City of San Dimas Transportation Study Guidelines for Vehicle Miles Traveled and Level of Service Assessment

May 2021

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Introduction

These guidelines describe the transportation analysis requirements for land development, roadway projects, and specific plans in the City of San Dimas. Guidelines are provided for evaluating a project's environmental transportation impacts and effects on the local transportation system.

The purpose of these guidelines is to provide guidance on how to prepare transportation studies in the City in conformance with all applicable City and State regulations.

Background Information

SB 743, signed by the Governor in 2013, has changed the way transportation impacts are identified. Specifically, the legislation directed the Office of Planning and Research (OPR) to look at different metrics for identifying transportation impacts under the California Environmental Quality Act (CEQA). The Final OPR guidelines were released in December 2018 and identified Vehicle Miles Traveled (VMT) as the preferred metric moving forward. The Natural Resources Agency completed the rule making process to modify the CEQA guidelines in December of 2018. The CEQA Guidelines identify that, by July of 2020 all lead agencies must use VMT as the new transportation metric for identifying transportation impacts for land use and transportation projects.

In anticipation of the change to VMT, the San Gabriel Valley Council of Governments (SGVCOG) undertook the SGVCOG SB 743 Implementation Study to assist with answering important implementation questions about the methodology, thresholds, and mitigation approaches for VMT impact analysis in its member agencies. The study includes the following main components.

- Analysis Methodologies Memorandum – Identification of potential thresholds that can be considered when establishing thresholds of significance for VMT assessment and recommendations of analysis methodologies for VMT impact screening and analysis
- Mitigation Memorandum – Types of mitigation that can be considered for VMT mitigation
- VMT Assessment Tool – A web-based tool that can be used for VMT screening and mitigation recommendation

The City of San Dimas utilized the information produced through the Implementation Study to adopt a methodology and significance thresholds for use in CEQA compliance. As noted in CEQA Guidelines Section 15064.7(b) below, lead agencies are encouraged to formally adopt their significance thresholds and this is a key part of the SB 743 implementation process.

> *(b) Each public agency is encouraged to develop and publish thresholds of significance that the agency uses in the determination of the significance of environmental effects. Thresholds of significance to be adopted for general use as part of the lead agency's environmental review process must be adopted by ordinance, resolution, rule, or regulation, and developed through a public review process and be supported by substantial evidence. Lead agencies may also use thresholds on a case-by-case basis as provided in Section 15064(b)(2).*

The City has produced these Transportation Study (TS) Guidelines to outline the specific steps for complying with the new CEQA expectations for VMT analysis and the applicable general plan consistency requirements related to Level of Service (LOS).

It should be noted that CEQA requirements may change as the CEQA Guidelines are periodically updated and/or legal opinions are rendered that change how analysis is completed. As such, the City will continually review their guidelines for applicability and consultants should contact the City to ensure that they are applying the City's most recent guidelines for project impact assessment.

CEQA Changes

A key element of SB 743 is the elimination of auto delay, LOS, and other similar measures of vehicular capacity or traffic congestion as a basis for determining significant environmental impacts. This change is intended to assist in balancing the needs of congestion management with statewide goals related to infill development, promotion of public health through active transportation, and reduction of greenhouse gas emissions.

SB 743 includes amendments to current congestion management law that allows cities and counties to effectively opt-out of the LOS standards that would otherwise apply in areas where Congestion Management Plans (CMPs) are still used. Further, SB 743 required OPR to update the CEQA Guidelines and establish criteria for determining the significance of transportation impacts. In December 2018, OPR released their final recommended guidelines based on feedback from the public, public agencies, and various organizations and individuals. OPR recommended VMT as the most appropriate measure of project transportation impacts for land use projects and land use plans. For transportation projects, lead agencies may select their own preferred metric but must support their decision with substantial evidence that complies with CEQA expectations. SB 743 does not prevent a city or county from continuing to analyze delay or LOS outside of CEQA review for other transportation planning or analysis purposes (i.e., general plans, impact fee programs, corridor studies, congestion mitigation, or ongoing network monitoring).

Level of Service Policy

The City has vehicle LOS standards for which local infrastructure will strive to maintain. The LOS standards apply to discretionary approvals of new land use and transportation projects. Therefore, these TS guidelines also include instructions for vehicle LOS analysis consistent with City requirements.

Transportation Impact Analysis Guidelines

State and Federal laws require the correlation of Land Use Element building intensities in a General Plan with the Circulation Element capacity. A TS is required by the City so that the impact of land use proposals on the existing and future circulation system can be adequately assessed and to ensure that the CEQA laws and guidelines are met.

The following TS Guidelines identify CEQA based requirements and non-CEQA based requirements intended for any person or entity who is proposing development in the City and should be used in coordination with the City's Local CEQA Guidelines and Municipal Code to guide the development review process.

For the past several decades, the preparation of a TS was integrated into the CEQA process, in which the TS was used primarily to analyze a project's impacts using intersection and/or roadway segment LOS. However, with the passage of SB 743, changes to the TS process are necessary. Specifically, a TS may be needed as a stand-alone document which is a requirement of project approval and will include information for the decision makers that is not required as part of the CEQA process.

The purpose of these TS guidelines is to provide general instructions for analyzing the potential transportation impacts of proposed development projects. These guidelines present the recommended format and methodology that should generally be utilized in the preparation of a TS.

Application of Guidelines

An applicant seeking project approval will submit the proposed project to the City with a planning and land use application. After a preliminary review of the project by City Staff, the applicant will be notified by the project planner as to whether or not a TS is required. The TS should consider changes in both Level of Service (LOS) and VMT.

A TS which includes LOS analysis shall be required for a proposed project when either the AM or PM peak hour trip generation from the proposed development is expected to exceed 50 total trips. (A *traffic study may be required for smaller projects based on land use and location per City's discretion.)*

Furthermore, all TS's must include a VMT assessment that explains either why the project screens out or provides a full VMT impact analysis. A proposed project may screen out of full VMT analysis if it meets one or more of the following project screening criteria:

- Transit Priority Areas Screening
- Low VMT-generating Areas Screening
- Project Type Screening

See Section, "CEQA Assessment - VMT Analysis" for details on the screening criteria.

Projects may be screened from VMT analysis and require level-of-service analysis, or vice-versa. In cases where insufficient information is available to make a preliminary assessment of a proposal's effect on traffic, the City Traffic Engineer shall determine, at his or her discretion, whether a TS will be required.

Guidelines Organization

The remainder of this document is organized to provide guidance on assessment for General Plan Consistency (e.g. Non-CEQA LOS analysis) and CEQA compliance (e.g. VMT analysis), as well as the format for the transportation study.

Transportation Study	
Non-CEQA Transportation Assessment	**CEQA Transportation Assessment**
LOS Analysis	VMT Analysis Active Transportation and Public Transit Analysis

Non-CEQA Transportation Assessment

Level of Service Analysis Procedure

Traffic analysis should be prepared under the direction and/or by a registered traffic engineer, registered civil engineer, or qualified transportation planner. To establish a mutually agreeable scope of work for the traffic analysis, the analyst and project applicant shall meet with Planning Department staff and Public Works staff to identify study area, assumptions, and methodologies of the traffic analysis. All assumptions and methodologies of the LOS analysis are subject to review and approval of the City Traffic Engineer.

An LOS analysis shall be required for a proposed project that meets any of the following criteria:

- Any project where variations from the standards and guidelines provided in this manual are being proposed;
- Either the AM or PM peak hour trip generation is expected to exceed 50 net[1] new vehicle trips; or,
- The combination of the land use and the location justify analysis per the City's discretion even if the net new trips does not meet the threshold above.

When determined by the Director of Public Works that existing or proposed traffic conditions in the project vicinity warrant evaluation

Traffic Counts

The traffic analysis should not use any traffic counts that are more than two (2) years old without approval of the City Traffic Engineer. If traffic counts taken within the last two (2) years are not available, then new traffic counts shall be collected by a qualified data collection firm. Turning movement data at the study intersections should be collected in 15-minute intervals during the hours of 7:00 AM to 9:00 AM. and 4:00 PM to 6:00 PM, unless the City Traffic Engineer specifies other hours (e.g., for a signal warrant determination or weekend analysis). Unless otherwise required, all traffic counts should generally be conducted when local schools or colleges are in session, on days of good weather, on Tuesdays through Thursdays during non-Summer months, and should avoid being taken on weeks with a holiday.

Trip Generation

The City will accept the trip generation rate of the latest edition of the Trip Generation Manual published by the Institute of Transportation Engineers (ITE). In addition, analysis for a proposed project with trip generation rates not provided in the ITE Trip Generation Manual, may use rates

[1] Net new trips include total in and out trips from the project site less trips attributed to the existing use.

from other agencies or locally approved studies for specific land uses. Documentation supporting the use of these trip generation rates will be required.

The traffic analysis should include justification for trip generation credits such as existing uses, transit, and internal capture. The pass-by traffic credit should be calculated based upon the Institute of Transportation Engineers Trip Generation Manual data or city approved special studies.

Trip Distribution and Assignment

Description of trip distribution and assignment for vehicle trips to and from the site along specific roadways that will be utilized by project generated traffic is required. The basic methodology and assumptions used to develop trip distribution and assignments must be clearly stated and approved by the City Traffic Engineer. The basis for trip distribution should be linked to the demographic or market data in the area and should consider the project's location relative to the regional roadway system.

The trip assignment for the project should be based on existing and projected travel patterns and the future roadway network and its travel time characteristics. The trip assignment should incorporate the trip generation of the project minus the appropriate credits.

Traffic Forecasts

The traffic analysis should include the total traffic which is expected to occur at buildout of the proposed project. This means that the analyst preparing the traffic study should also include all the cumulative effects of proposed projects based on information about future development and related projects provided by the City of San Dimas Planning Department and other surrounding agencies. The latest version of the Southern California Association of Governments (SCAG) Travel Demand Model or appropriate sub-area travel demand model should be used to generate future year forecasts. The City is in the process of updating the City's General Plan which will address future traffic projections and developmental buildout within the City. Until the City's General Plan has been updated, future buildout traffic forecasts should be developed utilizing growth rates per the prior Los Angeles County Congestion Management Program (CMP), the Southern California Association of Governments (SCAG) Travel Demand Model, or another appropriate sub-area travel demand model to generate future year forecasts. The future traffic projection methodology will need to be approved by the Director of Public Works.

Analysis Methodologies

The City utilizes the latest version of the Highway Capacity Manual (HCM) methodology to evaluate the AM and PM peak hour Level-of-Service (LOS) at both signalized intersections and unsignalized intersections. The HCM methodology is based on vehicular delay. The service levels range from LOS A (free flow conditions) to LOS F (heavy congestion). The peak hour will be identified as the highest one-hour period in both AM and PM counted periods, as determined by four consecutive 15-

minute count intervals. The following parameters should be used in determining the LOS at the intersections within the City.

HCM Methodology

Traffic Count Peak Hour Factor:

- A peak hour factor (PHF) based on observed conditions shall be used for the under existing conditions.
- A PHF of 0.95 shall be used for future conditions.

Signalized Intersections

- A peak hour factor (PHF) based on observed conditions shall be used for the under existing conditions.
- A PHF of 0.95 shall be used for future conditions.
- Cycle length and pedestrian timing parameters – existing
- Minimum left turn split time, including clearance interval timing – 10 seconds
- Saturation flow rates (unless otherwise specified by City Traffic Engineer):
    - Thru and right turns – 1,900 vehicles per hour (vph)
    - Left Turns –
        - Single Lane – 1,800 vph
        - Dual Lanes – 3,500 vph
        - Triple Lanes – 5,100 vph

Pedestrian and heavy truck activity should be considered on a case by case basis using reductions in saturation flow rates for affected lanes as determined by sound engineering judgement. The HCM is the best source of guidance for assessment of such influences on flow rates.

Programs such as Synchro, Vistro, or Highway Capacity Software (HCS) are acceptable to use for the HCM analysis. Any other program for HCM analysis will need to be first approved by the Director of Public Works.

Analysis Scenarios

The following identifies the analysis scenarios that should be evaluated for LOS analysis (at the discretion of the Director of Public Works).

- **Existing Conditions:**

  Existing traffic conditions: data must have been collected within the previous two (2) year period.

- **Opening Year:**

  Existing traffic conditions plus ambient growth and traffic from all the development within the study area for which an application has been submitted ("pending projects"), or that have been approved but not yet constructed. There may be multiple opening years if the project is proposed in phases.

- **<u>Opening Year plus Project</u>:**

  Traffic conditions of existing plus ambient growth and approved and pending developments, plus traffic generated by the proposed project.

- **<u>Horizon Year</u>:**

  Build-out of City General Plan combined with build-out of circulation system. SCAG Build-out projections should be used for this purpose. A General Plan build out analysis is generally required for any project that contributes traffic to an intersection projected to have unacceptable LOS, any project that requires a General Plan Amendment or otherwise proposes development that exceeds the land use intensity assumed for the General Plan, and/or at the discretion of the City Traffic Engineer and/or Planning Director.

- **<u>Horizon Year plus Project</u>:**

  Cumulative traffic conditions of Horizon Year plus proposed project.

OPTION 2 Language…Horizon Year is no longer required for LOS by CEQA so some cities are opting to replace the above language with the following:

- **<u>Horizon Year</u>:**

  Horizon (future buildout) traffic analysis is typically required for proposed projects that require CEQA impact analyses related to air quality, noise, or energy impacts. The City Traffic Engineer can require this scenario at their discretion. If required, this analysis will use City General Plan buildout (if an update is available) and/or other buildout of the circulation system based on City, SCAG, or other projections. Build-out of City General Plan combined with build-out of circulation system. SCAG Build-out projections should be used for this purpose. A General Plan build out analysis is generally required for any project that contributes traffic to an intersection projected to have unacceptable LOS, any project that requires a General Plan Amendment or otherwise proposes development that exceeds the land use intensity assumed for the General Plan, and/or at the discretion of the City Engineer.

Projects that are to be constructed in more than one (1) phase will require interim year future analysis to address each phase of the development and its associated traffic effects. The year(s) to be analyzed will coincide with the scheduled phasing and will be approved by the City Engineer or designee.

A table shall be included to show the forecast LOS for each intersection within the defined study area. This summary table shall present LOS for all scenarios evaluated-including improvements.

Transportation Effects

The acceptable LOS for intersections in the City is D or better as established in the City's General Plan. Any intersection operating at a LOS of E or F is considered deficient. Signalized intersections will require improvements if one of the following conditions is met:

- The addition of project traffic to an intersection results in the degradation of intersection operations from acceptable operations (LOS D or better to unacceptable operations (LOS E or F).
- Option 1: If an intersection is operating at an unacceptable LOS E or F for conditions without the project, the project will contribute their fair share of an improvement to bring back the intersection to an acceptable LOS. If a feasible identified improvement(s) cannot be provided as determined by the City Traffic Engineer, then contribution of fair share towards an improvement will be considered. An improvement for this matter can also include upgrading the traffic signal equipment/software, traffic signal communication and/or the traffic signal central system to improve the mobility of traffic in the study area. [added this last sentence since this is not a CEQA specific mitigation/improvement and if a "typical" improvement is not available, then the project should provide another improvement that could provide a benefit to improve the flow or monitoring of traffic in the study area]

OR

- Option 2: The project causes a signalized or unsignalized intersection operating at an unacceptable operating condition to further degrade and for a signalized intersection the change is:
    a) From LOS E to LOS F,
    b) An increase of at least 4 seconds for an LOS E intersection, or
    c) An increase of at least 2 seconds for an LOS F intersection.

  [May not have viable improvements: By applying an exact delay number, one can adjust the signal timing (split timing and/or cycle length) to improve the intersection delay and call it out as an improvement by the project. In order to make this an effective improvement, the corridor's coordination signal timing will need to be retimed to accommodate the change in cycle length]

Unsignalized intersections will require improvements if both of the following conditions are met:

- The addition of project traffic to an intersection results in the degradation of overall intersection operations from acceptable operations (LOS D or better) to unacceptable operations (LOS E or F), and

- The intersection meets peak hour signal warrants either caused by project volumes, or project volumes are added at an intersection that meets peak hour signal warrants in the baseline scenario(s). Peak hour signal warrants should be determined based on the latest California Manual on Uniform Traffic Control Devices (CA MUTCD). All-way stop control can also be considered based on the roadway characteristics of the unsignalized intersection.

The fair share cost for the proposed improvements in the cumulative condition should also be calculated.

On-Site Parking Analysis

This analysis will address the on-site parking supply versus parking required per City code. If the proposed development is of mixed-use type, a table shall be included presenting each land use, its size and the code parking requirement. This table should clearly indicate how the code parking was calculated and include the proposed on-site parking supply together with the resultant surplus or deficit from code requirements.

Should the on-site parking supply be less than required by the City code, a detailed explanation justifying a reduction to the code requirement must be included. Note that this does not eliminate the need for any zoning code variance. Shared parking evaluations will be considered when appropriate.

Access and Circulation Analysis

The project's effect on access points and on-site circulation shall be analyzed. The analysis shall, as appropriate, include the following:

- Number of access points proposed for the project site.
- Spacing between driveways and intersections.
- Potential signalization of driveways.
- On-site stacking distance. (Including uses with a drive thru.)
- Shared access.
- Turn conflicts/restrictions. For driveways that will involve large trucks, a truck turning template will be required.
- Adequate sight distance for both ingress and egress.
- Facility trash pickup and/or deliveries.
- Driveway improvements.
- Pedestrian connections.
- Any other operational characteristics (as identified by City staff).

CEQA Transportation Assessment - VMT Analysis

VMT Analysis Methodology

For purposes of SB 743 compliance, a VMT analysis should be conducted for land use projects as deemed necessary by the City Traffic Engineer and would apply to projects that have the potential to increase the baseline VMT per service population (e.g. population plus employment) for the City. Normalizing VMT per service population (e.g. creating a rate by dividing VMT by service population) provides a transportation efficiency metric that the analysis is based on. All assumptions and methodologies of the VMT analysis are subject to review and approval by the City Traffic Engineer.

A flowchart of the VMT analysis process is attached to these guidelines. See Attachment A, "VMT Assessment Flowchart". A web-based tool has been prepared as part of this implementation study to assist with VMT assessment screening and mitigation recommendations. A user guide for use of this tool is attached to these guidelines. See Attachment B, "SGVCOG VMT Assessment Tool Users Guide."

Project Screening

There are three types of screening that may be applied to effectively screen projects from project-level assessment. These screening steps are summarized below:

Step 1: Transit Priority Area (TPA) Screening

Projects located within a TPA[2] may be presumed to have a less than significant impact absent substantial evidence to the contrary. This presumption may ***NOT*** be appropriate if the project:

1. Has a Floor Area Ratio (FAR) of less than 0.75;
2. Includes more parking for use by residents, customers, or employees of the project than required by the City;

[2] A TPA is defined as a half mile area around an existing major transit stop or an existing stop along a high-quality transit corridor per the definitions below. Public Resources Code § 21099(a)(7)

Pub. Resources Code, § 21064.3 - 'Major transit stop' means a site containing an existing rail transit station, a ferry terminal served by either a bus or rail transit service, or the intersection of two or more major bus routes with a frequency of service interval of 15 minutes or less during the morning and afternoon peak commute periods.

Pub. Resources Code, § 21155 - For purposes of this section, a 'high-quality transit corridor' means a corridor with fixed route bus service with service intervals no longer than 15 minutes during peak commute hours.

3. Is inconsistent with the applicable Sustainable Communities Strategy (as determined by the lead agency, with input from the Southern California Association of Governments [SCAG]); or
4. Replaces affordable residential units with a smaller number of moderate- or high-income residential units.

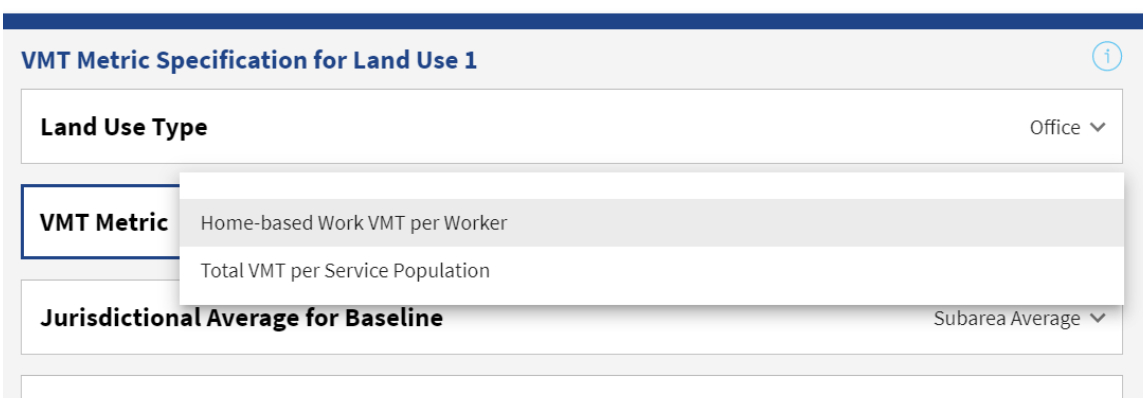
To identify if the project is in a TPA, the analyst may review the SGVCOG VMT assessment tool. Additionally, the analyst should confirm with all local transit providers that no recent changes in transit service have occurred in the project area (e.g. addition or removal of transit lines, addition or removal of transit stops, or changes to service frequency).

Step 2: Low VMT Area Screening

Residential and office projects located within a low VMT-generating area may be presumed to have a less than significant impact absent substantial evidence to the contrary. In addition, other employment-related and mixed-use land use projects may qualify for the use of screening if the project can reasonably be expected to generate VMT per resident, per worker, or per service population that is similar to the existing land uses in the low VMT area.

For this screening, the SCAG travel forecasting model was used to measure VMT performance for individual traffic analysis zones (TAZs). TAZs are geographic polygons similar to Census block groups used to represent areas of homogenous travel behavior. Total daily VMT per service population was estimated for each TAZ. This presumption may not be appropriate if the project land uses would alter the existing built environment in such a way as to increase the rate or length of vehicle trips. The project applicant should document whether or not any increase to the trip generation rate or length of vehicle trips is expected.

To identify if the project is in a low VMT-generating area, the analyst should use the SGVCOG VMT Evaluation Tool at: https://apps.fehrandpeers.com/SGVCOGVMT/. There are two VMT Metrics for each Land Use Type built into the tool as shown in the figure below:



Either one of these two options may be used to screen a single-use project (mixed use projects should be analyzed using the Boundary Method, which requires using the travel demand model rather than the Tool). To use the tool for a proposed project, the land use type must be either an existing or future land use within the Tier 1 Traffic Analysis Zone (TAZ) for Total VMT per Service Population, or within the Tier 2 TAZ for Home-based VMT per capita or Home-based Work VMT per employee. Additionally, if using the Total VMT per Service Population metric, the analyst must verify that the project is consistent with the existing land use (i.e. if the project is proposing housing, there should be existing housing within that TAZ) and use professional judgment that there is nothing unique about the project that would otherwise misrepresent utilizing the data from the travel demand model.

Step 3: Project Type Screening

Some project types have been identified as having the presumption of a less than significant impact. The following uses can be presumed to have a less than significant impact absent substantial evidence to the contrary as their uses are local serving in nature:

- Local-serving K-12 schools
- Local parks
- Daycare/Childcare/Pre-K centers
- Local-serving retail uses less than 50,000 square feet
- Community institutions (public libraries, fire stations, local government)
- Affordable, supportive, or transitional housing
- Assisted living facilities
- Senior housing (as defined by HUD)
- Student housing projects on or adjacent to a college campus
- Other local-serving uses as approved by the City Traffic Engineer
- Projects generating less than 110 daily vehicle trips[3,4]
    - This generally corresponds to the following "typical" development potentials:
        - 11 single family housing units
        - 16 multi-family, condominiums, or townhouse housing units
        - 10,000 sq. ft. of office

[3] Note that a redevelopment project replacing an existing use would estimate the net increase in trips above trips what already exists.

[4] This threshold ties directly to the OPR technical advisory and notes that CEQA provides a categorical exemption for existing facilities, including additions to existing structures of up to 10,000 square feet, so long as the project is in an area where public infrastructure is available to allow for maximum planned development and the project is not in an environmentally sensitive area. (CEQA Guidelines, § 15301, subd. (e)(2).) Typical project types for which trip generation increases relatively linearly with building footprint (i.e., general office building, single tenant office building, office park, and business park) generate or attract an additional 110-124 trips per 10,000 square feet. Therefore, absent substantial evidence otherwise, it is reasonable to conclude that the addition of 110 or fewer trips could be considered not to lead to a significant impact.

- 15,000 sq. ft. of light industrial[5]
- 63,000 sq. ft. of warehousing[3]
- 79,000 sq. ft. of high cube transload and short-term storage warehouse[3]

Local serving retail projects with a total square footage less than 50,000 square feet may be presumed to have a less than significant impact absent substantial evidence to the contrary. Local serving retail generally improves the convenience of shopping close to home and has the effect of reducing vehicle travel. Any project that uses the designation of "local-serving" should be able to demonstrate that its users (employees, customers, visitors) would be existing within the community. The project would not generate new "demand" for the project land uses but would meet the existing demand that would shorten the distance existing residents, employees, customers, or visitors would need to travel.

VMT Assessment for Non-Screened Development

Projects not screened through the steps above should complete VMT analysis and forecasting through the SCAG model or appropriate sub-area model to determine if they have a significant VMT impact. This analysis should include 'project generated VMT' for the project TAZ (or TAZs) and 'project effect on VMT' estimates under the scenarios below. Project generated VMT shall include the VMT generated by the site compared back to the CEQA threshold of significance. The project effect on VMT is the link based VMT for a geographic region which is more appropriate to review to evaluate how these developments change travel behavior in the region.

- **Baseline conditions:**

  This data is available from the SCAG model or appropriate sub-area model approved by the City Traffic Engineer. This data is also available in the SGVCOG VMT Assessment Tool. Baseline conditions typically represent the year of the Notice of Preparation (NOP). Interpolation between the base and future year model will be required to identify the VMT representative of the baseline year.

- **Baseline plus Project:**

  The project land use would be added to the project TAZ or a separate TAZ would be created to contain the project land uses. A full base year model run would be performed and VMT changes would be isolated for the project TAZ and across the full model network. The model output must include reasonableness checks of the production and attraction balancing to ensure the project effect is accurately captured. These reasonableness checks

[5] This number was estimated using rates from ITE's Trip Generation Manual. Some industrial and warehousing tenants may generate traffic differently than what is documented in ITE. In these cases, documentation of the project generating less than 110 daily trips will be required for review and approval by the City Traffic Engineer.

are subject to City Traffic Engineer's review. If this scenario results in a less-than-significant impact, then additional cumulative scenario analysis may not be required (more information about this outcome can be found in the Thresholds Evaluation discussion later in this chapter). The SGVCOG VMT assessment tool provides an estimate of the Baseline plus project conditions. This data could be presented in lieu of results from the full model run. However, it is recommended that a base year plus project run always be performed as a check for reasonableness and consistency with the cumulative year results.

- **Cumulative no Project:**

This data is available from the SCAG model or appropriate sub-area model approved by the City Traffic Engineer.

- **Cumulative plus project:**

The project land use would either be added to the project TAZ or a separate TAZ would be created to contain the project land uses. The addition of project land uses should be accompanied by a reallocation of a similar amount of land use from other TAZs; especially if the proposed project is significant in size such that it would change other future developments. Land use projects are often represented in the assumed growth of the cumulative year population and employment. It may be appropriate to remove land use growth that represents a project from the cumulative year model to represent the cumulative no project scenario. If project land uses are simply added to the cumulative no project scenario, then the analysis should reflect this limitation in the methodology and acknowledge that the analysis may overestimate the project's effect on VMT.

The model output should include total VMT, which includes all vehicle trips and trip purposes, and VMT per service population. Total VMT (by speed bin) is needed as an input for air quality, greenhouse gas (GHG), and energy impact analysis while total VMT per service population is recommended for transportation impact analysis[6].

The baseline and cumulative "plus project" scenarios noted above will summarize project generated VMT per service population and comparing it back to the appropriate benchmark noted in the thresholds of significance. The cumulative "plus project" scenario noted above will summarize the project effect on VMT, comparing how the project changes VMT on the network looking at citywide VMT per service population comparing it to the "no project" condition.

Project-generated VMT shall be extracted from the travel demand forecasting model using the origin-destination trip matrix and shall multiply that matrix by the final assignment skims. The project-effect on VMT shall be estimated using an appropriate boundary as approved by the City

[6] The City has selected VMT per service population for its impact threshold. However, the City will allow for use of VMT to be isolated by trip purpose with review and approval of the City Traffic Engineer.

Traffic Engineer and extracting the total link-level VMT for both the "no project" and "plus project" condition. The TAZ identification numbers within the study area shall be included in the report.

In some cases, it may be appropriate to extract the Project-generated VMT using the production-attraction trip matrix. This may be appropriate when a project is entirely composed of retail or office uses, and there is a need to isolate the home-based-work (HBW) VMT for the purposes of isolating commute VMT. The City Traffic Engineer will evaluate the appropriate methodology based on the project land use types and context.

A detailed description of this process is attached to these guidelines. See Attachment C, "Detailed VMT Forecasting Information".

CEQA VMT Impact Thresholds

VMT Impacts

VMT thresholds provided below are to be applied to determine potential project generated VMT impacts and project's effect on VMT impacts.

> A project would result in a significant project generated VMT impact if either of the following conditions are satisfied:
>
> 1. The baseline project generated VMT per service population exceeds the City of San Dimas baseline VMT per service population, or
> 2. The cumulative project generated VMT per service population exceeds the City of San Dimas baseline VMT per service population
>
> The project's effect on VMT would be considered significant if it resulted in the following condition being satisfied:
>
> 1. The cumulative link-level boundary Citywide VMT per service population increases under the plus project condition compared to the "no project" condition.

Please note that the cumulative "no project" shall reflect the adopted RTP/SCS; as such, if a project is consistent with the SCAG RTP/SCS, then the cumulative impacts (project effect on VMT) shall be considered less than significant subject to consideration of other substantial evidence.

VMT Mitigation Measures

The following mitigation strategies are available to reduce VMT impacts:

1. Modify the project's-built environment characteristics to reduce VMT generated by the project.

2. Implement transportation Demand Management (TDM) measures to reduce VMT generated by the project.
3. Participate in a VMT fee program and/or VMT mitigation exchange/banking program (if available) to reduce VMT from the project or other land uses to achieve acceptable levels.

As part of the Implementation Study, key TDM measures that are appropriate to the region were identified. Measures appropriate for most of the City are summarized in a table attached to these guidelines. See Attachment D, "VMT Reduction Strategies".

VMT reductions should be evaluated as part of the VMT impact analysis using state-of-the-practice methodologies recognizing that many of the TDM strategies are dependent on building tenant performance over time. As such, actual VMT reduction cannot be reliably predicted and monitoring may be necessary to gauge performance related to mitigation expectations.

When a Project is found to have a significant impact under CEQA, the City requires developers and the business community to assist in reducing peak hour and total vehicular trips by implementing Transportation Demand Management Plans (TDMs). The potential of a proposed project to reduce VMT through the use of a TDM plan should be addressed in the TS.

If a TDM plan is proposed as a mitigation measure for a project, and the TS attributes a reduction in peak and total traffic to the TDM plan, the following information must be provided:

1. A detailed description of the major components of the TDM plan and how it would be implemented and maintained on a continuing basis.
2. Case studies or empirical data that supports the anticipated reduction of traffic attributed to the TDM plan.
3. Additional Volume/Capacity ratio calculations that illustrate the circulation benefits of the TDM plan.
4. Enforcement Measures – how it will be monitored and enforced.
5. How it complies with the South Coast Air Quality Management District Regulations.

CEQA Assessment - Active Transportation and Public Transit Analysis

Potential impacts to public transit, pedestrian facilities and travel, and bicycle facilities and travel can be evaluated using the following criteria:

- A significant impact occurs if the project conflicts with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decreases the performance or safety of such facilities.

Therefore, the TS should evaluate whether a project is consistent with adopted policies, plans, or programs regarding active transportation or public transit facilities, or otherwise increases or decreases the performance or safety of such facilities and make a determination as to whether it has the potential to conflict with existing or proposed facilities supporting these travel modes.

Transportation Impact Study Format

Each TS submitted to the City shall contain each of the following elements unless the topic is not applicable. However, items omitted therefrom as "not applicable" shall first be approved by the City.

1. Executive Summary

This portion of the report shall present factual and concise information relative to the major issues in the report. The Executive Summary shall include a brief overview of the project, a short discussion of the project's traffic generation potential, the expected VMT impacts of the project, and a summary of mitigation measures. It should also summarize any deficiencies in roadway LOS and the corresponding proposed improvements.

2. Introduction

The introduction of the report shall include a detailed description of study procedures, a general overview of the proposed project site and study area boundaries, existing and proposed site uses, and existing and proposed roadways and intersections within the defined study area (defined study area to be determined by the City Traffic Engineer). Exhibits required for this section shall include a regional map showing the project vicinity and a site layout map.

3. Project Description and Location

This section shall expand on information presented in the introduction and shall provide a detailed development scenario and specific project location. Exhibits in this section shall include, at a minimum, a clear illustration of the project in terms of a site plan, its density, adjacent roadways, on-site parking supply, proposed traffic circulation within the project, gross square footage, number of rooms/units, and other descriptors as appropriate.

4. Methodology and Thresholds

Identify the methodology used to calculate LOS and VMT. Include the criteria used for screening projects from project-level VMT analysis, if applicable. Identify the impact threshold for VMT, and the City's LOS standards for roadways and intersections.

5. LOS Analysis

This should include the Traffic Generation Forecast, Traffic Distribution and Assignment, Traffic Analysis, and identify required improvements described in "Level of Service Analysis Procedure".

6. On-site Parking, Access, and Circulation Analysis

Refer to On-Site Parking Analysis section and Access and Circulation Analysis section.

7. Active Transportation and Public Transit Analysis

Refer to Active Transportation and Public Transit Analysis section.

8. Vehicle Miles Traveled (VMT) Analysis

Present the Project VMT per service population for all analysis scenarios and the Project effect on VMT for all analysis scenarios. Data should be presented in tabular format. If the project meets the City's VMT screening criteria, this should be documented. All VMT impacts should be identified in accordance with the VMT Impact Thresholds described above. Proposed VMT mitigation measures should be identified.

9. Appendix

Detailed appendix material shall be supplied as part of the report. If the main report is too large to include an appendix, such material shall be provided under a separate and identifiable cover. Typical material in this regard includes VMT and TDM calculations, traffic counts, LOS calculation sheets, fully completed signal warrants, accident diagrams at high accident locations, sketches of proposed roadway improvements, and other information necessary for the City's review of the report.

Attachments

Attachment A: VMT Assessment Flowchart

SGVCOG VMT Assessment Flowchart

FEHR & PEERS

Steps | Project Questions | Procedural Flowchart

Decision ○ Analytical process or procedural outcome

Step 1 Screening

Type A TPA Screening

1. Is the project in a Transit Priority Area?

2. Are the following requirements met?
   - Must have a total FAR greater than or equal to 0.75
   - Cannot provide more parking than the City Municipal Code Requirement
   - Must be consistent with SCAG RTP/SCS
   - Cannot replace affordable units with a smaller number of moderate- or high-income residential units

Type B Low VMT Area Screening

1. Is the project located in a low VMT area?

2. Are the following requirements met?
   - The project is composed of similar land use types and of a similar density to the land uses within the project TAZ
   - The project is assumed to generate VMT per person similar to those existing uses

Note: Review jurisdiction's thresholds of significance for definition of low VMT area.

Type C Project Type Screening

Is the project a local-serving project as noted in the Project Type Screening project list in the TIA Guidelines?

These projects include but are not limited to:
- Local serving K-12 schools
- Local-serving retail uses less than 50,000 square feet
- Community and Religious Assembly Uses
- Public Services
- Affordable or supportive housing
- Projects generating less than 110 daily vehicle trips
- Other projects as approved by the City Traffic Engineer

Note: If the project fulfills Type A, B or C screening, the project is presumed to result in a less-than-significant transportation impact.

Step 2 VMT Assessment

What is the project-level VMT and its effect on VMT assessment? Does the project have a less than significant impact?

Details for VMT Assessment are provided in Transportation Study guidelines.

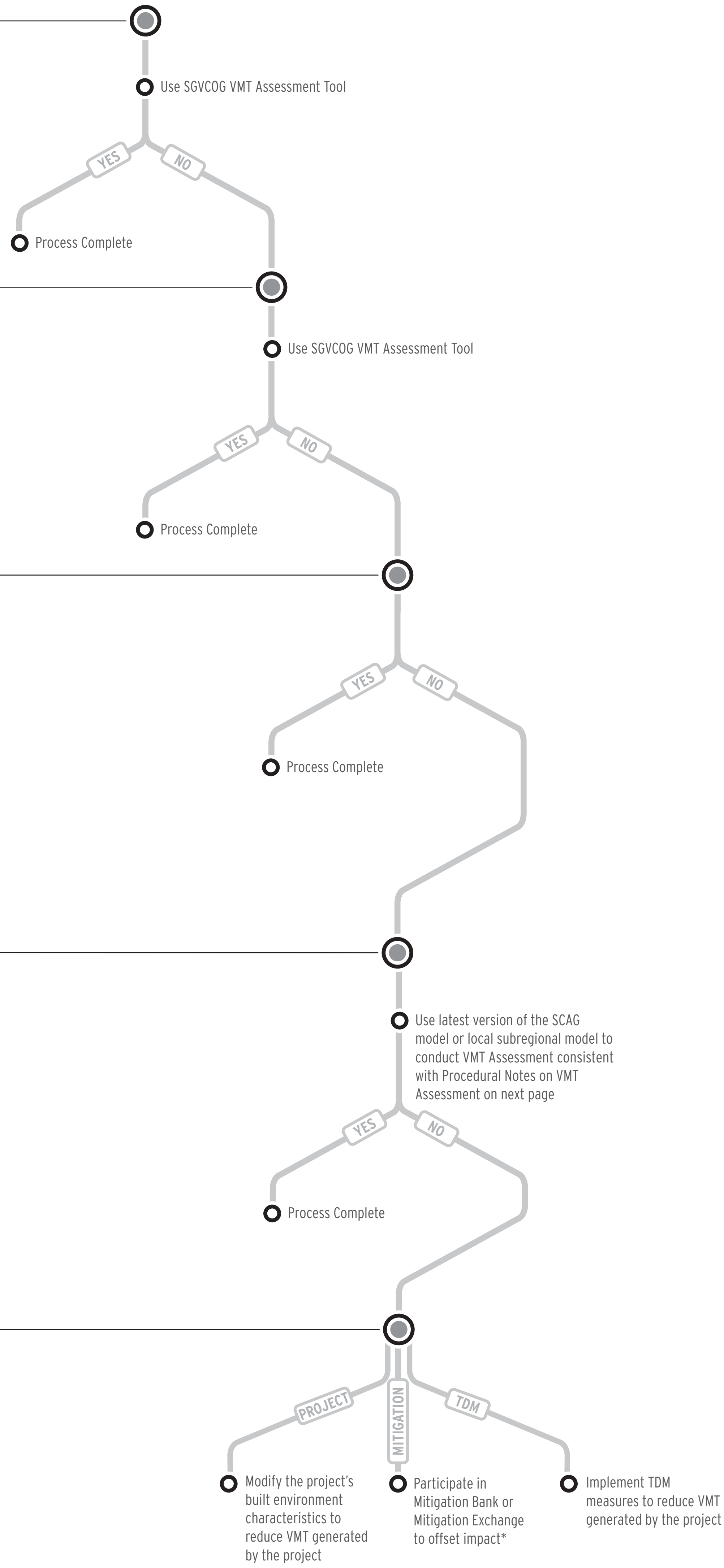
Note: If the project is not screened from assessment in Step 1, the project will require a full VMT assessment to disclose potential significant impacts.

Step 3 Developing Mitigation Measures

What are the options to mitigate VMT impacts?

Note: VMT reductions associated with proposed TDM mitigation measures can be estimated with:
- CAPCOA reduction equations
- Use of OCTAM and the PA Methodology to isolate commute VMT
- The SGVCOG VMT Assessment Tool TDM module can be utilized to estimate VMT reduction potential associated with TDM measures

*Please note that a Mitigation Bank or Mitigation Exchange program may not be readily available. Check with your local agency.



Abbreviations

CAPCOA = California Air Pollution Control Officers Association
FAR = Floor Area Ratio
PA = Production-Attraction
RTP = Regional Transportation Plan
SCAG = Southern California Association of Governments
SCS = Sustainable Communities Strategy
SGVCOG = San Gabriel Valley Council of Governments
TDM = Transportation Demand Management
TIA = Traffic Impact Analysis
TPA = Transit Priority Area
VMT = Vehicle Miles Traveled

Attachment B: SGVCOG VMT Assessment Tool User Guide

SGVCOG VMT Tool: Quick Start Guide

(August 18, 2020)

Led by the San Gabriel Valley Council of Governments (SGVCOG) at the direction of 27 of the 30 member cities that constitute SGVCOG, this tool is an outcome of the VMT implementation process whereby the participating cities adopted new significance thresholds for analyzing transportation impacts pursuant to Senate Bill 743 (SB 743). The tool covers the following SGVCOG cities:

Alhambra	Industry	Rosemead
Arcadia	Irwindale	San Dimas
Azusa	La Canada Flintridge	San Gabriel
Baldwin Park	La Puente	San Marino
Claremont	Laverne	Sierra Madre
Covina	Monterey Park	South El Monte
Diamond Bar	Montebello	Temple City
Duarte	Monrovia	Walnut
El Monte	Pomona	West Covina

The tool can be accessed at https://apps.fehrandpeers.com/SGVCOGVMT/. Each of the cities has unique thresholds of significance, and the methodologies for VMT screening may vary slightly due to the different development patterns and geographic location of each community. Please coordinate with the respective city when using this tool for development purposes.

WHAT DOES THIS TOOL DO?

The SGVCOG VMT Tool is designed to assist you in screening and estimating project-generated VMT for certain types of land use projects in the San Gabriel Valley and calculating VMT reductions associated with certain VMT-reducing measures. The tool is intended for use on four primary land uses:

- Residential
- Office
- Industrial
- Commercial (e.g. retail, restaurant, and entertainment uses)

The tool evaluates projects with one or a combination of these uses.

LIMITATIONS OF THE VMT EVALUATION TOOL

The VMT Evaluation Tool only covers some of the possible screening criteria that a city or county may establish for land use project VMT analysis per California Senate Bill 743. The Tool is limited to providing estimates based on data provided in the model, whereby if a proposed project is of a land use type that is not reflected in the Traffic Analysis Zone (TAZ) either now or in the future, the Tool is not capable of estimating the VMT efficiency rate for that land use type. Other land uses types, large, complex and/or mixed-use projects, or long-range land use plans should be analyzed using the Boundary Method, which requires running the SCAG RTP Model. Before making any decisions based on the information provided by the VMT Evaluation Tool, it is recommended that you contact the city in which the proposed development is located.

RUNNING THE VMT EVALUATION TOOL – 4 BASIC STEPS

The following are the four basic steps involved in running the VMT Evaluation Tool:

Page 1: Select Project Area

Step 1: Jurisdiction

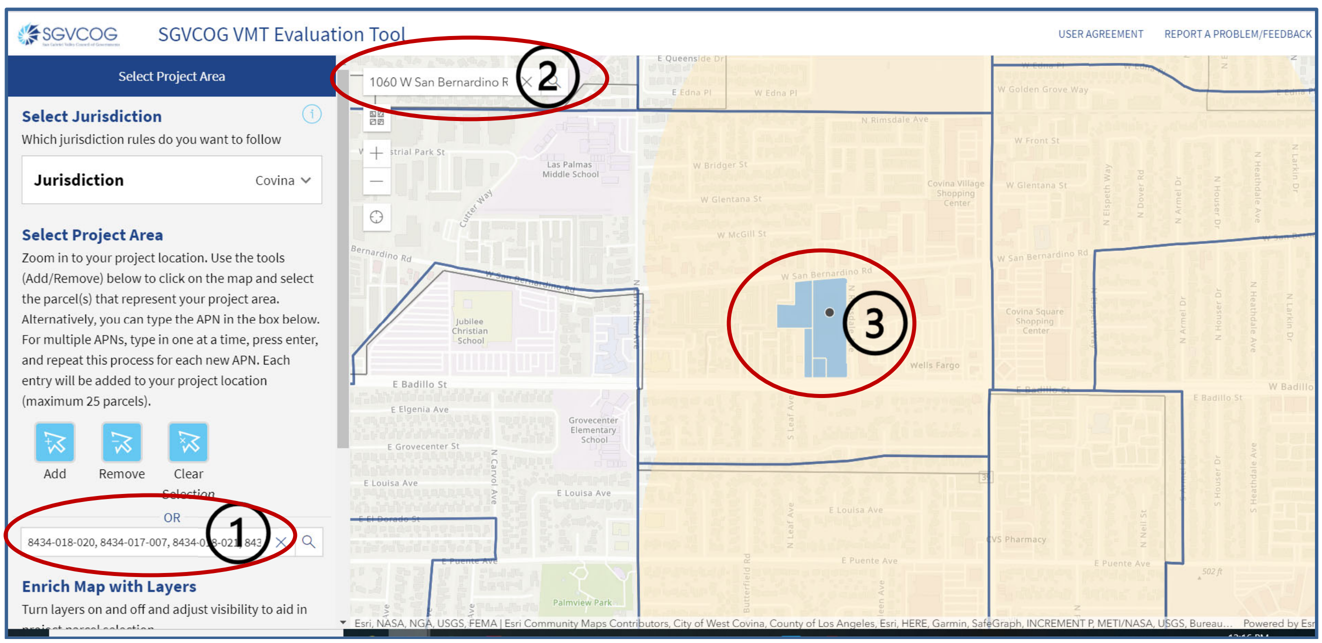
Using the drop-down box, select the city where the project is located. This is required.

Step 2: Select Parcel(s)

There are three ways to locate the parcels associated with a proposed project:

1. Type in the Assessor Parcel Number(s) (APN). The APN requires a dash between each grouping of numbers (XXXX-XXX-XXX).
2. Type in the Project Address; or,
3. Zoom into the map

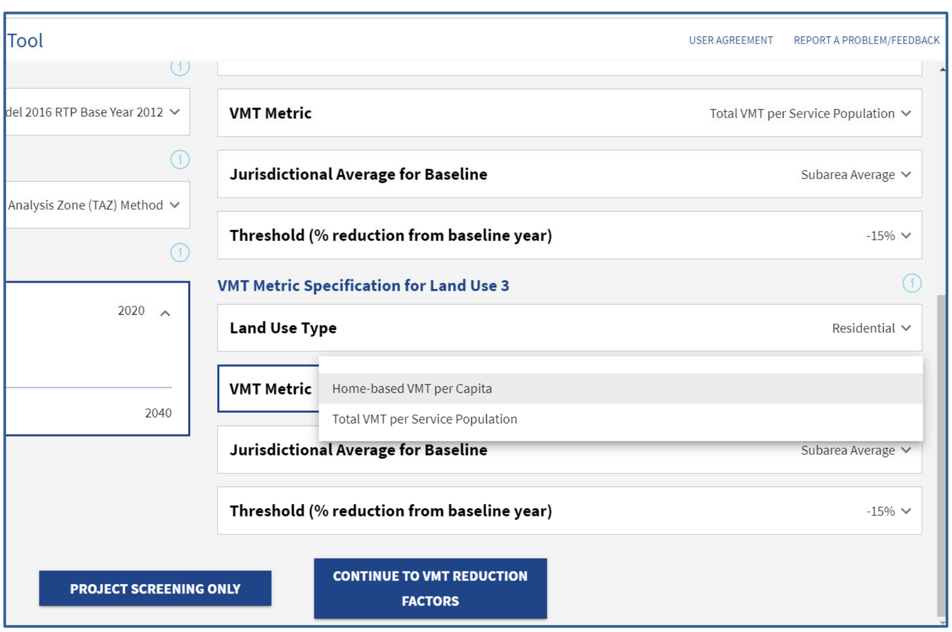
To select the parcel, click on "Add".



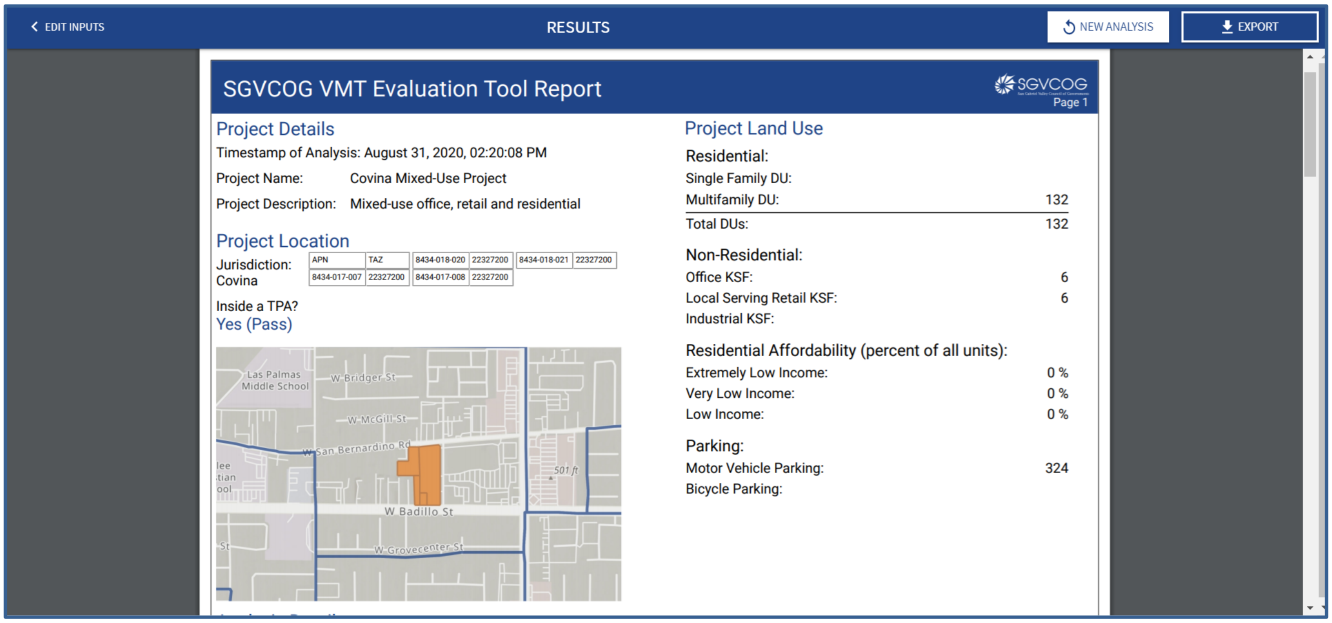
Page 2: Determine Screening Inputs

- **Project Information**
  - **Project Name:** Must type in a project name (required field) – max 250 characters
  - **Project Description:** Required field – max 250 characters
  - **APNs:** Auto-populated from Page 1

- **Select Base Data:** Auto-populated
- **Analysis Methodology:** Auto-populated
- **Select Baseline Year:** The tool has the capability of providing baseline VMT between 2012 and 2040 pursuant to the 2016 SCAG RTP Model. To select a baseline year, click on the timeline and slide the point to the preferred baseline year.
- **VMT Metric Specification for Land Use 1-3:** The tool is capable of evaluating up to three land use types per project. The tool is also capable of evaluating the difference in VMT Metrics for one land use type. For the latter, select the same land use type for Land Use 1 and Land Use 2 and select different VMT Metrics.
- **Land Use Type:** Select 1) Residential, 2) Office, 3) Industrial, or 4) Commercial.
- **VMT Metric:** Select Home-based VMT per Capita/Home-based VMT per Worker or Total VMT per Service Population
- **Jurisdictional Average for Baseline:** Pre-set (based on City preferences)
- **Threshold:** Pre-set (based on City preferences)
- **Project Screening Only** versus **Continue to VMT Reduction Factors:** Option to screen first without VMT reductions. The tool provides a mechanism to return to this page and select reductions.



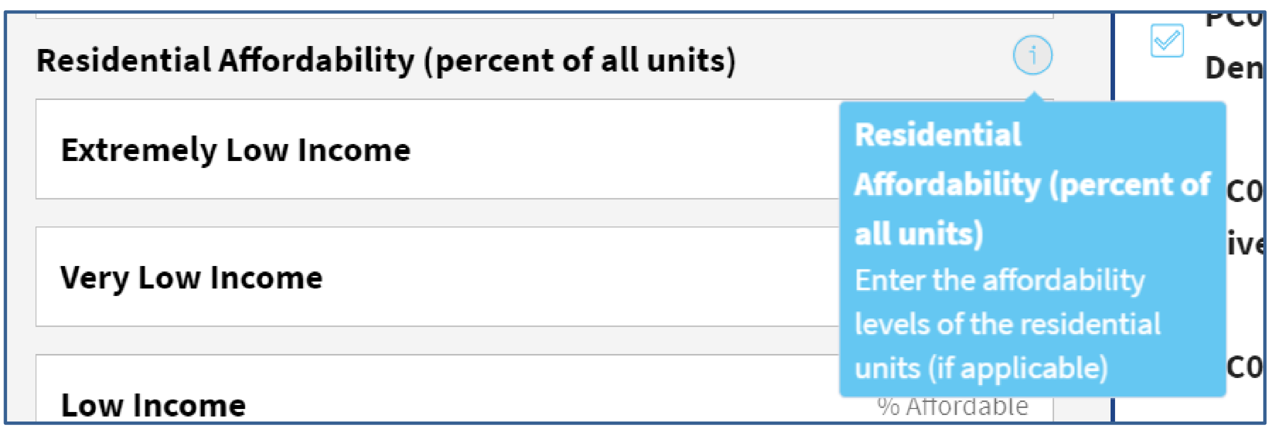
Page 4: Project Screening Results (without VMT Reduction Strategies)



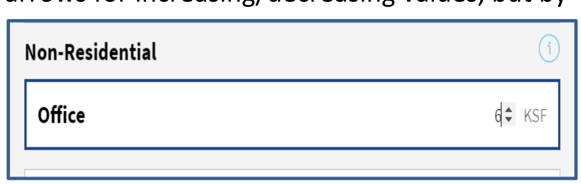
Page 4 (VMT Screening Results): From this page with Project Screening Results, there is an option at the top left of the page to "Edit Inputs". Click this to return to Page 3.

Page 3: Click on **Continue to VMT Reduction Strategies** to test VMT reduction strategies. Details about the VMT Reduction Strategies are provided in Appendix D of the Transportation Assessment Guidelines.

Page 4 (Land Use Info and VMT Reduction Strategies): On this page, populate the project details. Note that the light blue "i" in a circle can be clicked on for additional information, as demonstrated below.

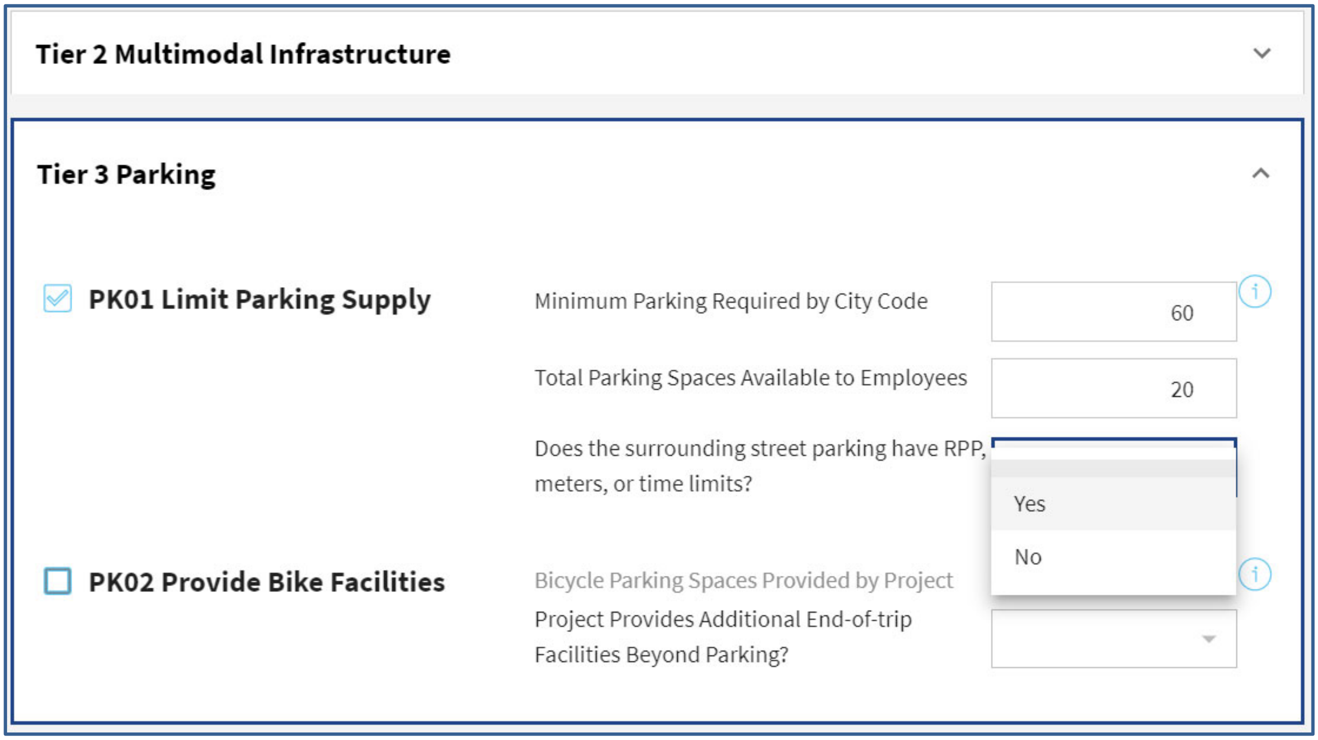


- **Project Land Use Information**
  - The left-hand entry boxes contain up/down arrows for increasing/decreasing values, but by clicking to the left of the up/down arrows, you may also type in a value, as shown below. Please note that all square-footage values are calculated in



the tool in terms of one thousand square feet (KSF) so for a 6,000 square-foot office, the field would be populated with a "6", as shown below.

- **VMT Reduction Strategies**
  - Select the desired VMT Reduction Strategies by first clicking the box next to the strategy. In some cases, additional inputs will be required, such as the example below for Tier 3 Parking (PK01 Limit Parking Supply)



- **A number of reduction strategies overlap with each other**. For instance, a strategy may consist of a basket of measures which may overlap with some of the measures in another strategy. Therefore, the SGVCOG VMT Evaluation Tool logic has been coded to reflect these dependencies, so that if one measure is chosen, other overlapping measures are not allowed. The dependencies in the tool are summarized below and are shown in the Tool by greying out certain reductions so that they cannot be selected.

If this strategy is chosen…	This strategy is not allowed…
PK 02 Provide Bike Facilities	TP 05 Implement CTR Program
TP 04 CTR Marketing and Education	TP 05 Implement CTR Program TP 15 Travel behavior Change TP 18 Voluntary Travel Behavior Change Program
TP 05 Implement CTR Program	PK 02 Provide Bike Facilities TP 04 CTR Marketing and Education TP 08 Telecommuting and Alternative Work Schedules TP 13 Ride-Sharing Programs TP 15 Behavioral Intervention TP 17 Vanpool Incentives TP 18 Voluntary Travel Behavior Change Program
TP 06 Employee Parking Cash-Out	TP 10 Price Workplace Parking
TP 07 Subsidized Transit Program	TP 11 Alternative Transportation Benefits
TP 08 Telecommuting and Alternative Work Schedules	TP 05 Implement CTR Program
TP 09 Free Door-to-Door Transit Fleet	TP 13 Ride-Sharing Programs TP 17 Vanpool Incentives
TP 10 Price Workplace Parking	TP 06 Employee Parking Cash-Out
TP 11 Alternative Transportation Benefits	TP 07 Subsidized Transit Program
TP 13 Ride-Sharing Programs	TP 05 Implement CTR Program TP 09 Free Door-to-Door Transit Fleet TP 17 Vanpool Incentives
TP 15 Behavioral Intervention	TP 04 CTR Marketing and Education TP 05 Implement CTR Program TP 18 Voluntary Travel Behavior Change Program
TP 17 Vanpool Incentives	TP 05 Implement CTR Program TP 09 Free Door-to-Door Transit Fleet TP 13 Ride-Sharing Programs
TP 18 Voluntary Travel Behavior Change Program	TP 04 CTR Marketing and Education TP 05 Implement CTR Program TP 15 Behavioral Intervention

- **Project Screening Results (with VMT Reduction Strategies):** The results of the Project Screening are summarized in this report. The Tool does not screen based on 110-daily trips. Screening for this factor must be completed outside of the tool using the ITE Trip Generation Manual. This Tool screens projects based on their location within a TPA and/or a Low VMT Area. The Screening Results provides the following information about these two screening criteria.

1. **Transit Priority Area (TPA):** Page 1 of the SGVCOG VMT Evaluation Tool Report

Project Location

Jurisdiction: Covina

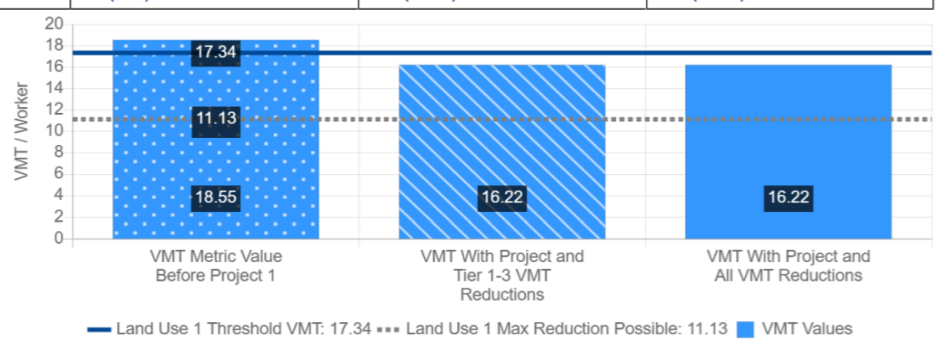
APN	TAZ				
8434-017-007	22327200	8434-018-020	22327200	8434-018-021	22327200
		8434-017-008	22327200		

Inside a TPA?
Yes (Pass)

2. **Low VMT Area:** Page 2 of the SGVCOG VMT Evaluation Tool Report provides details about the VMT generation in the area of the proposed project. The table in the figure below indicates the Home-based VMT per Employee Baseline (20.4), and the dark blue line indicated in the bar chart (17.34) indicates the threshold of 15 percent below the Baseline. The gray dotted line in the bar chart indicates the maximum potential VMT reduction (16.22) that could be available through the strategies in the tool.

Land Use Type 1:	Office
VMT Without Project 1:	Home-based Work VMT per Worker
VMT Baseline Description 1:	Subarea Average
VMT Baseline Value 1:	20.4
VMT Threshold Description 1:	-15%
Land Use 1 has been Pre-Screened by the Local Jurisdiction:	N/A

	Without Project	With Project & Tier 1-3 VMT Reductions	With Project & All VMT Reductions
Project Generated Vehicle Miles Traveled (VMT) Rate	18.55	16.22	16.22
Low VMT Screening Analysis	No (Fail)	Yes (Pass)	Yes (Pass)



READING THE REPORT & EXPORT FILES

The VMT Evaluation Tool produces two types of outputs: a formatted report, which shows up on the Results screen and can be downloaded as a PDF file, and data tables including all the user-provided inputs and the back-end data which can be downloaded as CSV files.

Key things to look for in the report / PDF:

- **Whether the project falls in proximity to transit** (within ½ mile of a Major Transit Stop, or ½ mile of a stop along a High-Quality Transit Corridor as defined in state law):
  Look for the 'Inside TPA?' question on Page 1 of the report.

Project Location

Jurisdiction: Campbell

APN	TAZ
27938075	21

Inside Transit Priority Area (TPA)?
Yes (Pass)

- **Whether the project falls in a low-VMT area** (i.e., below the VMT threshold specified by the city/town/county): Look for the 'Low VMT Screening Analysis' row on the Screening Results page(s) of the report, starting on page 2. There will be Low-VMT Screening results for each land use you select.

	Without Project	With Project and Tier 1-3 VMT Reductions	With Project and All VMT Reductions
Project Generated Vehicle Miles Traveled (VMT) Rate	14.69	14.53	11.75
Low VMT Screening Analysis	No (Fail)	No (Fail)	Yes (Pass)

The CSV files are intended to help the user understand how the VMT reduction results were obtained; the data in the files, along with the formulas in forthcoming User Manual, should help confirm the results.

TIPS FOR SUCCESS

- Look for the "tool-tips" across the tool to help understand fields where inputs are required.
- The tool may take 1 - 2 minutes to run a report; if it takes much longer, refresh and try again.
- If you are running variations on the same site and project, use the back arrows in the upper-left of the screen (such as < EDIT INPUTS) to go back, vary some inputs, and run the report again.
- To start a completely new analysis while staying in the tool, use the button in the upper-right of the Results screen. NEW ANALYSIS
- The tool is optimized for Chrome, Firefox, Edge or Safari on a Windows or Mac computer, although you may also access it from a tablet or another browser. If you encounter unexpected issues, try clearing your browser cache and cookies and running again.
- Please fill out the short feedback form by clicking on the link REPORT A PROBLEM/FEEDBACK in the upper-right of the tool. You may report errors, rate the tool, and offer suggestions for future improvements.

FOR MORE INFORMATION

SGVCOG will be providing further documentation of the VMT Evaluation Tool in Fall 2020, including a User Manual and Frequently Asked Questions (FAQ) sheet.

If you have questions about the VMT Evaluation Tool, you may email j.hayes@fehrandpeers.com.
For any inquiries about how the tool may be applied in a land use review and approval process, please contact staff at the city/town/county in which the project is located.

Attachment C: Detailed VMT Forecasting Information

This section provides detailed VMT forecasting instructions for use with the Southern California Association of Governments (SCAG) Travel Demand Model. Please note that SCAG periodically updates the travel demand model and the latest version available should be utilized for VMT assessment in the City.

The SCAG travel demand model is a trip-based model that generates daily person trip-ends for each TAZ across various trip purposes (Home-based-work, home-based-other, and non-home-based for example) based on population, household, and employment variables. This may create challenges for complying with the VMT guidance because trip generation is not directly tied to specific land use categories. The following methodology addresses this particular challenge among others.

Production and attraction trip-ends are separately calculated for each zone, and generally: production trip-ends are generated by residential land uses and attraction trip-ends are generated by non-residential land uses. Focusing on residential and employment land uses, the first step to forecasting VMT requires translating the land use into model terms, the closest approximations are:

- Residential: home-based production trips
- Employment: home-based work attraction trips

Note that this excludes all non-home-based trips including work-based other and other-based other trips.

The challenges with computing VMT for these two types of trips in a trip-based model are 1) production and attraction trip-ends are not distinguishable after the PA to OD conversion process and 2) trip purposes are not maintained after the mode choice step. For these reasons, it is not possible to use the VMT results from the standard vehicle assignment (even using a select zone re-assignment). A separate post-process must be developed to re-estimate VMT for each zone that includes trip-end types and trip purposes. In order to provide the most accurate estimates possible, the recommended approach to estimating VMT is outlined below. Deviating from this approach will require justification and approval from the City Traffic Engineer.

VMT Forecasting Instructions

This approach will calculate total Origin/Destination (OD) VMT using standard SCAG model output files. The OD method for calculating total VMT includes all vehicle trips that start in a specific traffic analysis zone, and all vehicle trips that end in a specific traffic analysis zone. The major steps of this approach are listed as follows:

- Re-skim final loaded congested networks and adjust the external skim for each mode and time period to account for truncated trips
- Multiply appropriate distance skim matrices by OD trip matrices to estimate VMT by time period
- Sum matrices by time period and mode to calculate daily automobile VMT

- Calculate automobile VMT for individual TAZs

Appropriateness Checks

The number of vehicle trips from the total VMT estimation should match as closely as possible with the results from the traditional model process. The estimated results should be checked against the results from a full model run to understand the degree of accuracy. Note that these custom processes may or may not include full lengths of IX/XI trips (trips with origins or destinations outside of the model roadway network) or special generator trips (airport, seaport, stadium, etc.).

When calculating VMT for comparison at the study area, citywide, or regional geography, the same methodology that was used to estimate project specific VMT should be used. The VMT for these comparisons can be easily calculated by aggregating the row or column totals for all zones that are within the desired geography.

Attachment D: VMT Reduction Strategies

1. SGVCOG VMT Reduction Calculations

This section describes the SCGCOG VMT Evaluation Tool's approach to calculating the effectiveness of VMT reduction strategies that are built into the tool. While a long list of potential VMT reduction measures are made available to users, care must be taken by the analyst to understand and carefully consider the research supporting each VMT reduction measure to determine the efficacy of the potential VMT mitigation.

1.1 Neighborhood Place Types

Based on empirical research that used quantitative methods to classify the census tracts of California into neighborhood place types, a place type is assigned to each parcel in the SGVCOG.[1] These place types, described in **Table 1**, categorize the neighborhood surrounding specific parcels in terms of density, general accessibility and access to transit, and land use. These factors have been shown to have a substantial effect on a location's ability to support low-VMT travel. To reflect this, the place types are used to identify maximum potential VMT reductions for projects, based on research studies. Where supported by research, the neighborhood place types are also used to identify the effectiveness of specific VMT reduction strategies.

Table 1. Neighborhood Place Types

Neighborhood Place Types	Description
Central City Urban	Very high density, excellent accessibility, high public transit access, low single-family homes, older high-value housing stock
Urban High Transit Use	High density, good accessibility, high public transit access, low single-family homes, middle-aged and older housing stock
Urban Low Transit Use	Good accessibility, low vacancy, middle-aged housing stock
Suburb with Multifamily Housing	Average on most indicators, low single-family homes, and relatively lower housing values
Suburb with Single-Family Homes	Low density and accessibility, low vacancy, high newer single-family homes, and relatively higher housing values
Rural in Urbanized Area	Slightly better accessibility than the truly "rural" tracts, more likely to have multifamily housing
Rural	Very low access, high vacancy, high newer single-family homes with lower housing values (mainly outside population centers of any kind)

Notes: Neighborhood place type coding used in script: 1) Urban Low Transit Use, 2) Suburb with Multifamily Housing, 3) Central City Urban, 4) Rural, 5) Suburb with Single Family Homes, 6) Urban High Transit Use, and 7) Rural in Urbanized Area.

[1] Neighborhood types from Salon, Deborah. February 2014. Quantifying the effect of local government actions on VMT. California Air Resources Board and the California Environmental Protection Agency.

1.2 VMT Reduction Strategies

Each strategy for the four different VMT mitigation categories is supported by evidence from a previous literature review prepared by Fehr & Peers, and from our work in VMT reduction strategies. This documentation also includes rural in Urbanized Area and Rural neighborhood place types.[2] The mitigation categories (or tiers) are:

- Tier 1: Project Characteristics
- Tier 2: Multimodal Infrastructure
- Tier 3: Parking
- Tier 4: Transportation Demand Management (TDM) Programs

Strategies and their corresponding evidence and calculations in the tool are described below. (Shortened versions of these descriptions are presented in the tooltips (information buttons) within the tool itself.) Matrices of reductions and elasticities are provided below for each of the four strategy categories (**Table 2** to **Table 5**). Strategy names are listed in the order in which they appear in the tool.

1.2.1 Standards of Evidence

While a long list of potential VMT reduction measures are made available to users of the SGVCOG VMT Evaluation Tool, care must be taken by the analyst to understand what VMT reduction strategies may have already been captured in the SCAG travel model to avoid double counting. Furthermore, the analyst should carefully consider the research supporting each VMT reduction measure to determine the efficacy of the potential VMT mitigation. For example, the analyst may consider whether the supporting studies were based on a statistical model (such as a regression analysis, logit model, etc.) or another type of study, such as a synthesis of available research or a model that provides inferential support for a VMT reduction. The analyst may also look at the geographic location(s) and setting(s) covered in the study or studies that support a VMT reduction.

1.2.2 Tier 1: Project Characteristics

This category is composed of strategies that change land use characteristics, such as density, mix of uses, and housing affordability. These strategies reduce VMT by increasing access to amenities or by attracting residents who generate lower VMT than the average household. Reductions and elasticities for the four strategies are in **Table 2**.

---

[2] These neighborhood place types were added for completeness and allows reductions similar to suburban with single family neighborhood place type to provide flexibility in testing VMT reductions in rural settings. Many VMT reduction measures are not as effective in rural settings and the analyst should consider available research and supplement that research with local data on VMT reductions in rural settings when evaluating VMT reductions in a rural setting.

1.2.2.1 PC 01 Increase Residential Density

Increased residential density, measured in dwelling units per existing residential acreage in a given area, affects the distances people travel and provides greater options for the mode of travel they choose. This measure provides a foundation for implementing other measures that would benefit from increased densities. This strategy applies to residential land uses only.

This study used a large sample of data from Chicago, Los Angeles, and San Francisco metropolitan areas to model the relationship between the VMT and urban design variables.[3] The study found that households per residential acre (Hh/RA) provided the greatest explanatory power for VMT variation across an area. VMT per household is estimated as a function of the ratio of households to residential acreage in the Traffic Analysis Zone (TAZ) or the half-mile buffer around a parcel under the existing condition and under the with project condition. The VMT reduction is based on the estimated change in calculated VMT per household without the project and with the project.

$$\%\,VMT\ reduction = \frac{\left(\frac{VMT}{Hh}\ with\ project - \frac{VMT}{Hh}\ without\ project\right)}{\frac{VMT}{Hh}\ without\ project}$$

The study's VMT per household equation for the Los Angeles metropolitan area is shown below. Data from the Los Angeles metropolitan area was incorporated into the SGVCOG VMT Evaluation Tool as shown below.

$$\frac{VMT}{Hh} = 19749\left(\frac{4.814 + \frac{Hh}{RA}}{4.814 + 7.140}\right)^{-0.639}$$

1.2.2.2 PC 02 Increase Development Diversity (and PC 05)

Increasing the amount of space dedicated to a less common or nonexistent use in the area surrounding the land use development project leads to a reduction in VMT. Having different types of land uses near one another can decrease VMT since trips between land use types are shorter and may be accommodated by non-auto modes of transport. For example, when residential areas are in the same neighborhood as retail and office buildings, residents do not need to travel outside of the neighborhood to run errands and may be able to live and work in the same neighborhood. This strategy applies to residential and employment land uses.

The land use diversity of the TAZ or half-mile buffer around a parcel is measured using an activity mix index. The activity mix index is a proportion of the number of people in the TAZ or parcel buffer participating as residents or employees in retail, office, industrial and other jobs to the number of possible land uses on the TAZ or parcel buffer. The activity mix index for the TAZ or

[3] Holtzclaw, et al. 2002. "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles, and San Francisco." Transportation Planning and Technology, Vol. 25, pp. 1–27.

parcel buffer without the development is compared with the activity mix with the development to estimate the VMT reduction accomplished by improving the mix of activities in the neighborhood.

The elasticities of per capita VMT and VMT per worker by neighborhood place type with respect to the activity mix index are estimated based on the empirical research supporting the strategy.[4] The study used multiple statistical modeling methods to estimate the effect of land use variables on VMT by neighborhood place type, using data from travel surveys conducted between 2001 and 2009. PC 05 is the Employment portion of strategy PC 02, which is not shown explicitly in the tool but is activated when the user selects strategy PC 02 for a project that includes employment land uses.

$$Activity\ Mix\ Index = \sum_{i=1}^{N} \frac{p_i \times \ln(p_i)}{\ln(N)}$$

$$p_i = proportion\ of\ people\ (residents\ and\ employees)\ engaged\ in\ activity\ i\ in\ the\ parcel$$
$$N = number\ of\ possible\ land\ use\ in\ the\ parcel$$
$$\%\ Change\ in\ VMT\ per\ capita = elasticity\ by\ place\ type\ and\ development\ use \times \%\ \Delta\ in\ activity\ mix\ index$$

1.2.2.3 PC 03 Affordable Housing

This strategy encourages building a greater percentage of affordable and below market rate (BMR) housing to allow for lower income families to live at the project. Research has shown that households with incomes at or below 80 percent of the regional median income make fewer trips by automobile than households with higher incomes, resulting in lower per capita VMT in some jurisdictions. BMR housing can also provide opportunities for lower income families to live closer to job centers and to use transit for their commutes. This strategy applies to residential land uses only.

This VMT reduction is based on a study that used data from the 2010-2012 California Household Travel Survey (CHTS) to determine a relationship between VMT and low-income households. The study reported the estimated VMT reductions of three lower income household groups when compared to the VMT of median family income (MFI) households.[5] The research that is available is based on the behavior of lower incomes households but not on the behavior of lower income households living in BMR housing. The reductions by income group are listed below.

$$Extremely\ Low\ Income\ (Household\ earns\ less\ than\ 30\%\ of\ MFI) = -32.5\%$$
$$Very\ Low\ Income\ (Household\ earns\ between\ 30\%\ and\ 50\%\ of\ MFI) = -25.2\%$$
$$Low\ Income\ (Household\ earns\ between\ 50\%\ and\ 80\%\ of\ MFI) = -10.2\%$$

[4] Salon, Deborah. 2013. Quantifying the effect of local government actions on VMT. California Air Resources Board and the California Environmental Protection Agency.
[5] Newmark, G. and Haas, P. 2015. Income, Location Efficiency, and VMT: Affordable Housing as a Climate Strategy. The California Housing Partnership.

1.2.2.4 PC 04 Increase Employment Density

Like increasing residential density, increasing employment density affects the distances people commute and provides greater options for the modes of travel they choose. Employment density is measured as the ratio of the number of employees to the net commercial and industrial acreage in a given area. Employment includes office, retail, industrial, and other employment. This strategy applies to employment land uses only.

The study used to support this strategy reported VMT decreases in lower density locations, such as suburban places, with an increase in employment density.[6] The study is based on results from a linear regression model of cross-sectional data collected from Austin's Capital Area Metropolitan Planning Organization to determine the differences in VMT associated with employment density.

For suburban neighborhood place types (suburban with multifamily home and single-family homes), a 0.03 percent reduction in VMT was observed for a 1 percent increase in employment density. In higher-density locations (urban neighborhood place types), VMT was observed to increase in response to employment density. This increase could be related to the replacement of housing with employment uses in an already job-rich environment.

$$\%\, VMT\ Reduction\ (for\ suburban\ place\ types) = -0.03 \times \%\ change\ in\ employment\ density$$

[6] Zhou, B. and K. M. Kockelman. 2008. Self-selection in home choice: use of treatment effects in evaluating relationship between built environment and travel behavior. Transportation Research Record: Journal of the Transportation Research Board, 2077(1): 54-61. Cited in Circella, Giovanni et al. 2014. Impacts of Employment Density on Passenger Vehicle Use and Greenhouse Gas Emissions (Policy Brief and Technical Background Document). California Air Resources Board and the California Environmental Protection Agency.

Table 2. Project Characteristics Strategy Elasticities and Reductions

Strategy ID	Strategy	Development Input	Type of Elasticity or Reduction[1]	Neighborhood Place Type						
				Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
PC 01	Increase Residential Density	Project Density (Dwelling Units)	% change in VMT / % change in household density	See strategy methods for reduction.						
PC 02	Increase Development Diversity (Residential and Employment)	Land Use Types (Dwelling Units and 1,000 square feet)	% change in residential VMT / % change in the activity mix index	-0.191	0	0	-0.0325	0	0	0
PC 05			% change in employment VMT / % change in the activity mix index	-0.14	-0.144	0	-0.0329	0	0	0
PC 03	Affordable Housing	BMR Units by income type	VMT / capita	Extremely Low Income (Household earns less than 30% of MFI) = -32.5% Very Low Income (Household earns between 30% and 50% of MFI) = -25.2% Low Income (Household earns between 50% and 80% of MFI) = -10.2%						
PC 04	Increase Employment Density	Project Density (Jobs)	% change in VMT / % change in employment density	0.074	0.074	-0.03	-0.03	-0.03	-0.03	-0.03

Note:
1. Elasticities are expressed as a decimal less than 1 while reductions are expressed as a percentage or a constant.

1.2.3 Tier 2: Multimodal Infrastructure

These strategies require project developers to provide funding for and/or construct improvements to the surrounding transportation network that encourage the use of biking, walking, and transit instead of driving. Reductions and elasticities for the five strategies are in **Table 3**.

1.2.3.1 MI 01 Increase Bike Access

This strategy requires the project developer to provide funding for or construct bicycle facilities that close gaps in the bicycle network and/or lower the level of traffic stress on the existing bicycle network (e.g., construct a barrier or buffer for an existing bike lane). Improving bike access to project sites encourages people to bike instead of drive, thus reducing VMT. This strategy only applies to bicycle facilities that provide a dedicated lane for bicyclists or a completely separated right-of-way for bicycles and pedestrians. This includes the construction of or improvements to Class I (trail), Class II (bike lane), and Class IV (protected bike lane) bikeways. This measure would not be applicable if the resulting gap between the project and the external bikeway exceeds 1/3 mile. This strategy applies to residential and employment land uses,

The research supporting this reduction used a large sample of travel data within the city limits of Montreal to investigate the link between bicycle infrastructure accessibility and cycling modal share.[7] The study reports a 3.71 percent increase in bicycle mode share for a 1 percent decrease in distance to cycling infrastructure for the urban with low transit neighborhood place type. The same study reports different elasticities for urban (central city urban and urban high transit) and suburban (suburban multifamily housing and single-family homes) neighborhood place types. These elasticities are shown in **Table 3**.

$$\%\ change\ in\ bike\ mode\ share = 0.371\ \times \%\ change\ in\ distance\ to\ cycling\ infrastructure$$

The shift from vehicle trips to bicycle trips is expected to occur for vehicle trips that are of bikeable length. Thus, the actual VMT reduction is prorated by the ratio of the average bicycle trip length to the average vehicle trip length. Average trip lengths are derived from California Household Travel Survey (CHTS) data.

$$\%\ VMT\ Reduction = \frac{(\%\ change\ in\ bike\ mode\ share \times average\ trip\ length\ by\ bicycle)}{(vehicle\ mode\ share\ for\ TAZ \times average\ trip\ length\ by\ vehicle)}$$

[7] Zahabi, S., Chang, A., Miranda-Moreno, L., and Patterson, Z. 2016. Exploring the link between the neighborhood typologies, bicycle infrastructure and commuting cycling over time and the potential impact on commuter GHG emissions. *Transportation Research Part D: Transport and Environment. 47*:89–103.

1.2.3.2 MI 02 Improve Connectivity – Network Connectivity/Design Improvements

Building a new street connection and/or connecting cul-de-sacs to provide pedestrian and bicycle access enhances walkability, connectivity, and street accessibility within a neighborhood. VMT reductions are based on the change to intersection densities within a quarter mile buffer of the project and on internal connections within the project site. Intersection density is a calculated as the number of intersections per square mile within a quarter mile buffer around the project site. The user can estimate existing intersection density manually or using Geographic Information System (GIS) software. The strategy applies to residential and employment land uses.

The study synthesized the results of nine studies to determine the effect of intersection and street density on VMT reductions.[8] The study reports a -0.12 elasticity of VMT reduction with respect to a one percent increase in intersection density. This reduction only applies to suburban neighborhood place types, as the relative improvement to pedestrian accessibility is greater in suburban areas than in urban areas that already have dense street networks.

$$\%\, VMT\ Reduction = -0.12 \times \%\, increase\ of\ intersection\ density$$

1.2.3.3 MI 03 Increase Transit Accessibility

Building the project within a proximity to a transit station or stop with high-quality service enhances access to transit which facilities the use of transit for people traveling to/from the project site. Facilitating transit use results in a mode shift from driving to transit and thereby reduces VMT. In the SGVCOG VMT Evaluation Tool, this strategy is applied by taking the distance between the project site and the closest transit stop without project improvements and the distance to the closest transit stop with project improvements and applying an elasticity factor; therefore, the project can reduce its VMT by relocating a transit stop closer to the site. Proposed changes to transit stop locations should be negotiated with the Lead Agency and the applicable transit operator. The strategy applies to residential and employment land uses.

The study supporting this strategy provides results on the effect of urban form, including distance to transit, on VMT through modeling data from the 1990 National Personal Transportation Survey data.[9] The associated reduction in VMT with the reduction in distance to transit (elasticity) is reported as -0.08.

$$\%\, VMT\ Reduction = -0.08 \times \%\, change\ in\ distance\ to\ nearest\ transit\ stop$$

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[8] Ewing, R., and Cervero, R. 2010. Travel and the Built Environment - A Meta-Analysis. *Journal of the American Planning Association.*

[9] Bento, A.M., Cropper, M.L., Mobarak, A.M., and Vinha, K. 2003. The Impact of Urban Spatial Structure on Travel Demand in The United States. World Bank policy research working paper, 3007.

1.2.3.4 MI 04 Traffic Calming

This strategy requires the project design to include pedestrian/bicycle safety and traffic calming measures both on-site and in the surrounding neighborhood. Providing traffic calming measures encourages people to walk or bike instead of using a vehicle, resulting in decreased VMT. VMT reductions are based on whether the project will be providing at a minimum median refuges, bulb-outs, and/or other pedestrian crossing enhancements beyond the frontage of the development. This strategy applies to residential and employment land uses.

The study supporting this strategy quantified the effects of traffic calming on VMT by comparing the change in VMT in suburban and urban neighborhood place types with same pedestrian environment conditions with and without traffic calming improvements.[9] The study found that traffic calming improvements yield higher VMT reductions in suburban places than in urban places, as the relative reduction in traffic speeds is greater in suburban areas than in urban areas where traffic already tends to move slowly. If the project provides traffic calming improvements beyond the project site frontage, the reduction from the evidence is applied based on the neighborhood place type of the project site. These reductions are shown in **Table 3**.

$$\%\, VMT\ Reduction = \ rate\ based\ on\ placetype$$

1.2.3.5 MI 05 Pedestrian Networks

This strategy requires the project design to include pedestrian improvements both on-site and in the surrounding neighborhood. Providing a pedestrian accessible network encourages people to walk instead of drive, thereby reducing VMT. The pedestrian improvements include but are not limited to buffered sidewalks on both sides of the street, marked or signalized pedestrian crossings at intersections (enhanced crosswalks), lighting, and curb ramps. This strategy applies to both residential and employment land uses.

The study supporting this strategy quantified the effects of the pedestrian environment on VMT by comparing the change in VMT in suburban and urban neighborhood place types with same pedestrian environment conditions with and without pedestrian improvements.[10] The study found that pedestrian improvements yield higher VMT reductions in suburban places than in urban places, since suburban places tend to have less developed pedestrian networks to begin with. If the project provides pedestrian network improvements beyond the project site frontage, the reduction is then applied based on neighborhood place type of the project site. These reductions are shown in **Table 3**.

$$\%\, VMT\ Reduction = \ rate\ based\ on\ placetype$$

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[10] Cambridge Systematics. 2009. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions – Technical Appendices.* Prepared for the Urban Land Institute.

Table 3. Multimodal Infrastructure Strategy Elasticities and Reductions

Strategy ID	Strategy	Development Input	Type of Elasticity or Reduction[1]	Neighborhood Place Type						
				Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
MI 01	Bike Access Improvements	Distance to nearest existing bicycle facility	% change in bicycle mode share / % decrease in distance to cycling infrastructure	-0.371	-0.371	-0.371	-0.371	-0.371	-0.371	-0.371
MI 02	Improve Connectivity (Network Connectivity/ Design Improvements)	Intersection Density	% change in VMT / % change in intersection density	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12
MI 03	Increase Transit Accessibility	Distance to closest transit stop	% change in VMT / % reduction in distance to transit	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
MI 04	Traffic Calming Measures	Binary Answer	VMT / capita VMT/worker	-0.6%	-0.6%	-2%	-2%	-2%	-2%	-2%
MI 05	Pedestrian Networks	Binary Answer	VMT / capita VMT/worker	-0.6%	-0.6%	-2%	-2%	-2%	-2%	-2%

Note:
1. Elasticities are expressed as a decimal less than 1 while reductions are expressed as a percentage or a constant.

1.2.4 Tier 3: Parking

Strategies in this category reduce automobile parking supply, making driving less attractive, and provide high-quality bicycle parking, making biking more attractive. Reductions and elasticities for the two strategies are in **Table 4**.

1.2.4.1 PK 01 Limit Parking Supply

This strategy would require the development to decrease parking supply at the project site to rates lower than those documented in the Institute of Transportation Engineers (ITE) Parking Generation manual or to those documented by the municipal code if that is what the jurisdiction has chosen. Decreasing parking supply encourages employees to choose an alternative transportation mode for their commutes. This measure only applies if street parking is not free or unrestricted during typical working hours. Surrounding street parking must be metered, have time limits during typical working hours, and/or be available to residential parking permit (RPP) holders only. The strategy applies to employment land uses only.

VMT reductions for this strategy are based on the project's parking supply compared to the minimum parking supply requirement from municipal or ITE code. The parking supply reduction is limited to 25 percent from minimum required by municipal code. The strategy uses an equation derived from the URBEMIS model parking mitigation component. The URBEMIS model is used to calculate air quality impacts for development projects based on VMT reduction and other emissions reduction approaches.[11]

$$\%\ VMT\ Reduction = \\ \%\ Reduction\ of\ parking\ supply\ from\ minimum\ required\ by\ municipal\ or\ ITE\ code \times 0.5$$

1.2.4.2 PK 02 Provide Bike Facilities

This strategy requires the project developer to provide and maintain facilities for bicycle users at the project site. Providing end of trip facilities encourages people to bike instead of drive, thereby reducing VMT. Examples of end of trip facilities include bike parking, bicycle lockers, showers, and personal lockers. The extent of the VMT reduction is based on whether the project provides only secure bike parking or secure bike parking and additional facilities. This strategy applies to employment land uses only and overlaps with the TP 05 Commute Trip Reduction Program strategy.

The VMT reduction for this strategy is based on evidence from a study that examined the effects of bicycle infrastructure on the probability of cycling to work using a multivariable regression analysis of 2010 travel survey data collected by the Metropolitan Washington Council of

[11] Nelson\Nygaard. 2005. *Crediting Low-Traffic Developments: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS.*

Governments.[12] From a final sample of 4,711 households, the study determined that employees are 1.78 times more likely to commute by bicycle when secure bicycle parking is provided than when it is not, and that employees are 4.86 times more likely to commute by bicycle when bicycle parking and additional end of trip facilities are provided than when they are not. These odds ratios are multiplied by the existing bicycle mode share of the TAZ or half-mile buffer around a parcel to determine the new bicycle mode share for the TAZ or parcel buffer.

The shift from vehicle trips to bicycle trips is expected to occur for vehicle trips that are of bikeable length. Thus, the actual VMT reduction is prorated by the ratio of the average bicycle trip length to the average vehicle trip length. Average trip lengths are derived from California Household Travel Survey (CHTS) data.

$$\%\, VMT\ Reduction = \frac{(\%\ change\ in\ bike\ mode\ share \times average\ trip\ length\ by\ bicycle)}{(vehicle\ mode\ share\ for\ TAZ \times average\ trip\ length\ by\ vehicle)}$$

[12] Buehler, R. 2012. Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work. *Transportation Research Part D, 17*: 525-531.

Table 4. Parking Strategy Elasticities and Reductions

Strategy ID	Strategy	Development Input	Type of Elasticity or Reduction	Neighborhood Place Type						
				Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
PK 01	Limit Parking Supply	Total Employee Parking Spaces	Maximum VMT / worker reduction	-12.5%	-12.5%	-12.5%	-12.5%	-12.5%	-12.5%	-12.5%
PK 02	Provide Bike Facilities	Binary Answer	bicycle commuters when bicycle parking is available / bicycle commuters when bicycle parking is not available	1.78	1.78	1.78	1.78	1.78	1.78	1.78
			bicycle commuters when bicycle end trip facilities are available / bicycle commuters when bicycle end trip facilities are not available	4.86	4.86	4.86	4.86	4.86	4.86	4.86

Note:
1. Elasticities are expressed as a decimal less than 1 while reductions are expressed as a percentage or a constant.

1.2.5 Tier 4: TDM Programs

Included in this category are programmatic strategies that reduce VMT by providing alternatives to driving alone, as well as incentives, such as ride sharing programs, transit subsidies, and shuttle services. These strategies would be implemented on an ongoing basis once the project is occupied. Reductions and elasticities for the 18 strategies are in **Table 6**.

1.2.5.1 TP 01 School Pool Programs

The strategy would require the organization of a program that matches families in carpools for school pick-up and drop-off. The program would be open to all families in the development. Organizing a School Pool Program helps match parents who transport students to schools without a bussing program, including private schools, charter schools, and neighborhood schools where students cannot walk or bike. School pools reduce the total number of vehicle trips traveling to and from schools, thereby reducing VMT. This strategy is supported by evidence from 2012 California Household Travel Survey where 2.3% of the home-based VMT is generated by home-based K-12 school trips. According to American Community Survey (ACS 2017), about 27.85% of the households have kids in K-12 school.

$$\%\,VMT\ Reduction = 8.25\% \times \%\ of\ households\ expected\ to\ participate$$

1.2.5.2 TP 02 Bike Sharing Programs

This strategy requires the project developer to dedicate space for or provide subsidies to a bike sharing system, ideally one with high penetration in a larger area, such as Bay Wheels. Bike share substitutes for some driving trips and provides a first/last-mile connection for transit users, reducing auto trips and thereby reducing VMT. This reduction only applies if a bike share station is eventually built on site. This strategy applies to residential and employment land uses.

This strategy is supported by a study that reported the effects of a pilot bicycle share system on bicycle usage in London.[13] Online surveys of existing customers were used to assess mode shifts due to bike share use. The study reported that 6 percent of users shifted from driving to using bike share for work or school trips.

The shift from vehicle trips to bicycle trips is expected to occur for vehicle trips that are of bikeable length. Thus, the actual VMT reduction is prorated by the ratio of the average bicycle trip length to the average vehicle trip length. Average trip lengths are derived from California Household Travel Survey (CHTS) data.

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[13] Noland, R.B., and Ishaque, M.M. 2006. Smart bicycles in an urban area: Evaluation of a pilot scheme in London. *J. Public Transportation. 9* (5), 71–95.

$$\% \, VMT \, Reduction = \frac{(-6\% \, change \, in \, bike \, mode \, share \times average \, trip \, length \, by \, bicycle)}{(vehicle \, mode \, share \, for \, TAZ \times average \, trip \, length \, by \, vehicle)}$$

1.2.5.3 TP 03 Car Sharing Programs

The strategy requires the project to provide subsidies and promotions, as well as dedicated parking spaces, for car sharing services such as ZipCar, Car2Go, and/or GetAround. Supporting a car sharing program allows people to have on-demand access to a shared fleet of vehicles. Car sharing helps support the use of walking, biking, carpooling, and transit by providing access to vehicles for occasional trips and a guaranteed ride home option, allowing for overall reductions in auto use which results in reduced VMT. This strategy applies to residential and employment land uses.

Evidence supporting this strategy is from a study that examined the impact of car sharing on household VMT in the Bay Area.[14] Travel diary surveys were collected from 527 members and 45 non-members at five points between 2001 and 2005. Members reported reducing their household VMT by 32.8 percent. The expected participation rate of 2 percent is derived from report by UCLA documenting commuting characteristics of faculty, staff, and students.[15]

$$\% \, VMT \, Reduction = 32.8\% \times \% \, expected \, participation \times \% \, eligible \, residents/employees$$

1.2.5.4 TP 04 Commute Trip Reduction (CTR) Marketing and Education

This strategy requires implementing a marketing campaign, targeting all project employees and visitors, that encourages the use of transit, shared rides, and active modes and thereby reducing VMT. Marketing strategies may include new employee orientation on alternative commute options, event promotions, and publications. The strategy applies to employment land uses only. This strategy overlaps with the TP 05 Implement Commute Trip Reduction Program and TP 18 Voluntary Travel Behavior Change Program strategies.

The strategy is based on a study that synthesizes evidence from four studies on the link between TDM strategies and travel behavior.[16] The study documents 82 case studies of employer and institutional TDM programs from different locations in the US. Programs that primarily offered commute trip reduction marketing/education yielded an average 4 percent reduction of commute vehicle trips. This strategy assumes a 1:1 ratio of vehicle trips to vehicle miles traveled.

$$\% \, VMT \, Reduction = 4\% \times 1(vehicle \, trip \, to \, VMT \, ratio) \times \% \, employees \, eligible$$

[14] Cervero, R., Golub, A., and Nee, B. 2007. City CarShare: Longer-term travel demand and car ownership impacts. *Transportation Research Record, 1992:* 70-80.
[15] UCLA Transportation. *2011 State of the Commute Report.*
[16] Transit Cooperative Research Program. 2010. *TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies.*

1.2.5.5 TP 05 Implement Commute Trip Reduction (CTR) Program

This strategy requires providing a comprehensive program to reduce the number of drive-alone commute trips to the project and to actively monitor and react to changes in mode share. The program includes encouraging and assisting employees to use an alternative commute mode. Tools may include carpooling encouragement, ride share assistance, flexible/alternative work schedules, vanpool assistance, bicycle end of trip facilities, and other measures. The strategy applies to employment land uses only. This strategy overlaps with the PK02 Provide Bike Facilities, TP04 Commute Trip Reduction Marketing and Education, TP08 Telecommuting and Alternative Work Schedules, TP13 Ride-Sharing Programs, TP15 Behavioral Intervention, TP17 Vanpool Incentives, and TP18 Voluntary Travel Behavior Change Program strategies.

The strategy's evidence is from research that used a multivariable model to estimate the effects of TDM measures on VMT for various neighborhood place types.[17] VMT reductions by neighborhood place type are shown in **Table 6**.

$$\%\,VMT\ Reduction = reduction\ of\ commute\ vehicle\ miles\ by\ place\ type \times \%\ employees\ eligible$$

1.2.5.6 TP 06 Employee Parking Cash-Out

This strategy requires project employers to offer employee parking "cash-out," which gives employees the choice to forgo subsidized/free parking for a cash payment equivalent to the cost that the employer would otherwise pay for the parking space. Providing an alternative to subsidized/free parking encourages commuters to travel via walking, biking, carpooling, and transit, thereby reducing VMT. This strategy applies to employment land uses only and overlaps with the TP10 Price Workplace Parking strategy.

The strategy is supported by a study that used a multivariable model to estimate the effects of TDM measures, such as providing a parking "cash-out," on VMT for various neighborhood place types.[18] The strategy is less effective in suburban and low transit neighborhood place types than in urban and high transit neighborhood place types. The VMT reductions by neighborhood place type are shown in **Table 6**.

$$\%\,VMT\ Reduction = \%\ reduction\ of\ commute\ VMT\ by\ place\ type \times \%\ employees\ eligible$$

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[17] Cambridge Systematics. 2009. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions – Technical Appendices.* Prepared for the Urban Land Institute.

[18] Cambridge Systematics. 2009. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions – Technical Appendices.* Prepared for the Urban Land Institute.

1.2.5.7 TP 07 Subsidized Transit Program

This strategy requires project employers or building operators to provide either partially or fully subsidized transit passes for all project affiliates (employees and/or residents). Providing subsidies for transit use encourages people to use transit rather than driving, thereby reducing VMT.

The VMT reduction for this strategy is based on a study that synthesizes five studies documenting the effects of transit service strategies on transit ridership.[19]

$$\%\,VMT\ Reduction = \frac{\%\,vehicle\ mode\ share}{1 - \%\,transit\ mode\ share} \times 0.43 \times \%\,fare\ subsidy \times \%\,transit\ mode\ share$$

1.2.5.8 TP 08 Telecommuting and Alternative Work Schedules

This strategy requires project employers to allow and encourage employees to telecommute from home when possible, or to shift work schedules such that travel occurs outside of peak congestion periods. This strategy reduces commute trips, thereby reducing VMT. This strategy applies to employment land uses only and overlaps with the TP05 Implement Commute Trip Reduction Program strategy.

The VMT reduction for this strategy is based on a study that uses a multivariable model that provides the effects of specific TDM measures on VMT.[20] VMT reductions are quantified for telecommuting 1.5 days a week, a 9/80 schedule, and a 4/40 schedule. The VMT reductions for the different telecommuting and alternative work schedule approaches are shown in **Table 6**.

$$\%\,VMT\ Reduction = reduction\ based\ on\ type\ of\ alternative\ schedule \times \%\,employees\ eligible$$

1.2.5.9 TP 09 Free Door-to-Door Transit Fleet

This strategy requires project employers to provide direct shuttle service to the project site from areas with high concentrations of employees. This strategy reduces drive-alone commute trips, thereby reducing VMT. This strategy applies to employment land uses only and overlaps with the TP13 Ride-Sharing Program and TP17 Vanpool Incentives strategies.

The VMT reduction for this strategy is based on a study from San Francisco Municipal Transportation Agency (SFMTA).[21] The commuter Shuttle Pilot Program Evaluation Report reported that 47 percent of users would have driven if the shuttle were not available. The evidence is used to estimate the shift from vehicle commuting to shuttle commuting, thereby

[19] Handy, Susan et al. 2013. Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions. California Air Resources Board and the California Environmental Protection Agency.
[20] Cambridge Systematics. 2009. Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions – Technical Appendices. Prepared for the Urban Land Institute.
[21] SFMTA. 2015. Commuter Shuttle Pilot Program Evaluation Report.

reducing vehicle commute trips. Assuming a one-to-one adjustment factor for commuter trips to commute miles the operating shuttle service could achieve about 47% reduction in commute VMT.

$$\%\,VMT\ Reduction = 47\% \times \%\ participating\ employees$$

1.2.5.10 TP 10 Price Workplace Parking

This strategy would require commuters to pay for parking on-site. This strategy provides a disincentive to driving and encourages commuters to use other modes, thereby reducing VMT. The strategy applies to employment land uses only and overlaps with the TP 06 Employee Parking Cash-Out strategy.

The VMT reduction for this strategy is based on a study that used a multivariable model to determine the effects of TDM measures on VMT, and on a synthesis of research documenting the effects of annual vehicle costs on VMT.[22,23] Pricing on-site workplace parking contributes to annual vehicle operating costs, which reduces driving and thus reduces VMT. The parking charges documented in the research have been updated to 2017 dollars. **Table 5** documents the VMT reductions by neighborhood place type and parking charge. Users should select the daily parking fee closest to the per-day cost to commuters, whether it is paid on a daily, monthly, or annual basis.

$$\%\,VMT\ Reduction = \%\ reduction\ from\ Table\ 5\ \times\ \%\ employees\ subject\ to\ priced\ parking$$

[22] Cambridge Systematics. 2009. Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions – Technical Appendices. Prepared for the Urban Land Institute.

[23] Todd Litman. 2017. *Understanding Transport Demands and Elasticities*. Victoria Transport Policy Institute (VTPI). http://www.vtpi.org/elasticities.pdf. Accessed July 2017.

Table 5. VMT Reduction by Daily Parking Fee and Neighborhood Place Type

Daily Parking Fee	Place Type						
	Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
$1.14	6.9%	6.9%	0.9%	0.9%	0.9%	0.9%	0.9%
$2.28	12.5%	12.5%	1.9%	1.9%	1.9%	1.9%	1.9%
$3.42	16.8%	16.8%	2.7%	2.7%	2.7%	2.7%	2.7%
$4.56	17.8%	17.8%	3.0%	3.0%	3.0%	3.0%	3.0%
$5.70	18.8%	18.8%	3.2%	3.2%	3.2%	3.2%	3.2%
$6.85	19.8%	19.8%	3.5%	3.5%	3.5%	3.5%	3.5%

1.2.5.11 TP 11 Alternative Transportation Benefits

This strategy requires the project employers to provide general commute benefits to employees, which may include financial subsidies or pre-tax deductions for transit, carpooling, and vanpooling activities.

The strategy's evidence is from a study that contains several case studies on the influence of commuter benefits on employee travel.[24] The one most fitting for this category is that travel impacts are affected by the magnitude of the benefit and the quality of travel options available. Mode shifts tend to be greatest if current transit use is low. In New York City, where transit commute rates are already high, transit benefits only increased transit use 16% to 23%, while in Philadelphia, transit commuting increased 32% (Schwenk, 1995). Similarly, only 30% of employees who received transit benefits who work in San Francisco increased their transit use, while 44% of those in other parts of the region commuted by transit more (Oram Associates, 1995). The 44% figure was used in the SGVCOG VMT Evaluation Tool and an assumption was made of a one-to-one relationship between increased transit use and reduced commute VMT.

$$\%\,VMT\ Reduction = 44\%\ reduction\ in\ commute\ VMT \times \%\ of\ employees\ eligible\ for\ benefits$$

1.2.5.12 TP 12 Neighborhood Schools

This strategy requires the project to contribute to the development of a neighborhood school that would serve families living in the development. Neighborhood schools primarily serve the neighborhoods immediately surrounding the school and allow students to walk or bike to school,

[24] Litman, Todd. 2017. *Understanding Transport Demands and Elasticities.* Victoria Transport Policy Institute (VTPI). http://www.vtpi.org/elasticities.pdf. Accessed July 2017.

reducing the use of automobiles for drop-off and pick-up trips and thereby reducing VMT. This strategy applies to residential land uses only.

The strategy's evidence is from a study that investigated the effects of school choice on walkability and mode choice for schools in St. Paul, Minnesota.[25] The study reported a 78 percent decrease in vehicle miles traveled by households traveling to a neighborhood school compared to a citywide school. This reduction only affects home-based school VMT, which makes up 2.3% of all home-based VMT per the California Household Travel Survey. The decrease in VMT is estimated by multiplying the decrease in VMT for school trips by the share of home-based VMT made up by school trips and by the user's estimate of total households with school-aged children in the project.

$$\%\,VMT\ reduction = 77.7\% \times 2.3\% \times percent\ of\ households\ with\ school\ aged\ children\ living\ in\ project$$

1.2.5.13 TP 13 Ride-Sharing Programs

This strategy would require project employers or building operators to organize a carpool matching program for individuals who have similar commute patterns. This strategy encourages the use of carpooling, reducing the number of vehicle trips and thereby reducing VMT. The strategy applies to employment land uses only. This strategy overlaps with three strategies: TP05 Implement Commute Trip Reduction Program, TP09 Free Door-to-Door Transit Fleet, and TP17 Vanpool Incentives.

The effect of ride-sharing programs on VMT is derived from a study by United States Environmental Protection Agency.[26] The study found that ride-sharing programs had an average occupancy of 2.2 people per car and could achieve a 54.5% VMT reduction. This assumed reduction is multiplied by the expected participation rate, which typically ranges between 2% and 10%.

$$\%\,VMT\ Reduction = 54.5\%\ reduction\ in\ commute\ VMT \times expected\ participation\ rate$$

1.2.5.14 TP 14 Transit Service Expansion

This strategy requires the project developer to subsidize transit service through fees and other contributions to the transit provider, thereby improving transit service to the project, resulting in increased use of transit and reduced VMT. The VMT reduction is based on the contribution's effect on transit frequency and the number of routes affected by the contribution. This strategy

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[25] Wilson, Elizabeth J., Ryan Wilson, and Kevin J. Krizek. 2007. "The Implications of School Choice on Travel Behavior and Environmental Emissions." *Transportation Research Part D: Transport and Environment. 12.7*: 506-518.

[26] United States Environmental Protection Agency. 2005. Implementing Commuter Benefits as One of the Nation's Best Workplaces for Commuters.

differs from TP07 Subsidized or Discounted Transit Program in that subsidies are provided to the public transit agency, not to transit riders. This strategy applies to both residential and employment land uses. Proposed changes to transit service should be negotiated with the Lead Agency and the applicable transit operator.

A synthesis of research documenting the effects of transit service strategies on transit ridership and VMT found that a 1 percent increase in service frequency leads to a ridership increase of 0.5 percent.[27] The user-input change in transit frequency is multiplied by this elasticity, and the route contribution proxy.

The route contribution proxy is an adjustment factor to account for the share of transit ridership increases that reflect ridership shifting from other lines. It is determined by the percentage of routes affected by the improvement. If less than half are affected, 50 percent of riders are assumed to come from other lines. If more than half are affected, 15 percent are assumed to come from other lines.[25]

The resulting increase in ridership is multiplied by the existing transit mode share for the TAZ or half-mile buffer around the parcel and an adjustment factor prorating VMT to transit trips (0.67)[28] to yield the percent VMT reduction.

$$\%\,VMT\ Reduction = 0.5 \times 0.67 \times \%\,change\ in\ frequency \times route\ contribution\ proxy \times existing\ transit\ mode\ share$$

$$Route\ Contribution\ Proxy = 50\%\ (when\ less\ than\ 50\%\ of\ the\ routes\ are\ improved);\quad 85\%\ (when\ more\ than\ or\ equal\ to\ 50\%\ of\ the\ routes\ are\ improved)$$

1.2.5.15 TP 15 Behavioral Intervention

This strategy requires project to provide intensive one-on-one counseling and encouragement, along with subsidies, to encourage individuals to use non-drive alone modes. Implementing this program encourages the use of transit, shared ride modes, bicycling, walking, and telecommuting, reducing drive-alone trips and thereby reducing VMT. This strategy applies to residential and employment land uses. This strategy overlaps with TP04 Commute Trip Reduction Marketing and Education, TP05 Implement Commute Trip Reduction Program, and TP18 Voluntary Travel Behavior Program.

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[27] Handy, Susan et al. 2013. Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions. California Air Resources Board and the California Environmental Protection Agency.

[28] California Air Pollution Control Officers Association (CAPCOA). 2010. Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhous Gas Mitigation Measures.

The strategy is based on the study that analyzed the effects of a targeted behavioral intervention treatment (UCLA Transportation Guide) on travel behavior of incoming graduate students in UCLA. The study included 3,166 admitted students, half of whom received the guide and half of whom where in the control group.[29] The treatment guide provides detailed information on how to use alternative modes of transportation to access campus. Students in the treatment group drove 23.6 miles per week on average compared to 33.6 miles for the control group, representing an approximately 30% decrease. The study noted that the treatment was only effective among students who moved within the past six months and was also only effective among students who have automobile resources.

$$\% \, VMT \; Reduction = 30\% \; reduction \; \times percent \; individuals \; participating/eligible$$

1.2.5.16 TP 16 Unbundle Parking Costs from Property Cost (On Site Parking)

The strategy requires project developers or building operators to unbundle the cost of parking spaces from the price of the property. Residents must rent or purchase parking spaces separately from their residential units. This increases the cost of auto ownership, thereby discouraging auto ownership and use, which reduces VMT. Surrounding streets must have parking restrictions in place, such as metered parking, time limits restricting overnight parking, and residential parking permits (RPP) for which project residents are not eligible. This strategy applies to residential land uses only.

The -0.4 elasticity of vehicle ownership with respect to vehicle costs is derived from a study that provides inferential support on the effect of vehicle costs on vehicle ownership.[30] Charging for parking separately increases the cost of vehicle ownership, which makes owning a car less attractive, thus reducing automobile use and VMT. The estimated reduction in vehicle ownership is estimated by multiplying the percent change in vehicle cost (based on monthly parking fees and the cost of vehicle ownership) by the elasticity of demand. The average base vehicle ownership cost is $8,849, as reported by the American Automobile Association in 2018.[31] Since reducing vehicle ownership does not eliminate driving or use of taxis and ride-hailing apps, the reduction in vehicle ownership is multiplied by 85 percent to produce the percent VMT reduction generated by this strategy.[32]

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[29] Brown, Anne, et al. 2016. The Right Time and Place to Change Travel Behavior: An Experimental Study.

[30] Litman, Todd. 2009. Parking Requirement Impacts on Housing Affordability. Victoria Transport Policy Institute.

[31] American Automobile Association. August 2018. *Your Driving Costs*. http://newsroom.aaa.com/tag/driving-cost-per-mile/. Accessed October 2018.

[32] California Air Pollution Control Officers Association (CAPCOA). Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhous Gas Mitigation Measures. 2010

$$\% \, VMT\ Reduction = Change\ in\ vehicle\ cost \times elasticity \times A$$

$$Where: Change\ in\ vehicle\ cost\ =\ (monthly\ parking\ cost)/((\$8{,}849/12))$$

$$A\ =\ Adjustment\ from\ Vehicle\ Ownership\ to\ VMT\ =\ 0.85$$

1.2.5.17 TP 17 Vanpool Incentives

The strategy requires project employers or building operators to provide subsidies for individuals forming new vanpools for their commute. This encourages the use of vanpools, reducing drive-alone trips and thereby reducing VMT. This strategy applies to employment land uses only. This strategy overlaps with the TP05 Implement Commute Trip Reduction Program, TP09 Free Door-to-Door Transit Fleet, and TP13 Ride-Sharing Program strategies.

The strategy's evidence is from a study that used 1999 survey data from the Commute Trip Reduction Program of the Puget Sound region to analyze the relationship of demand for vanpool services to fare changes using a conditional discrete choice model.[33] The study found a -0.73 elasticity of vanpool demand in response to a change in fares (or costs to driver). This elasticity is multiplied by the percent reduction in vanpool fare as well as the percent of employees who are expected to participate in vanpooling, An adjustment factor of 82.1% is applied to adjust the vanpool demand to VMT, reflecting an average occupancy of 5.6 commuters per vanpool including the driver.[34]

$$\% \, VMT\ Reduction = elasticity\ \times \% \, reduction\ of\ vanpool\ fare \times\ 82.1\% \times \% \, employees\ expected\ to\ participate$$

[33] Concas, S. Winters, F. 2005. Fare Pricing Elasticity, Subsidies and The Demand for Vanpool Services. Via Victoria Transport Policy Institute. *Online TDM Encyclopedia.* http://www.vtpi.org/tdm/. Accessed July 2017.
[34] Way to Go program Annual Report, Denver Regional Council of Governments, 2015.

1.2.5.18 TP 18 Voluntary Travel Behavior Change Program

This strategy requires project employers or building operators to administer a program that targets individual attitudes and behaviors towards travel and provides tools for individuals to analyze and alter their travel behavior. Voluntary Travel Behavior Change programs include communication campaigns, marketing and promotions, and travel feedback programs, such as travel diaries or feedback on calories burned from activities and travel. This strategy encourages the use of shared ride modes, transit, walking, and biking, thereby reducing VMT. This strategy applies to residential and employment land uses. This strategy overlaps with the TP04 Commute Trip Reduction Marketing/Education, TP05 Implement Commute Trip Reduction Program, and TP15 Behavioral Intervention strategies.

The VMT reduction is based on a synthesis of research that reviewed five studies reporting the impact of Voluntary Travel Behavior Change programs on VMT.[35] A 4% reduction in VMT, which represents a lower-end figure from the range of VMT reductions among the United States examples in the study, is used in the calculation for this strategy.

$$\%\, VMT\ Reduction = 4\% \times \%\ of\ residents\ or\ employees\ expected\ to\ participate$$

[35] Spears, Steven et al. 2013. Policy Brief on the Impacts of Voluntary Travel Behavior Change Programs Based on a Review of the Empirical Literature. California Air Resources Board and the California Environmental Protection Agency.

Table 6. TDM Program Strategy Elasticities and Reductions

Strategy ID	Strategy	Development Input	Type of Elasticity or Reduction[1]	Neighborhood Place Type						
				Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
TP 01	School Pool Programs	Binary Input	VMT / participating household	-8.25%	-8.25%	-8.25%	-8.25%	-8.25%	-8.25%	-8.25%
TP 02	Bike Sharing Programs	Binary Input	Percent change in bicycle trips	-6%	-6%	-6%	-6%	-6%	-6%	-6%
TP 03	Car Sharing Programs	Percent of eligible residents or employees	VMT / member	-32.8%	-32.8%	-32.8%	-32.8%	-32.8%	-32.8%	-32.8%
TP 04	Commute Trip Reduction (CTR) Marketing and Education	Percent of eligible employees	VMT / worker	-4%	-4%	-4%	-4%	-4%	-4%	-4%
TP 05	Implement Commute Trip Reduction Program	Percent of eligible employees	VMT / worker	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%
TP 06	Employee Parking Cash-Out	Percent of eligible employees	VMT / worker	7.7%	7.7%	3.7%	3.7%	3.7%	3.7%	3.7%
TP 07	Subsidized Transit Program	Percent of Transit Subsidy	VMT / worker	-43%	-43%	-43%	-43%	-43%	-43%	-43%
TP 08	Telecommuting and Alternative Work Schedules	Alternative Work Schedule and Percent of eligible employees	VMT / worker	Telecommuting 1.5 days per week: -0.22 4/40 schedule: -0.15 9/80 schedule: -0.07						
TP 09	Free Door-to-Door Transit Fleet	Percent of eligible employees	VMT / worker	47%	47%	47%	47%	47%	47%	47%

Strategy ID	Strategy	Development Input	Type of Elasticity or Reduction[1]	Neighborhood Place Type						
				Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
TP 10	Price Workplace Parking	Percent of eligible employees and parking fee	VMT / worker	Varies based on price of parking. See strategy method, Table 5.						
TP 11	Alternative Transportation Benefits	Percent of reduction in commute VMT Percent of eligible employees	VMT / worker	44%	44%	44%	44%	44%	44%	44%
TP 12	Neighborhood Schools	Type of school serving project and percent of households with school aged children	VMT / household	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%
TP 13	Ride-Sharing Programs	Percent of eligible employees	VMT / worker	54.5%	54.5%	54.5%	54.5%	54.5%	54.5%	54.5%
TP 14	Transit Service Expansion	Percent of increase in transit frequency and Percent of routes affected by upgrade	% change in transit ridership / % change in frequency	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TP 15	Behavioral Intervention	Percent individuals participating / eligible	VMT / worker	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Strategy ID	Strategy	Development Input	Type of Elasticity or Reduction[1]	Neighborhood Place Type						
				Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
TP 16	Unbundle Parking Costs from Property Cost (On Site Parking)	Monthly Parking Costs	% change in vehicle ownership / % change in annual vehicle cost	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
TP 17	Vanpool Incentives	Percent of employer subsidized vanpool costs and percent of eligible employees	% change in vanpool demand / % change in vanpool costs	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73
TP 18	Voluntary Travel Behavior Change Program	Percent of eligible employees	VMT / worker	4%	4%	4%	4%	4%	4%	4%

Note:
1. Elasticities are expressed as a decimal less than 1 while reductions are expressed as a percentage or a constant.

1.2.6 Category, Cross Category, and Global Maxima

To provide reasonable estimates of VMT reduction effectiveness, maximum VMT reductions are set for the category, cross-category, and global levels. These maxima ensure that 1) strategies that target travel behavior in similar ways are not over-counted and 2) combined reductions are reasonable given a project's context (neighborhood place type). The maxima applied in the SGVCOG VMT Evaluation Tool are derived from the 2010 CAPCOA Quantifying Greenhouse Gas Mitigation Measures report.[36]

1.2.6.1 Category Maxima

Each category has a maximum allowable per capita VMT or per worker VMT reduction for the combination of measures in the category. The maxima vary depending on the project's neighborhood place type. (Neighborhood place type definitions and assignments to specific parcels are informed by research, as summarized in Section 1.1 and **Table 1**.)

The effects of multiple measures within a category are combined using multiplicative dampening, which reduces the effect of individual strategies as new strategies are added. Since multiple measures may affect the same user populations, this approach is used to ensure that reductions are not over-counted. For example, a transit-related measure and a bicycle-related measure may target the same person, but that person cannot switch from driving to both using transit and bicycling. As a result, the overall per capita VMT that can be affected by added strategies is lower than for any strategy implemented on its own. The equation for multiplicative dampening is shown below:

$$Combined\ Reduction\ within\ a\ Category = 1 - \prod_{i=1}^{K}(1 - Reduction_i)$$

$$where\ \ Reduction_i = \ Per\ Capita\ VMT\ Reduction\ for\ Measure\ i\ in\ the\ Category$$

Per capita and per worker VMT reductions should be multiplied using the above multiplicative dampening equation across all mitigation measures in that category up to the maxima shown in **Table 7**.

[36] California Air Pollution Control Officers Association (CAPCOA). Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures. 2010.

Table 7. Project Characteristics Maxima

Category	Neighborhood Place Type						
	Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
Project Characteristics	65%	30%	30%	10%	10%	10%	10%
Multimodal Infrastructure	15%	15%	15%	15%	15%	15%	15%
Parking	20%	20%	20%	20%	20%	20%	20%
Program	25%	25%	25%	25%	25%	25%	25%

1.2.6.2 Physical Cross-Category Maxima

A cross-category maximum is provided for the combination of project characteristics, multimodal infrastructure, and parking strategies. Like the method used for the category maxima, the effect of multiple categories is combined using multiplicative dampening to ensure that reductions are not over-counted.

$$Combined\ Reduction\ of\ All\ Physical\ Measures = 1 - \prod_{i=1}^{K}(1 - Reduction_i)$$
$$where\ \ Reduction_i = \ Per\ Capita\ VMT\ Reduction\ for\ Category\ i$$

The development's per capita VMT and per worker VMT reduction across these three categories should be capped at the levels shown in **Table 8**.

Table 8. Physical Cross-Category Maxima

Cross-Category Maximum	Neighborhood Place Type						
	Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
Per Capita / Employee VMT Reduction	70%	35%	35%	15%	15%	15%	15%

1.2.6.3 Programmatic Cross-Category Maxima

For the programmatic measures, per capita and per employment VMT reductions are capped to a 25 percent maximum.

1.2.6.4 Global Maxima

Across physical and programmatic categories, per capita and per worker VMT reductions are capped to maxima based on neighborhood place type, as shown in **Table 9**. Like the category maximums, the physical and programmatic categories are combined using multiplicative dampening to ensure reductions are not double counted. The reductions are calculated as noted below.

$$Combined\ Reduction\ of\ All\ Categories = 1 - \prod_{i=1}^{K}(1 - Reduction_i)$$

Table 9. Global Maxima

Cross-Category Maximum	Neighborhood Place Type						
	Central City Urban	Urban High Transit	Urban Low Transit	Suburb w/ Multifamily Housing	Suburb w/ Single Family Homes	Rural in Urbanized Area	Rural
Per Capita / Employee VMT Reduction	75%	40%	40%	20%	20%	20%	20%

2. VMT Reduction Strategies Dependencies

As noted in the descriptions of the individual VMT reduction strategies in Section 1.2, a number of reduction strategies overlap with each other. For instance, a strategy may consist of a basket of measures which may overlap with some of the measures in another strategy. Therefore, the SGVCOG VMT Evaluation Tool logic has been coded to reflect these dependencies, so that if one measure is chosen, other overlapping measures are not allowed. The dependencies in the tool are summarized below and are shown in the SGVCOG VMT Evaluation Tool by greying out certain reductions so that they cannot be selected.

If this strategy is chosen…	This strategy is not allowed…
PK 02 Provide Bike Facilities	• TP 05 Implement CTR Program
TP 04 CTR Marketing and Education	• TP 05 Implement CTR Program • TP 15 Travel behavior Change • TP 18 Voluntary Travel Behavior Change Program
TP 05 Implement CTR Program	• PK 02 Provide Bike Facilities • TP 04 CTR Marketing and Education • TP 08 Telecommuting and Alternative Work Schedules • TP 13 Ride-Sharing Programs • TP 15 Behavioral Intervention • TP 17 Vanpool Incentives • TP 18 Voluntary Travel Behavior Change Program
TP 06 Employee Parking Cash-Out	• TP 10 Price Workplace Parking
TP 07 Subsidized Transit Program	• TP 11 Alternative Transportation Benefits
TP 08 Telecommuting and Alternative Work Schedules	• TP 05 Implement CTR Program
TP 09 Free Door-to-Door Transit Fleet	• TP 13 Ride-Sharing Programs • TP 17 Vanpool Incentives
TP 10 Price Workplace Parking	• TP 06 Employee Parking Cash-Out
TP 11 Alternative Transportation Benefits	• TP 07 Subsidized Transit Program

If this strategy is chosen…	This strategy is not allowed…
TP 13 Ride-Sharing Programs	• TP 05 Implement CTR Program • TP 09 Free Door-to-Door Transit Fleet • TP 17 Vanpool Incentives
TP 15 Behavioral Intervention	• TP 04 CTR Marketing and Education • TP 05 Implement CTR Program • TP 18 Voluntary Travel Behavior Change Program
TP 17 Vanpool Incentives	• TP 05 Implement CTR Program • TP 09 Free Door-to-Door Transit Fleet • TP 13 Ride-Sharing Programs
TP 18 Voluntary Travel Behavior Change Program	• TP 04 CTR Marketing and Education • TP 05 Implement CTR Program • TP 15 Behavioral Intervention