North Front Range Metropolitan Planning Organization

NFRMPO GHG Transportation Report

DRAFT

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

Anticipated Adoption: July 2, 2026

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List of Acronyms

Acronym	Meaning/Context
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
MOVES3	MOtor Vehicle Emission Simulator Model
MPA	Metropolitan Planning Area
MPO	Metropolitan Planning Organization
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.

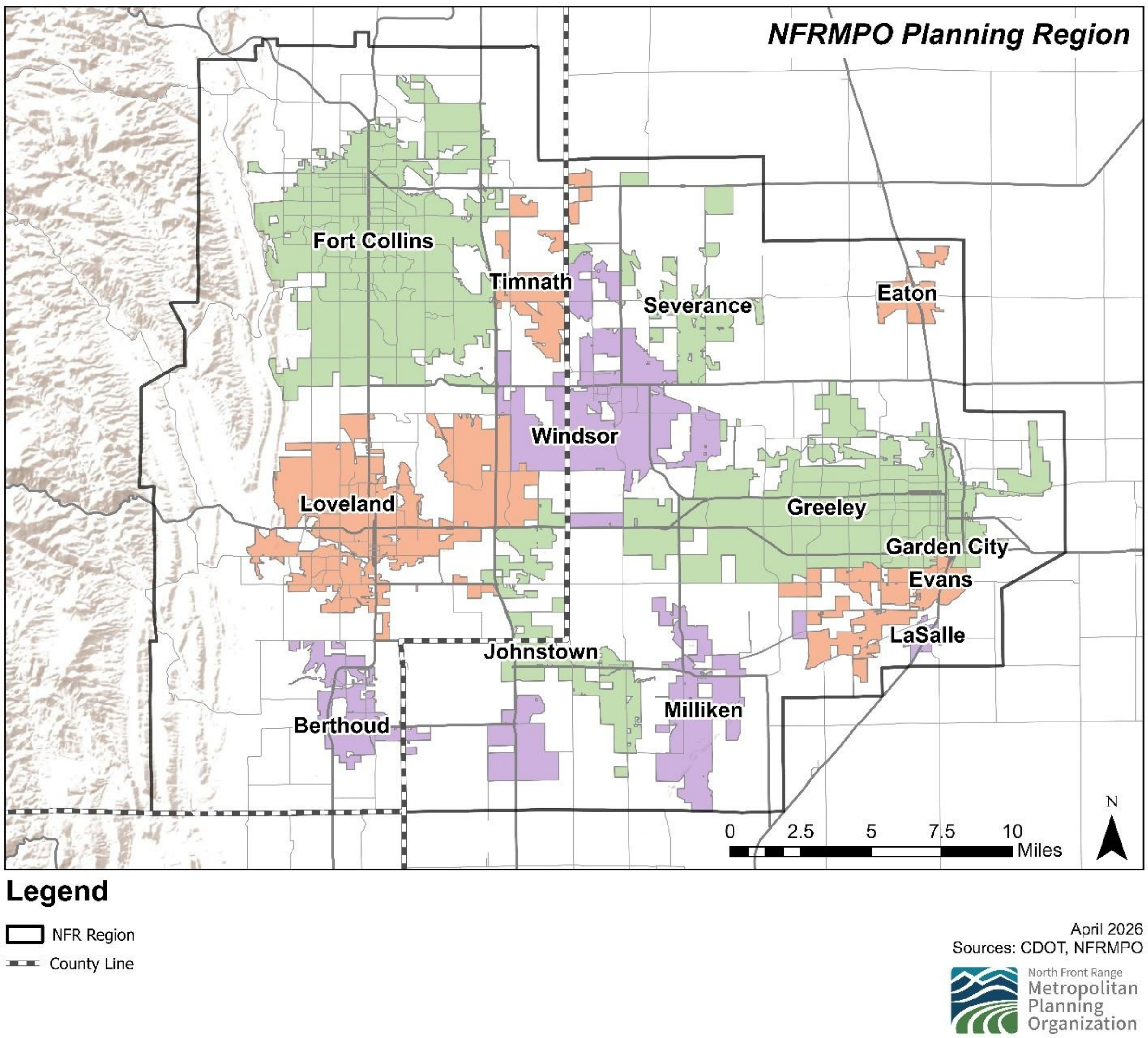
Background

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



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***: GHG Modeling Assumptions and Model Execution Intergovernmental Agreement (2023). 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 (NOx) 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	1.56	1.53	1.08	0.78
Updated Plan: 2050 RTP Amendment	1.44	1.42	0.97	0.71
Reduction	**0.12**	**0.11**	**0.11**	**0.07**
Required GHG Reduction Level	0.08	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 must be 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;
- New/Increased Fixed-Route Transit Service – Intercity Fleet Average Bus;
- 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	1.56	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	**0.12**	**0.13**	**0.11**	**0.07**
Required GHG Reduction Level	0.08	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 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

Policy Directive 1610 Measure	2030 GHG Reduction
Bike Lanes/Facilities	0.0005

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

Policy Directive 1610 Measure	2030 GHG Reduction
Sidewalks/Pedestrian Facilities	0.003

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

Policy Directive 1610 Measure	2030 GHG Reduction
Shared Use Paths	0.001

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

Policy Directive 1610 Measure	2030 GHG Reduction
Shared Use Paths	0.00002

New/Increased Fixed-Route Transit Service – Intercity Fleet Average Bus

Since the base year, CDOT began operating Bustang service along North I-25 and into downtown Fort Collins in the NFRMPO region. Additionally, the Poudre Express began operating in January 2020, with stops in Greeley, Windsor, and Fort Collins.

Calculations for GHG emission reductions associated with this effort were made using the method described in PD 1610. GHG emission reductions are calculated for every 1,000 vehicle revenue miles on a new or increased intercity fixed-route transit service in a year. In the NFRMPO region, CDOT's Bustang Service and the Poudre Express have 144,108 vehicle revenue miles (VRM) per year, which is an expansion of service beyond the baseline VRM in 2019.

Table 7 shows the calculated GHG emission reduction for 2030 based on 144,108 vehicle revenue miles per year.

Table 7: New/Increased Fixed-Route Transit Service – Intercity Fleet Average Bus 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
New/Increased Fixed-Route Transit Service – Intercity Fleet Average Bus	0.0003

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

Table 8: Waive Transit Fares 100% 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
Waive Transit Fares 100%	0.0006

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

Table 9: Trip Reduction Program – Voluntary 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
Trip Reduction Program – Voluntary	0.0009

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

Table 10: Broadband Expansion 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
Broadband Expansion	0.014

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 11**.

Table 11: 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 and Carpenter Intersection Roundabout	City of Fort Collins	8,489	5,829	6,795	7,213	Construction will start by Summer 2027
23rd and 4th/ 5th Street intersection Roundabout	City of Greeley	5,980	8,061	6,506	3,530	Construction starting on May 2026
Colorado Blvd and Crossroads intersection Roundabout	Town of Windsor	5,435	4,348	7,971	11,957	Construction will start summer or fall 2026

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 82,114.53.

Table 12 shows the calculated GHG emission reduction for 2030 based on 82,114.53 AADT.

Table 12: Replace Signalized Intersections with Roundabouts 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
Replace Signalized Intersections with Roundabouts	0.002

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

Table 13: Replace Diesel Transit Buses with Battery-Electric Buses 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
Replace Diesel Transit Buses with Battery-Electric Buses	0.0009

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

Table 14: Replace Diesel Transit Buses with Hybrid Diesel-Electric Buses 2030 GHG Reduction

Policy Directive 1610 Measure	2030 GHG Reduction
Replace Diesel Transit Buses with Hybrid Diesel-Electric Buses	0.00003

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 15** 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 15: 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 16** and **Table 17**. 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 16: 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 17: 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 MOVES3 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)

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

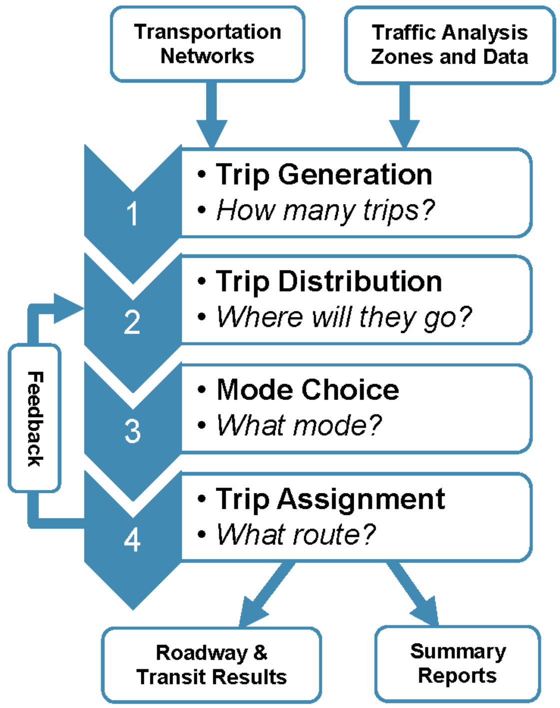


Figure 2 Additional Context: Key inputs to the four-step travel model include the transportation network and TAZs and data. The first step of the travel model is trip generation, which figures out how many trips there are. The second step is trip distribution, which figures out where people will go. 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 18**. 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

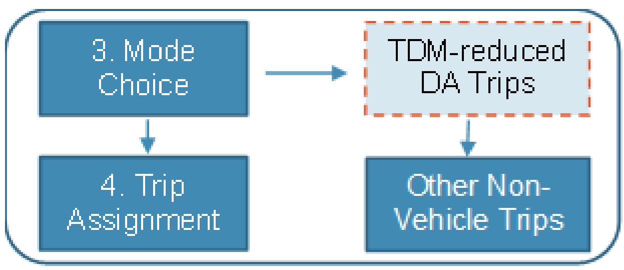


Figure 3 Additional Context: TDM in the model accounts for the development of Transportation Management Organizations (TMOs), increased outreach and marketing, expanded vanpooling and carpooling options, the development of Safe Routes to School (SRTS) programs, and development of regional resources and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

Table 18: 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 19** 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 19: 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 2050	3%	2%	25%	5.5%	1.5%
Greeley, Loveland, Windsor	2030	1.5%	1.5%	15%	5%	1.5%
	2040 2050	1.5%	1.5%	25%	5%	1.5%
Timnath, Severance	2030	0.5%	0.5%	15%	5%	1.5%
	2040 2050	0.5%	0.5%	25%	5%	1.5%
Remaining NFRMPO Areas	2030 2040 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 20**. 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 20: Walk and Bicycle Speed Assumptions

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

Table *22* converts the Bicycle and Pedestrian Alternative Specific Constants (ASCs) developed by Cambridge Systematics from **Table 21** 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 21: 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 22: 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 23 identifies the unadjusted and adjusted transit assumptions for transit speeds and the transfer penalty.

Table 23: 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 24**. 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 24: 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 25 shows validation data for the NFRMPO's 2019 BY RTDM to use as a comparison to data shown in the GHG Transportation Report.

Table 25: 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: MOVES3 Model Description

Overview

This Appendix summarizes the methodology used to calculate greenhouse gas (GHG) emissions for the NFRMPO area, using emission rates from EPA's MOtor Vehicle Emission Simulator (MOVES).

MOVES is a state-of-the-science emissions modeling system that estimates air pollution emissions for criteria air pollutants, greenhouse gases and air toxics. MOVES estimates emissions from on-road vehicles such as cars, trucks and buses, accounting for the phase-in of federal emissions standards, vehicle and equipment activity, fuels, temperatures, humidity, and emission control activities such as inspection and maintenance (I/M) programs.

In Colorado, the Air Pollution Control Division (APCD), a branch of the Colorado Department of Health and Environment (CDPHE), develops the locally defined inputs to MOVES, which is run to establish over 47,000 unique emission rates for each combination of month, hour, road type, speed bin, and vehicle type. These rates are multiplied by distances, total vehicle volumes, volumes per time period, and speeds per time period outputs from the NFRMPO's Regional Travel Demand Model a relational database, resulting in a GHG emissions inventory of surface transportation.

To develop baseline and compliance GHG emission inventories for the state's GHG rule, APCD staff created versions of these relational databases for each compliance year (2025, 2030, 2040, and 2050) and provided them to NFRMPO. NFRMPO staff and others subject to this initial deadline were trained by APCD staff on the methodology to perform the GHG emissions analysis on February 23, 2022, and, per agreement, NFRMPO staff is authorized to perform the GHG emissions analysis for compliance with the rule. In the event of an update to the MOVES relational database, APCD staff will inform NFRMPO staff. Every time there is an update to the MOVES relational database including to the input assumptions, NFRMPO staff will be notified and retrained as necessary to continue being able to perform the required GHG emissions analysis.

The MOVES documentation which follows was developed by CDOT's consultant Felsburg Holt & Ullevig (FHU) in January 2022 and modified where appropriate by NFRMPO staff. It describes the inputs and methodology used to create the MOVES relational databases.

MOVES3 Run Specifications

The run specification (RunSpec) parameters outlined below were used to calculate GHG emission rates with MOVES. They are consistent with APCD's process to calculate GHG emissions.

The four modeled years 2025, 2030, 2040, and 2050 used the same run specifications except for where specified (e.g., the year being modeled). Each of the four modeled years has six related run specifications to separate the emission rates by vehicle type, as described in the On-road Vehicles section.

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 SIPs and transportation conformity, either the County or National scale can be used for GHG inventories. EPA recommends using the County scale for GHG analysis. The County scale allows the user to enter county-specific data through the County Data Manager. Providing local data significantly improves the precision of the modeling results (EPA 2016).

The County scale was used.

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 hoteling emissions) in a look-up table format must be post-processed to produce an inventory. Either may be used to develop emissions estimates for GHGs (EPA 2016).

The Emission Rates calculation type was used.

Time Span

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

When Emission Rates is chosen, 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 Page 34 temperatures for each month, users could create a table of running emission rates by all the possible temperatures over an entire season or year (EPA 2016).

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 (EPA 2016). However, the year, month, and day must still be specified and will affect the emission rates calculated.

The time span parameters specified below were also used because the travel demand model outputs represent an annual average weekday.

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 (EPA 2016).

The years used were 2025, 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 and their corresponding fuel efficiency.

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 (EPA 2016).

The months used were January and July to match the process described 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.

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 (EPA 2016).

The days used were weekdays to match the travel demand model output data. These represented the emission rates for an average weekday. The results were escalated later to approximate a full year.

Hours

The hours used were all 24 hours of the day (i.e., clock hours of 1 AM, 2 AM, 3 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. The county defines input parameters such as the meteorology data used to estimate emission rates.

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.). The [Panel] is used to specify the vehicle types included in the MOVES run (EPA 2016).

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 MOVES3 were used to calculate the emission rates. APCD’s process, which was being followed, assigns travel demand model mileage based on a modified HPMS category. To calculate aggregate emission rates for each HPMS category (i.e., merging all the relevant source types and fuel types), each of the six HPMS categories used a separate RunSpec. It is important to note that APCD’s modified HPMS category does not match the MOVES HPMS types for source types 21, 31, and 32.

When this methodology document refers to HPMS categories, it is generally referring to APCD's HPMS categories. **Table 26** below illustrates the HPMS categories.

Table 26: HPMS Categories

sourceTyp	sourceTypeName	HPMSVtypeID	HPMSVtypeName	HPMS from APCD
11	Motorcycle	10	Motorcycles	10
21	Passenger Car	25	Light Duty Vehicles	20
31	Passenger Truck	25	Light Duty Vehicles	30
32	Light Commercial Truck	25	Light Duty Vehicles	30
41	Other Buses	40	Buses	40
42	Transit Bus	40	Buses	40
43	School Bus	40	Buses	40
51	Refuse Truck	50	Single Unit Trucks	50
52	Single Unit Short-Haul Truck	50	Single Unit Trucks	50
53	Single Unit Long-Haul Truck	50	Single Unit Trucks	50
54	Motor Home	50	Single Unit Trucks	50
61	Combination Short-Haul Truck	60	Combination Trucks	60
62	Combination Long-Haul Truck	60	Combination Trucks	60

Road Type

The Road Type Panel is used to define the types of roads that are included in the run. MOVES defines five different road types as shown in **Table 27**. Generally, all road types should be selected including Off-Network. Selection of road types in the Road Type Panel determines the road types that will be included in the MOVES run results (EPA 2016).

Table 27: MOVES Road Types

Roadtypeid	Road Type	Description
1	Off-Network	Locations where the predominant activity is vehicle starts, parking and idling (parking lots, truck stops, rest areas, freight or bus terminals)
2	Rural Restricted Access	Rural highways that can be accessed only by an on-ramp
3	Rural Unrestricted Access	All other rural roads (arterials, connectors, and local streets)
4	Urban Restricted Access	Urban highways that can be accessed only by an on-ramp
5	Urban Unrestricted Access	All other urban roads (arterials, connectors, and local streets)

All road types available in MOVES3 were used.

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 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.

The CO2 Equivalent pollutant is the sum of the global warming potential of other greenhouse gases expressed as a unit of CO2 (EPA 2016) and CO2 Equivalents (CO2e) is the pollutant of interest for these GHG calculations. MOVES requires several other prerequisite pollutants for CO2e; however, only the emission rates for CO2e were needed for this project.

Units

Users are free to choose any of the mass unit selection options but should generally choose a unit whose magnitude is appropriate for the parameters of the RunSpec (EPA 2016).

The units used for models were grams for mass, joules for energy, and miles for distance.

Activity

MOVES allows the user to select multiple activity output options (e.g., distance traveled, population, etc.). For Emission Rate calculations, distance and population are reported automatically, but the values in the output are intermediate steps in the rate calculation and do not represent the true activity (EPA 2016).

When calculating emission rates (as opposed to emission inventories), MOVES selects the activities hoteling hours, population, and starts without the option of changing them.

Output Emissions Detail

This panel allows the user to select the amount of detail provided in the output database. Certain selections on this panel are made by the MOVES software and cannot be changed, based on selections made on earlier panels. The more boxes checked on this panel, the more detail and segregation provided in the MOVES output database. More detail generally is not helpful for this process so no optional selections should be checked on this panel. For example, if Source Use Type were selected on this panel, emission rates for each of the MOVES vehicle Source Use Type categories would be reported in the output database, which would defeat the purpose of performing MOVES calculations based on consolidated HPMS category.

No optional aggregation selections were made on this panel. Source type detail was captured via the six HPMS RunSpecs for each year modeled, as described in the On-road Vehicles section. Since multiple source types were used for HPMS 30, 40, 50, and 60, emission rates were aggregated for into HPMS categories. That is, emission rates for MOVES source types 31 and 32 were aggregated into the HPMS 30 RunSpec, etc.

Input Database/County Data Manager

After completing the RunSpec, the next step is to supply MOVES with data to create an input database that is the basis for the emission rate calculations. When using the County scale, the County Data Manager (CDM) is used to create an input database and populate it with local data. Modelers can either rely on MOVES default information or local data that the user inputs, as is appropriate for the goals of the MOVES modeling. The data contained in the MOVES default database are typically not the most current or best available for any specific county. Therefore, with the exception of fuels, EPA recommends using local data for MOVES for GHG analyses when available to improve the accuracy of GHG emissions estimates. However, the MOVES default data (county level) may be the only or best source of that data readily available. Also consider that data consistency may be more important than data perfection for some Page 49 GHG analyses. At a minimum, EPA strongly encourages the use of local VMT and vehicle population data. EPA believes these inputs have the greatest impact on the quality of results. However, if local data are not available, MOVES default data may be useful for some inputs without affecting the quality of the results (EPA 2016).

In Emissions Rates mode, a full gamut of input data must be provided, described below, for MOVES to run. Some of these inputs actually do not affect the ultimate emission rates (they would affect inventory mode output) but reasonable inputs in the CDM should be used for general data integrity. As a general rule, users should input accurate activity for the scenario being modeled regardless of whether MOVES is being used in Inventory or Emissions Rates mode (EPA 2016).

The “Create Input Database” parameters define the region-specific inputs such as distributions of road types, vehicle age distributions, and meteorology data. The parameters specified in RunSpecs pre-populate the input database with default data for some of the parameters. However, region-specific data should be used when available and not all parameters have default data.

One comprehensive input database was created for each year modeled. Each of the six HPMS RunSpecs for that year used that single input database and were saved to a single output database. The input data were entered with the MOVES County Data Manager window, as specified below.

Age Distribution

A typical vehicle fleet includes a mix of vehicles of different ages, referred to as Age Distribution in MOVES. MOVES covers a 31 year range of vehicle ages, with vehicles 30 years and older grouped together. MOVES allows the user to specify the fraction of vehicles in each of 30 vehicle ages for each of the 13 source types in the model. For estimating on-road GHG emissions, EPA recommends and encourages states to develop age distributions that are applicable to the area being analyzed (EPA 2016).

APCD has developed a vehicle age distribution for the DRCOG and NFRMPO areas, and it was used for each year modeled.

Average Speed Distribution

This input is more important for Inventory than Emission Rates. Vehicle power, speed, and acceleration have a significant effect on vehicle emissions, including GHG emissions. MOVES Page 50 models those emission effects by assigning activity to specific drive cycles. The Average

Speed Distribution Importer in MOVES calls for a speed distribution in VHT in 16 speed bins, by each road type, source type, and hour of the day included in the analysis. EPA urges users to develop the most detailed local speed information that is reasonable to obtain. However, EPA acknowledges that average speed distribution information may not be available at the level of detail that MOVES needs (EPA 2016).

The Emission Rates option in MOVES will produce a table of emission rates by road type for each speed bin. Total running emissions are then quantified outside of MOVES by multiplying the emission rates by the VMT for each source type in each vehicle speed category. Users should supply an appropriate speed distribution to produce the necessary emission rates (EPA 2016).

APCD uses MOVES default data for all years in emission rate mode for their GHG models. This was used for each year modeled. Since emission rates were calculated (as opposed to emission inventories), the average speed distribution used in MOVES will not change the emission rates calculated. The speeds are accounted for in the travel demand model data.

Fuel

Entering this input data into MOVES involves four tables – called FuelFormulation, FuelSupply, FuelUsageFraction, and AVFT (alternative vehicle fuels and technology) – that interact to define the fuels used in the area being modeled.

- The FuelSupply Table identifies the fuel formulations used in a region (the regionCounty Table defines which specific counties are included in these regions) and each formulation's respective market share;
- The FuelFormulation Table defines the properties (such as RVP, sulfur level, ethanol volume, etc.) of each fuel;
- The FuelUsageFraction Table defines the frequency at which E-85 capable (flex fuel) vehicles use E-85 vs. conventional gasoline; and
- The AVFT Table is used to specify the fraction (other than the default included in the sampleVehiclePopulation Table) of fuel types capable of being used (such as flex fuel vehicles) by model year and source type.

In general, users should review/use the default fuel formulation and fuel supply data provided in MOVES, with important exceptions noted below. EPA strongly recommends using the default fuel properties for a region unless a full local fuel property study exists.

The GHG effects of changes in the fuel mix used by vehicles can be modeled in MOVES. AVFT can be used to change the fraction of future vehicles using gasoline, diesel, CNG and electricity. These changes will be reflected in MOVES GHG emission rates.

The FuelUsageFraction Table allows the user to change the frequency at which E-85 capable vehicles use E-85 fuel vs. conventional fuel, when appropriate. MOVES contains default estimates of E-85 fuel usage for each county in the U.S. In most cases, users should rely on the default information.

The AVFT Table allows users to modify the fraction of vehicles using different fuels and technologies in each model year. In other words, the Fuel Tab allows users to define the split between diesel, gasoline, ethanol, CNG, and electricity, for each vehicle type and model year. For transit buses, the default table assumes that gasoline, diesel, and CNG buses are present in the fleet for most model years. If the user has information about the fuel used by the transit bus fleet in the county modeled, the user should be sure it is reflected in the AVFT Table (EPA 2016).

****NOTE: This tab is critically important in GHG calculations. This is where electric vehicle percentages, etc. are defined.****

APCD uses MOVES default data for fuel supply, fuel formulation, and fuel usage fraction for all years in their GHG models. For AVFT, APCD uses custom inputs that includes electric vehicles for all years. These were used for each year modeled.

Meteorology

Ambient temperature and relative humidity data are important inputs for estimating on-road GHG emissions with MOVES. Ambient temperature and relative humidity are important for estimating GHG emissions from motor vehicles as these affect air conditioner use. MOVES requires a temperature (in degrees Fahrenheit) and relative humidity (in terms of a percentage, on a scale from 0 to 100) for each hour selected in the RunSpec. EPA recommends that users input the average daily temperature profile for each month if they are modeling all 12 months. Temperature assumptions used for estimating on-road GHG emissions should be based on the latest available information. The MOVES database includes default monthly temperature and humidity data for every county in the country. These default data are based on average monthly temperatures for each county from the National Climatic Data Center for the period from 2001 to 2011. These national defaults can be used for a GHG inventory, or more recent data can be used (EPA 2016).

If the Emission Rate calculation type is chosen in the RunSpec, users can enter a different temperature and humidity for each hour of the day to create an emission rate table that varies by temperature for running emissions processes. Emission rates for all running processes that vary by temperature can be post-processed outside of MOVES to calculate emissions for any mix of temperatures that can occur during a day. This creates the potential to create a lookup table of emission rates by temperature for the range of temperatures that can occur over a longer period of time such as a month or year from a single MOVES run (EPA 2016).

MOVES default meteorology data was used for all years. The county used was Adams County, Colorado for the months of January and July. Emission rates were post-processed to average winter and summer emission rates.

Road Type Distribution

MOVES does not have default data for this input, so it must be developed. The fraction of VMT by road type varies from area to area and can have a significant effect on GHG emissions from on-road mobile sources. EPA expects states to develop and use their own specific estimates of VMT by road type (EPA 2016).

If the Emission Rates option is used, MOVES will automatically produce a table of running emission rates by road type. Running emissions would then be quantified outside of MOVES by multiplying the emission rates by the VMT on each road type for each source type in each speed bin. In that case, data entered using the Road Type Distribution Importer is still required but is not used by MOVES to calculate the rate. However, road type distribution inputs are important for Emission Rates runs involving non-running processes, because they are used by MOVES to calculate the relative amounts of running and non-running activity, which in turn affects the rates for the non-running processes (EPA 2016).

APCD uses a custom road type distribution for all years in their GHG models. This was used for each year modeled. Since emission rates were calculated (as opposed to emission inventories), the road type distribution used in MOVES will not change the emission rates calculated. The road types are accounted for in the travel demand model.

Source Type Population

MOVES does not have default data for this input, so it must be developed. APCD uses a custom source type distribution for all years in their GHG models. These data were used for each year modeled. The source type populations used in MOVES will not change the emission rates Page

53 calculated. However, source population data are still needed as inputs for an emission rates MOVES run.

Vehicle Type VMT

MOVES does not have default data for this input, so it must be developed. EPA believes VMT inputs have the greatest impact on the results of a state or local GHG or energy consumption analysis. Regardless of calculation type, MOVES requires VMT as an input. MOVES can accommodate whatever VMT data is available: annual or average daily VMT, by HPMS class or MOVES source type. Therefore, there are four possible ways to enter VMT, allowing users the flexibility to enter VMT data in whatever form they have. EPA recommends that the same approach be used in any analysis that compares two or more cases (e.g., the base year and a future year) in a GHG analysis (EPA 2016).

The Output Emission Detail panel determines the detail with which MOVES will produce emission rates for running emissions, such as by source type and/or road type in terms of grams per mile. Total emissions are quantified outside of MOVES by multiplying the emission rates by the VMT for each source type and road type. However, users will still need to enter data using the Vehicle Type VMT Importer that reflects the VMT in the total area where the lookup table results will be applied. This is necessary because MOVES uses the relationship between source type population and VMT to determine the relative amount of time vehicles spend parked vs. running (EPA 2016).

APCD uses HPMS as the source type and annual as the time span for their GHG models. This was used for each year modeled. Since emission rates were calculated (as opposed to emission inventories), the VMT used in MOVES will not change the emission rates calculated. The VMT values are in the travel demand model data. However, VMT data are still needed as inputs for an emissions rate MOVES run.

Inspection/Maintenance Program

Because the DRCOG and NFRMPO areas are an ozone nonattainment area, an inspection and maintenance (I/M) program applies. I/M program inputs should are used for SIP and conformity analyses and are generally available as defaults within MOVES.

APCD uses inputs into MOVES to represent the I/M program in the DRCOG and NFRMPO area. This was used for each year modeled.

Others

APCD assumes MOVES default values for the starts, hoteling, idle, retrofit data, and generic tabs. This was left as is for each modeled year.

MOVES Rate per Distance Table

The critical table in the output database with the calculated emission rates was the “rateperdistance” table. It contained emission rates for each combination of month, hour, pollutant, road type, speed bin, and vehicle type as specified in the RunSpec. The MOVESScenarioID field was the mechanism used by FHU to identify the HPMS source type.

The table was filtered to include only CO2e (i.e., pollutant ID 98) emission rates and exported to a comma- separated value (CSV) file. Because the table included emission rates for both January and July and MOVES speed bins are not discrete speeds in miles per hour, postprocessing of the emission rates was required to calculate emission inventories.

Processed Emission Rates

APCD provided several Access databases with calculation tools for processing the MOVES and travel demand model data. These Access databases are the basis for the post-MOVES data processing. The instructions contained below provide a narrative of what occurs, but these actions are already built into the Access databases.

The MOVES rate per distance output table needed to be manipulated to produce emission rates that could be related to the calculated vehicle speeds for road links in the travel demand model data. The emission rates for January and July needed to be averaged to create composite emission rates. The emission rates for the 16 speed bins (which cover 5 MPH ranges) in MOVES were linearly interpolated to provide emission rates for every mile per hour speed from 1 to 75, which is how speed data are presented in the travel demand model data.

The resulting table includes a total of 43,776 unique emission rates. That is, an emission rate for each combination of:

- MOVES Road Types 2-5
- HPMS Types 10/20/30/40/50/60
- Hours 1-24
- Speeds 1-75

Processing Annual Average Emission Rates

For each year/rate per distance table (i.e., this process must be repeated for 2025, 2030, 2040, and 2050):

- Filter to include only CO2e (pollutant ID 98) emission rates
- There were unique emission rates for each combination of:
    - Road type o HPMS type
    - Speed Bin
    - Hour
    - Month
- To get the average emission rates per year, each combination of road type, HPMS type, average speed bin, and hour were summed and divided by two (to average the corresponding emission rates for January and July)
- Seasonally averaged emission rate = (Winter Rate + Summer Rate)/2

Interpolating Emission Rates from Speed Bin to Integer Speeds

After seasonally averaging the emission rates, these rates were used to interpolate (linearly) between speed bins to get an emission of rate for every mile per hour for the speeds of 1 to 75 miles per hour. In general, the process used was:

- For adjacent speed bins, subtract the lower bin number emission rate from the higher bin number emission rate and divide by five to calculate a per mile per hour change in the emission rate (NOTE: emission rates generally decrease with increased speed)
- Add the appropriate emission rate change to the lower bin avgBinSpeed value to interpolate each mile per hour emission rate between the avgBinSpeed values
- For reference, **Table 28** below illustrates the MOVES speed bins
- Example for interpolating emission rate of 11 mph:
    - Speed per mph = 11 mph
    - Speed of Lower Speed Bin = 10 mph
    - Number of Speeds per Speed Bin = 5 (= 2.5 for speed bin 1; = 5 for all other speed bins) o ER of Lower Speed Bin = 4055 g/m (dummy data)
    - ER of Upper Speed Bin = 3421 g/m (dummy data)
    - 4055 + (3421 – 4055) * (11 – 10)/5 = 3928

Table 28: MOVES Speed Bins

avgSpeedBinID	avgBinSpeed	avgSpeedBinDesc
1	2.5	speed<2.5mph
2	5	2.5mph<=speed<7.5mph
3	10	7.5mph<=speed<12.5mph
4	15	12.5mph<=speed<17.5mph

5	20	17.5mph<=speed<22.5mph
6	25	22.5mph<=speed<27.5mph
7	30	27.5mph<=speed<32.5mph
8	35	32.5mph<=speed<37.5mph
9	40	37.5mph<=speed<42.5mph
10	45	42.5mph<=speed<47.5mph
11	50	47.5mph<=speed<52.5mph
12	55	52.5mph<=speed<57.5mph
13	60	57.5mph<=speed<62.5mph
14	65	62.5mph<=speed<67.5mph
15	70	67.5mph<=speed<72.5mph
16	75	72.5mph<=speed

Processed Travel Demand Model

The travel demand model data are exported as a table, each record representing a traffic link attributed with distances, total volumes, volumes per time period, and speeds per time period. This data is imported into the MOVES relational database and associated with the appropriate MOVES emission rates, as described below.

The resulting table includes aggregated VMT for each combination of:

- MOVES Road Types 2-5
- HPMS Types 10/20/30/40/50/60
- Hours 1-24 · Speeds 2.5-75

This process provides respective county names for each link to aggregate VMT by geography/region.

Attribute Travel Demand Model with County Names

The first step was to attribute each link with the county name. The county information was necessary because it was used later in the process to filter VMT (and thus, on-road emissions inventory) by geography/region (e.g., MPO or non-MPO traffic). Performing this step later in the process would require significant modifications to the process.

Access Database

The travel demand model CSV file from the step above was imported into an Access database. The remaining post-processing steps were performed in this Access database, as described below.

Speeds

The travel demand model speeds were in floating decimal format and rounded to the nearest integer. Speeds less than 2.75 mph were rounded to 2.5 mph. This was because emission rates for speeds of 2.5 mph or less were the same, as described in the **Processed Emission Rates** section.

Time Periods

The travel demand model provides aggregated data for 8 blocks of time for a day, not hour by hour—see the "name" column below. The data for these travel demand model periods were recategorized/interpolated into data for discrete clock hours 1-24 based on methodology from APCD.

Table 29 below was used to split the travel demand model data for different time periods (AM1, PM2, OP1, etc.) into 24 clock hour time periods. VMT was calculated for each combination of integer speed (2.5 – 75mph), interstate (yes or no), road functional class (1-8), rural (yes or no), periodCog (1-10), and county. The periodCog 1-10 were related to hours 1-24 as shown in the "hour" column. That provided a VMT per clock hour for each combination of speed and functional class. This was used to relate the VMT to fractions of VMT by HPMS per functional class and hour. The cVMT was divided by the number of "periods" corresponding with each clock hour to calculate the VMT.

Table 29: Time Periods

Interval	periodCog	Name	Hour	hrsT	Periods
11:00 PM – 6:30 AM	7	Op1.bin	1	7.5	7
11:00 PM – 6:30 AM	7	Op1.bin	2	7.5	7
11:00 PM – 6:30 AM	7	Op1.bin	3	7.5	7
11:00 PM – 6:30 AM	7	Op1.bin	4	7.5	7
11:00 PM – 6:30 AM	7	Op1.bin	5	7.5	7
11:00 PM – 6:30 AM	7	Op1.bin	6	15	7
6:30 – 7:00 AM	1	Am1.bin	7	1	1
7:00 – 8:00 AM	2	Am2.bin	8	1	1
8:00 – 9:00 AM	3	Am3.bin	9	1	1
9:00 – 11:30 AM	8	Op2.bin	10	2.5	2.5

9:00 – 11:30 AM	8	Op2.bin	11	2.5	2.5
11:30 AM – 3:00 PM	9	Op3.bin	12	3.5	7
	8	Op2.bin	12	2.5	5
	9	Op3.bin	13	3.5	3.5
	9	Op3.bin	14	3.5	3.5
	9	Op3.bin	15	3.5	3.5
3:00 – 5:00 PM	4	Pm1.bin	16	2	2
3:00 – 5:00 PM	4	Pm1.bin	17	2	2
5:00 – 6:00 PM	5	Pm2.bin	18	1	1
6:00 – 7:00 PM	6	Pm3.bin	19	1	1
7:00 – 11:00 PM	10	Op4.bin	20	4	4
7:00 – 11:00 PM	10	Op4.bin	21	4	4
7:00 – 11:00 PM	10	Op4.bin	22	4	4
7:00 – 11:00 PM	10	Op4.bin	23	4	4
11:00 PM – 6:30 AM	7	Op1.bin	24	7.5	7

Fraction of VMT by HPMS

Once VMT was calculated for each road functional class and clock hour, the fractions of VMT by HPMS for each corresponding functional class and clock hour were applied. This calculated the VMT for HPMS 10-60. The fractions used were from APCD and were consistent with their methodology.

Road Types

The travel demand model used roadway functional classes that were recategorized to MOVES road types. That allowed the road types from the travel demand model to be related to the emission rates.

Table 30: Road Types

DRCOG Facil	FHWA Facility Type	Rural	FHWA	Urban	MOVESrt	fhwaRT	fcCode	Interstate
1	Principle Arterial - Interstate	-1	R	R	2	1	1	1
1	Principle Arterial - Interstate	-1	R	R	2	1	1	0
1	Principle Arterial - Interstate	0	N	U	4	11	1	0
1	Principle Arterial - Interstate	0	N	U	4	11	1	1
2	Principle Arterial -Other	-1	N	R	3	2	2	0
2	Principle Arterial – Other Freeways or Expressway	0	N	U	4	12	2	0
3	Principle Arterial -Other	-1	N	R	3	2	3	0
3	Principle Arterial -Other	0	N	U	5	14	3	0
4	Minor Arterial	-1	N	R	3	6	4	0
4	Minor Arterial	0	N	U	5	16	4	0
5	Major Collector	-1	N	R	3	7	5	0
5	Collector	0	N	U	5	17	5	0
6	Principle Arterial	-1	R	R	2	1	1	0
6	Principle Arterial	0	N	U	4	11	1	0
8	Local System	-1	N	R	3	9	7	0
8	Local System	0	N	U	5	19	7	0

Filter by Geography/Region

The statewide GHG inventory was filtered to contain VMT for all counties in Colorado, except for the nine-county region in the ozone non-attainment area. The nine counties excluded were Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer, and Weld. The statewide results were subdivided further into Pikes Peak area and the rest of the state.

Emissions Inventory

The processed emission rates table and the processed VMT table were related by road type, HPMS type, hour, and speed. This relate was used to multiply the emission rate (g/mi) by the VMT (mi) to get a total in grams of CO2e for an average weekday. The formula used was:

- CO2e (g/day) = SUM(Emission Rate (g/mi) * VMT (mi))
- CO2e (MMt/day) = CO2e (g/day) * 1 (MMt) / 1e+12 (g)
- CO2e (MMt/year) = CO2e (MMt/day) * 338 (travel demand model weekdays/calendar year)

The calculated emissions inventory was for on-road emissions. Non-road emissions were not included in this calculation.

References

EPA. 2016. Using MOVES for Estimating State and Local Inventories of On-road Greenhouse Gas Emissions and Energy Consumption. June.
https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OW0B.pdf

Appendix D: Resolution 2026-# North Front Range Transportation & Air Quality Planning Council (NFRT&AQPC) Adoption

Appendix E: APCD Verification

Appendix F: Colorado Transportation Commission Resolution