

# **EAST COLFAX AVENUE BUS RAPID TRANSIT (BRT) PROJECT TECHNICAL MEMORANDUM**

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**For Air Quality / Greenhouse Gas Emissions**

**Prepared for:**

**City and County of Denver and Regional Transportation District**

**April 2024**

# Contents

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<b>1. PROJECT DESCRIPTION.....</b>	<b>1</b>
1.1. PURPOSE OF THE PROJECT	4
1.2. NEED FOR THE PROJECT	4
<b>2. REGULATORY AND AFFECTED ENVIRONMENT.....</b>	<b>5</b>
2.1. AIR QUALITY CONFORMITY	5
2.2. GREEN HOUSE GAS EMISSIONS	5
<b>3. METHODOLOGY.....</b>	<b>5</b>
<b>4. GHG ANALYSIS RESULTS.....</b>	<b>6</b>
<b>5. MITIGATION DURING CONSTRUCTION.....</b>	<b>7</b>

# Figures

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Figure 1. BRT Service Routing and Travel Headways	1
Figure 2. Project Area and Station Locations	4

# Tables

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<b>Table 1. Proposed Station Features.....</b>	<b>2</b>
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# Appendices

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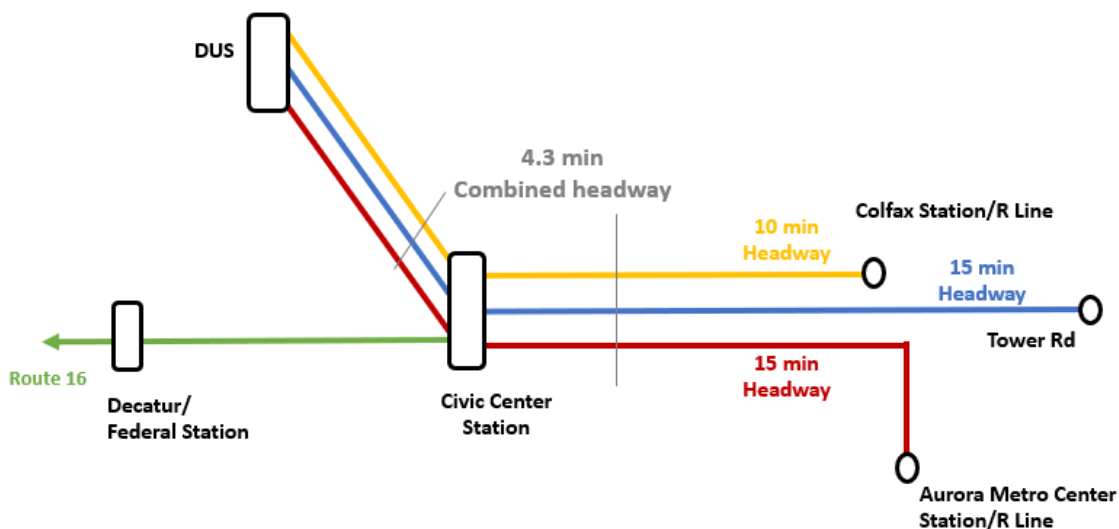
Appendix A - FTA GHG Calculator

# 1. Project Description

The Federal Transit Administration (FTA) in coordination with the City and County of Denver (CCD) and the Regional Transportation District (RTD) are performing a National Environmental Policy Act (NEPA) evaluation for a Bus Rapid Transit (BRT) system that would serve East Colfax Avenue between downtown Denver and the RTD R Line light rail transit (LRT) Colfax Station at Interstate 225 (I-225) in Aurora (Project). The Project qualifies as a Categorical Exclusion (CE) per the FTA, which is the lead federal agency for this undertaking. The City of Aurora (COA), Colorado Department of Transportation (CDOT) and the Denver Regional Council of Governments (DRCOG) are active Project participants along with numerous public and private stakeholders. The CCD and the RTD implemented a robust stakeholder involvement program as a part of the Project and will continue to work with the stakeholders as design advances, funding is obtained, and construction is initiated.

The Project has completed preliminary design for BRT operations, including the identification of routing and station locations. The East Colfax Avenue BRT would run on existing, heavily traveled bus routes and would serve downtown Denver at the western end of the corridor, communities and businesses along East Colfax Avenue, and the Anschutz Medical Campus at I-225 and East Colfax Avenue in the east. Specifically, the 9.9-mile-long Project would include:

- Reliable BRT service (combined Route 15/15L) operating 24 hours per day, 7 days per week. This would include three service patterns all serving Denver Union Station (DUS) and three patterns that diverge at the eastern project terminus in the COA (including bus turnarounds at the RTD R LRT Colfax Station, Tower Road, and the R Line Aurora Metro Center Station). Two patterns would occur with 15-minute headways and one pattern with a 10-minute headway to provide a composite 4.3-minute BRT headway from DUS to the RTD R Line LRT Colfax Station. Connection between Civic Center Station and the Decatur/Federal Station is also provided via Route 16 (Figure 1).



**Figure 1. BRT Service Routing and Travel Headways**

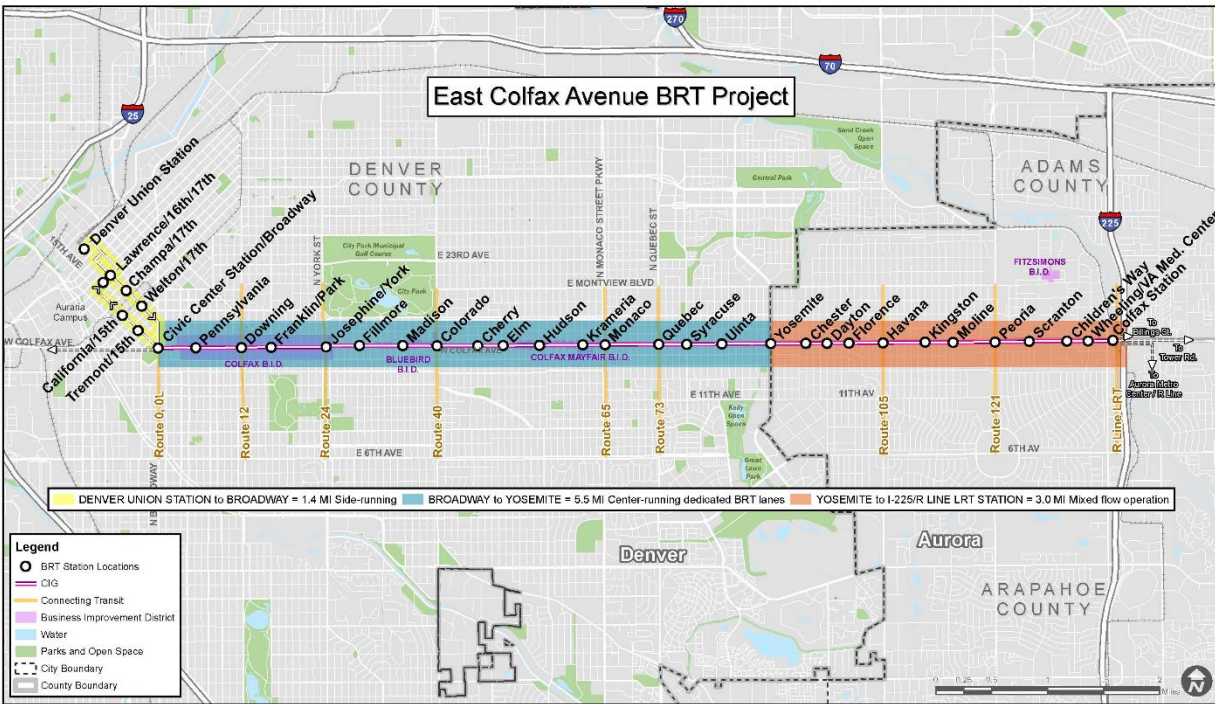
- Curbside-running alignment in existing 15th Street and 17th Street on-street bus lanes between DUS and Civic Center (East Colfax Avenue / Broadway), – 1.4 miles.
- Center-running alignment in dedicated bus-only lanes between Civic Center (East Colfax Avenue/Broadway) and East Colfax Avenue/Yosemite Street – 5.5 miles.
- Curbside-running alignment in mixed-flow traffic through COA between East Colfax Avenue/Yosemite Street and the existing RTD Colfax Station just east of Potomac Street at I-225 – 3.0 miles.
- Upgraded signals to provide Transit Signal Priority (TSP) throughout the center-running section.
- Branded service, stations, and vehicles.
- Thirty-five (35) station locations with an average spacing of 0.32 miles.
- Enhanced station amenities including level boarding platforms, high-quality shelters, off-board fare collection, lighting, security features, real-time system traveler information, protection from traffic and weather, and public art opportunities.
- The COA has contributed funding for upgraded station improvements at certain locations between Yosemite Street and I-225 along East Colfax Avenue. At East Colfax Avenue and Havana Street, a station design similar to those planned in the center-running alignment section in Denver would be located at the corner of East Colfax Avenue and Havana Street. In addition, level boarding platforms are planned at the intersections of East Colfax Avenue and Peoria Street, Moline Street, and the R Line Colfax Station. The level boarding platforms would be constructed where the existing 15L shelters are currently located at these three locations, and the 15L shelters would be attached on top of each new platform.
- Dual northbound left-turn lanes on Colorado Boulevard at the intersections of East 13<sup>th</sup> Street and East 17<sup>th</sup> Street to improve traffic operations and travel times within the project area. An approximate 5-foot southbound travel lane shift would be required for the turn lane improvements. These improvements consist of widening of the roadway at the intersection by 10 feet. The added lane width would be accomplished by removal of the existing 5-foot median and shifting the existing curb line 5 feet to the west at both intersections.

Station locations and proposed features are highlighted in Table 1 and Figure 2 below.

**Table 1. Proposed Station Features**

Station	Stop Location	Full Signature BRT Station	Level Boarding Platforms	Existing Enhanced 15L Shelter to Remain	New Relocated Enhanced 15L Shelter	Branding and BRT Amenities
Denver Union Station (DUS)	Curbside					✓
Lawrence /16 <sup>th</sup>	Curbside					✓

Station	Stop Location	Full Signature BRT Station	Level Boarding Platforms	Existing Enhanced 15L Shelter to Remain	New Relocated Enhanced 15L Shelter	Branding and BRT Amenities
California/15 <sup>th</sup>	Curbside					✓
Tremont/15 <sup>th</sup>	Curbside					✓
Lawrence /17 <sup>th</sup>	Curbside					✓
Champa/17 <sup>th</sup>	Curbside					✓
Welton/17 <sup>th</sup>	Curbside					✓
Civic Center Station/Broadway	Curbside			✓		✓
Pennsylvania	Center	✓	✓			✓
Downing	Center	✓	✓			✓
Franklin/Park	Center	✓	✓			✓
Josephine/York	Center	✓	✓			✓
Fillmore	Center	✓	✓			✓
Madison	Center	✓	✓			✓
Colorado	Center	✓	✓			✓
Cherry	Center	✓	✓			✓
Elm	Center	✓	✓			✓
Hudson	Center	✓	✓			✓
Krameria	Center	✓	✓			✓
Monaco	Center	✓	✓			✓
Quebec	Center	✓	✓			✓
Syracuse	Center	✓	✓			✓
Uinta	Center	✓	✓			✓
Yosemite	Curbside			✓		✓
Chester	Curbside				✓	✓
Dayton	Curbside			✓		✓
Florence	Curbside				✓	✓
Havana	Curbside	✓	✓			✓
Kingston	Curbside				✓	✓
Moline	Curbside		✓	✓		✓
Peoria	Curbside		✓	✓		✓
Scranton	Curbside			✓	✓	✓
Children's Way	Curbside			✓		✓
Wheeling / Fitzsimons (VA)	Curbside				✓	✓
R Line LRT Colfax Station	Curbside		✓		✓	✓



**Figure 2. Project Area and Station Locations**

## 1.1. Purpose of the Project

The purpose of the Project is to provide additional person-trip capacity to meet growing travel demand with a high-quality, high-capacity, cost-effective, reliable, and safe transit solution serving the East Colfax Avenue corridor. This new service would provide a faster, more reliable, and more comfortable passenger experience compared with existing bus service, and thereby attract additional transit ridership. The Project would improve local and regional accessibility, mobility, safety, transit travel times and reliability, and passenger facilities in the most heavily used transit corridor in the Denver region.

## 1.2 Need for the Project

The need for the Project is demonstrated by increasing transit travel demand in the corridor. The Project would aid the growth of transit ridership in the corridor by providing a comfortable, more frequent, and more reliable service for transit patrons, to a variety of destinations along the corridor. The Project also supports Denver’s Vision Zero initiative, making travel safer for pedestrians, cyclists, motorists, and transit riders. The Project would also support future investment along the East Colfax Avenue corridor, while continuing to provide an affordable travel option to help reduce household transportation costs. Seven needs have been identified and outlined for the Project:

- Serve the Growing Travel Demand
- Provide Improved Mobility

- Provide Equity and Affordability
- Improve Safety
- Provide Improved Access to Major Destinations
- Align Mobility Improvements with Land Use, Neighborhood and Economic Plans
- Improve Placemaking

## 2. Regulatory and Affected Environment

### 2.1. Air Quality Conformity

FTA-funded projects must meet the requirements of the Clean Air Act (42 U.S.C. § 7401 et seq.) under the NEPA process. The Clean Air Act requires that, in areas experiencing air quality problems, transportation planning and projects must be consistent with – or conform to – air quality goals established in a state air quality implementation plan (SIP).

The Project is in an area which is designated as attainment 4 for nitrogen dioxide (NO<sub>2</sub>), particulate matter less than or equal to 2.5 micrometers in diameter (PM<sub>2.5</sub>), sulfur dioxide, and lead for National Ambient Air Quality Standards (NAAQS). The area is in nonattainment for ozone and is in maintenance for carbon monoxide (CO) and particulate matter with a diameter of less than or equal to 10 micrometers (PM<sub>10</sub>).

The Project is exempt from transportation conformity requirements and further analysis because it is a combination of safety improvement, transportation enhancement, pavement resurfacing and rehabilitation, and pedestrian facility. These activities are exempt from the transportation conformity requirements per 40 CFR 93.126.

### 2.2. Green House Gas Emissions

As a part of the air quality analysis for the East Colfax Avenue Bus Rapid Transit Project (Project), Federal Transit Administration's (FTA) Transit Greenhouse Gas Emissions Estimator, version 3.0, was used to estimate the lifecycle greenhouse gas (GHG) emissions and energy use associated with the construction, operations, and maintenance phases of the Project. This memorandum provides a summary of the calculated GHG emissions and energy use; the model inputs and results file are provided as Appendix A.

## 3. Methodology

GHGs include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), perfluorinated carbons, sulfur hexafluoride, and hydrofluorocarbons. The primary GHGs of concern related to the Project are CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O. Methods have been set forth to describe emissions of GHGs in terms of a single gas to simplify reporting and analysis. Global warming potential (GWP) is a concept developed to compare the ability of each GHG to trap heat in the atmosphere relative to another gas. GWP is based on several factors, including the relative effectiveness of a gas to absorb infrared radiation and the length of time the gas remains in the atmosphere (its "atmospheric lifetime"). The GWP of



each gas is measured relative to CO<sub>2</sub>. Therefore, CO<sub>2</sub> has a GWP of 1. GHGs with lower emissions rates than CO<sub>2</sub> may still contribute to climate change because they are more effective at absorbing outgoing infrared radiation than CO<sub>2</sub> (i.e., high GWP). The concept of CO<sub>2</sub> equivalence (CO<sub>2</sub>e) is used to account for the different GWP potentials of GHGs. GHG emissions are typically measured and are presented in the summary result of the FTA calculator, in terms of metric tons (MT) of CO<sub>2</sub>e.

## 4. GHG Analysis Results

The Project would result in the temporary generation of GHG emissions from the use of vehicles and equipment for construction. In addition, Project operations would generate GHG emissions as a result of maintenance, electricity serving stations and platforms, and vehicle travel. The Project would also result in an avoidance of GHG emissions from the displacement of passenger vehicle miles travelled with travel on the BRT. The Estimator calculates both upstream and downstream GHG emissions. Upstream emissions are associated with the extraction, production, and transportation of the materials, including and fuel for construction and operations; downstream emissions are the emissions resulting from the operation of a Project component, including tailpipe emissions and emissions associated with electricity or heat generation. The following summarizes the emissions sources and resultant GHG emissions associated with the Project.

The analysis period (i.e., timespan over which impacts are assessed for the purpose of calculating GHG emissions) is 22 years, which is the period over which total construction emissions are amortized.

Long-term operations of the Project would include 14 buses per hour for 14 hours per day, and an additional four buses per hour operating 10 hours per day. Based on the one-way trip mileage of 9.9 miles per trip, Project operations would generate approximately 1,705,572 BRT-miles per year. For the purposes of conservative analysis, all buses are modeled as being diesel fueled and no assumptions are made about incorporating alternative-fueled or electric-powered buses in the fleet. In addition to adding BRT-miles, the Project would also reduce passenger vehicle miles traveled (VMT) by 12,786,374 miles per year; these miles represent the displaced emissions and are assumed to be miles that would otherwise be traveled by gasoline-powered vehicles. The passenger vehicle decrease compared to the project operations expected mileage would result in a net decrease in CO<sub>2</sub> as a direct result of the project. Annual VMT for all vehicles through the corridor in the year 2040 were also calculated to estimate total GHG emissions through the corridor for all vehicles. Long-term operational emissions also account for long-term maintenance and operations of the stations.

Appendix A includes the summary tables of annual and total GHG emissions, as well as the energy consumption of the Project in metric million British Thermal Unit (MMBTU). Energy use accounts for the same sources of fuel, electricity, and heat consumption, and avoided fuel use from displaced passenger vehicle miles travelled, as those associated with the generation of GHG emissions. Total annual amortized construction emissions are 7,857 MT of CO<sub>2</sub>e per year.

Total long-term operational GHG emissions, inclusive of GHG emissions from all vehicles through the corridor, are approximately 138,931 MT CO<sub>2</sub>e per year. This also accounts for approximately 5,217



MT CO<sub>2</sub>e avoided as a result of displaced emissions (i.e., replacing passenger vehicle use with BRT ridership). The total Project GHG emissions are approximately 146,788 MT CO<sub>2</sub>e per year, including amortized construction and total operational emissions, and 3,229,332 MT CO<sub>2</sub>e over the 22-year period of analysis, including total construction and operational emissions. Total energy use is approximately 1,722,208MMBTU per year and 37,888,570 MMBTU over the period of analysis.

## 5. Mitigation during Construction

In coordination with the CCD and the COA, the contractor will be required to adhere to the following to limit air quality impacts and GHG emissions:

- Ensure the project is in compliance with federal and state air quality standards for fugitive dust control, as required in the Standard Specifications for Construction, General Contract Conditions (CCD, 2011).
- Implement a Construction Air Quality Control Plan and Fugitive Dust Control Plan. CCD will also monitor Air Quality through the Denver Department of Public Health and Environment monitoring throughout construction.
- Develop measures to minimize exhaust emissions and exposure to exhaust emissions.

## Welcome to the FTA's Transit Greenhouse Gas Emissions Estimator, version 3.0

### OVERVIEW

The Federal Transit Administration's (FTA's) Transit Greenhouse Gas (GHG) Emissions Estimator v3.0 is a spreadsheet tool that allows users to estimate the partial lifecycle GHG emissions and energy use associated with the construction, operations, and maintenance phases of projects across select transit modes. Users input general information about a project, and the tool calculates annual GHG emissions and energy use by project phase. Total annual GHG emissions for a transit project is the sum of amortized construction emissions, annual maintenance emissions, and annual operations emissions, minus annual displaced emissions. The tool also calculates the total GHG emissions and energy use by project phase over the analysis period selected.

The Estimator was developed in connection with FTA's Greenhouse Gas Emissions from Transit Projects Programmatic Assessment (2016). Although the tool lacks the precision that may be attainable by using more complex emission models or route-specific ridership estimates, it provides a resource to generate coarse but informative estimates of GHG emissions and energy use for a broad range of transit projects. In no case is the use of this tool mandatory, and transit agencies should work with FTA Regions to determine whether to conduct project-specific analyses of GHG emissions and the best approach for doing so.

### NAVIGATING THE TOOL

The tool asks users to enter information associated with four different elements of a project - Construction; Facility Operations; Vehicle Operations and Maintenance, and Displaced Emissions. Users can navigate to the different data input screens using the buttons on the main calculator page or by clicking the individual tabs. To begin, click the "GHG Calculator" tab.

### ADDITIONAL INFORMATION

Refer to the accompanying user guide for detailed instructions on how to use the tool, as well as information about the GHG emissions factors, data sources, and assumptions used in the tool. The User Guide is available on the FTA Environmental Programs website.

# FTA's TRANSIT GREENHOUSE GAS EMISSIONS ESTIMATOR

The tables below summarize the construction, facility operations, vehicle operations and maintenance, and displaced emissions inputs for the project. Users can navigate to the different data input screens using the associated buttons. Once the inputs are added, scroll to the Results section below to view results.

1. Select State: CO      2. Enter Analysis Period (years): 22

Calculate Results

## Construction Information

Structured Parking Spots	<input type="text" value="0"/>	Miles of New Track/Alignment				Miles of Converted or Upgraded Track/Alignment	Number of Stations		
		Underground	Elevated	At-Grade	Catenary		Underground	Elevated	At-Grade
Surface Parking Lot Spots	<input type="text" value="0"/>	0.00	0.00	0.00	0.00	9.90			45
Trees Removed	<input type="text" value="0"/>								

## Facility Operations Information

Transit Mode	Building Type	Facility Square Footage
Bus/BRT	Station	40,000.00
Bus/BRT	Station	6,240.00

## Vehicle Operations & Maintenance Information

Operation Mode	Fuel Source	eGrid Subregion (if applicable)	VMT
Bus/BRT	Diesel		1,705,572
Sedan/Auto	Gas		344,076,702

## Displaced VMT

Operation Mode	Fuel Source	eGrid Subregion (if applicable)	VMT
Sedan/Auto	Gas		12,786,374

## RESULTS

Calculate Results

Press 'Calculate Results' above to check for errors and calculate GHG emissions

### Summary Results

#### GHG Emissions (MTCO2eq)

Annual Total Analysis Period	Upstream	Downstream	Total

#### Energy Use (mmBTU)

Annual Total Analysis Period	Upstream	Downstream	Total

### Detailed Results

#### GHG Emissions (MTCO2eq)

Annual Results	Upstream	Downstream	Total
	Construction		
	Transitway Maintenance		
	Facility Operations		
	Vehicle Operations		
	Vehicle Maintenance		
	Displaced Emissions		
	Cumulative Emissions		

#### Energy Use (mmBTU)

Annual Results	Upstream	Downstream	Total
	Construction		
	Transitway Maintenance		
	Facility Operations		
	Vehicle Operations		
	Vehicle Maintenance		
	Displaced Emissions		
	Cumulative Emissions		

#### GHG Emissions (MTCO2eq)

Total Analysis Period	Upstream	Downstream	Total
	Construction		
	Transitway Maintenance		
	Facility Operations		
	Vehicle Operations		
	Vehicle Maintenance		
	Displaced Emissions		
	Cumulative Emissions		

#### Energy Use (mmBTU)

Total Analysis Period	Upstream	Downstream	Total
	Construction		
	Transitway Maintenance		
	Facility Operations		
	Vehicle Operations		
	Vehicle Maintenance		
	Displaced Emissions		
	Cumulative Emissions		











Input Parameter	Response	Source
<i>GHG Calculator</i>		
1. Select State	Colorado	Denver, CO
2. Enter Analysis Period (years)	22	Year 2040 minus Year 2019 including Year 2019
<i>Construction</i>		
1. Select Transit Mode	Bus/BRT	Colfax BRT project
2. Enter Underground miles of new track/lanes to be built	0	no new miles
3. Enter Elevated miles of new track/lanes to be built	0	no new miles
4. Enter At-Grade miles or new track/lanes to be built	0	no new miles
5. Enter Catenary to be built	0	no new catenaries
6. Enter the miles of Track/Alignment to be converted or upgraded	9.9	miles
7. Enter the number of Underground new stations to be built	0	no new underground stations
8. Enter the number of Elevated new stations to be built	0	no new elevated stations
9. Enter the number of At-Grade new stations to be built (Curbside Enhanced Shelter/Level Boarding Platform)	13	See 5/10 email in folder
9. Enter the number of At-Grade new stations to be built (BRT Station Platform)	32	See 5/10 email in folder
<i>Facility Operations</i>		
1. Enter square footage of Bus/BRT (Aurora)	480	square feet; Per Aurora Enhanced 15L Shelter Locations document (dated 2/23/2022), the approximate shelter square footage will be 15 feet 1 inch by 5 feet 9 inches. This number is multiplied by 9 in the GHG calculator for total facilities.
1. Enter square footage of Bus/BRT (Denver)	1250	square feet; per design drawings, the width of the platforms are a maximum of 11 feet. On average, the platforms are about 125 feet.
<i>Vehicle Operations &amp; Maintenance</i>		
1. 1st Vehicle Type and Fuel Source	Bus/BRT Diesel	Conservative assumption that all buses on the BRT will be diesel-fueled
2. 1st Vehicle Annual Transit VMT Anticipated	1,705,572	Provided data of 14 buses per hour for 14 hours per day with 4 buses per hour for 10 hours per day. Roundtrip mileage is 19.8 miles (9.9 x 2) estimated operation for 365 days per year. $(14 \cdot 14 + 4 \cdot 10) \cdot 19.8 \cdot 365 = 1,705,572$ miles/yr
3. 2nd Vehicle Type and Fuel Source	Sedan/Auto Gas	Assumption that all other traffic on the BRT roadway will be passenger vehicles fueled by gasoline
4. 2nd Vehicle Annual Transit VMT Anticipated	344,076,702	miles; see steps below

**Vehicle Miles Travelled (VMT)**

provided data by traffic team

Corridor	AM Peak Hour		
	19 EX	19 PP	40 BL
17th/18th from Broadway to Peoria	8,480	9,910	9,620
Colfax from Broadway to I-225	17,340	12,890	18,620
13th/14th from Broadway to Yosemite	8,340	11,200	9,920
<b>Total</b>	<b>34,160</b>	<b>34,000</b>	<b>38,160</b>

since these are peak hour estimates, reviewed current OTIS data for annual average daily traffic (annual data not available)

101923 21,345 vehicles/day

closest OTIS monitors to project area are 101923 (SH40, Colfax Ave W/O Broadway) and 101924 (SH40, Colfax Ave E/O Broadway)

101924 28,689 vehicles/day

Distance from Colfax from Broadway to I-225 8.6 miles  
Existing AADT for Colfax from Broadway to I-225 430,292 miles  
19EX Daily VMT 430,292 miles

Corridor	Daily VMT		
	19 EX	19 PP	40 BL
17th/18th from Broadway to Peoria	230,446	266,321	254,081
Colfax from Broadway to I-225	430,292	339,338	466,590
13th/14th from Broadway to Yosemite	221,794	276,240	257,036
<b>Total</b>	<b>882,532</b>	<b>881,899</b>	<b>977,707</b>

linearly scaled the 19PP, 40BL, and 40PP volumes based on the 19EX volumes from OTIS and PM Peak Hour. PM Peak Hour is chosen due to its higher volume compared to AM

Multiply Daily VMT by 365 day/yr

Annual VMT 322,124,192 321,893,113 356,863,076

<i>Displaced Emissions</i>		
1. 1st Vehicle Type and Fuel Source	Sedan/Auto Gas	Vehicles moved off the BRT roadway due to more passengers using busways and less lanes for passenger vehicles
2. 1st Vehicle Annual Vehicle VMT Displaced	12,786,374	miles: estimated mileage of 40BL (2040 annual VMT without project) minus 40PP (2040 annual VMT with project)

40 PP
10,860
13,700
11,860
36,420

40 PP
286,580
349,890
306,206
942,676

344,076,702