Applying TEAM in Regional Sketch Planning:

A Case Study in Austin, Texas

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Acronyms and Abbreviations

BAU	business as usual
CAPCOG	Capital Area Council of Governments
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
LRTP	Long Range Transportation Plan
MOVES	Motor Vehicle Emission Simulator (EPA's motor vehicle emissions model)
MPO	Metropolitan Planning Organization
NOx	nitrogen oxides
PM	particulate matter
TAZ	traffic analysis zone
TDM	Transportation Demand Management
TEAM	Travel Efficiency Assessment Method
TE	travel efficiency
TRIMMS	Trip Reduction Impacts of Mobility Management Strategies
VMT	vehicle miles traveled
VOCs	volatile organic compounds

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1 Introduction

Air quality in the U.S. has improved over the years, as regulations and technologies have affected emissions from all pollution sectors. Yet, even with improvements in vehicle technologies and fuels, the transportation sector continues to be a major source of criteria pollutants and greenhouse gas (GHG) emissions across the country. While emissions per mile traveled have decreased, growth in travel activity has partially offset those reductions, and presents a challenge to achieving and maintaining public health. For air quality and transportation planners interested in reducing transportation emissions in their regions, the ability to estimate the emission reduction potential of a given strategy is critical to long range planning and programmatic investment. Over the past several years, the U.S. Environmental Protection Agency (EPA) has supported air quality and transportation planning activities by developing the Travel Efficiency Assessment Method (TEAM) to quantify the potential emission reduction benefits of travel efficiency strategies, and has worked with various state and local agencies to apply TEAM in a series of case studies.[1]

The term "travel efficiency" (TE) strategies refers to a broad range of strategies designed to reduce travel activity, especially single-occupancy travel. TE strategies build on the traditional Transportation Control Measures (TCMs) listed in Section 108(f)(1)(A) of the Clean Air Act such as employer-based transportation management programs and transit improvements by adding smart growth and related land use strategies, road and parking pricing, and other strategies aimed at reducing mobile source emissions by reducing vehicle travel activity. Over the years, these types of strategies have been promoted by non-governmental organizations, academics, and a variety of government agencies at the local, state, and federal level.

EPA developed TEAM, an approach to quantify the potential emission benefits of travel efficiency strategies without having to run an area's travel demand model, saving time and resources. TEAM uses available travel data and a transportation sketch model analysis to quantify the change in vehicle miles travelled (VMT) resulting from TE strategies. In a TEAM analysis, a future analysis year is chosen. VMT and emissions are estimated in the future "Business as Usual" (BAU) case that does not include the TE strategies. Then VMT and emissions estimated in future TE strategy scenarios are compared against the BAU case. Emission factors are developed using the current version of EPA's MOVES model (the Motor Vehicle Emission Simulator, EPA's emissions model for both onroad and nonroad mobile sources). The focus of a TEAM analysis is the effect of a strategy primarily on personal passenger vehicles. Therefore, VMT and emissions impacts are estimated for personal passenger vehicles only (i.e., passenger cars, passenger trucks, and motorcycles). Furthermore, potential increases in transit VMT and emissions resulting from transit strategies are not accounted for in the VMT and emission results for this case study.

This document details the TEAM analysis conducted in partnership with the Capital Area Council of Governments (CAPCOG).[2] CAPCOG represents a ten-county region in and around Austin, Texas. This region is home to the Austin-Round Rock-Georgetown Metropolitan Statistical Area (MSA), which is the fastest-growing large metropolitan area in the country.[3] The geographic focus of the analysis, depicted

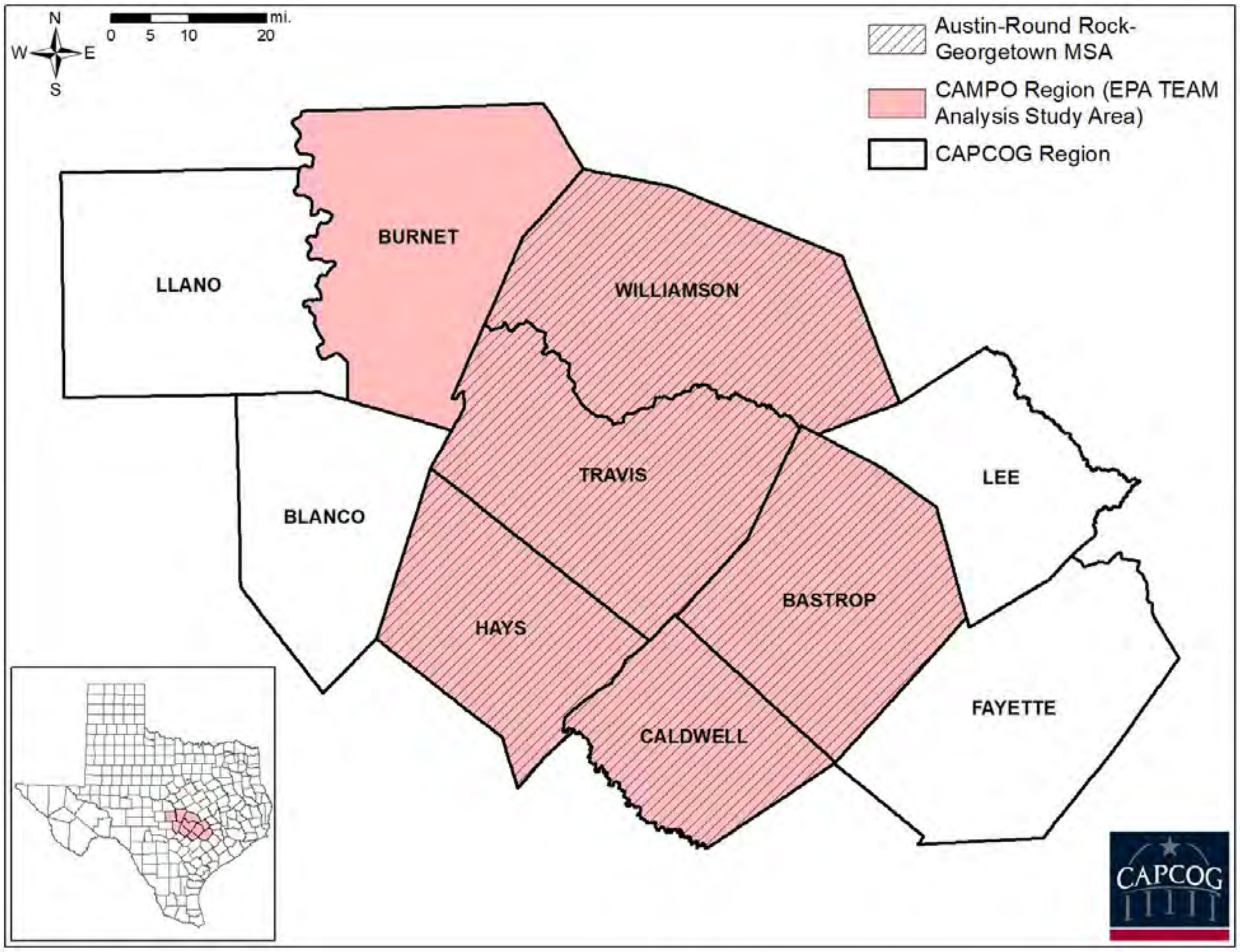
[1] More information on EPA's Travel Efficiency Assessment Method, including past case studies, can be found at www.epa.gov/state-and-local-transportation/estimating-emission-reductions-travel-efficiency-strategies.

[2] More information on the Capital Area Council of Governments can be found at www.capcog.org/.

[3] Keemahill, Dan, and Mary Huber. "Austin Region Fastest-Growing Large Metro in the Nation 8 Years Running, Data Shows." *Statesman*, Austin American-Statesman, 18 Apr. 2019, www.statesman.com/news/20190418/austin-region-fastest-growing-large-metro-in-nation-8-years-running-data-shows.

in the figure below, includes the five-County Austin-Round Rock-Georgetown MSA that includes Bastrop, Caldwell, Hays, Travis, and Williamson Counties, as well as Burnet County.

Figure 1: CAPCOG TEAM Analysis Geographic Scope



Worsening traffic congestion is anticipated due to regional population growth, which is projected to reach 4 million people by 2040. The most recent long-range transportation plan (LRTP) adopted by the Capital Area Metropolitan Planning Organization (CAMPO) anticipates a 118% growth in VMT between 2010 and 2040, but only a 21% increase in road capacity.[4] Austin is currently designated "attainment" for all national ambient air quality standards (NAAQS).[5] However, fast regional growth and increased demand for travel has the potential to degrade Austin's air quality, thus prompting CAPCOG's interest in conducting a TEAM analysis.

CAPCOG initially partnered with a large group of area stakeholders to discuss strategy selection and data collection, including the Capital Metropolitan Transportation Authority (CapMetro), the Capital Area Rural Transit System (CARTS), the Central Texas Regional Mobility Authority (CTRMA), City of Austin,

[4] CAMPO 2040 Regional Transportation Plan, Table 7: Supply and Demand on Regional Roadways: https://47kzwj6dn1447gy9z7do16an-wpengine.netdna-ssl.com/wp-content/uploads/2018/03/CAMPO2040PlanFinal.pdf

[5] *Central Texas Air Pollution Levels Compared to National Standards*, Capital Area Council of Governments, http://aircentraltexas.org/en/regional-air-quality/how-is-the-air-in-central-texas.

Travis County, Capital Metropolitan Planning Organization (CAMPO), and the Federal Highway Administration (FHWA). CapMetro is the primary transit provider for the Austin Urbanized Area. The strategies evaluated in this analysis are the result of this stakeholder engagement.

2 TEAM Analysis Tools

A TEAM analysis is performed to determine the potential VMT and emissions reductions of various strategies. The VMT component of the analysis in TEAM uses the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) sketch model developed by the Center for Urban Transportation Research (CUTR) at the University of South Florida.[6] TRIMMS relies on a number of user-supplied parameters, or default parameters if user-supplied inputs are not available, to describe the regional travel and transportation patterns. The parameters include:

- Mode Share - the percentage of travelers using a type (mode) of transportation.
- Average Vehicle Occupancy by Mode – the average number of people in each vehicle type.
- Average Trip Length – the average one-way trip length by mode of transportation.
- Demographic and Employment Characteristics – area-wide population and employment information.

At the core of TRIMMS is the capability to estimate mode share changes through scenario analysis. Scenario analysis in TRIMMS estimates impacts on travel patterns from adjusting the direct influences of travel demand, namely trip cost, trip time, etc. Some data inputs need pre-processing before use in TRIMMS. Pre-processing steps are described within the individual scenario discussions below. This analysis was conducted with TRIMMS 4.0, the latest version of this sketch model available at the time the case studies were undertaken.

A key user-supplied TRIMMS input for scenario analysis is the “commuters affected” value. The commuters affected value represents the population affected by the policy or scenario under consideration. A policy or scenario may affect the entire regional resident population or have a more specific impact on a population subset, such as the employees of a certain industry or residents within a defined project radius. While there is some subjectivity when specifying the commuters affected value, it should comprehensively capture the VMT impacts of a given policy or scenario. The commuters affected value is stated in the narratives for each of the scenarios evaluated in this analysis.

The emissions component of the analysis in TEAM uses MOVES2014a to determine regional average emission rates for the study area. MOVES is EPA’s state-of-the-science emissions modeling system that estimates emissions for mobile source at the national, county, and project level for criteria pollutants, greenhouse gases, and air toxics.[7] MOVES was run in Inventory mode using inputs provided by CAPCOG to produce activity-weighted composite light-duty emission rates for each pollutant evaluated in this analysis. This process is described further in the Emissions Analysis section of this document. The pollutants evaluated in this analysis include:

- CO_2-equivalent (CO_2e);
- nitrogen oxides (NO_X);
- fine particulate matter ($PM_{2.5}$); and
- volatile organic compounds (VOCs).

[6]The TRIMMS model and supporting documentation can be found at http://trimms.com/.
[7]For more information on EPA’s MOVES model, visit https://www.epa.gov/moves.

3 Scenario Analysis

In a TEAM analysis, data is collected to represent conditions at a defined baseline year and a BAU future year. BAU conditions are based on the CAMPO 2040 Plan, the current long-range regional transportation plan.[8] VMT and emissions are estimated in the future year BAU case. Then, future-year TE strategies are selected for evaluation, and VMT and emissions are estimated in future TE strategy scenarios. These estimates are compared against the BAU case. In addition to providing the baseline and BAU data, CAPCOG selected the following four TE strategy scenarios for evaluation:

Table 1: CAPCOG TE Strategy Scenario Overview

Scenario	Description
Scenario 1: Improved Transit Frequency and Travel Times on Key Corridor	A hypothetical high-frequency transit service along a major North/South corridor loosely based on the Orange Line route highlighted in Project Connect, CapMetro's long-term service vision. This transit service is expected to improve transit travel times and access times for residents and commuters within the corridor
Scenario 2: Region-wide Transit Frequency Improvements	Region-wide transit frequency improvements that reduce transit access and travel times, loosely based on what could be expected from implementation of CapMetro's Project Connect Vision Plan
Scenario 3: Public Sector Worker Transit Subsidy	Full transit fare subsidies for public sector workers.
Scenario 4: Region-wide VMT Pricing	A hypothetical state VMT fee at a level needed to bring all modes up to a "state of good repair" beyond existing revenue (see discussion below in Section 3.6).

The following sections cover the analysis' baseline, BAU, and TE strategy scenarios in greater detail including the primary TEAM analysis inputs.

3.1 Baseline and BAU Details

The data below defines the regional 2010 baseline and regional 2040 BAU modeling parameters used as the basis for the VMT portion of the analysis. The parameters in Table 2 below were supplied by CAPCOG unless otherwise noted.

[8] https://www.campotexas.org/regional-transportation-plans/2040-plan/.

Table 2: Baseline and BAU Regional Parameters

Parameter Description	2010 Baseline	2040 BAU
Regional population	1,759,024	4,120,322
Regional employment	774,786	2,324,770
Mode share:		
Auto, drive alone	48.75%	48.75%
Auto, rideshare	42.76%	42.76%
Transit	4.48%	4.48%
Vanpool	0.02%	0.02%
Bike	0.56%	0.56%
Walk	2.46%	2.46%
Other[a]	0.98%	0.98%
Average vehicle occupancy:		
Auto, drive alone	1.00	1.00
Auto, rideshare	2.19	2.18
Vanpool	4.59	4.69
Public Transport	8.49	8.60
Other[a]	1.67	1.67
Average vehicle trip lengths (miles):		
Auto, drive alone[b]	11.07	11.07
Auto, rideshare[b]	13.26	13.26
Transit[b]	13.26	13.26
Vanpool[b]	4.59	4.59
Bike[b]	1.48	1.48
Walk[b]	0.68	0.68

[a] This value reflects adjustments needed to make mode share sum to 100%.

[b] Denotes TRIMMS default

3.2 Scenario 1: Improved Transit Frequency and Travel Times on Key Corridor

This scenario assumes the implementation of a high-frequency transit service along a major North/South corridor similar to the Orange Line in Project Connect, CapMetro's long-term service vision.[9] This scenario would improve transit travel times and access times for residents and commuters within the corridor. Generally, transit strategies evaluated in TEAM are applied to the population within ½ mile of transit stops, for whom travel choices are assumed to be influenced by the service improvements. The affected population of 523,371 was determined through a spatial mapping of traffic analysis zones (TAZs) along the corridor. The analysis inputs in Table 3 were supplied by CAPCOG unless otherwise noted.

Table 3: Scenario 1 Improved Transit Frequency and Travel Times on Key Corridor Analysis Inputs

	BAU	Scenario
Affected population (2040)	523,371	
Public Transport – Access Time (min)	26.11	10.00
Public Transport – Travel Time (min)	28.66	13.70

[9] The proposed Orange Line route as of 11/13/19 is available at: https://capmetro.org/uploadedFiles/New2016/ProjectConnect_Vision/Maps/Project-Connect-Vision-Plan-Map.pdf

3.3 Scenario 2: Region-wide Transit Frequency Improvements

This scenario includes broader transit improvements at the region-wide level. This strategy assumes a doubling in the region-wide public transport service frequency and a five-minute decrease in region-wide average travel time, with no change in trip length. The full regional 2040 population was used to represent the affected population. The analysis inputs in Table 4 were supplied by CAPCOG unless otherwise noted.

Table 4: Scenario 2 Region-wide Transit Frequency Improvements Analysis Inputs

	BAU	Scenario
Affected population (2040)	4,120,322	
Public Transport – Access Time (min)	38.16	19.08
Public Transport – Travel Time (min)	28.66	23.66

3.4 Scenario 3: Public Sector Worker Transit Subsidy

Transit subsidies are a common way to encourage commuters to ride transit. As the capital of Texas and home to several federal offices, the Austin region is home to a significant number of public sector workers beyond the already-large number of local government employees, all of whom generate trips within the region. Many of the local governments and state or federal agencies where these workers are employed participate directly in the region's air quality planning efforts or otherwise play a supporting role. Government entities can also directly influence commuting behavior for their own employees in ways they might not be able to for private sector employees. Therefore, CAPCOG targeted public sector employee commuting incentives as a possible strategy to reduce regional travel demand. For this scenario, CAPCOG wanted to evaluate the effect of a full fare subsidy such that individual public sector workers could use transit at no cost. The BAU public transport trip cost, $0.77, was assumed to be the average fare paid across all trips provided and not necessarily the posted fare rate. This value was calculated from the total fare revenue divided by the total number of unlinked trips. The affected population provided by CAPCOG for this strategy is 398,107. This figure is calculated from a ratio of public sector workers, from the sum of Local, State, and Federal government worker classes in the 2008-2012 American Community Survey, to all workers within the region (approximately 17.12%) applied to the CAMPO 2040 regional total jobs estimate (i.e., the 2040 BAU regional employment).[10] Table 5 provides the analysis inputs for Scenario 3.

Table 5: Scenario 3 Public Sector Worker Transit Subsidy Analysis Inputs

	BAU	Scenario
Affected population (2040)	398,107	
Public Transport – Trip Cost ($)	0.77	0.00

3.5 Scenario 4: Region-wide VMT Pricing

VMT pricing is a strategy to levy a distance-based fee on vehicle use. This kind of program is expected to reduce single occupancy vehicle travel and encourage commuters to use other forms of transportation, including public transit, carpool, or vanpool where costs are spread across multiple riders. In recent years, states have increasingly been considering alternative sources of revenue to make up shortfalls in funds available to support their transportation plans. CAPCOG noted discussion in the Texas State

[10] United States Census Bureau. "Summary File." 2008 – 2012 American Community Survey. U.S. Census Bureau's American Community Survey Office, 2018. Web. 1 November 2019. www.census.gov/programs-surveys/acs/data/summary-file.html.

Legislature about the potential need to collect transportation funding from alternate mechanisms than fuel taxes due to increased fuel efficiency and the increasing market penetration of electric vehicles (EVs). CAPCOG also noted that the Texas Department of Transportation's (TxDOT's) long-range plan identified $15.5 billion per year in additional statewide funding that would be needed to bring all modes of transportation up to a "state of good repair."[11] By considering a pricing strategy, the analysis can inform local transportation planners and state leaders about the VMT and emissions impacts of shifting to VMT pricing to compliment gas tax revenue. An analysis of VMT pricing is also useful to the region for understanding the impacts of tolled versus untolled roadway capacity projects, which have been a hot topic within the region and across the state.

Consideration of a specific price to apply for this strategy was challenging without any previous discussion on what might be reasonable in the region. Options considered were:

1. Fuel Tax Replacement: A price equivalent to the revenue collected from the fuels tax for FY 2018; considering $3,674,997,000 in motor fuels tax revenue and 97,234,128,089 VMT in FY 2018. This price would be $0.0186 per mile. This would offer a substitute for EVs not paying fuel tax, but for most people in the area, driving behavior is already impacted by paying the gas tax.
2. State of Good Repair: The extra revenue needed to achieve TxDOT goals: an extra $15.5 billion (2014 dollars) was identified as needed for "state of good repair" for all modes beyond 2014 revenue of $5.5 billion. The funding gap was updated to 2019 dollars for a total of $16.7 billion using the Bureau of Labor Statistics' Consumer Price Index calculator. Comparing this amount to FY 2018 VMT, this price would be $0.0846 per mile and represent revenue not currently included in the TxDOT budget.[12]
3. Comparable VMT Fees: Other options included comparison to previous TEAM analyses, using the highest or the lowest price per VMT.

CAPCOG selected the second option described above for the TEAM analysis. Pricing was applied to the full anticipated regional population in 2040 of 4,120,322. TRIMMS uses the change in costs between the BAU and scenario as the basis for the calculation of the change in VMT. The current cost for the affected modes, auto-drive alone and auto-rideshare, was input as zero to reflect the absence of VMT pricing in the BAU scenario. Note, for the purposes of this analysis, the VMT fee was only applied to light-duty vehicle travel from passenger cars, passenger trucks, and motorcycles (i.e., MOVES sourcetypes 11, 21, 31). VMT from commercial vehicles was outside the scope of the analysis. Additionally, for this analysis, services such as vanpool and public transit were assumed to not be subject to the VMT fee. The new trip costs input reflects the new marginal costs associated with the VMT fee for the given mode. The new costs were derived by multiplying the VMT price of $0.0846/mile by the 2 times the "average one-way trip length" values by mode. Table 6 provides the components of the trip cost calculation.

Table 6: Scenario 4 Trip Costs Calculations

Mode	VMT Price ($/mi) (A)	One-way trip Length (mi) (B)	New Trip Cost ($) = (A x (B x 2))
Auto-Drive Alone	$0.0846	11.07[1]	$1.87
Auto-Rideshare	$0.0846	13.26[1]	$2.24
[1]Denotes TRIMMS default			

[11] Texas Department of Transportation "Texas Transportation Plan 2040 – Executive Summary" Exhibit ES-4 available at: http://ftp.dot.state.tx.us/pub/txdot-info/tpp/2040/plan/exec-summary.pdf.

[12] Texas Department of Transportation "Texas Transportation Plan 2040 – Executive Summary" available at: http://ftp.dot.state.tx.us/pub/txdot-info/tpp/2040/plan/exec-summary.pdf.

Table 7 provides the analysis inputs for Scenario 4.

Table 7: Scenario 4 Region-wide VMT Pricing Analysis Inputs

	BAU	Scenario
Commuters Affected (2040)	4,120,322	
Auto-Drive Alone – Trip Cost ($)	0.00	1.87
Auto-Rideshare – Trip Cost ($)	0.00	2.24

4 Scenario VMT and Emissions Analysis Results

TEAM results combine VMT analysis from TRIMMS with the emission rates derived from MOVES. Results can be contextualized both in terms of reduction within the affected scenario geography, or population, and in terms of the reduction in VMT on a regional basis. Contextualizing the results in these two ways avoids the possibility of misrepresenting a strategy that may be highly effective within the geographic scale in which they are implemented but has a smaller regional impact. For example, transit service improvements can be effective and could significantly affect VMT in a corridor or other sub-geography of a region, however, without additional public investment, may only impact a small sub-population of the entire region. Conversely, if public transit was available everywhere across a region, these strategies could be more competitive with the driving (auto-drive alone and auto-rideshare) mode shares.

In TEAM, the focus of the analysis is the effect of a strategy on passenger vehicle travel activity. For the VMT analysis, this activity is captured as the Auto-Drive Alone and Auto-Rideshare modes in TRIMMS. For the MOVES emissions analysis, this activity is represented by the passenger car, passenger truck, and motorcycle source types. Potential increases in transit VMT and emission resulting from mode shift to transit are not accounted for in the VMT and emission results presented below. For transit service improvement strategies based on reduced wait and trip times (Scenarios 1 and 2), headway and trip time reductions are assumed to be achieved by increasing the number of buses and thus route-miles traveled in a given route. For example, halving the headway would require doubling the buses running that route. Additional transit vehicle type, fuel type, and operational details of the transit frequency improvement strategies are needed to assess the transit VMT and emission impacts of these strategies and is beyond the scope of this analysis.

4.1 VMT Analysis

TRIMMS runs were used to determine the changes in light-duty VMT (Auto-Drive Alone and Auto-Rideshare) for each scenario. The VMT analysis results are provided both in terms of the percent change in VMT reduction within the affected scenario geography, or population, and in terms of the percent change in regional VMT. As noted above, contextualizing the results this way allows the reader to see the direct effect of a strategy on the affected scenario geography or population and the effect on the region as a whole. Table 8, below, provides the scenario total reduction in daily light-duty VMT, and the percent changes in light-duty VMT at the affected geography or population level and at the regional level compared to the 2040 Regional BAU.

Table 8: Changes in VMT by Scenario Within Affected Geography/Population and at Regional Scale

Scenario	*Affected Geography or Population*	Reduction in Light-Duty VMT (mi)	Percent Change in Light-Duty VMT within Affected Geography or Population	Percent Change in Light-Duty VMT within Region
Scenario 1: Improved Transit Frequency and Travel Times on Key Corridor	Population within ½ mile of transit stop along corridor	-56,671	-0.76%	-0.10%
Scenario 2: Region-wide Transit Frequency Improvements	Region-wide population	-233,425	-0.40%	-0.40%
Scenario 3: Public Sector Worker Transit Subsidy	Public sector workers	-587,977	-10.42%	-1.01%
Scenario 4: Region-wide VMT Pricing	Region-wide VMT	-2,443,044	-4.18%	-4.18%

4.2 Emissions Analysis

In TEAM, the MOVES analysis is focused on generating activity-weighted, regional average emission factors to represent the general conditions of the study region. Fuel efficiency and emission standards are assumed to improve for vehicles over time consistent with assumptions in MOVES, thus emission rates are lower in future years. Data used for this analysis was adapted from a Texas Commission on Environmental Quality file transfer protocol site supplied by CAPCOG.[13] EPA compiled MOVES input databases for Bastrop, Burnet, Caldwell, Hays, Travis, and Williamson counties for both the 2010 baseline year and 2040 BAU analysis year. Activity-weighted emission factors were generated developed by summing total emissions, by pollutant and associated process, and dividing by the appropriate activity value, whether starts or VMT for the light-duty vehicles included in the analysis (by passenger cars, and passenger trucks, and motorcycles source types). Activity-weighted emission factors were generated by summing total emissions, by pollutant and associated process, and dividing by the appropriate activity value, whether starts or VMT for the light-duty vehicles included in the analysis (passenger car, and passenger truck, and motorcycle source types). Table 9 provides the activity-weighted emission factors generated for the entire 6-county analysis region by activity type and analysis year for light-duty vehicles.

Table 9: CAPGOG Emission Factors by Process and Analysis Year for Light-Duty Vehicles

Pollutant	Emissions per mile (g/mi)		Emissions per start (g/start)	
	Base Year (2010)	Future Year (2040)	Base Year (2010)	Future Year (2040)
CO_2e	459.75	218.47	97.49	55.47
NO_x	0.85	0.02	1.64	0.12
$PM_{2.5}$	0.01	0.01	0.01	0.004
VOCs	0.27	0.01	2.30	0.16

[13] Texas Commission on Environmental Quality FTP site available at ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/.

MOVES emission factors for 2040 were combined with scenario-level light-duty VMT changes for 2040 to estimate emissions reductions for both the scenario affected geography, or population, and at the regional level. Table 10, below, provides the daily VMT reductions, in miles, and emission reductions, in kilograms, by scenario.

Table 10: Daily VMT (mi) and Emission (kg) Reductions by Scenario Compared to the 2040 BAU

Scenario	Light-Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Improved Transit Frequency and Travel Times on Key Corridor	-56,671	-12,672	-1.90	-0.37	-1.14
Scenario 2: Region-wide Transit Frequency Improvements	-233,425	-52,197	-7.81	-1.52	-4.69
Scenario 3: Public Sector Worker Transit Subsidy	-587,977	-132,398	-21.64	-3.90	-14.42
Scenario 4: Region-wide VMT Pricing	-2,443,044	-552,762	-95.53	-16.38	-67.42

Table 11, below, provides the percent changes compared to the 2040 BAU in light-duty VMT and by pollutant for each scenario for the affected geography, or population, of the scenario. Note, pollutant percent changes generally track closely with VMT percent changes.

Table 11: Affected Scenario Geography or Population Percent Changes in Emissions for the 2040 Scenario Compared to the 2040 BAU

Scenario	Light-Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Improved Transit Frequency and Travel Times on Key Corridor	-0.76%	0.76%	0.68%	0.75%	0.59%
Scenario 2: Region-wide Transit Frequency Improvements	-0.40%	0.40%	0.35%	0.39%	0.31%
Scenario 3: Public Sector Worker Transit Subsidy	-10.42%	10.40%	10.15%	10.37%	9.89%
Scenario 4: Region-wide VMT Pricing	-4.18%	4.19%	4.33%	4.21%	4.47%

Table 12, below, provides the regional percent changes compared to the 2040 BAU in light-duty VMT by pollutant for each scenario. Note, pollutant percent changes generally track closely with VMT percent changes.

Table 12: Regionally Normalized Percent Changes in Emissions for the 2040 Scenario Compared to the 2040 BAU

Scenario	Light-Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Improved Transit Frequency and Travel Times on Key Corridor	-0.10%	-0.10%	-0.09%	-0.09%	-0.08%
Scenario 2: Region-wide Transit Frequency Improvements	-0.40%	-0.40%	-0.35%	-0.39%	-0.31%
Scenario 3: Public Sector Worker Transit Subsidy	-1.01%	-1.00%	-0.98%	-1.00%	-0.96%
Scenario 4: Region-wide VMT Pricing	-4.18%	-4.19%	-4.33%	-4.21%	-4.47%

4.3 Discussion of Results

Among the scenarios selected, *Scenario 4: Region-wide VMT* pricing is the most effective strategy for VMT reduction at the regional level. This strategy may be increasingly important as states grapple with transportation funding shortfalls and as vehicle fleets shift to alternative fuel sources, such as electricity, that do not contribute towards fuel tax revenues. However, transit service improvements or subsidies can be effective and could significantly affect VMT in a corridor or other geography or population of a region. *Scenario 3: Public Sector Worker Transit Subsidy* had the single largest impact on VMT and emissions within the affected geography or population.