COLORADO

Department of Transportation

Division of Transportation Development

CDOT requests that NFRMPO coordinate with their member local jurisdictions as well as DRCOG and their member local jurisdictions to make minor refinements to the MPO boundary files for each agency such that each exactly matches the legal definitions and are consistent with each other in a manner that is precise enough for the purposes of calculating emissions for the GHG Rule prior to NFRMPO's next long range regional transportation planning cycle (2055 Regional Transportation Plan) and GHG Report submission. Note that this does not request any changes be made to the legal definition of the MPO boundary for either agency and only reflects minor refinements to digital files and roadway representations for the purposes of being precise enough to accurately calculate emissions. Refinements to MPO boundary files to facilitate accurate emissions accounting practices should be made based on regional and local agency coordination and consensus on the interpretation of the correct legal definitions established between agencies and the Governor.

CDOT Office of Multimodal Planning, CDOT GIS Section, and CDOT Modeling Staff will be available to facilitate conversations between agencies as needed to support interagency cooperation and requests that future representations of NFRMPO's MPO boundary be provided to the CDOT GIS Section as refinements are made.

Sincerely,

Aaron Willis

Aaron Willis, Statewide and Regional Planning Section Manager, Division of Transportation Development

CC: Marissa Gaughan, Assistant Director, Division of Transportation Development
Sabrina Williams, GHG Program Modeler, Division of Transportation Development
M. Scott Ramming, PhD, PE, Professional Engineer II, Division of Transportation Development
Taylor Bartlett, Climate and Air Quality Specialist, Division of Transportation Development
Chris Laplante, Air Quality and Climate Section Manager, Division of Transportation Development



Appendix E: Hourly Traffic Volume/Speed Assignment Memorandum



COLORADO

Department of Transportation

NFRMPO GHG Emissions Modeling Memorandum

To: Transportation Commission of Colorado

From: Sabrina Williams

Date: June 9, 2026

Subject: Methodology for Assigning Individual Hourly Volumes from NFRMPO's Travel Model in the GHG Emissions Database.

Background:

The MOVES modeling conducted by APCD generated greenhouse gas (GHG) emissions rates in grams of CO₂eq/VMT for each individual hour of the day (24hrs) that is further disaggregated by speed, vehicle type, and road type. APCD uses the MOVES emissions rates in conjunction with a GHG compliance area's predicted total daily on-road travel activity for each compliance year within a database platform to calculate predicted total annual GHG emissions (million metric tonnes, MMT/yr) to verify whether an area can demonstrate compliance with GHG Rule for Transportation Planning. To accurately calculate total daily and annual GHG emissions it is necessary for the GHG database to assign individual hourly volumes and speeds (24hrs/day) at the link level from the travel model's daily output. Most travel models for GHG compliance areas in Colorado do not use 24 time periods that facilitate this individual hourly assignment. Therefore, as the NFRMPO GHG compliance area travel model has fewer than 24 time periods, APCD developed a methodology for the assignment of individual hourly volumes within the GHG database that interacts with the travel model output to calculate GHG emissions.

This methodology was developed and put into place by APCD as part of NFRMPO's initial GHG Report and associated emissions reduction compliance demonstration. The process for the assignment is documented in this NFRMPO GHG Emissions Modeling Memorandum by CDOT after reviewing the most recent GHG database developed by APCD and associated travel model documentation. The data used to develop this assignment can be found in the "North Front Range 2012 Base Year Regional Travel Model—Technical Documentation (NFRMPO, 2012)."

NFRMPO has a 4-step travel model that provides volumes aggregated to the following eight time periods (Table 7.1; NFRMPO, 2012):

Hour of the Day	Time Period	Description
7:00 AM to 8:00 AM	AM1	AM Peak Hour
8:00 AM to 9:00 AM	AM2	AM Shoulder

12:30 PM to 1:30 PM	MD	Mid-Day Peak
4:30 PM to 5:30 PM	PM1	PM Peak Hour
3:30 PM to 4:30 PM	PM2	PM Shoulder
2:30 PM to 3:30 PM	PM3	PM Shoulder
5:30 PM to 6:30 PM	PM4	PM Shoulder
All Other Hours	OP	Off-peak

Thus, it is necessary to disaggregate the 17-hour off-peak period into individual hourly volumes at the link level for the purposes of GHG emissions calculations.

Methodology

APCD developed a process for assignment of individual hourly volumes from travel model's off-peak period using the "VMT by Time of Day" data shown in the travel model technical documentation (Figure 7.1; NFRMPO, 2012). The use of hourly traffic counts as shown in the NFRMPO's travel model validation is the most appropriate dataset for this purpose as it uses real-world data down to the individual hour of day level of detail.

To further disaggregate the individual hour of the day volumes at the link level during the off-peak periods and also map it to the variables considered by the travel model during its calibration and validation, APCD used the "Off-Peak VMT Distribution by Time of Day" in the travel model technical documentation (Table 7.2; NFRMPO, 2012) as shown below:

Off-Peak VMT Distribution by Time of Day (Table 7.2; NFRMPO, 2012)

Off-Peak Time Period	Description	Off-Peak Percentage	Number of Off-Peak Hours
12:00 AM to 7:00 AM	Early Morning Off-Peak	18%	7
9:00 AM to 12:30 PM	Mid-Morning Off-Peak	42%	3.5
1:30 PM to 2:30 PM	Mid-Afternoon Off-Peak	9%	1
6:30 PM to 12:00 AM	Night-Off Peak	30%	5.5

In this table, the column labeled Off-Peak Percentage indicates what fraction those hours counts represents of the total off-peak count. This Off-Peak Percentage is divided by the number of hours in each off-peak time period shown above to calculate what percentage of the 17-hour off-peak predicted volume at that link occurs during each clock hour for that off-peak period.

Individual Hourly Volume Assignment

For the individual AM and PM peak periods that during a single hour of the day, the total predicted hourly volumes were applied at the link level without further travel model output data manipulation. As discussed above, rather than performing a simple average of the 17-hour total predicted off-peak volumes, data was used from the travel model technical documentation that further disaggregated the 17-hour off-peak period volumes using the VMT distribution also in the documentation into an additional 4 off-peak periods of contiguous hours in varying duration. Each percentage of off-peak VMT is then divided by the number of hours in the off-peak period to determine the ratios for assignment of individual hourly volumes for the NFRMPO's travel model off-peak period.

Conclusion

APCD developed a process for assigning individual hourly volumes at the link level that is appropriate for the purposes of calculating GHG emissions for the GHG compliance area. APCD relied on information provided by NFRMPO as part of their travel model technical documentation for the travel model platform, reviewed the travel counts used in the analysis for the individual hourly assignments and developed the methodology described in this memo that should result in an accurate depiction of individual hourly daily travel activity in the area required for use in the GHG database. The result of this process is a table housed within the GHG database containing the equations provided in this memo, that interacts with the travel model output table, as well as the MOVES GHG emissions rates that result in prediction of annual GHG emissions for the GVMPO GHG compliance area to determine whether the GHG reduction targets established in CDOT's GHG rule have been met.

**Appendix F: Resolution 2026-14 North Front Range
Transportation & Air Quality Planning Council (NFRT&AQPC)
Adoption**

RESOLUTION NO. 2026-14
OF THE NORTH FRONT RANGE TRANSPORTATION & AIR QUALITY PLANNING COUNCIL
ADOPTING THE NFRMPO GREENHOUSE GAS (GHG) TRANSPORTATION REPORT

WHEREAS, 23 CFR §450.324 requires development through continuing, cooperative, and comprehensive (“3C”) multimodal transportation planning process of a fiscally constrained Regional Transportation Plan (RTP) and Transportation Improvement Program (TIP) for Metropolitan Planning Organizations (MPOs); and

WHEREAS, pursuant to the legislation above, the North Front Range Transportation & Air Quality Planning Council (NFRTP & AQPC) was designated by the Governor of the State of Colorado as the MPO responsible for carrying out the transportation planning process, and for developing and amending the RTP; and

WHEREAS, Colorado Senate Bill 21-260 specified implementing relevant measures pursuant to § 25-7-105, C.R.S.; reducing GHG emissions to help achieve statewide GHG pollution reduction targets established in House Bill 19-1261 (now codified in § 25-7-102(2)(g) and 105(1)(e), C.R.S.); and considering the role of land use in the transportation planning process; and

WHEREAS, the NFRMPO will provide the GHG Transportation Report containing a GHG emissions analysis, to the Transportation Commission at least 30 days prior to adoption by the Planning Council of the 2050 RTP in accordance with the Planning Rules demonstrating 2050 RTP is in compliance with the GHG Reduction Levels in Table 1 of the Planning Rules; and

WHEREAS, under Rule 8.05 of the Planning Rules, the Transportation Commission, within 30 days of receipt of the GHG Transportation Report or at the next regularly scheduled Transportation Commission meeting, whichever is later, shall determine whether the applicable GHG Reduction Levels in Table 1 have been met and the sufficiency of any GHG Mitigation Measures needed for compliance; and

WHEREAS, the Transportation Commission reviewed the NFRMPO’s GHG Transportation report on June 17, 2026 and found it to be compliant with the Planning Rules;

NOW, THEREFORE, BE IT RESOLVED THAT the North Front Range Transportation & Air Quality Planning Council adopts the NFRMPO Greenhouse Gas (GHG) Transportation Report, for the 2050 RTP Amendment.

Passed and adopted at the regular meeting of the North Front Range Transportation & Air Quality Planning Council held this 2nd day of July 2026.

Elizabeth R Heid
Elizabeth R Heid (Jul 6, 2026 09:34:15 MDT)

Liz Heid, Vice Chair

ATTEST:



Elizabeth Relford, Executive Director

Appendix G: APCD Letter of Verification



COLORADO

Department of Public Health & Environment

June 10, 2026

North Front Range Metropolitan Planning Organization
419 Canyon Ave #300
Fort Collins, CO 80521

Subject: Greenhouse Gas Transportation Report as required by the Colorado Greenhouse Gas Pollution Reduction Planning Rule

Per 2 CCR 601-22, Rules Governing Statewide Transportation Planning Process and Transportation Planning Regions, the Colorado Department of Public Health and Environment (CDPHE), Air Pollution Control Division (Division), is respectfully submitting our verification of the North Front Range Metropolitan Planning Organization (NFRMPO) 2050 Regional Transportation Plan 2024 Amendment.

Thank you for the opportunity for CDPHE to review and verify the NFRMPO Transportation Greenhouse Gas Report..

Based on the analysis of the report, supporting datasets, and information provided, we can verify that the report and data inputs address the requirements of the Colorado Greenhouse Gas Pollution Reduction Planning Rule. The submitted package describes the baseline and compliance transportation demand modeling (TDM) runs and how with additional mitigation projects for the year 2030 they meet the Rule requirements. The submitted package describes how the TDM model was deployed and how emissions were calculated. The Division finds the outputs to be mathematically correct.

The Division would like to thank the Colorado Department of Transportation for approving the network shapefile. The Division would also like to thank Dale Wells, Megan Carroll, Cody Johnston, and Mary George from the Division who performed the verification analysis.

Sincerely,

JIM REASOR Digitally signed by JIM REASOR
Date: 2026.06.09 09:24:59 -06'00'

Jim Reasor
Deputy Director for Business Operations
Air Pollution Control Division
Colorado Department of Public Health and Environment

CC:

Becky Karasko NFRMPO
Christopher Laplante, CDOT
Elizabeth Rollins, CDOT
Darius Pakbaz, CDOT
Erik Sabina, CDOT
Scott Ramming, CDOT
Sabrina Williams, CDOT
Dale Wells, APCD
Kevin Briggs, APCD
Erick Mattson, APCD

Appendix H: Colorado Transportation Commission Resolution

Transportation Commission Resolution #20260609

Concerning the North Front Range Metropolitan Planning Organization's June 2026 GHG Transportation Report associated with their amended 2050 Regional Transportation Plan and amended FY26-FY29 Transportation Improvement Program as required in Rule 2 CCR 601-22 (Planning Rules).

Approved by the Transportation Commission on June 18, 2026.

Whereas, Senate Bill 21-260 directed the Transportation Commission of Colorado ("the Commission") to adopt procedures and guidelines requiring CDOT and MPOs to take additional steps in the planning process for regionally significant transportation projects to account for the impacts on the amount of statewide GHG pollution and statewide vehicle miles traveled that are expected to result from those projects; and

Whereas, Senate Bill 21-260 also specified implementing relevant measures pursuant to §25-7-105, C.R.S.; reducing GHG emissions to help achieve statewide GHG pollution reduction targets established in House Bill 19-1261 (now codified in § 25-7-102(2)(g) and 105(1)(e), C.R.S.); and considering the role of land use in the transportation planning process; and

Whereas, on December 16, 2021 the Commission adopted updated Planning Rules, which included greenhouse gas reduction levels for CDOT in non-MPO areas, DRCOG, and NFRMPO; and

Whereas, the Commission adopted Policy Directive No. 1610 on May 19, 2022, with minor amendments thereafter (as amended, the "Policy Directive") which guides implementation on the planning rules and use of GHG Mitigation measures; and

Whereas, the NFRMPO is nearing completion of their 2050 Regional Transportation Plan amendment and FY26-29 TIP amendment and the Planning Rules require NFRMPO to provide the Commission "at least 30 days prior to adoption" of their applicable planning document a GHG Transition Report (Report) containing a GHG emissions analysis, and if applicable a GHG Mitigation Action Plan demonstrating the the Applicable Planning Document is in compliance with the GHG Reduction Levels in Table 1 of the Planning Rules; and

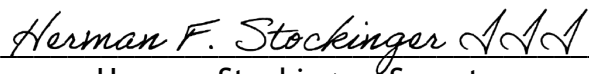
Whereas, Under Rule 8.05 of the Planning Rules, the Commission, within thirty days of receipt of the GHG Transportation Report or at the next regularly scheduled Commission meeting, whichever is later, shall determine whether the applicable GHG Reduction Levels in Table 1 have been met and the sufficiency of any GHG Mitigation measures needed for compliance.

Whereas, on June 10, 2026 the Commission received NFRMPO's GHG Transportation Report reflecting the results of modeling the amended 2050 Regional Transportation Plan and amended FY26-29 TIP for NFRMPO's GHG compliance area pursuant to the Planning Rules; and

Whereas, NFRMPO and CDOT have discussed the practice of using PD 1610 calculation methods and presenting them as "off-model" GHG emissions reductions in the GHG Transportation report and CDOT will be revisiting the suitability of using PD 1610 emission factors to represent GHG reduction benefits outside of a Mitigation Action Plan for future applicable planning document compliance demonstrations; and

Whereas, the Report concludes that NFRMPO will achieve the required reduction levels under the Planning Rules; and

Now Therefore Be It Resolved, after review and consideration of the NFRMPO Report, the Commission finds the Report and the NFRMPO to be in compliance with the Planning Rules and to have achieved the required reduction levels.



Herman Stockinger, Secretary
Transportation Commission of Colorado