North Front Range Metropolitan Planning Organization

Virtual Attendance Option

Call-in Number: +1 (408) 650-3123
Access Code: 488-080-565
Weblink: https://bit.ly/2022NFRTAC

UPDATED

VIRTUAL NFRMPO TECHNICAL ADVISORY COMMITTEE (TAC)—AGENDA
August 17, 2022
1:00 – 3:00 p.m.

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1. **Call Meeting to Order, Welcome, and Introductions**
2. **Public Comment *(2 minutes each)***
3. **Approval of July 20, 2022 Meeting Minutes *(Page 2)***

AIR QUALITY AGENDA

1)	Regional Air Quality Updates	Wayne Chuang, RAQC Rick Coffin, CDPHE-APCD Karasko

METROPOLITAN PLANNING ORGANIZATION AGENDA

CONSENT AGENDA

No Items this Month.

ACTION ITEM

1)	Off-Cycle August 2022 TIP Amendment *(Page 6)*	Cunningham

PRESENTATION

2)	Bike & Ped Safety Reporter Tool Demonstration *(Handout)*	Cunningham

DISCUSSION ITEMS

3)	2045 RTP Update and Greenhouse Gas (GHG) Analysis *(Handout)*	Karasko

OUTSIDE PARTNER REPORTS

4)	NoCo Bike & Ped Collaborative	Gordon
5)	Regional Transit Agencies	
6)	Mobility Updates	Schmitt

REPORTS

7)	August Planning Council Meeting Summary Draft *(Page 19)*	***Written Report***
8)	Community Advisory Committee (CAC) Summary	***Handout***
9)	Mobility Committee Updates *(Page 20)*	***Written Report***
10)	Roundtable	All

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4. **Final Public Comment *(2 minutes each)***
5. **Next Month's Agenda Topic Suggestions**
6. **Next TAC Meeting: September 21, 2022**

419 Canyon Avenue, Suite 300
Fort Collins, Colorado 80521
(970) 800.9065
nfrmpo.org

Bike & Ped Safety Reporter

Help your community by identifying areas that feel unsafe while you are biking, walking, or rolling.

What is the Bike & Ped Safety Reporter?

A crowdsourced tool where residents and visitors can identify areas that feel unsafe by putting a pin on a map.

What happens after I submit a report?

The NFRMPO reviews all reports and sends them to the city or town responsible for the area. The NFRMPO and local agencies can then identify where safety improvments can be made.

How do I submit a report?

Scan the QR code with your mobile device and follow the on screen prompts!

What can be reported?

Infrastructure or behavior issues including:

- Accessibility Issues
- Missing Curb Ramps
- Crosswalk timing too short
- Poor lighting
- Near Misses
- Missing sidewalks or bike lanes

Scan me!

For more information visit nfrmpo.org/safety

DRAFT

NFRMPO GHG Transportation Report

Determining Compliance with the GHG Transportation Planning Standard

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for the

North Front Range Metropolitan Planning Area

2045 Regional Transportation Plan 2022 Update

The North Front Range Metropolitan Planning Organization
419 Canyon Avenue, Suite 300 Fort Collins, CO 80521

Preparation of this report has been financed in part through grants from the Federal Highway Administration, Federal Transit Administration, Colorado Department of Health and the Environment, and local government contributions.

August 16, 2022

North Front Range Metropolitan Planning Organization

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LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

APCD – Air Pollution Control Division

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

CCR – Code of Colorado Regulations

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

SIP – State Implementation Plan

SDO – State Demography Office

TAZ – Traffic Analysis Zone

TC – Transportation Commission

TDM – Transportation Demand Management

TIP – Transportation Improvement Program

TMA – Transportation Management Area

UNC – University of Northern Colorado

VHT – Vehicle Hours Traveled

VMT – Vehicle Miles Traveled

Purpose

This report demonstrates the 2045 Regional Transportation Plan (RTP) 2022 Update complies with Colorado's greenhouse gas (GHG) Transportation Planning Standard ("GHG Planning Standard"). The 2045 RTP 2022 Update was developed to meet the October 1, 2022 deadline specified in Colorado Revised Statutes §43-4-1103 and the Code of Colorado Regulations (2 CCR 601-22, Section 8.02.5.1).

The demonstration is based on analysis of all trips conducted using the NFRMPO's 2015 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 entertain adoption of the 2045 RTP 2022 Update, this GHG Transportation Report, and the ozone and carbon monoxide (CO) air quality conformity determination at their regular monthly meeting on October 6, 2022.

Background

In 2021, SB21-260: Sustainability of the Transportation System was enacted. The bill, which substantially increases 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.

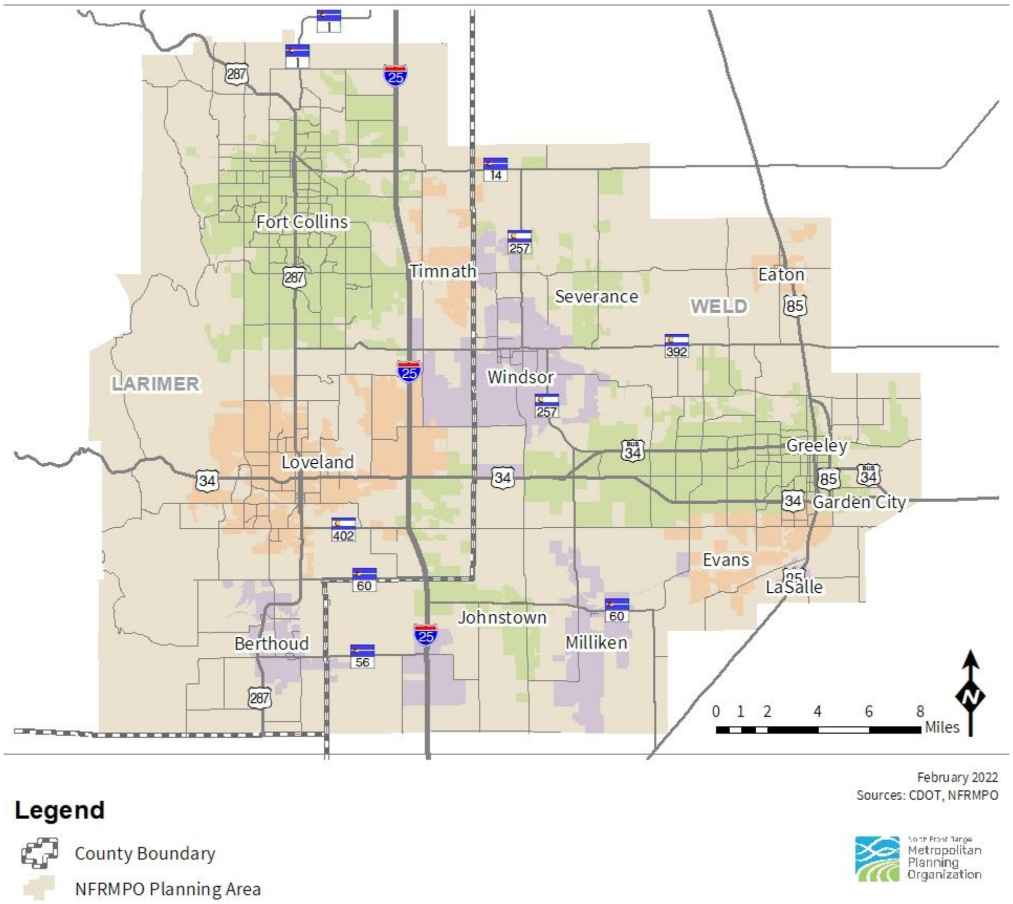
The NFRMPO is the MPO for the Fort Collins Transportation Management Area (TMA), which includes Berthoud, Fort Collins, Loveland, and portions of Johnstown, Timnath, and Windsor, and the Greeley Urbanized Area (UZA), which includes Greeley, Evans, and LaSalle. The NFRMPO has 15 local government members, including 13 municipalities and the urbanized portions of Larimer and Weld counties. The NFRMPO Planning Boundary is shown in **Figure 1**.

The Baseline Plan for the NFRMPO is the 2045 RTP, which was adopted by the NFRT&AQPC on September 5, 2019. For this GHG Transportation Report, the 2045 RTP will be referred to as the Baseline Plan and the 2045 RTP 2022 Update will be referred to as the Updated Plan.

An Intergovernmental Agreement (IGA) is currently under development by the Air Pollution Control Division (APCD) of the Colorado Department of Public Health and Environment (CDPHE), CDOT, and the NFRMPO, and once completed will be included in ***Appendix A***. The IGA will identify 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 and carbon monoxide per the federally prescribed transportation conformity process for nonattainment areas. The conformity determination for the 2045 RTP 2022 Update, which demonstrates conformity with the SIP, is available for review at: https://nfrmpo.org/public-comment/.

Figure 1: NFRMPO Planning Area



Greenhouse Gas (GHG) Emissions Analysis

Annual GHG emissions for the Baseline Plan and Updated Plan are shown in **Table 1** for each of the four compliance years: 2025, 2030, 2040, and 2050. The "Reduction" row of **Table 1** displays the 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. As shown in **Table 1**, the 2045 RTP 2022 Update meets or exceeds the required GHG Reduction Levels in each of the four compliance years, demonstrating compliance with the GHG Planning Standard.

Table 1: GHG Emissions Results, Million Metric Tons (MMT) per Year				
	2025	2030	2040	2050
Baseline Plan: 2045 RTP, 2019	1.73	1.60	1.22	0.82
Updated Plan: 2045 RTP, 2022 Update	1.68	1.48	1.11	0.72
Reduction	**0.05**	**0.12**	**0.11**	**0.11**
Required GHG Reduction Level	0.04	0.12	0.11	0.07
Pass/Fail	**PASS**	**PASS**	**PASS**	**PASS**
* Some numbers in this chart may not add correctly due to rounding.				

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 and its associated modeling.

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 additional commitments to transit, non-motorized facility improvements, and other GHG-reducing strategies identified in *Appendix D*, the 2045 RTP 2022 Update. **Table 2** describes improvements based on categories and funding sources. How these projects are incorporated into the modeling is explained throughout this document. Additional detail on these strategies is also available in the 2045 RTP 2022 Update, *Appendix D*.

Table 2: Modeled Improvements and Funding Sources

Category	Improvement	Funding Source	Additional Funding
Transit	Advance US34 transit service between Loveland and Greeley from 2045 to 2030	CDOT 10-Year Plan, FTA, MMOF	$147M
Transit	Expansion of COLT's local transit network as identified in Connect Loveland by 2030	Connect Loveland, FTA, Local Funds	
Transit	Double frequency of Bustang North Line in all compliance years	CDOT 10-Year Plan	
Transit	Addition of mobility hubs and transit centers planned since 2019	CDOT 10-Year Plan, MMOF, IIJA, Local Funds	
TDM	Increase in work from home in all compliance years	MMOF, IIJA	$40M
TDM	Development and expansion of TDM programs by 2030 and increasing scope through 2050	MMOF, IIJA	
Operations	Arterial signal timing improvements by 2030 and additional signal timing improvements through 2050	CDOT 10-Year Plan, IIJA, Local funds	$51M
Active Transportation	Expansion of the local bicycle and pedestrian network by 2030 and increasing to 2050	IIJA, MMOF, Local Funds	$283M
Active Transportation	Increased prevalence of e-bikes and scooters by 2030 and increasing to 2050	IIJA, MMOF, Local Funds	

Modeling Summary

Key inputs and outputs from the travel model runs for each of the four compliance years for the Baseline Plan and the Updated Plan are provided in **Tables 3 and 4**. 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 2015 BY RTDM. The forecasted demographic data is from the NFRMPO 2010 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. Due to the limited time available to conduct this

GHG emissions analysis, the same land use outputs were used for modeling both the Baseline Plan and Updated Plan.

The NFRMPO 2015 BY RTDM forecasts travel demand for a typical weekday when school is in session. The vehicle and transit data shown in the **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 detail on the NFRMPO 2015 BY RTDM is available in ***Appendix B***.

Strategies are additive in the model, but NFRMPO staff considered the individual impact of each strategy in the development of a final GHG scenario. Each strategy on its own was evaluated for its reasonableness, appropriateness, and its fundability through existing and expected funding sources. NFRMPO staff created several scenarios based on different potential strategies and discussed these strategies with DRCOG and CDOT staff to determine their reasonableness. Based on the strategies explored in this report, the model results show a large increase in bicycle and a moderate increase in transit trips. Better connectivity and accessibility on the bicycle network and better frequency and more regional transit service account for the large increase. In addition, congestion is expected to grow into the future because of the population and job growth, making transit and bicycling more attractive than they otherwise would.

Based on training provided by CDPHE, NFRMPO staff ran a version of MOVES. 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 2019 Public Involvement Plan (PIP) guides the NFRMPO's public participation activities for all plans and programs. The NFRMPO held a 30-day public comment period on the 2045 RTP 2022 Update, this GHG Transportation Report, and the associated ozone and CO conformity determination beginning on September 6, 2022. The documents will be available on the NFRMPO website at https://nfrmpo.org/public-comment/ and at the NFRMPO Office as a hard copy. The public comment period ended at 5:00 p.m. on October 5, 2022.

The NFRT&AQPC will entertain adoption of the 2045 RTP 2022 Update, this GHG Transportation Report, and the conformity determination at their regular monthly meeting on October 6, 2022. 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/.

Table 3: NFRMPO Modeling Summary, Baseline Plan				
	2025	2030	2040	2050
Socioeconomic Data				
Population	583,439	651,400	792,208	950,460
Households	236,778	267,658	329,315	398,410
Employment	327,944	357,129	416,833	494,949
Lane Miles by Roadway Type				
Interstate	146	146	146	146
Expressway	210	210	210	210
Principal Arterial	674	697	752	752
Minor Arterial	775	784	838	848
Collector	1,199	1,207	1,236	1,236
Ramp	18	18	18	18
Frontage Road	46	45	45	45
Centroid Connector	1,332	1,331	1,329	1,329
Total Lane Miles	***4,400***	***4,439***	***4,574***	***4,584***
Person Trip Mode Share				
Single occupancy in auto	45.3%	45.3%	45.5%	45.7%
Shared ride in auto	43.4%	43.6%	43.9%	44.1%
Walk	7.8%	7.7%	7.3%	7.1%
Bicycle	2.9%	2.9%	2.7%	2.7%
Transit	0.5%	0.5%	0.6%	0.5%
Other non-vehicle *	0.0%	0.0%	0.0%	0.0%
Total Daily Trips	***3,437,924***	***3,813,606***	***4,589,295***	***5,473,974***
Vehicle and Transit Data – Typical Weekday				
Vehicle Miles Traveled (VMT)	14,450,986	16,158,176	19,900,362	24,021,474
VMT per capita	24.8	24.8	25.1	27.6
Average vehicle speed (mph)	35.2	33.9	30.6	28.8
Average vehicle trip length (mi)	6.9	7.0	7.1	7.8
Vehicle Hours Traveled (VHT)	410,008	477,262	650,464	832,714
Hours of vehicle delay	56,496	79,633	151,892	223,970
Transit trips (linked)	18,650	20,302	25,380	29,888

Source: NFRMPO 2015 Regional Travel Demand Model, 2010 Land Use Allocation Model
** Other non-vehicle includes the Reduced Drive Alone trips using the TDM tool.*

Table 4: NFRMPO Modeling Summary, Updated Plan				
	2025	**2030**	**2040**	**2050**
Socioeconomic Data				
Population	583,439	651,400	792,208	950,460
Households	236,778	267,658	329,315	398,410
Employment	327,944	357,129	416,833	494,949
Lane Miles by Roadway Type				
Interstate	146	146	146	146
Expressway	210	210	210	210
Principal Arterial	674	697	752	752
Minor Arterial	775	784	838	848
Collector	1,199	1,207	1,236	1,236
Ramp	18	18	18	18
Frontage Road	46	45	45	45
Centroid Connector	1,332	1,331	1,329	1,329
Total Lane Miles	***4,400***	***4,439***	***4,574***	***4,574***
Person Trip Mode Share				
Single occupancy in auto	43.3%	41.0%	40.9%	40.5%
Shared ride in auto	45.3%	43.1%	43.5%	43.1%
Walk	8.0%	10.7%	10.2%	10.7%
Bicycle	2.8%	4.5%	4.3%	4.5%
Transit	0.5%	0.6%	0.6%	0.7%
Other non-vehicle	0.0%	0.1%	0.4%	0.4%
Total Daily Trips	***3,439,640***	***3,812,451***	***4,586,540***	***5,481,842***
Vehicle and Transit Data – Typical Weekday				
Vehicle Miles Traveled (VMT)	14,059,340	15,159,963	18,557,721	22,611,051
VMT per capita	24.1	23.3	23.4	24.4
Average vehicle speed (mph)	35.5	34.8	31.9	30.0
Average vehicle trip length (mi)	6.9	7.0	7.2	7.5
Vehicle Hours Traveled (VHT)	395,731	435,019	582,166	672,543
Hours of vehicle delay	51,920	64,598	121,088	164,134
Transit trips (linked)	18,528	23,754	29,561	35,583

Source: NFRMPO 2015 Regional Travel Demand Model, 2010 Land Use Allocation Model
* Other non-vehicle includes the Reduced Drive Alone trips using the TDM tool.

Impact

Based on the proposed investments, 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. **Table 5** shows the overall impacts comparing the *2045 RTP Baseline* and *2045 RTP 2022 Update*. An overall explanation for reduction 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. This speed factor change made active transportation trips more attractive for shorter and medium-length trips. Currently many of these options are available in Fort Collins and throughout pockets in the region, but it is expected these strategies will be adopted by the region overall 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. More walking and bicycle trips replace short vehicle trips, accounting for the greater average vehicle trip length over time.
  - **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, 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 *2045 RTP 2022 Update*. 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. TDM rates are expected to increase in each year as more communities implement TDM programs and strategies.
  - **Model impact**: The NFRMPO anticipates no major impacts from a TDM program in 2025, but a light-impact program in 2030 and growing to a more successful program in 2040 and beyond.
  - **Context**: According to the US Department of Transportation and 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** - Many emissions happen as vehicles are delayed because of congestion, waiting at traffic signals, or other obstacles. Improving traffic signals and keeping vehicles moving reduces emissions. This is because hours of delay and average vehicle speed are an important aspect of GHG modeling.

    - **Model impact**: Traffic signal and operational improvements show an increasing reduction in hours of vehicle delay resulting from fewer VMT and VHT.

    - **Context**: Research by the California Air Resource Board shows that traffic signal coordination can reduce GHG emissions between one and 10 percent without accounting for induced demand.

- **Transit –** Since the 2019 adoption of the 2045 RTP, the NFRMPO held multiple Call for Projects and new legislation has been passed at the State and federal levels. New funding for Bustang and local transit support the increases in transit in future years. In addition, CDOT and Greeley have invested in mobility hubs, which will grow in usefulness over time.

    - **Model impact**: Transit trips show large growth in the future, maintaining little to no change in overall transit mode share. These increases in transit trips reduce VMT, VMT per capita, and VHT.

    - **Content**: 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 up to 82 percent compared to SOV on a per-passenger-mile basis.

Table 5: NFRMPO Modeling Summary, Comparison of Baseline to Updated Plan

	2025	2030	2040	2050
Person Trip Mode Share (Percentage Point difference)				
Single occupancy in auto	- 2.0%	- 4.3%	- 4.6%	- 5.2%
Shared ride in auto	1.9%	- 0.5%	-0.4%	- 1.0%
Walk	0.2%	3.0%	2.9%	3.6%
Bicycle	- 0.1%	1.6%	1.6%	1.8%
Transit	0.0%	0.1%	0.0%	0.2%
Other non-vehicle	0.0%	0.1%	0.4%	0.4%
Vehicle and Transit Data – Typical Weekday (Percent change)				
Vehicle Miles Traveled	- 2.7%	- 6.2%	- 6.8%	- 5.9%
VMT per capita	- 2.8%	- 6.1%	- 6.8%	- 11.6%
Average vehicle speed (mph)	0.9%	2.7%	4.3%	4.2%
Vehicle Hours Traveled (VHT)	- 3.5%	- 8.9%	- 10.5%	- 19.2%
Hours of vehicle delay	- 8.1%	- 18.9%	- 20.3%	- 26.8%
Transit trips (linked)	- 0.7%	17.0%	16.5%	19.1%

Appendix A: GHG Modeling Assumptions and Model Execution Intergovernmental Agreement (2022)

[TO BE PROVIDED]

Appendix B: NFRMPO 2015 Base Year Regional Travel Demand Model Description

Introduction

The NFRMPO 2015 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 2019 and replaces the 2012 BY RTDM developed in 2014. Major improvements to the 2015 BY RTDM compared to the 2012 BY RTDM include updated traffic counts, freight data, land use data, and various modeling improvements. The NFRMPO's GHG emissions analysis for the 2045 RTP 2022 Update uses the NFRMPO 2015 BY RTDM version 5.13 in TransCAD Version 8.0.

This document provides an overview of the 2015 BY RTDM. More detailed information on the modeling process, inputs, and procedures are available in the *North Front Range Regional Travel Demand Model 2015 Base Year: Technical Report*. The Technical Report reflects the model as it was developed in 2019. Minor updates to the 2015 BY RTDM were implemented in 2020 and 2022. These updates include:

- Improvements to the truck model based on GPS and Location Based Service (LBS) data;
  - The NFRMPO's truck model generates, distributions, and assigns medium and heavy trucks. It includes truck trips within the region, to and from the region, and through the region.
- Improvements to the transit aspects of the mode choice model, including removal of density coefficients and enabling of boarding/alighting restrictions;
- Additional adjustment capabilities including rate of work-from-home and implementation of Vehicle Miles Traveled (VMT) mitigation strategies; and
- Expansion of the modeling area to include northern Weld County.

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 998 zones.

The RTDM has a base year of 2015 and forecast years of 2020, 2025, 2030, 2035, 2040, and 2045. The GHG Planning Standard requires a compliance demonstration for 2050, which is beyond the horizon of the 2015 BY RTDM. Therefore, estimates for 2050 are extrapolated from 2045 using methodology developed by CDOT and APCD to set the GHG reduction levels for 2050 in the GHG Planning Standard.

Demographic Development Estimation

Socio-economic data is the input activity-based information that provides the foundation for trip-making in the RTDM. Data is recorded for basic, retail, medical, and service employment types and for households by income groups and household sizes. Employment data is used in the RTDM primarily as generators of trip attractions. 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 2015 BY RTDM is the 2010 BY LUAM. Additional information on the 2010 BY LUAM is available in the "NFRMPO 2010 Land Use Allocation Model: Technical Documentation". The model uses forecasted growth in employment and households from the Colorado State Demography Office (SDO).

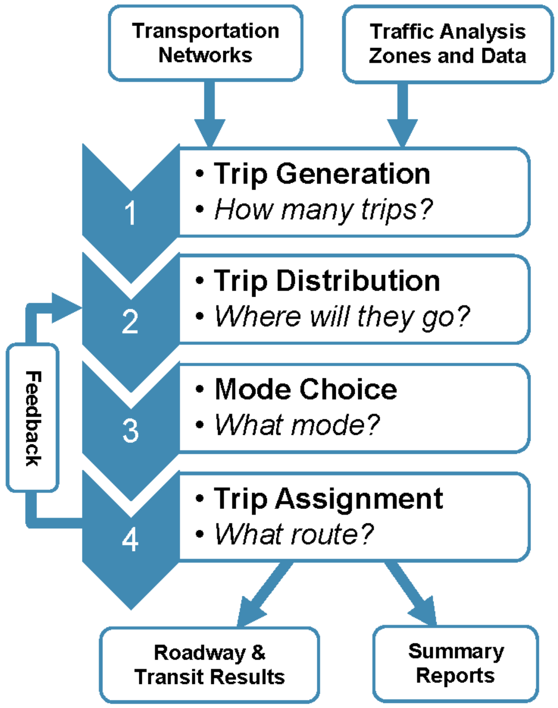
Roadway and Transit Systems

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 8,400 links 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 2015 BY RTDM are illustrated in **Figure B-1**. 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 B-1. The Four-Step Travel Model



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. Cross-classified trip rates are applied in the model to represent trip-making characteristics that vary by household size and income. Generally, trip rates increase as household size and income increase. 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.
- ***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 EE trip purpose and were estimated using traffic count data and information from the Statewide Travel Model developed by CDOT. 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 and analysis of the 2010 *NFRMPO Household Travel Survey* (HHTS) data.

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.

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 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.

As part of the RTDM's 2015 base year development using the household survey and traffic count data, additional time-of-day parameters were developed to represent the variation of travel patterns throughout the day. The time-of-day assignment process uses the vehicle trip table in production/attraction format for the three time periods and divides it into 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. The mid-day and off-peak periods may 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 tele-travel, 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 B-2, Table B-1**. The reduced drive alone trips are identified as "other non-vehicle" trips in the model summary tables included in the GHG Transportation Report.

Figure B-2. TDM in the Model

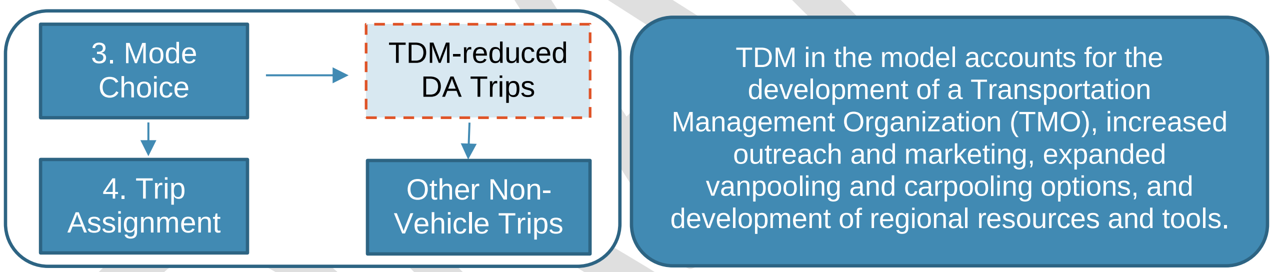


Table B-1: TDM Improvements and Funding Sources		
Category	**Improvement**	**Funding Source**
TDM	Transportation Management Organization (TMO) to conduct business outreach and develop resources	MMOF, CDOT 10-Year Plan, CDOT, IIJA
TDM	Expansion of RideNoCo program for trip planning, ridesharing, and vanpooling	MMOF, FTA, CDOT, IIJA
TDM	Schoolpooling and Regional Safe Routes to School 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 the NFRMPO's TDM program, the 2025 compliance year for the Updated Plan does not account for any benefits of the TDM program. **Table B-2** and **Table B-3** display 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. Best practice for TDM programs assumes a 5 percent reduction in SOV trips and a 4 to 6 percent reduction in VMT. NFRMPO staff considered a conversative estimate for this report.

Table B-2. TDM Reduction Factor by Location and Trip Purpose, 2030

Location	Home Based Work and Work Based Trips	Home Based Shopping/ Other Trips	Trips to School	Trips to Universities	All Other Trips
Fort Collins	0.5%	0.25%	1%	1.5%	0%
Greeley, Loveland, Windsor	0.25%	0.25%	1%	1.5%	0%
Remaining NFRMPO Areas	0%	0%	0%	0%	0%

Table B-3. TDM Reduction Factor by Location and Trip Purpose, 2040 and 2050 (moderate)

Location	Home Based Work and Work Based Trips	Home Based Shopping/ Other Trips	Trips to School	Trips to Universities	All Other Trips
Fort Collins	2%	1%	3%	5%	0%
Greeley, Loveland, Windsor	1%	1%	3%	5%	0%
Remaining NFRMPO Areas	0%	0%	0%	0%	0%

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. The NFRMPO considered a 33 percent increase in speed 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 B-4**. 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 B-6 converts the Bicycle and Pedestrian Alternative Specific Constants (ASCs) developed by Cambridge Systematics from **Table B-5** 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 7.5 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 B-4. Walk and Bicycle Speed Assumptions

	Unadjusted Values	Adjusted Values
Walk Speed	3 mph	4 mph
Bicycle Speed	12 mph	16 mph

Table B-5. 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 B-6. 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 implicit assumptions about the rate of work from home, which reflects the rate of telework along with the lack of commute trips for workers at self-employed small businesses, those working at home offices, and employees with alternative schedules such as three 12 hour shifts a week. For the 2045 RTP, the work from home rate was based on the HHTS and was assumed to hold constant in future years 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. As of July 2022, the NFRMPO, Fort Collins, and CSU are developing TDM Plans, which will address investments in TDM resources, strategies, and programming throughout the region. These Plans will build 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 RTDM accounts for the increase in other trip types resulting from decreased commute trips using a trip rebound factor developed from an analysis of the HHTS. **Table B-7** identifies the work from home assumptions used for each compliance year for the Updated Plan. For the Baseline Plan, the work from home share is 11 percent and no trip rebound factors are used.

Table B-7. Work From Home Assumptions, Updated Plan	
Assumption	Value
Work From Home Share	25%
Home-Based Shop Trip Rebound	39.1%
Home-Based Other Trip Rebound	42.2%
Other-Based Other Trip Rebound	15.6%
Resulting Reduced Trip Length	0.9

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 B-8 identifies the unadjusted and adjusted transit assumptions for transit speeds and the transfer penalty.

Table B-8. 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 B-9**. 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 B-9. 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 2015 BY RTDM addresses three of the five elements of induced demand:

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

The trip generation submodel of the 2015 BY RTDM does not consider destination accessibility, and therefore the model does not address additional trips. Lastly, the 2015 BY RTDM does not address the new development element of induced demand. Future updates to the NFRMPO's RTDM will consider how these two elements of induced demand can be represented.

Model Calibration

The 2015 BY RTDM was calibrated using data from the *NFRMPO Household Survey,* 2010 and the *NFRMPO On-Board Transit Survey*, 2009 (OBTS). The household survey was used to develop the trip generation rates, trip length frequency distributions, and auto occupancy rates. The OBTS was used in combination with the household survey and 2015 transit boarding counts to produce mode share targets. Additional detail on model calibration is available in Section 12 of the 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 2015 (collected between 2013 and 2017). 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 eight percent of the sum of traffic counts for arterials and freeways and within 23 percent for collectors. The overall percent root mean square error (percent RMSE) is within 40 percent. Additional detail on model validation is available in Section 12 of the RTDM Technical Report.

Table B-10 shows validation data for the NFRMPO's 2015BY RTDM to use as a comparison to data shown in the GHG Transportation Report.

Table B-10: NFRMPO Modeling Summary, Validation	
	2015
Socioeconomic Data	
Population	455,302
Households	180,780
Employment	270,064
Person Trip Mode Share	
Single occupancy in auto	44.9%
Shared ride in auto	42.4%
Walk	8.8%
Bicycle	3.3%
Transit	0.5%
Other non-vehicle	0.0%
Total Daily Trips	***2,713,803***
Vehicle and Transit Data – Typical Weekday	
Vehicle Miles Traveled (VMT)	10,571,348
VMT per capita	23.2
Average vehicle speed (mph)	37.6
Average vehicle trip length (mi)	6.6
Vehicle Hours Traveled (VHT)	281,011
Hours of vehicle delay	26,888
Transit trips (linked)	13,564

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 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. The figure below illustrates the HPMS categories.

	A	B	C	D	E
1	sourceTyp	sourceTypeName	HPMSVtypeID	HPMSVtypeName	**HPMS from APCD**
2	11	Motorcycle	10	Motorcycles	**10**
3	21	Passenger Car	25	Light Duty Vehicles	**20**
4	31	Passenger Truck	25	Light Duty Vehicles	**30**
5	32	Light Commercial Truck	25	Light Duty Vehicles	**30**
6	41	Other Buses	40	Buses	**40**
7	42	Transit Bus	40	Buses	**40**
8	43	School Bus	40	Buses	**40**
9	51	Refuse Truck	50	Single Unit Trucks	**50**
10	52	Single Unit Short-haul Truck	50	Single Unit Trucks	**50**
11	53	Single Unit Long-haul Truck	50	Single Unit Trucks	**50**
12	54	Motor Home	50	Single Unit Trucks	**50**
13	61	Combination Short-haul Truck	60	Combination Trucks	**60**
14	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 3-1***. 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 3-1: 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 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 area, 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 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 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 area is 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 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, post-processing 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
    - 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, the table 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)
    - 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

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 Name

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 10 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.

The PeriodHour24 table 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.

PeriodHour24

Interval	periodCog	name	hour	hrsT	periods
11:00 PM - 6:30AM	7	Op1.bin	1	7.5	7
11:00 PM - 6:30AM	7	Op1.bin	2	7.5	7
11:00 PM - 6:30AM	7	Op1.bin	3	7.5	7
11:00 PM - 6:30AM	7	Op1.bin	4	7.5	7
11:00 PM - 6:30AM	7	Op1.bin	5	7.5	7
11:00 PM - 6:30AM	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 AM - 11:30 AM	8	Op2.bin	10	2.5	2.5
9:00 AM - 11:30 AM	8	Op2.bin	11	2.5	2.5
	9	Op3.bin	12	3.5	7
	8	Op2.bin	12	2.5	5
11:30 AM - 3:00 PM	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 - 6:30AM	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.

FractionsByHourHPMSnaaT

NAA?	Weld?	Rural?	FC	Hr	10f	20f	30f	40f	50f	60f
-1	W	R	1	1	1.12494375281236E-03	0.442984079764564	0.408981870287873	8.24958752062397E-04	3.60606876834793E-03	0.14247807867434
-1	W	R	1	2	6.50325162581291E-04	0.418107821883677	0.388118179039889	1.40070035017509E-03	5.57032759041272E-03	0.186152645973265
-1	W	R	1	3	1.1907462009526E-03	0.402448608970853	0.376594285267901	1.9278748015423E-03	8.86488378110699E-03	0.208973600977645
-1	W	R	1	4	1.88772529102432E-03	0.400795540811441	0.375296865809669	3.5956672209987E-03	8.74568726325532E-03	0.209678513603612
-1	W	R	1	5	1.27600843728028E-03	0.438002933384539	0.406922735865401	8.59352621025494E-04	5.91653137282429E-03	0.14702243831893
-1	W	R	1	6	9.86892049192773E-04	0.462978652961131	0.429325812630245	1.88521686320158E-03	5.20852159466524E-03	9.96149039015637E-02
-1	W	R	1	7	8.56477631797771E-04	0.47063947538398	0.437825973989187	1.19740562115417E-03	7.50554404406707E-03	8.19751233298142E-02

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.

RTt

DRCOG Facil	FHWA facility type	rural?	FHWA	Urban	MOVESrt	fhwaRT	fcCode	Intestate
1	Principal Arterial - Interstate	-1	R	R	2	1	1	1
1	Principal Arterial - Interstate	-1	R	R	2	1	1	0
1	Principal Arterial - Interstate	0	N	U	4	11	1	0
1	Principal Arterial - Interstate	0	N	U	4	11	1	1
2	Principal Arterial - Other	-1	N	R	3	2	2	0
2	Principal Arterial - Other Freeways or Expresswa	0	N	U	4	12	2	0
3	Principal Arterial - Other	-1	N	R	3	2	3	0
3	Principal 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	Principal Arterial	-1	R	R	2	1	1	0
6	Principal 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)

- CO_2e (MMt/year) = CO_2e (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: 2045 RTP 2022 Update

Appendix D: 2022 Update

In 2021 and 2022, new State requirements to account for greenhouse gas (GHG) emissions resulting from transportation plans were implemented. To address these requirements, the NFRMPO updated the 2045 RTP in 2022 and developed a *GHG Transportation Report* that was developed in conjunction with and reviewed by the Colorado Department of Transportation (CDOT) and the Colorado Department of Public Health & Environment (CDPHE) Air Pollution Control Division (APCD). This **Appendix** contains the 2022 updates to the 2045 RTP, including identified projects and strategies and the demonstration of fiscal constraint.

GHG Strategy Commitments

The State's GHG Planning Standard requires the NFRMPO to demonstrate a reduction in GHG emissions resulting from the RTP as compared with GHG emissions resulting from the Baseline Plan. The Baseline Plan is the plan in place at the time the GHG Planning Standard became effective on January 30, 2022. For the NFRMPO, the Baseline Plan is the 2045 RTP, adopted by the NFRMPO Planning Council on September 5, 2019

The 2045 RTP included a wide range of transportation investments, many of which will contribute to reductions in GHG emissions compared to a no-build scenario. These investments, such as expanding transit service and building out the Regional Non-Motorized Corridors (RNMCs, now known as Regional Active Transportation Corridors or ATCs) are not eligible for the required GHG reductions in the State's GHG Planning Standard because they were incorporated into the baseline GHG estimates.

GHG strategies which are eligible to be applied toward achieving the GHG Planning Standard include any new commitments to reduce GHG emissions that were not included in the Baseline Plan or commitments that are being advanced to an earlier staging year since the Baseline Plan was adopted. These strategies were discussed with the NFRMPO Technical Advisory Committee (TAC) and Planning Council to determine feasibility, appropriateness, and fundability. For the 2045 RTP 2022 Update, the NFRMPO is committing to the strategies and projects identified in **Table D-1**. The **Table** categorizes the projects into transit projects, TDM projects, operations projects, and active transportation projects, and explains the funding sources identified to maintain fiscal constraint.

GHG Emission Analysis

The GHG emission analysis of the 2045 RTP 2022 Update was conducted in compliance with state regulations and found the RTP meets or exceeds the requirements in the state's GHG Planning Standard, as shown in **Table D-2**. Documentation of the GHG emission analysis is available in the **NFRMPO GHG Transportation Report: Determining Compliance with the GHG Transportation Planning Standard**, adopted by the North Front Range Transportation & Air Quality Council (NFRT&AQPC) on October 6, 2022.

	Table D-1: 2045 RTP Amendment Strategies	
Category	**Improvement Description**	**Funding Source**
Transit	Advance US34 transit service between Loveland and Greeley from 2045 to 2030	CDOT 10-Year Plan, FTA, MMOF
Transit	Expansion of COLT's local transit network as identified in Connect Loveland by 2030	Connect Loveland, FTA, MMOF, Local Funds
Transit	Double frequency of Bustang North Line in all compliance years	CDOT 10-Year Plan
Transit	Addition of mobility hubs and transit centers planned since 2019	CDOT 10-Year Plan, MMOF, IIJA, Local Funds
TDM	Increase in work from home in all compliance years	MMOF, IIJA
TDM	Development and expansion of TDM programs by 2030 and growth in 2040 and 2050	MMOF, IIJA
Operations	Arterial signal timing improvements by 2030 and carried through to 2040 and 2050	CDOT 10-Year Plan, IIJA, Local funds
Active Transportation	Expansion of the local bicycle and pedestrian network by 2030	IIJA, MMOF, Local Funds
Active Transportation	Increased prevalence of e-bikes and scooters by 2030	IIJA, MMOF, Local Funds

Table D-2: GHG Emissions Results, Million Metric Tons (MMT) per Year				
	2025	**2030**	**2040**	**2050**
Baseline Plan: 2045 RTP, 2019	1.73	1.60	1.22	0.82
Updated Plan: 2045 RTP, 2022 Update	1.68	1.48	1.11	0.75
Reduction	**0.05**	**0.12**	**0.11**	**0.07**
Required GHG Reduction Level	0.04	0.12	0.11	0.07
Pass/Fail	**PASS**	**PASS**	**PASS**	**PASS**

Financial Plan

The financial plan of the 2045 RTP, also known as the fiscally constrained plan, is detailed in Chapter 3, Section 4. The financial plan identifies the total amount of revenue anticipated to be available throughout the horizon year of the RTP (2045) and the estimated cost of operating, maintaining, and improving the transportation system over the same timeframe.

Since the NFRMPO Planning Council adopted the 2045 RTP, new federal and state funding legislation has been adopted: the new federal transportation authorization bill known as the Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law (BIL); and Colorado Senate Bill (SB) 21-260 Sustainability Of The Transportation System. CDOT provided the revenue estimates used in the 2045 RTP and projected additional statewide HUTF funds in future years, which accounts for the increased funding and programming provided in IIJA and SB260. While a deeper analysis of the impacts of the new legislation will be undertaken for the 2050 RTP, NFRMPO staff determined using the existing levels of identified revenues from the 2045 RTP would be sufficient for this amendment. Strategies do, however, identify the new funding sources, as well as if projects have funding identified in CDOT's 10 Year Plan.

In the financial plan, each funding program is assigned to one or more expenditure categories in **Table 3-14** (see page 252), with total revenue estimates summed by category. The expenditure categories include roadway operations and maintenance (O&M), intersection improvements, bike & ped, transit, and flexible. A total of $9.097B is anticipated to be available in year of expenditure dollars (YOE) from 2020 through 2045. The available funding is then allocated to the identified operations, maintenance, and expansion costs in **Table 3-16** (see page 255).

To fund the GHG strategies identified in this RTP Update, the resource allocation originally identified in **Table 3-16** is replaced with the resource allocation in **Table D-3**, with all updated values shown in blue. The relationship between expenditure category and amendment strategy is shown in **Figure D-1**. A column to denote the percentage of total expenditure category cost dedicated to GHG-reducing projects is also included. Important to note in **Table D-3** is additional funding for capacity projects would be used for TDM strategies, transit upgrades, and bicycle and pedestrian improvements.

Resource allocation was determined based on fiscal constraint rationale, shown in **Table D-4**. To maintain fiscal constraint, intersection improvement project funding was reduced with the funding redistributed to strategies like TDM, transit, and bicycle and pedestrian improvements. A total of $600M in funding will be allocated to the GHG strategies newly committed to in this RTP Update.

Figure D-1: Expenditure Category and Amendment Strategy Relationship

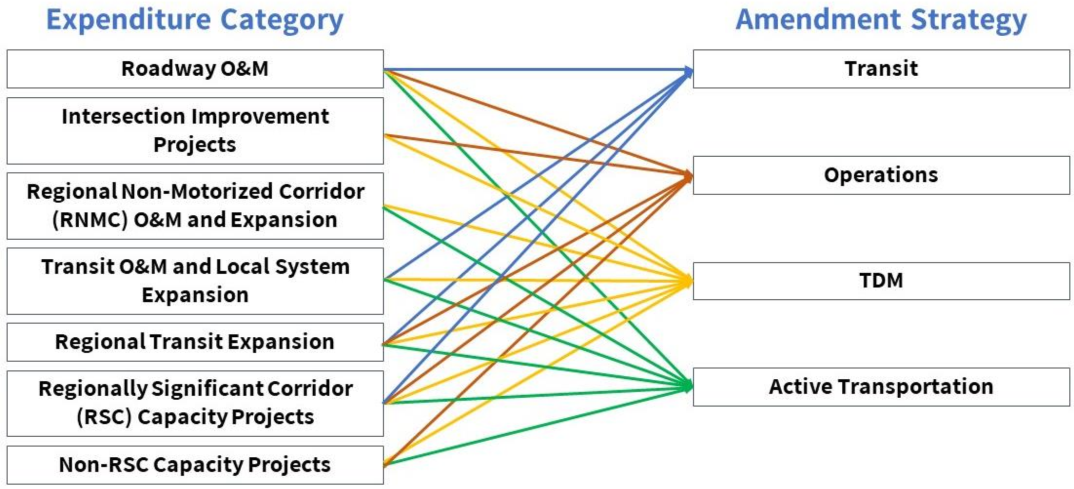


Table D-3: Resource Allocation by Expenditure Category in Millions of YOE Dollars, 2020-2045

Expenditure Category	Cost	Dedicated Funding	Flexible Funding	Total Funded	Unfunded	Share for GHG Strategies	GHG Funding Total
Roadway O&M	$5,070	$1,339	$3,731	$5,070	$0	6%	$304
Intersection Improvement Projects	$531	$99	$229	$328	$203	9%	$28
Regional Non-Motorized Corridor (RNMC) O&M and Expansion	$273	$122	$151	$273	$0	0%	$0
Transit O&M and Local System Expansion	$1,486	$950	$536	$1,486	$0	10%	$201
Regional Transit Expansion: RTE Corridors and Front Range Passenger Rail	$2,069	$0	$40	$40	$2,029	66%	$3
Regionally Significant Corridor (RSC) Capacity Projects	$3,638	$0	$1,407	$1,407	$2,231	5%	$70
Non-RSC Capacity Projects	$678	$0	$493	$477	$185	5%	$24
TOTAL	**$13,776**	**$2,510**	**$6,586**	**$9,097**	**$4,649**	**N/A**	**$600**

The Transit O&M and Local System Expansion includes funding for the West Elizabeth Bus Rapid Transit project in development by Fort Collins/Transfort.

Table D-4: Fiscal Constraint Rationale

Category	Cost (2019-2045)	Rationale and Funding Opportunity
Transit	$147M	CDOT and local communities have identified funding for similar projects between 2019 and 2022, showing a commitment to GHG-reducing strategies. Examples include: • CDOT has identified 10-Year Plan funds to partially fund US34 transit service capital and operating costs • Colorado legislature passed SB22-180, which will provide funds to CDOT for Bustang expansion • Loveland has received MMOF and local funds for transit expansion between 2021 and 2022 • CDOT has funded two mobility hubs along I-25 at Kendall Parkway and SH56 and is partnering with Greeley on a US34 and Centerplace mobility hub Transit projects will be funded through sources included in four categories and could be included as part of multimodal corridor investments, not just as standalone projects.
Operations	$51M	Since at least the 2014 Call for Projects, communities have submitted applications and received funding for adaptive signal and other operational improvement projects. Additionally, transit signal priority is installed in existing transit signals on some state highways. Operational improvements will be funded through sources included in five categories and should be considered as part of maintenance where applicable.
TDM	$40M	CDOT has held a Call for Projects on a semiannual basis since 2021 for TDM related projects. The NFRMPO, Fort Collins, and Colorado State University (CSU) are in the process of developing TDM plans and strategies. TDM strategies will be funded through each category.
Active Transportation	$283M	Funding requests for bicycling and walking infrastructure have increased in each passing Call for Projects. Bicycle and pedestrian improvements are considered throughout the transportation and land use development stage, with more developers citing trails as a perk. Active transportation investments will be funded through six categories.

Cost estimates for each strategy are based on CDOT's Cost Benefit Analysis, local and regional plans, local and state input, National Transit Database (NTD), and data from recent NFRMPO Calls for Projects.

Appendix E: Resolution 2022-XX North Front Range Transportation & Air Quality Planning Council (NFRT&AQPC) Adoption

[TO BE PROVIDED]

Appendix F: APCD Verification

[TO BE PROVIDED]

Appendix G: Colorado Transportation Commission Resolution

[TO BE PROVIDED]

Executive Summary of the
North Front Range Metropolitan Planning Organization
Community Advisory Committee
August 11, 2022

Attendees: Brad Ragazzo, Cliff Moore, Cindy Beemer, Diego Lopez, Louisa Andersen

Staff: Alex Gordon, AnnaRose Cunningham

Pre-Meeting Introduction

Cunningham provided a general outline of the NFRMPO and its programs, plans, and initiatives. Ragazzo asked for guidance about what the expectation for the CAC is. Cunningham explained the CAC meets once per month with some requests for review in-between meetings.

Introductions

Cunningham introduced the new members of the Community Advisory Committee (CAC) through a GIF activity and asking members about their thoughts on transportation around the world.

Public Involvement Plan (PIP)

Cunningham reviewed the purpose, guiding principles, and strategies from the 2019 Public Involvement Plan as a basis for the 2023 Public Involvement Plan. Lopez recommended working with utilities (Xcel Energy) and the universities as partners for events. Andersen recommended attending a Friday Fest in Greeley. Cunningham reviewed implemented 2019 strategies and added lessons learned from COVID. Beemer noted online meetings can sometimes lead to less attention from participants compared to in-person meetings but expands the opportunities for people to participate. In-person meetings should still be the default.

Transportation Demand Management (TDM)

Gordon reviewed the TDM recommendations from the TDM Action Plan. Ragazzo asked if there is a forum for people to share rides. Other CAC members highlighted the need for schoolpooling. Lopez asked if the Via project is moving forward.

GHG Transportation Report

Gordon reviewed the results from the GHG Transportation Report the NFRMPO staff has been working on. There is a fact sheet on the NFRMPO website at nfrmpo.org/air-quality/ghg-rulemaking.

Next Steps

Cunningham reviewed possible ideas for future meetings, including tours of construction projects, walk audits, and Cycling Without Age demonstrations. The group stated the 2045 Regional Transportation Plan (RTP) is an important topic.