TRANSPORTATION IMPACT ANALYSIS GUIDELINES

APPENDIX L
VEHICLE MILES TRAVELED (VMT)/ INDUCED AUTOMOBILE TRAVEL

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Appendix L
Vehicle Miles Traveled/Induced Automobile Travel Memorandum

Date:	February 14, 2019
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RE:	**Transportation Impact Analysis Guidelines Update, Vehicle Miles Traveled/Induced Automobile Travel**

INTRODUCTION

The prior Transportation Impact Analysis Guidelines did not include the Vehicle Miles Traveled (VMT) topic. VMT is a measure of the amount and distance of vehicle travel attributable to a project, including induced automobile travel. On March 3, 2016, the San Francisco Planning Commission adopted a resolution to modify the environmental review process by removing automobile delay, as described solely by level of service or similar measures of vehicular capacity or traffic congestion, as a significant impact on the environmental pursuant to the California Environmental Quality Act and replacing it with VMT criteria.[1]

This memorandum provides guidance on the VMT topic. The department prepared this memorandum in consultation with stakeholders (e.g., city and county agencies, consultants). The department will issue memoranda that provide updates to other topics (e.g., transit, loading) within the guidelines. When the department issues a memorandum about a topic, it will supersede existing guidance regarding that topic.

This memorandum provides specific guidance on the methodology and impact analysis required for the VMT transportation topic. Overall guidance on conducting transportation analysis for environmental review, including developing the project description, how to address the significance criteria, methodology, and impact analysis, is in the guidelines.

The guidance provided herein assumes a land use development project located outside of an area plan that requires a transportation impact study. Guidance on other types of projects, such as projects located in an area plan or infrastructure projects, is discussed below under the "Other" subsection. The department may use this guidance for multiple projects, but the department has discretion on applying the guidance on a project by project basis.

[1] Planning Commission Resolution No. 19579, adopted March 3, 2016.

The organization of the memorandum is as follows:

1) Project Description
2) Significance Criteria
3) Existing and Existing plus Project
   a) Methodology
   b) Existing Baseline
   c) Impact Analysis
4) Cumulative
   a) Methodology
   b) Impact Analysis
5) Other (covers different types of projects)

Attachments are under separate cover. Attachment A includes a screening criteria checklist. If a project meets the screening criteria, then the project would not be subject to the contents within this memorandum. The department may update the attachments to the memoranda more frequently than the body of the memoranda.

PROJECT DESCRIPTION

Refer to the Transportation Impact Analysis Guidelines Appendix A, Tables 1-3, for a list of the typical physical, additional physical, and programmatic features for existing and existing plus project conditions, as applicable. The geographic extent of these features must, at a minimum, include the project's frontage and may include the entirety of the project's block. Appendix A, Table 4 of the guidelines provides a non-exhaustive list of approvals from agencies other than the planning department that a project sponsor may need to obtain for the project description features described in the guidelines.

SIGNIFICANCE CRITERIA

San Francisco Administrative Code chapter 31 directs the department to identify environmental effects of a project using as its base the environmental checklist form set forth in Appendix G of the California Environmental Quality Act (CEQA) Guidelines. As it relates to VMT, Appendix G states: "For a land use project, would the project conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?" The department uses the following significance criteria to evaluate that question: A project would have a significant impact if it:

1) Causes substantial additional vehicle miles traveled; or
2) Substantially induces additional automobile travel by increasing physical roadway capacity in congested areas (i.e. by adding new mixed flow travel lanes) or by adding new roadways to the network.

EXISTING AND EXISTING PLUS PROJECT

Methodology

This section describes the typical methodology required to address the significance criteria. The methodology section identifies the collection, generation, and approach to analyze data. The department will determine whether to adjust the methodology as necessary, to inform the analysis. General guidance on the typical methodology for a transportation analysis can be found in the guidelines. Specific direction on the appropriate geographical area and period of study for evaluating existing and existing plus project conditions for this topic, including data collection, is provided below. This section also indicates in bracketed text [ ] whether the presentation of typical methodological elements in other sections of a transportation study (e.g., baseline, impact analysis) could occur in text, a figure, and/or a table (see Appendix A of the guidelines for examples of typical tables).

Geography

The methodology will typically focus on the transportation analysis zone[2] that the project site is in or multiple transportation analysis zones if the project site is in more than one zone as well as the nine-county San Francisco Bay Area region.

Period

The methodology should typically reflect weekday daily VMT using an efficiency metric (e.g. VMT per capita or VMT per employee).

Existing Conditions

The following identifies the typical methodology for assessing existing conditions.

<u>VMT</u>

For most projects, use a travel demand model to estimate existing VMT. The travel demand model should, to the extent information is available, account for multiple variables that affect travel behavior and calibrate to reflect observed data. A travel demand model, the San Francisco County Transportation Authority's San Francisco Chained Activity Modeling Process (SF-CHAMP), accounts for many of these variables and the transportation authority calibrates the model to reflect observed data.[3] The travel demand model should, to the extent information is available, account for VMT associated with private automobiles and for-hire vehicles.

For residential-type projects, estimate existing daily household VMT. The estimate should use a tour-based analysis (i.e., the outputs account for the entire chain of trips to and from a home). Then divide the total daily household VMT by the applicable geographic area household population to estimate VMT per capita. [text, figure, table]

For office-type projects, the methodology must estimate existing daily work-related VMT. The estimate should use a tour-based analysis (i.e., an output that accounts for the entire chain of trips to and from a job, including intermediary trips going to and from the workplace). Then divide the total daily work-related VMT by the applicable geographic area job population to estimate VMT per office employee. [text, figure, table]

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[3] The California Household Travel Survey 2010-2012 is the most current available household travel survey for the San Francisco Bay Area. SF-CHAMP is updated periodically as new data becomes available.
[3] The California Household Travel Survey 2010-2012 is the most current available household travel survey for the San Francisco Bay Area. SF-CHAMP is updated periodically as new data becomes available.

For retail-type projects, estimate existing daily VMT. The estimate should use a trip-based analysis (i.e., the outputs account for trips to and from the project, not the chain) that allows apportioning of all retail related VMT to retail sites without double counting.[4] Then divide the total daily retail related VMT by the applicable geographic area retail job population to estimate VMT per retail employee.[5] [text, figure, table]

For mixed-use projects, estimate VMT for each the project land use type separately. For each applicable land use, present the appropriate existing VMT per employee or per capita for the project site transportation analysis zone(s) and region. The methodology must also present the existing regional VMT minus 15 percent. Refer to the definitions section of Attachment A for definitions of other land uses in relation to these three land uses.[6]

<u>Transit Proximity</u>

For most projects, identify if the existing site is within a half mile of an existing major transit stop.[7]

Existing plus Project Conditions

The following identifies the typical methodology for assessing existing plus project conditions.

<u>VMT</u>

Identify if the project site VMT is 15 percent below the regional VMT average for each applicable land use: residential, office, and retail. The department uses VMT efficiency metrics (per capita or per employee) for thresholds of significance. VMT per capita reductions mean that individuals will, on average, travel less by automobile than previously but, because the population will continue to grow, it may not mean an overall reduction in the number of miles driven.

<u>Transit Proximity</u>

For most projects, identify if the existing site is within a half mile of an existing major transit stop and if the project includes a floor area ratio greater than 0.75; includes parking less than or equal to the amount required or allowed by planning code, without a conditional use; and is consistent with the applicable Sustainable Communities Strategy.[8]

<u>Vehicular Parking Rate Comparison</u>

Most travel demand models do not directly account for vehicular parking supply in their VMT estimates. However, travel demand models may indirectly account for parking supply in their VMT estimates to the

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[4] To state another way: a tour-based assessment of VMT at a retail site would consider the VMT for all trips in the tour, for any tour with a stop at the retail site. If a single tour stops at two retail locations, for example, a coffee shop on the way to work and a restaurant on the way back home, then both retail locations would be allotted the total tour VMT. A trip-based approach allows the apportioning of all retail- related VMT to retail sites without double-counting.

[5] Regional travel demand models do not typically explicitly capture retail travel. Rather, they typically include a generic "Other" purpose which includes retail shopping, medical appointments, visiting friends or family, and all other non-work, non-school tours. For SF-CHAMP, the retail efficiency metric captures all of the "Other" purpose travel generated by Bay Area households. The denominator of employment (including retail; cultural, institutional, and educational; and medical employment; school enrollment, and number of households) represents the size, or attraction, of the zone for this type of “Other” purpose travel.

[6] Other land use projects mean a land use other than residential, retail, and office. OPR has not provided methodology for other types of land uses.

[7] CEQA section 21064.3 defines a major transit stop as a 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.

[8] The department considers a project inconsistent with the Sustainable Communities Strategy if the Sustainable Communities Strategy did not identify the project site in area contemplated for development.

extent the parking supply affects the travel behavior of people within different geographic locations. For projects with a substantial amount of parking,[9, 10] the methodology can address this indirect relationship. In these instances, include an estimate of the existing parking supply rate in the surrounding neighborhood (e.g., neighborhood parking rate) in comparison to the project's parking rate. Neighborhood parking rate[11] is the number of existing accessory parking spaces per 1,000 square feet of non-residential uses or the number of parking spaces per dwelling unit for residential uses for each transportation analysis zone within San Francisco. Alternatively, the methodology could estimate neighborhood parking rate using other methodologies the department identified in the Parking memorandum.

<u>Transportation Demand Management Measures</u>

Most travel demand models also do not directly account for other (i.e., besides parking) site-specific transportation demand management measures, that are applicable to the project, in their VMT estimates. If the project site VMT is not 15 percent below the regional VMT average for each applicable land use and the projects includes a substantial amount of parking that exceed the existing parking supply rate in the surrounding neighborhood (e.g., neighborhood parking rate), the methodology should, to the extent substantial evidence for transportation demand management measures' VMT reduction effectiveness is available, account for these transportation demand management measures being applied to the project by applying a percentage reduction to the VMT estimates derived using the above methodologies. For most transportation demand management measures, the percentage reduction would apply to the modal split calculation of the VMT analysis, while the vehicle occupancy and trip length would remain constant. If substantial evidence for transportation demand management measures is not available to quantify a percentage reduction, the methodology should qualitatively discuss whether the measures or other attributes of the project would reduce VMT per capita or employee.

Existing Baseline

Refer to the guidelines for direction on including existing baseline in transportation studies.

Impact Analysis

This section ties the project description, methodology, and existing baseline together to address the significance criteria for existing plus project conditions. This section addresses the typical approach for the impact analysis and provides more details related to VMT. The impact analysis section should present a format (text, figure, or table) consistent with earlier sections of this memorandum for easy comparison.

The impact analysis must address whether the project would create substantial VMT impacts. Refer to the guidelines for direction on what to consider when conducting the existing plus project impact analysis and how to present the findings.

Substantial VMT Impacts

The department uses the following quantitative thresholds of significance to address the substantial additional VMT significance criterion:

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[9] Refer to San Francisco Planning Commission, *Standards for the Transportation Demand Management Program*, August 4, 2016 or subsequent updates, for projects that meet this definition.

[10] Throughout this memo, the term "substantial amount" or "substantial number" is used but not defined. This is because what constitutes a substantial amount or number of people, vehicles, etc., depends on the context in which the project is being evaluated (e.g., existing conditions, proposed land uses, and other variables).

[11] The methodology should use the neighborhood parking rate most appropriate for the project proposed (i.e., residential or non-residential uses). This neighborhood parking rate may differ from that rate used in the city's transportation demand management program (planning code section 169).

- A residential-type project would exceed the existing city household VMT[12] per capita minus 15 percent and the existing regional household VMT per capita minus 15 percent
- An office-type project would exceed the existing regional VMT per employee minus 15 percent
- A retail-type project would exceed the existing regional VMT per retail employee minus 15 percent

The following examples are some of the circumstances which may result in substantial VMT impacts. This is not an exhaustive list of circumstances, under which, potential VMT impacts may occur:

- A project site is in a transportation analysis zone with average daily VMT per capita and/or employee greater than 15 percent below the regional average daily VMT per capita and/or employee and project characteristics (e.g., code compliant TDM) would not reduce VMT to 15 percent below the existing regional average daily VMT per capita and/or employee
- A project site is in a transportation analysis zone with average daily VMT per capita and/or employee at or less than 15 percent below the regional average daily VMT per capita and/or employee and project characteristics (e.g., project parking rate substantially higher than the neighborhood parking rate) would increase site level VMT to greater than 15 percent below the existing regional average daily VMT per capita and/or employee, even accounting for other project characteristics (e.g., code compliant TDM) that would reduce VMT

CUMULATIVE

Methodology

VMT by its nature is largely a cumulative impact. The number of trips and distances of these trips of past, present, and future projects might cause people to contribute to the physical environmental impacts associated with VMT. It is likely that no single project by itself would be sufficient in size to prevent the region or state in meeting its VMT reduction goals. Instead, a project's individual VMT contributes to cumulative VMT impacts. The department set existing plus project-level thresholds of significance for VMT based on levels at which the department does not anticipate new projects to conflict with state and regional long-term greenhouse gas emission reduction targets and statewide VMT per capita reduction targets.

The guidelines detail the typical methodology for cumulative analysis, including the geographical area, period, cumulative projects, and adjustments (refer to Appendix B) under cumulative conditions. Further direction on identifying reasonably foreseeable projects for this topic under cumulative conditions is provided below. The cumulative section only needs to expand upon the methodology section for existing and existing plus project to the extent the methodology differs. The department will determine the appropriate methodology as necessary to inform the impact determination. The cumulative section in transportation studies must present (text, figure, or table) the applicable elements included in the methodology.

Vehicular Parking Rate Comparison

[12] Governor's Office of Planning and Research, Revised Proposal on Updates to the CEQA Guidelines on Evaluating Transportation Impacts in CEQA, January 20, 2016recommends the city average as a possible threshold for areas where residential VMT is substantially higher than the regional average. Given San Francisco has lower residential VMT compared to the regional average, the department has chosen to use the regional average as the appropriate metric because the intent of the OPR Guidelines was not to disincentive developments that were located in proximity to major transit stops.

The methodology may require a list-based approach of cumulative projects (refer to the guidelines for a discussion of conducting a cumulative analysis using a list-based approach), as described above for projects that require a neighborhood parking rate comparison under existing plus project conditions analysis. The department has not projected neighborhood parking rate for cumulative conditions. To conduct a cumulative neighborhood parking rate comparison, the methodology should identify private development projects in the project site transportation analysis zone or adjacent transportation analysis zones actively undergoing environmental review, recently completed environmental review, or are anticipated to undertake environmental review in the near future with sufficient project definition. For these developments projects, the methodology should estimate the parking rate per residential unit and/or the parking rate per 1,000 square feet of non-residential use. Then, the methodology should qualitatively describe how existing neighborhood parking rate could change under cumulative conditions with development of the project in combination with these cumulative development projects. If the baseline neighborhood parking rate stays the same or goes down between existing and cumulative conditions, the project that is proposing parking greater than the neighborhood parking rate under existing plus project conditions would continue to have a parking rate higher than the neighborhood parking rate under cumulative conditions.

Impact Analysis

This section ties the methodology and description of cumulative conditions together to address the significance criteria for cumulative conditions. Refer to the guidelines for direction on what to consider when conducting the cumulative impact analysis and how to present the findings. The same examples of the types of circumstances that could result in a substantial VMT impact that were provided for existing plus project conditions apply here, except for cumulative conditions.

Substantial VMT Impacts

The impact analysis must address whether the cumulative projects would create substantial VMT impacts. The department uses the following thresholds of significance to address the substantial additional VMT significance criterion:

- The region would not meet its Sustainable Communities Strategy long-range greenhouse gas reduction goals or VMT reduction goals (if applicable)

If a cumulative impact would occur, the department uses the following quantitative thresholds of significance to address whether a project would contribute considerably to the substantial additional VMT significance criterion:

- A residential-type project would exceed the future city household VMT per capita minus 15 percent and the future regional household VMT per capita minus 15 percent
- An office-type project would exceed the future regional VMT per employee minus 15 percent
- A retail-type project would exceed the future regional VMT per retail employee minus 15 percent

The following examples are some of the circumstances which may result in substantial cumulatively considerable VMT impacts. This is not an exhaustive list of circumstances, under which, potential cumulatively considerable VMT impacts may occur:

- A project site is in a transportation analysis zone with future average daily VMT per capita and/or employee greater than 15 percent below the future regional average daily VMT per capita and/or employee and project characteristics (e.g., code compliant TDM) would not reduce VMT to 15 percent below the future regional average daily VMT per capita and/or employee
- A project site is in a transportation analysis zone with future average daily VMT per capita and/or employee at or less than 15 percent below the future regional average daily VMT per

capita and/or employee and project characteristics (e.g., project parking rate substantially higher than the neighborhood parking rate) would increase site level VMT to greater than 15 percent below the existing regional average daily VMT per capita and/or employee, even accounting for other project characteristics (e.g., code compliant TDM) that would reduce VMT

OTHER

The guidance provided in this memorandum assumes a land use development project located outside of an area plan that requires a transportation impact study. This section describes the type of additional or different information that may be necessary to address VMT impacts for the following circumstances: land use development project located within an area plan, an area plan, atypical trip generators, or infrastructure project (which may be located in a different county than San Francisco). In addition, this section describes the extent to which a code compliance analysis and/or a discussion of policy inconsistencies may be necessary.

Land Use Development Project Located within an Area Plan

For projects that are consistent with an area plan for which an environmental impact report (EIR) was certified, pursuant to CEQA guidelines section 15183, the assessment must limit its analysis to such conditions specified in that section. The guidelines provide direction on how to analyze a land use development project in an area plan and a list of area plan EIRs that have been certified as of February 2019.No mitigation and improvement measures from these abovementioned EIRS are related to VMT.

Area Plans

This section applies to area plans that include both land use (e.g. changes to existing zoning) and/or infrastructure changes (e.g. street redesign).

Project Description

Typically, the department conducts an analysis to estimate the amount of future growth and the infrastructure changes that could occur in the plan area as a result of its implementation. The department typically does not have all the project description details described herein. However, the project description may include policies that may relate to the methodology and impact analysis (e.g., off-street parking requirements). The department will determine the inclusion of programmatic features in the project description based on whether they are inherent project features, which may typically be considered, or whether they are actions related to project operations that are used to avoid a significant impact (e.g., funding mechanisms).

Methodology

The assessment will estimate daily VMT per appropriate efficiency metric associated with implementation of the area plan using the approach described in the Existing and Existing plus Project Methodology subsection. The methodology will estimate the appropriate efficiency metric using larger study geography such as transportation analysis zones in the plan area and the region.

Impact Analysis

If implementation of the area plan is consistent with the latest Sustainable Community Strategy (Plan Bay Area), then the area plan would not have a significant impact. Additionally, the analysis of VMT impacts should present daily VMT per efficiency metric for the plan area and region with and without implementation of the area plan. For example, the impact analysis will assess whether the area plan is located within an area contemplated for development in the latest Plan Bay Area and, if applicable, if its implementation leads to daily VMT per efficiency metric that is equal to or less than the VMT per efficiency metric reduction goal or projected for the plan area within the latest Plan Bay Area cumulative year land use forecast and transportation system changes and policies.

Atypical Trip Generators or Substantial Rezoning

This section applies to projects that would require rezoning outside of area plans[13], such that the development density allowed at a site would substantially increase, and the following non-exhaustive list of atypical trip generators: large event centers (e.g., museums, sports arenas, or public parking garage). For these projects, the assessment of the project description and significance criteria should be similar to Existing and Existing plus Project conditions identified herein.

Methodology

The methodology may typically require a different methodology than identified herein, including potentially requiring its own travel demand model run or VMT estimation based on sketch tools or other spreadsheet tools that estimate VMT based on land use and transportation characteristics. See Attachment B for examples of these sketch tools and spreadsheet tools. The methodology may identify, in order of preference, existing land uses and/or sources of data (e.g., surveys data, global positioning system user data) that are similar to the proposed atypical land use in San Francisco, the bay area, or California or nationally recognized transportation engineering materials. Based on that information, under both existing and existing plus project conditions, estimate to the extent applicable:

- The components of average daily VMT: trip generation, automobile modal split, vehicular occupancy, and automobile trip length
- Daily population or other relevant size variables such as employees, seats, size, rooms, etc.
- Average Daily VMT per appropriate efficiency metric using the relevant size variables above
- Change in total VMT of the site between existing and existing plus project

The methodology should also qualitatively describe the project in relation to the criteria set forth in California Senate Bill 743 (Public Resources Code Section 21099(b)(1)).[14] For example, qualitatively describe the project in relation to diverting existing trips, reducing existing trip lengths, or overall reduction in existing trips.

Impact Analysis

The department may rely on one or more criteria to determine project impacts, including but not limited to: VMT per efficiency metric quantitative thresholds of significance mentioned for typical land use projects; change in total VMT; and the criteria set forth in California Senate Bill 743.

Infrastructure Project

For infrastructure projects (e.g., new roads, bridge repair, sewer line, rail service, roadway modifications, etc.), the assessment of the project description, significance criteria, and impact analysis should be similar to private development projects. The analysis typically does not require trip generation analysis as infrastructure projects usually do not generate trips.[15] However, some infrastructure project may induce

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[13] On occasion, redevelopment of large areas within the city consisting of multi-structure, multi-phased development is proposed that is not within a formal plan area. These proposals often require rezoning in the form of special use districts or changes to zoning similar to the rezoning under an area plan. In terms of the project description, development for some aspects or phases may be well defined, while others may rely on consistency/conformance with associated design guidelines or performance standards.

[14] The criteria for determining the significance of transportation impacts for projects "shall promote the reduction of greenhouse gas emissions, the development of multimodal transportation networks, and a diversity of land uses."

[15] Governor's Office of Planning and Research, Revised Proposal on Updates to the CEQA Guidelines on Evaluating Transportation Impacts in CEQA, January 20, 2016.

trips, such as the addition of through lanes on existing or new highways or streets.[16] In addition, infrastructure projects may generate short-term trips due to construction workers and vehicles accessing the project site. See Attachment C for research regarding infrastructure projects and their effects on VMT (as well as other research).

Project Description

The department will determine the inclusion of programmatic features in the project description based on whether they are inherent project features, which may typically be considered, or whether they are actions related to project operations that are used to avoid a significant impact (e.g., funding mechanisms).

Methodology

Use the following methodology to assess a transportation project's impacts to VMT.

- Assess whether the proposed infrastructure project can be considered an active transportation, rightsizing, transit project or a minor transportation project (see the definitions section of Attachment A for definition of these projects) or a non-trip inducing infrastructure project (e.g. installation of sewer lines, water lines, or other utilities).
- If the transportation project is not considered an active transportation, rightsizing, transit project or a minor transportation project, in consultation with the planning department, qualitatively and/or quantitatively assess impacts as follows:
  - Qualitative: Consider whether the transportation project would result in lower automobile travel time thereby causing trip-making changes, changes in mode choice, route changes, or newly generated trips, that could increase vehicle travel.
  - Quantitative: Estimate VMT induced by the transportation project using approaches such as 1) simulating potential trip-making changes due the transportation project with a travel demand model, and 2) use an elasticity model to estimate the amount of induced vehicle travel resulting from the transportation project (e.g. additional lane mile of roadway capacity added). See Attachment D for guidance on quantitative analysis for transportation projects.

Impact Analysis

The analysis of VMT impacts should compare the project's estimated VMT to the department's quantitative threshold of significance. The department uses a threshold of significance of approximately 2 million VMT per year in order to meet the greenhouse gas emission reduction goal of 40 percent below 1990 levels by 2030 set forth in California Senate Bill 32.[17] A project that leads to an addition of more VMT than the threshold of significance may indicate a significant impact on VMT.

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[16] Generally, minor transportation projects would not result in additional trips. Examples include, but are not limited to, rehabilitation, maintenance, and repair of transportation infrastructure; installation, removal or reconfiguration of non-through traffic lanes and traffic control devices; removal of through lanes; installation of traffic calming measures and wayfinding; removal of on- or off-street parking. Governor's Office of Planning and Research, *Technical Advisory on Evaluating Transportation Impacts in CEQA*, November 2017.

[17] This estimate is based on the methodology outlined by Governor's Office of Planning and Research, Revised Proposal on Updates to the CEQA Guidelines on Evaluating Transportation Impacts in CEQA, January 20, 2016, page III:31. To the extent information is available, the department may revise this estimate to reflect data within California Air Resources Board reports, Plan Bay Area, or other sources to account for the latest allowable increases VMT increases to meet long-range greenhouse gas reduction goals and estimated total number of transportation projects by greenhouse gas reduction goal target year.

The impact analysis must address whether the infrastructure project would substantially induce additional automobile travel by increasing physical roadway capacity in congested areas or by adding new roadways to the network. The following examples are some of the circumstances relevant to infrastructure projects, which may result in impacts related to VMT. This is not an exhaustive list of circumstances under which an impact would occur:

- A project would include new roadways, bridges, or expansion of existing roadway capacity on a roadway
- A project would include the creation of new or addition of roadway capacity that would worsen conditions for people walking, bicycling, and, if applicable, riding transit (e.g. construction of new freeway on/off-ramps) thereby reducing the number of people that would use non-automobile modes
- A project would add a substantial number of new on-street parking spaces
- Conversion of existing managed lanes (e.g., HOV, HOT, or trucks) or transit lanes to general purpose lanes (including vehicle ramps) or parking
- Removal of existing transit service without comparable transit service nearby or creation of new routes to maintain existing transit service

ATTACHMENT A

Screening Criteria (SB 743 Checklist)

The Planning Department created a SB743 Checklist in response to California Environmental Quality Act (CEQA) Section 21099 – Modernization of Transportation Analysis for Transit Oriented Projects and Planning Commission Resolution 19579. Planning Commission Resolution 19579 replaces automobile delay with vehicle miles traveled analysis. This appendix lists out the screening criteria from the SB743 Checklist used by the Planning Department to identify types, characteristics or locations of projects and a list of transportation project types that would not result in significant transportation impacts under the VMT metric. These screening criteria are consistent with CEQA Section 21099 and the screening criteria recommended by OPR. If a project would generate VMT, but meets the screening criteria in Tables 1 and 2, or falls within the types of transportation projects listed in Table 3, then a detailed VMT analysis is not required for a project.

Attachment A-1 below provides definitions related to the these screening criteria, and Attachment A-2 would be customized for each project to show major transit stops within a half mile radius of the project site.

TABLE 1

Vehicle Miles Traveled Analysis – Screening Criterion If a project meets the screening criterion listed below, then a detailed VMT analysis is not required. See Attachment A-1 for definitions and other terms.	
☒	**Criterion 1. Is the proposed project site located within the *"map-based screening"* area?** [Identify regional, and transportation analysis zone (TAZ) VMT per efficiency metric. Consult with transportation planner if project does not meet this screening criterion.]

Note: Projects with a substantial amount of parking may not meet screening criterion.

TABLE 2

Vehicle Miles Traveled Analysis – Additional Screening Criteria Identify whether a project meets any of the additional screening criteria. See Attachment A-1 for definitions and other terms.	
☒	**Criterion 1. Does the proposed project qualify as a "*small project*"? or** [Identify number of daily vehicle trips from whole of the project – show your work]
☒	**Criterion 2. Proximity to Transit Stations (must meet all four sub-criteria)** Is the proposed project site located within a half mile of an existing major transit stop; and [NOTE: this is definition is different than transit priority area, as it does not include planned major transit stops. Add transit stop headway/schedule, or other applicable qualifying information such as nearby rail transit station or multi-modal ferry terminal.] Would the proposed project have a floor area ratio of greater than or equal to 0.75, and Would the project result in an amount of parking that is less than or equal to that required or allowed by the Planning Code without a conditional use authorization, and Is the proposed project consistent with the Sustainable Communities Strategy? [NOTE: if project site is located in priority development area, reference that. Refer to Attachment 1 of 2013 staff report for San Francisco's priority development areas: http://www.sf-planning.org/ftp/files/plans-and-programs/emerging_issues/scs/Plan-Bay-Area-Memo-5_02_13.pdf.) As noted by footnote, however, a project site does not need to be within a priority development area to be consistent. All land within San Francisco, except for parks and open spaces was considered for development in Plan Bay Area.]

TABLE 3

Induce Automobile Travel Analysis If a project contains transportation elements and fits within the general types of projects described below, then a detailed VMT analysis is not required. See Attachment A-1 for definitions and other terms.	
☒	**Project Type 1. Does the proposed project qualify as an "*active transportation, rightsizing (aka Road Diet) and Transit Project*"? or** [Specify how project meets this criterion – state n/a if no transportation elements]
☒	**Project Type 2. Does the proposed project qualify as an "*other minor transportation project*"?** [Specify how project meets this criterion – state n/a if no transportation elements]

ATTACHMENT A-1
DEFINITIONS

Active transportation, rightsizing (aka road diet) and transit project means any of the following:

- Reduction in number of through lanes
- Infrastructure projects, including safety and accessibility improvements, for people walking or bicycling
- Installation or reconfiguration of traffic calming devices
- Creation of new or expansion of existing transit service
- Creation of new or conversion of existing general purpose lanes (including vehicle ramps) to transit lanes
- Creation of new or addition of roadway capacity on local or collector streets, provided the project also substantially improves conditions for people walking, bicycling, and, if applicable, riding transit (e.g., by improving neighborhood connectivity or improving safety)

Employment center project means a project located on property zoned for commercial uses with a floor area ratio of no less than 0.75 and that is located within a transit priority area. If the underlying zoning for the project site allows for commercial uses and the project meets the rest of the criteria in this definition, then the project may be considered an employment center.

Floor area ratio means the ratio of gross building area of the development, excluding structured parking areas, proposed for the project divided by the net lot area.

Gross building area means the sum of all finished areas of all floors of a building included within the outside faces of its exterior walls.

Infill opportunity zone means a specific area designated by a city or county, pursuant to subdivision (c) of Section 65088.4, that is within one-half mile of a major transit stop or high-quality transit corridor included in a regional transportation plan. A major transit stop is as defined in Section 21064.3 of the Public Resources Code, except that, for purposes of this section, it also includes major transit stops that are included in the applicable regional transportation plan. 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.

Infill site means a lot located within an urban area that has been previously developed, or on a vacant site where at least 75 percent of the perimeter of the site adjoins, or is separated only by an improved public right-of-way from, parcels that are developed with qualified urban uses.

Lot means all parcels utilized by the project.

Major transit stop is defined in CEQA Section 21064.3 as a 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.

Map-based screening means the proposed project site is located within a transportation analysis zone that exhibits low levels of VMT.

Net lot area means the area of a lot, excluding publicly dedicated land and private streets that meet local standards, and other public use areas as determined by the local land use authority.

Other land use projects mean a land use other than residential, retail, and office. OPR has not provided proposed screening criteria or thresholds of significance for other types of land uses, other than those that meet the definition of a small project.

- Student housing, single room occupancy hotels, and group housing land uses should be treated as residential for screening and analysis.
- Tourist hotel workers, childcare, K-12 schools, post-secondary institutional (non-student housing), Medical, and production, distribution, and repair (PDR) land uses should be treated as office for screening and analysis.
- Tourist hotels, grocery stores, local-serving entertainment venues, religious institutions, parks, and athletic clubs land uses should be treated as retail for screening and analysis.
- Public services (e.g., police, fire stations, public utilities) and do not generally generate VMT. Instead, these land uses are often built in response to development from other land uses (e.g., office and residential). Therefore, these land uses can be presumed to have less-than-significant impacts on VMT. However, this presumption would not apply if the project is sited in a location that would require employees or visitors to travel substantial distances and the project is not located within ½ mile of a major transit stop or does not meet the small project screening criterion.
- Event centers and regional-serving entertainment venues would most likely require a detailed VMT analysis. Therefore, no screening criterion is applicable.

Other minor transportation project means any of the following:

- Rehabilitation, maintenance, replacement and repair projects designed to improve the condition of existing transportation assets (e.g., highways, roadways, bridges, culverts, tunnels, transit systems, and bicycle and pedestrian facilities) and that do not add additional motor vehicle capacity
- Installation, removal, or reconfiguration of traffic lanes that are not for through traffic, such as left, right, and U-turn pockets, or emergency breakdown lanes that are not used as through lanes
- Conversion of existing general purpose lanes (including vehicle ramps) to managed lanes (e.g., HOV, HOT, or trucks) or transit lanes
- Grade separation to separate vehicles from rail, transit, pedestrians or bicycles, or to replace a lane in order to separate preferential vehicles (e.g. HOV, HOT, or trucks) from general vehicles
- Installation, removal, or reconfiguration of traffic control devices, including Transit Signal Priority (TSP) features
- Traffic metering systems
- Timing of signals to optimize vehicle, bicycle or pedestrian flow on local or collector streets
- Installation of roundabouts
- Adoption of or increase in tolls
- Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes
- Addition of transportation wayfinding signage
- Removal of off- or on-street parking spaces

- Adoption, removal, or modification of on-street parking or loading restrictions (including meters, time limits, accessible spaces, and preferential/reserved parking permit programs)

Small project means the project would not result in over 100 vehicle trips per day or would have less than or equal to a 10,000 square feet of retail.

Transit priority area means an area within one-half mile of a major transit stop that is existing or planned, if the planned stop is scheduled to be completed within the planning horizon included in a Transportation Improvement Program adopted pursuant to Section 450.216 or 450.322 of Title 23 of the Code of Federal Regulations.

Vehicle miles traveled measures the amount and distance that a project might cause people to drive and accounts for the number of passengers per vehicle.

ATTACHMENT A-2
MAJOR TRANSIT STOPS

[insert map showing stops within a half-mile radius of the project site]

ATTACHMENT B

Vehicle Miles Traveled Sketch Tools

This appendix provides an overview of existing sketch tools and spreadsheet tools for estimating VMT based on land use and transportation characteristics. For each tool, this appendix provides a summary of the its functionality, inputs and outputs, and where the tool has been applied. The Planning Department provides this appendix for informational purpose and does not endorse these tools. Please consult Planning Department staff prior to using any of the tools for VMT analysis.

ASAP (Plan+, MXD+, TDM+)

- Developer: Fehr & Peers, Measures: VMT and Transportation-related GHG, Year: 2013, Cost: Paid, URL: http://asap.fehrandpeers.com/tools/sustainable-development/plan
- While the trip generation rates are manually adjustable, the MXD+ tool calculates reduced trip generation rates
- The Plan+ tool takes into account built environment and transit characteristics that reduce VMT
- Outputs are VMT (Daily, AM, PM), Trips (Daily, AM, PM), CO_2e (Metric tons per day)

Bay Area Simplified Simulation of Travel, Energy and Greenhouse Gases (BASSTEGG)

- Developed by the Bay Area Metropolitan Transportation Commission
- GIS simulation of Regional VO, VMT, and GHG based on TAZ-level BE and SES
- ftp://ftp.abag.ca.gov/pub/mtc/planning/forecast/BASSTEGG/
- Used in the Bay Area, CA

CalEEMod 2013 & 2016

- Developer: California Air Pollution Control Officers Association (CAPCOA), Measures: GHG and VMT, Year: 2013, Cost: Free, Format: Downloadable program, URL: http://www.caleemod.com Documentation: http://www.aqmd.gov/caleemod/user's-guide
- Adjustment to VMT based on elasticities
- Applicable to commercial (subset), educational, industrial, recreational, residential, retail (subset).
- Any context area
- Measures in CAPCOA Quantifying GHG Mitigations Report
- Uses this method with elasticities taken from the Quantifying GHG Mitigation Measures report published by the California Air Pollution Control Officers Association (CAPCOA)
- Calculates transportation-related VMT using estimates of trips based on the traditional ITE trip generation rates multiplied by trip lengths
- The tool includes default trip lengths based on the 1999 California Household Survey, but it allows users to input other trip lengths

- With its focus on project rather than area characteristics, the tool may not be well suited to the analysis of plans
- VMT projections are made for each land use in a project as well as the entire projects
- It reports household VMT per day, which can be aggregated to the project and year levels within the web interface
- CalEEMod offers a platform for entirely customizable travel parameters such as trip lengths by trip purpose and trip generation rates (new, diverted, pass-by) allowing customization to reflect the local travel patterns in the area of a project.

California SmartGrowth Trip Generation (SGTG) Adjustment Tool

- Developer: UC Davis ULTRANS, Measures: Trips Generated, Year: 2012, Cost: Free, Format: Spreadsheet, URL: http://ultrans.its.ucdavis.edu/projects/smart-growth-trip-generation
- Developed by researchers affiliated with the Institute of Transportation Studies at UC Davis calculates an adjustment factor based on eight variables related to land use characteristics and transit availability
- Adjustment factors are based on data collected at 50 project sites in California and were validated using data from another sample of California sites
- The reduced trip projections from this tool should be used only for projects that meet certain “smart growth” criteria and can be multiplied by trip lengths to calculate VMT

CNT (2015)/Green Trip Connect

- Developer: Center for Neighborhood Technology, Measures: Trip Generation Rate Adjustments, Year: 2016, Cost: Free, Format: Web tool URL: http://connect.greentrip.org/
- Statistically-based reduction in VMT
- Residential applicability using any context area
- Outputs VMT using location (surrounding land use and transportation characteristics, parking spaces/ charges, presence of affordable housing/rents, offers of residential transit passes/carshare/bikeshare
- GreenTrip Connect produces only a partial estimate of VMT impacts for mixed-use projects

Envision Tomorrow

- Developed by Fregonese Associates
- GIS tool that tests financial feasibility of development regulations and their impact on indicators
- Allows planners to model land use scenarios based on aggregate building level data and assess area outcomes such as housing and jobs (mix and density), jobs-housing balance, land consumption (vacant, agricultural, infill), impervious surface, open space, housing affordability, resource usage (energy and water), waste production (water, solid, carbon), transportation (travel mode choice, vehicle miles traveled), fiscal impact (local revenue and infrastructure costs), balanced housing index (how a scenario’s housing mix matches the expected future demographic profile)
- www.frego.com/services/envision-tomorrow/
- Used in various locations, including Mountlake Terrace, WA

Envision Tomorrow + Tool

- Developer: Fregonese Associates / University of Utah, Year: 2013, Cost: Free, Format: Spreadsheet and ArcGIS extension, URL 1: http://www.arch.utah.edu/cgi-bin/wordpress-etplus/ URL 2: http://www.envisionutah.org/wasatch-choice-toolbox/tool-et
- Incorporates two models, one that calculates trip generation reductions for mixed-use project sites and one for mixed-use districts
- Based on the EPA MXD method
- District level model is based on studies by Reid Ewing of the Center for Metropolitan Studies at the University of Utah
- Key variables are project land use characteristics, surrounding land use characteristics, street network, land values, population and economic data
- Outputs are vehicle miles traveled (VMT), vehicle trips, walk trips, bike trips, transit trips, greenhouse gas and pollutant emissions, and many other additional outputs

H+T (Housing and Transportation) Affordability Index

- It uses census and other nationally available datasets to estimate auto ownership, auto use (VMT), and transit use
- From these three estimates, it calculates various downstream outcomes, such as transportation costs and GHG emissions
- Auto ownership data was obtained from the ACS as a ratio of autos and occupied households per block group
- Auto use data came from Massachusetts odometer readings from 2005-2007 at a 250-meter grid cell level
- Transit data were measured from the ACS as the percent of commuters using transit at the block group level
- All three regression models employ 11 explanatory variables derived from readily available national and regional databases: (1) median income, (2) per capita income, (3) average household size, (4) average commuters per household, (5) residential density, (6) gross density, (7) average block size, (8) intersection density, (9) transit connectivity, (10) transit access shed, and (11) employment access
- Its ease of use is limited to displaying current conditions; the underlying regression model coefficients would have to be used to explore how planned changes to the built environment (BE) might affect travel outcomes

Improved Data and Tools for Integrated Land Use-Transportation Planning in California

- Developed by UC Davis
- Uses California-specific relationships of Built Environment (BE) and travel for scenario planning at multiple scales using various tools
- Original research was then conducted on the relationship between BE and travel demand and a suite of software tools was developed for use in local and regional integrated land use-transportation scenario planning processes in California. Three tools were developed: (1) a sketch planning spreadsheet, (2) a GIS-integrated sketch planning tool, and (3) a travel demand forecasting model post-processor

- The suite of tools was based on three statistical models for different regions: (1) small/medium MPOs, (2) large MPOs, and (3) major rail corridors. The models were fitted using GIS and travel survey data (NHTS and regional) from 13 smaller and medium-size MPOs, two major metropolitan areas, and several sub-regions within the two largest MPOs in California
- The models quantified the influence of built environment “D” variables captured within a half-mile buffer around a household and household demographics on three outcomes: vehicle ownership (VO), vehicle trip generation (VT), and vehicle miles travelled (VMT)
- VMT was estimated through multiple steps: a binary logistic regression model to estimate the probability that a household will make a vehicle trip; then either one linear regression model to estimate household VMT or two linear regression models to estimate the number of vehicle trips and the average vehicle trip length, the product of which is VMT
- This tool addressed two of the major limitations of previous sketch planning tools: (1) Travel mode choice differences associated with the BE at workplace and shopping destinations were modeled in addition to those at home locations; and (2) separate models were developed for study regions of varying sizes, which resulted in different relationships between the BE and travel
- http://ultrans.its.ucdavis.edu/projects/improved-data-and-toolsintegrated-land-usetransportation-planning-california
- Used in various locations in California

Local Sustainability Planning Tool

- Developed by Southern California Association of Governments (SCAG)
- GIS tool to model land use scenarios on VO, VMT, mode share, and GHG emissions
- http://rtpscs.scag.ca.gov/Pages/Local-SustainabilityPlanning-Tool.aspx
- Used in various communities in Southern California

Low-carb Land Tool

- Developed by Sonoma Technology, Inc.
- Web tool for examining VMT and GHG under various growth and land use scenarios
- http://www.sonomatech.com/project.cfm?uprojectid=672
- Used by Thurston County, WA and Marin County, CA

MXD

- Developer: Envision Tomorrow, Measures: Trip Generation Rate Adjustments, Year: 2014, Cost: Free, Format: Spreadsheet, URL: http://www.envisiontomorrow.org/district-level-travel-model/
- A spreadsheet-based tool built by the transportation consulting firm Fehr & Peers and hosted by the Environmental Protection Agency
- Statistically-based reduction in trips
- Applicability is residential, retail, office, industrial (subset), commercial (subset), educational, other
- Any context area
- Calculated VMT is a result of MXD’s adjusted trip generation rates multiplied by the average trip length by trip purpose

- Trip length input source is important and can drastically influence the results
- Important input data may be difficult to find

Rapid Fire Tool

- Developed by Calthorpe Associates
- Models VMT, GHG emissions, etc. based on land use scenarios
- http://www.calthorpe.com/
- Used in California and Honolulu

Sketch 7

- Developer: Fehr & Peers, Sacramento Area Council of Governments, UC Davis Urban Land Use and Transportation Center (ULTRANS), Measures: Change in VMT, transit trips per capita, bicycle and walk trips per capita, Year: 2012, Cost: Free, Format: Spreadsheet and Web-based GIS Application, URL: http://ultrans.its.ucdavis.edu/projects/improved-data-and-tools-integrated-land-usetransportation-planning-california
- Spreadsheet tool that estimates VMT based on seven land use and transportation characteristics
- Primarily used and maintained in the Sacramento region
- Projects VMT for several situations including a given project, the surrounding area (the context area) in a before-and-after project scenario, and compares the project scenarios to the regional VMT averages
- Key variables are seven D's of land use and transportation (auto/ transit accessibility, jobs/housing balance, residential density/diversity, street pattern, demographics)
- Its use is limited to the Sacramento region without investment from other regional planning agencies to develop the needed inputs
- Is able to estimate transit, bike and walk trips
- The proper functioning of Sketch7 requires development maintenance of a parcel database to use as baseline data
- Regional TAZ data used to calibrate tool may be difficult to obtain

UrbanFootprint

- Developer: Calthorpe Associates/Calthorpe Analytics, Year: 2012, Cost: Free, Format: Browser-based downloadable program, URL: http://www.scag.ca.gov/Documents/UrbanFootprintTechnicalSummary.pdf
- Open-source downloadable software program, analyzes fiscal, environmental, public health, and transportation impacts of plans and policies
- Runs a sketch-level travel model based on land use and transportation system characteristics that outputs VMT
- Uses land use, road network, transit data demographic and economic data for determining rates

VMT Reduction: Phase One

- Developed by WSDOT
- Estimates neighborhood residential VMT and CO_2 based on BE and demographic factors
- Estimates household-level vehicle use (VMT in miles per day, month, year or other unit of time) and related CO_2 emission (grams per unit time) as well as the 95% confidence interval around each estimate
- It can be used for baseline and forecasted estimates based on changes to input variables.
- Estimates are based on the relationships found in two Ordinary Least Squares (OLS) linear regression models of household VMT and CO_2. The OLS linear regression models were fitted using data from 1,929 households that responded to the 2006 PSRC household travel survey and who lived in King County jurisdictions where sidewalk data were available.
- It relies on models of VMT and CO_2 based only on household neighborhood urban form, it does not account for the effect of destination 17 urban form characteristics on VMT. The tool also does not estimate travel for non-residential land uses in the planning area.
- It was developed from a sample of households located in a limited number of jurisdictions in King County, and therefore may not be generalizable to other parts of the state.
- http://www.wsdot.wa.gov/research/
- Used in Rainier Beach and Bitter Lake, Seattle

VMT +

- Developer: Fehr & Peers, Measures: VMT and Transportation-related GHG, Year: 2013, Cost: Free, Format: Calculator on website, URL: http://www.fehrandpeers.com/vmt
- VMT is estimated by a multiplication of trips generated multiplied by trip lengths
- Outputs are VMT (per household per day), CO_2e (MT per day)

Sources:
http://depts.washington.edu/trac/bulkdisk/pdf/806.3.pdf
https://rosap.ntl.bts.gov/view/dot/32750

ATTACHMENT C

Combined Vehicle Miles Traveled Research Annotated Bibliography

This appendix documents existing research on travel behavior and vehicle miles traveled (VMT). The first portion presents research that supports significance assumptions under SB 743. Based on existing research, certain transportation projects are not considered likely to lead to a substantial or measurable increase in VMT. The second portion summarizes the relationship between VMT and density, land use context, and access to parking at home and work.

Contents of this Appendix

1. Projects with assumed less-than-significant VMT impacts under SB 743

In January 2016, the California Office of Planning and Research (OPR) published for public review and comment a *Revised Proposal on Updates to the CEQA Guidelines on Evaluating Transportation Impacts in CEQA*[1]. The document includes a list of transportation project types that would not likely lead to a substantial or measurable increase in vehicle miles traveled (VMT). If a project fits within the general types of projects (including combinations of types) described below, then it is presumed that VMT impacts would be less than significant and a detailed VMT analysis is not required. Some of these types of projects are reducing the number of through lanes, creating new or expanding transit services, adoption of tolls, and removal of on- or off-street parking. Each project type is listed in Table 1; project types have been grouped together by the City and County of San Francisco.

This appendix documents existing research that supports and furthers the substantial evidence in the Technical Advisory document regarding these projects' presumed less-than-significant VMT impacts. Some papers address more than one type of project; Table 1 lists sources that address each project type's VMT contributions. This document is and will continue to be a working draft; new research that advances understanding of these projects' VMT impacts will inform future drafts.

[1] This document is available online at: https://www.opr.ca.gov/s_sb743.php.

Table 1: Transportation projects not likely to lead to a substantial or measurable increase in VMT, and reviewed references that support this conclusion

Project Type	References
Active Transportation, Rightsizing (aka Road Diet), and Transit Projects	
Reduction in number of through lanes	2, 4, 9, 11, 15, 16
Infrastructure projects, including safety and accessibility improvements, for people walking or bicycling	8, 15, 16
Creation of new or expansion of existing transit service	5, 8, 9, 14
Creation of new or conversion of existing general purpose lanes (including vehicle ramps) to transit lanes	9, 14
Other Minor Transportation Projects	
Adoption of or increase in tolls	8
Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes	1, 3, 7, 10
Removal of off- or on-street parking spaces	6, 12, 13
Adoption, removal, or modification of on-street parking or loading restrictions (including meters, time limits, accessible spaces, and preferential/reserved parking permit programs)	13

1. Goodwin, Phil, Carmen Hass-Klau, and Sally Cairns. "Evidence on the effects of road capacity reduction on traffic levels." Traffic Engineering+ Control 39.6 (1998): 348-54. http://nacto.org/docs/usdg/traffic_impact_highway_capacity_cairns.pdf

Reduction in number of through lanes

This report was a meta-analysis of over 100 studies of projects that reduced vehicular capacity on roadways (popularly termed “road diets”). The overall sample of studies showed an average reduction in traffic in the treatment area by 41%, with *less than half* reappearing on alternative routes or at different times of day. There were 7 cases of overall traffic increase.

The paper does list some potential caveats:

- Drivers could have rerouted to longer diversions that were not captured by the projects’ designated “study area.” However, most studies were conducted by local professionals who tried to account for reasonable diversion possibilities.
- Partial sampling is also an issue; that is, surveying pre-project road users who stop using the road but not capturing the anyone who began driving on the road after the project.

In spite of possible sources of bias and error in particular cases, the authors conclude that, taken as a whole, the sum of case studies seems to point to a proportion of traffic possibly “disappearing” when capacity is reduced. They conclude: “The balance of evidence is that measures which reduce or reallocate road capacity, when well-designed and favoured by strong reasons of policy, need not automatically be rejected for fear that they will inevitably cause unacceptable congestion.” Although the focus of the paper is congestion, it does have findings that support the idea that a reduction in vehicular capacity does not generate additional VMT.

2. Walker, G. Wade, Walter M. Kulash, and Brian T. McHugh. Downtown Streets: Are We Strangling Ourselves in One-Way Networks?. No. E-C019, 2000.

Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes

The author, a transportation consultant, enumerates the drawbacks of one-way street networks relative to two-way street networks. Although the author presents a cogent argument, it is unclear where exactly he draws his conclusions from – no data is presented when citing “our experience.”

> *As stated previously, one of the inherent disadvantages with one-way streets is that they force additional turning movements at the intersections caused by motorists who must travel “out-of-direction” to reach their destination. These additional turning movements increase the chance of a vehicular-pedestrian conflict at any given intersection, and also result in a systemwide increase in VMT over a comparable two-way system due to the amount of recirculating traffic…. Our experience shows that a one-way system usually yields approximately 120 to 160% of the turning movements when compared to a two-way system, and the travel distance between portal and destination is usually 20 to 50 percent greater in a one-way street system.*

3. Meng, Lum Kit, and Soe Thu. "A microscopic simulation study of two-way street network versus one-way street network." Journal of the Institution of Engineers, Singapore 44 (2004): 111-122.

Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes

The authors conducted CORSIM simulations with a created network and compared one-way coordinated signal timings and two-way. They found a statistically significant difference among the following findings:

Measures of Effectiveness at the systemwide level	**Two-way Results (compared to one-way)**
VMT	Lower
Veh-hr of delay	Higher
Avg speed	Lower
Fuel consumption **rate**	Lower
Emission **rate** (HC, CO, NOx)	Higher
Emissions **amount**	Lower

The table of results shows that the emissions rate is higher in the two-way network. However, because fewer miles are driven, overall emissions are lower. The simulation was conducted using a user equilibrium (rather than a system optimal equilibrium) in which every simulation agent searches for the shortest path between a prescribed origin and destination. However, the paper does not clarify whether a path's cost is measured in purely distance or distance plus delay time due to congestion. Therefore, it is not obvious whether the additional VMT includes route diversions due to congestion or just network circuity.

This simulation supports the idea that one-way to two-way conversion does not substantially increase VMT (and in fact, may decrease it).

4. Cervero, Robert; Junhee Kang & Kevin Shively (2009) "From elevated freeways to surface boulevards: neighborhood and housing price impacts in San Francisco." Journal of Urbanism: International Research on Placemaking and Urban Sustainability, 2:1, 31-50, http://dx.doi.org/10.1080/17549170902833899

Reduction in Number of Through Lanes

The paper details the conversion of the Central Freeway in San Francisco to an arterial street (Octavia Boulevard), contrasting doomsday predictions of perpetual gridlock with what is instead described as a relatively smooth transition.

A study conducted shortly after the Central Freeway's 1996 closure revealed that in the short term, most drivers redistributed onto parallel routes. One year after the closure, surveys mailed to 8,000 drivers formerly identified driving the freeway revealed:

76% used another freeway
11% used city streets entirely
3% used a combination of freeways and transit
3% no longer made the trip that used the freeway.
2% switched to transit
2% used freeways and surface streets instead
1% used freeways still, and took fewer trips.

The paper concludes with the idea of "triple divergence," to explain how travel behavior reacts to the reduction of vehicular capacity:

> *"The survey also found that 19.8% of survey respondents stated they made fewer trips since the freeway closure. Most were discretionary trips, such as for recreation. Also, average one-way trip length increased by 7.7% (from 21.2 to 22.8 miles). . . . This might be thought of as 'triple divergence,' the obverse of Downs's 'triple convergence' explanation as to why freeways remain congested when new capacity is added. Just as adding capacity prompts traffic to redistribute itself to maintain similar levels of service, withdrawing capacity likely unleashes a similar response – motorists shift routes, modes, and times of travel to maintain a homeostasis."*

Although the average one-way trip length increased by 7.7%, that increase was swamped by the 19.8% of people who made fewer trips (given that the average trip length was 21.8 miles). Therefore, these findings and Cervero's theory of triple divergence substantiate the idea of no significant increase in VMT with the reduction of vehicular capacity.

5. Duranton, Gilles, and Matthew A. Turner. "***The fundamental law of road congestion: Evidence from US cities." The American Economic Review 101.6 (2011): 2616-2652. http://www.nber.org/papers/w15376.pdf***

Creation of new or expansion of existing transit service
The authors hypothesize that the addition of public transit service miles, to the extent that it attracts drivers to ride transit instead, will only free up extra lane miles for traffic congestion to revert to equilibrium levels – a corollary to the well-known "fundamental law of traffic congestion" (which offers the same hypothesis for lane-miles rather than transit service miles).

Conducting ordinary least squares (OLS) regressions using number of buses and lane kilometers of service at the metropolitan statistical area (MSA) scale, the authors found inconsistent and mostly statistically insignificant estimates for the coefficient of "number of large buses." In other words, an increased public transit supply (as measured by the count of large buses at the MSA level) was not associated with a reduction or increase in vehicle-kilometers traveled (VKT).

This research supports the idea that an increased the supply of public transit does not contribute to a significant increase in VMT.

6. Weinberger, Rachel. "Death by a thousand curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive." Transport Policy 20 (2012), doi:10.1016/j.tranpol.2011.08.002

Removal of off- or on-street parking spaces

The author created a data set monitoring home parking provision in three New York City boroughs, combining a tax lot database and aerial images to estimate the presence of off-street parking in a number of census tracts. They used that data to estimate a regression model explaining the percentage of commuters who drive to work in a census tract as a function of the tract's built environment characteristics, socioeconomic and demographic characteristics, and an on-site parking per dwelling unit rate.

They describe their results thusly:

> *"The research shows a clear relationship between guaranteed parking at home and the greater propensity to use the automobile for journey to work trips even between origin and destinations pairs that are reasonably well and very well served by transit. Because journey to work trips to the downtown are typically well served by transit, we infer from this finding that trips for other purposes from these areas of higher on-site, off-street parking are also made disproportionately by car."*

These findings support the conclusion that the provision of off-street parking spaces is associated with additional VMT, implying that the removal of them would not be associated with such.

7. Gayah, Vikash V. "Two-way street networks: More efficient than previously thought?." ACCESS Magazine 1.41 (2012).

Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes

The author explains that in a downtown, a one-way street network may have higher vehicle-moving capacity (i.e., the ability to move more cars through a point or series of points) than a two-way street network. However, the one-way network will have a lower trip-serving capacity, because trips through and within the network are more circuitous: "Thus, the use of one-way street networks increases the average driving distance between any paired origin-destination points and will result in more vehicle miles traveled (VMT). Increased VMT means increased fuel consumption, emissions, and exposure to accidents."

The author does explain that in a larger downtown or network, the difference in trip lengths between one-way and two-way networks approaches a negligible amount. Even so, the two-way network is always associated with lower VMT.

The paper is a thought experiment, with supporting evidence like what is shown in Figure 3 below. This research supports the idea that converting a street (or couplet, or network of streets) from one-way to two-way would lower VMT.

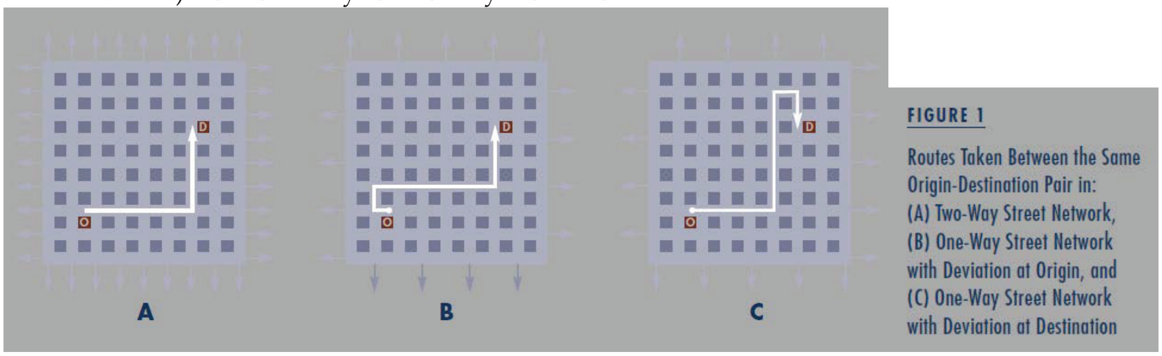

Figure 1: Illustration of the additional circuity of a one-way network compared to a two-way network

8. Salon, D., Boarnet, M. G., Handy, S., Spears, S., & Tal, G. (2012). *How do local actions affect VMT? A critical review of the empirical evidence*. *Transportation Research Part D: Transport and Environment*, *17*(7), 495-508. DOI: 10.1016/j.trd.2012.05.006

This paper provides an assessment of existing research concerning land use, policy, and programmatic decisions that "local-level policymakers can take . . . that are likely to affect vehicle miles traveled." The paper covers research on many topics, pointing out what appears to be known about the effect on VMT and also discussing gaps in the research. Pertinent topics are listed below.

Infrastructure projects, including safety and accessibility improvements, for people walking or bicycling

The authors list the results of various studies on bicycle infrastructure and surrogate measures of such:

Study Authors	Measure Studied	Estimate
Dill and Carr (2003)	Elasticity of bicycle commute mode share with respect to bike lane density *or* per capita bicycle spending	0.32
Parsons Brinckerhoff (1993)	Elasticity of VMT with respect to with respect to a measure of pedestrian quality	-0.19
Kitamura et al (1997)	Number of vehicle trips (person level) given the presence of sidewalks in a neighborhood	-0.14%
Guo and Gandavarapu (2010)	VMT with respect to sidewalk presence	-0.645 VMT per mile of roadway with sidewalks within 1 mile of a person's home

The authors note that a link between increased bicycling and reductions in VMT does not appear to have been established in the literature, in part because bicycle trips are relatively short (i.e., they compete with walking trips rather than driving) and the effects of infrastructure closely concentrated (sub-regional, and perhaps sub-city level).

The authors conclude with the following assessment of the state of research into these two areas:

> *Estimates of the effect on VMT of both pricing strategies and strategies that make alternatives to the auto more attractive (transit and non-motorized transport) are generally lacking. In our estimation, these areas represent the largest gap in the literature.*

<u>However, the survey of research finds evidence that sidewalk presence, bicycle infrastructure, and a positive pedestrian quality are associated with lower VMT and therefore may reduce VMT.</u>

Creation of new or expansion of existing transit service

The authors convey findings that show positive elasticities for transit ridership, but no studied effect on VMT:

- 0.5 ridership elasticity with respect to increased service frequency;
- 0.7 ridership elasticity with respect to increases in service miles or hours; and
- -0.4 ridership elasticity with respect to fare increases.

Regarding the missing link to VMT effects, the authors explain: "We expect that as transit ridership increases, VMT will decrease, but the effect is likely to be less than one-to-one, both because new transit trips do not always replace car trips and because of latent demand for road space."

Adoption of or increase in tolls

These research findings are based on a per-mile toll, or a VMT charge:

- "Deakin et al (1996) reported a simulated price elasticity of VMT of between -0.2 and -0.25 based on models of the San Francisco and Los Angeles metropolitan areas."
- "Rodier (2002) found that a simulated 5 cent per mile VMT charge in the Sacramento area would result in a 10% VMT reduction."
- "Safirova (2007) found that a simulated 10 cent per mile VMT charge in the Washington DC area would result in a 14.5% drop in VMT."
- "The Oregon pilot program yielded similar-sized VMT reductions from an experimental distance charging scheme that replaced gas tax and therefore was designed to be revenue neutral (Rufolo and Kimpel, 2008)."

The authors highlight that even in the revenue-neutral scheme discussed above, designed not to change the average cost of driving, drivers showed responsiveness to being tolled on a per-mile basis. These findings support the idea that adopting or increasing tolls reduces VMT.

9. Van Ness BRT Final EIS/EIR (Chapter 3). ***http://www.sfcta.org/van-ness-avenue-bus-rapid-transit-planning-and-environmental-studies#DOW***. Accessed 6/27/2016.

Reduction in number of through lanes

Creation of new or expansion of existing transit service

Creation of new or conversion of existing general purpose lanes (including vehicle ramps) to transit lanes

Air Quality analysis displayed that each of the alternatives would result in a net decrease in Citywide VMT. Terry A. Hayes Associates Inc., Air Quality Technical Report and Addendum, 2013.

10. Wang, Jinghui, Lei Yu, and Fengxiang Qiao. "Micro Traffic Simulation Approach to the Evaluation of Vehicle Emissions on One-way vs. Two-way Streets: A Case Study in Houston Downtown." 92nd annual meeting of the Transportation Research Board in Washington DC. 2013.

Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes

The authors used the street network and real traffic volumes for downtown Houston, Texas, but created an entirely one-way street network and an accompanying two-way street network. They conducted simulations in VISSIM and reported the simulation outputs, for both peak and off-peak travel conditions.

Per-mile emissions in the two-way network were higher across the board, but the reduction in VMT relative to the one-way network generally overwhelms that difference such that overall emissions are lower for the two-way network (with the sole exception of peak condition HC emissions). However, the difference in per mile emissions factors is exacerbated in peak hour conditions (owing to more friction and delay in the two-way network). As such, peak condition emissions for the two-way versus one-way network are much closer.

11. Kattan, Lina, Alexandre G. de Barros, and Hina Saleemi. "Travel behavior changes and responses to advanced traveler information in prolonged and large-scale network disruptions: A case study of west LRT line construction in the city of Calgary." Transportation Research Part F: Traffic Psychology and Behaviour 21 (2013): 90-102.***http://www.sciencedirect.com/science/article/pii/S1369847813000697***

Reduction in Number of Through Lanes

Construction of a light rail transit line in Calgary, Alberta, Canada reduced capacity along an 8.2 kilometer corridor for three years. As a preemptive mitigation measure, the City of Calgary implemented a temporary bus rapid transit (BRT) service along an alignment similar to the future light rail line and also provided up-to-date disruption information through internet, radio, and message display signs. As construction progressed, the capacity interruptions varied. The authors conducted surveys of users of the main road affected by the construction of the West Light Rail Transit (LRT) line in Calgary, Alberta, Canada. Among the findings:

- "Despite the significant increase in self-reported travel time, the total demand for travel in the area did not seem to decrease or result in rescheduled trip departure times. In response to pre-trip information disseminating road closure information, only 1.5% of trips were reported to be cancelled or have rescheduled departure times."
- "A substantial shift towards public transport was reported as a result of pre-trip information. This reported shift towards transit can be attributed to the presence of both incentives for taking transit (i.e., the added high-frequency transit service and the presence of pre-trip information for transit) and disincentives for driving (i.e., the road capacity reduction resulting from road/lane closures)." Note here that the authors are referring to the temporary BRT service implemented along the corridor.
- "…there was a decrease in the percentage of respondents who reported private vehicles as their first choice and an increase in the percentage of respondents who preferred public transit as their first and second choices."

Although this paper does not explicitly mention VMT, it seems that this disruption in the network did not contribute substantial additional VMT. This conclusion can be drawn from two points:

- "The characteristics of the grid network that consists of urban arterials and major collectors giving several alternative route choices to travelers," i.e, diversions were short and plentiful rather than circuitous; and
- The reported mode shifting behavior during the disruption among respondents, with many switching from driving to transit.

The authors did not observe travel behavior once the light rail transit line opened.

12. McCahill, Chris, et al. "Effects of Parking Provision on Automobile Use in Cities: Inferring Causality." (2015).

This study used longitudinal citywide parking supply data from seven US cities from three decades: the 1950s, the 1980s, and the 2000s. In short, they find that "an increase in parking provision from 0.1 to 0.5 parking spaces per resident and employee is associated with an increase in commuter automobile mode share of roughly 30 percentage points . . . **we infer that parking provision in cities is a likely cause of increased driving among residents and employees**." (bold emphasis added).

13. Chatman, Daniel G. "Does Transit-Oriented Development Need the Transit?." ACCESS Magazine 1.47 (2015).

Removal of off- or on-street parking spaces

The author conducted a mail survey of households within two miles of rail stations in New Jersey. The households and neighborhoods varied in design, age, distance to rail, and on- and off-street parking supply (which was collected through observation). The data was regressed thrice, with different dependent variables in each case:

1) **Auto ownership.** When proximity to rail is controlled for with the other factors listed above, its effect was not a significant predictor of auto ownership. Instead, "When the effects of more bus stops and low on- and off-street parking availability were combined, they reduce auto ownership by 44 percent. Most of this effect is due to parking availability."
2) **Commuting to work.** "Scarce off-street parking (having less than one parking space per adult in the household) was associated with a 40 percent reduction in auto commuting . . . "
3) **Grocery store visits.** Scarce on- and off-street parking was associated with a 25 percent reduction in grocery store trips made by driving. The two parking types were not significant independently, as the author explains: "This makes sense, because carrying groceries is inconvenient on foot or via transit, so only significant impediments to auto ownership and use are likely to make a difference."

Although the study uses cross-sectional data and thus cannot make causal claims in a before-and-after manner, the author concludes with the following two conclusions (among others):

- "What does reduce car ownership and use? **Lower parking availability**, better bus service, smaller housing units, more rental housing, more destinations within walking distance, better proximity to downtown, and higher population and employment density all reduce car ownership and use." (emphasis added)
- "At the very least, [transit-oriented developments] should be developed with less parking. If they are not, they will not reduce auto use."

This paper supports the conclusion that the removal of off- and/or on-street parking will reduce VMT.

14. San Francisco County Transportation Authority. Geary Corridor Bus Rapid Transit Project Draft EIS/EIR, Section 4.10 Air Quality and Greenhouse Gases, 2015. http://www.sfcta.org/sites/default/files/content/Planning/GearyCorridorBusRapidTransit/DraftEIR/Geary%20Corridor%20Bus%20Rapid%20Transit%20Project%20Draft%20EIS_EIR.pdf

Creation of new or expansion of existing transit service

Creation of new or conversion of existing general purpose lanes (including vehicle ramps) to transit lanes

Air Quality analysis displayed that each of the alternatives (all of which include bus rapid transit on Geary Blvd.) would result in a net decrease of <1%, or a negligible change, in Regional VMT. Model outputs for VMT are shown in Figure 1 and Figure 2 (split out by travel mode in the latter). This study supports the idea that implementation of bus rapid transit system with dedicated lanes does not contribute to an increase in VMT.

Table 4.10-6 Regional VMT and Traffic Speed Data Under the No Build and Build Alternatives

SCENARIO	REGIONAL VEHICLE MILES TRAVELED (VMT)	AVERAGE SPEED (MILES PER HOUR)
EXISTING CONDITIONS		
2020 No Build Alternative	9,220,000	21
2020 Alternative 2	9,210,000	21
2020 Alternative 3	9,200,000	21
2020 Alternative 3-Consolidated	9,190,000	21
Hybrid Alternative	9,200,000	21
FUTURE YEAR BUILDOUT		
2035 No Build Alternative	11,160,000	17
2035 Alternative 2	11,140,000	17
2035 Alternative 3	11,130,000	17
2035 Alternative 3-Consolidated	11,120,000	17
Hybrid Alternative	11,120,000	17

Source: SFCTA, March 2014

Figure 2: Travel Model output displaying regional VMT levels associated with the proposed Geary Corridor Bus Rapid Transit System

Table 4.12-2 Energy Use - Build and No Build Alternatives; 2020 and 2035

2020	ANNUAL VMT (MILLIONS)			REGIONAL ENERGY EQUIVALENT IN MILLION MBTUS	INCREASE/ DECREASE RELATIVE TO NO BUILD	% CHANGE FROM NO BUILD
	AUTO	BUS	TOTAL			
No Build Alternative	3,186	1.9	3,188	9,291	-	-
Alternative 2 (Side-Lane BRT)	3,184	2.6	3,186	9,298	+7	+0.1%
Alternative 3 (Center-Lane BRT with Dual Medians and Passing Lanes)	3,180	2.6	3,183	9,288	-3	-<0.1%
Alternative 3-Consolidated (Center-Lane with Dual Medians and Passing Lanes)	3,178	2.5	3,180	9,280	-11	-0.1%
Hybrid Alternative	3,181	2.5	3,183	9,289	-3	-<0.1%
2035	**ANNUAL VMT (MILLIONS)**			**ENERGY EQUIVALENT IN MILLION MBTUS**	**INCREASE/ DECREASE RELATIVE TO NO BUILD**	**% CHANGE FROM NO BUILD**
	AUTO	**BUS**	**TOTAL**			
No Build Alternative	3,857	1.9	3,859	8,998	-	-
Alternative 2	3,850	2.6	3,853	8,998	+0	+<0.01%
Alternative 3	3,848	2.6	3,851	8,993	-5	-0.1%
Alternative 3-Consolidated)	3,843	2.5	3,845	8,979	-19	-0.2%
Hybrid Alternative	3,842	2.5	3,845	8,979	-19	-0.2%

Source: Terry A. Hayes Associates Inc., 2014

Figure 3: Travel model output displaying regional VMT levels associated with the proposed Geary Corridor Bus Rapid Transit System (broken out by travel mode)

15. San Jose, California: Lincoln Avenue Road Diet Trial Data Collection Report. 6/1/2015. https://sanjoseca.gov/DocumentCenter/View/44259 . Accessed 6/27/2016.

This is a study conducted for a road diet along Lincoln Avenue in San Jose, California. The project involved the conversion of four travel lanes (two in each direction) to three (one in each direction, with a two-way left turn lane). At the time the road diet was a temporary pilot project, and this study was conducted to inform decision makers whether to make the project permanent.

Reduction in number of through lanes
Infrastructure projects, including safety and accessibility improvements, for people walking or bicycling
The report indicates that traffic volumes were 3 to 13% lower throughout the corridor after project implementation. Neighboring local streets experienced relatively negligible changes (up or down by approximately 50 vehicles, variations that are "within expected daily variations for local streets"). Eight other streets saw meaningful decreases of traffic. These data were collected and averaged over three days (Tuesday, Wednesday, Thursday) of the same week.

The preliminary findings of this report indicate that this road diet project likely reduced VMT.

16. Road Diet Case Studies. Federal Highway Administration.
https://safety.fhwa.dot.gov/road_diets/. Modified July 2016. Accessed 6/28/2016.

Reduction in number of through lanes
Infrastructure projects, including safety and accessibility improvements, for people walking or bicycling
The FHWA case study document details several road diet projects and lists outcomes of the projects without much detail. Some highlights are below.

Grand Rapids, Michigan Division Street Road Diet: Grand Rapids Michigan reported increased emissions as a result of road diet project (+19.8% AM, +1.1% off-peak, and -5.3% PM).

Los Angeles Seventh Street Road Diet: "After the completion of the Seventh Street Road Diet, LADOT received positive feedback from users, and a before-and-after bicycle count conducted by the Los Angeles County Bicycle Coalition showed that bicycle use in the corridor tripled once the Road Diet and new bicycle lanes were completed. LADOT also conducted some traffic analyses at several key intersections along the corridor and found that the results were satisfactory." It's unclear (and not explained) if these are **new** bicycle trips—genuine mode shift—or if they are diversions by cyclists to use the new facility. Either way, these results indicate that in response to the project, VMT likely remained the same or decreased (rather than increasing).

Reston, Virginia (Lawyers Road): "47 percent of respondents bicycled on Lawyers Road more often than before, indicating that the Road Diet encourages bicycling as a travel mode." The same logic may be applied here from the Los Angeles Seventh Street Road Diet results regarding a significant increase in VMT.

These case studies do not explicitly address VMT changes, but the evidence provided (with the exception of the Grand Rapids case) indicates that VMT likely did not increase.

2. Parking access, land use context, density, and VMT

The amount of available parking, land use context, and travel mode choice are intricately linked. The research presented below supports the conclusion that more off-street vehicular parking is linked to more driving and that people without dedicated parking spaces are less likely to drive. One article indicates that an area with more available parking in residential areas influences a higher demand for more automobile use. Another study found a direct relationship between the availability of free on-street parking supply and the number of cars per household. The remaining research examines techniques and results of attempting to reduce vehicle miles traveled through transit access, reduced parking availability, and shifting locational context (dense vs. suburban).

1. Weinberger, Rachel. "Death by a thousand curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive." Transport Policy 20 (2012), doi:10.1016/j.tranpol.2011.08.002

   Weinberger examines the relationship between the availability of residential parking in three New York boroughs and residents' choices to drive their personal vehicles to work in the Manhattan Core. First, the author estimated the amount of parking per dwelling unit for Census tracts in Queens, the Bronx, and Brooklyn; the amount of residential parking per unit was regressed against 'Journey to Work' mode split data, as reported in the Census, using a generalized linear model with a logit link function. The regression was used to explain the factors that increase or decrease the percentage of people driving to transit accessible work destinations.

   The author concludes that Census tracts with higher levels of on-site parking have higher levels of drive mode share to the transit rich Manhattan Core. Thus, guaranteed parking at home is a contributing factor to a worker's decision to drive to work. From this the author infers that driving to other activities is also likely to be higher.

2. California Air Pollution Control Officers Association (CAPCOA), *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emissions Reductions from Greenhouse Gas Mitigation Measures*, August 2010.

   This report focuses on quantifying various strategies for greenhouse gas (GHG) reduction. Below are summaries of policies related to land use context, density, and parking access, with the range of effectiveness equaling both the reduction in the VMT as well as the reduction in GHG emissions.

   Land Use / Location 1 – Increase Density – Range of effectiveness: 0.8– 30%
   The range of effectiveness is derived from looking at the effects of increasing density in urban and suburban contexts. The effectiveness in rural contexts was negligible. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects. The Transportation Research Board Special Report 298 literature suggests that doubling neighborhood density across a metropolitan area might lower household VMT by about 5

to 12 percent, and perhaps by as much as 25 percent, if coupled with higher employment concentrations, significant public transit improvements, mixed uses, and other supportive demand management measure.

Land Use / Location 2 – Increase location efficiency to reduce VMT – Range of effectiveness: 10–65%

The range of effectiveness is derived from looking at the effects of increasing location efficiency in urban and suburban contexts. The effectiveness in rural contexts was negligible. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects.

Land Use / Location 3 – Increase density of urban and suburban developments (mixed use) – Range of effectiveness: 9– 30%

The range of effectiveness is derived from looking at the effects of increasing density of urban and suburban developments. The effectiveness in rural contexts was negligible unless the project is a master-planned community. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects. Project would need to provide the percentage of each land use type in the project to calculate a land use index.

Land Use / Location 4 – Increase destination accessibility – Range of effectiveness: 6.7– 20%

The range of effectiveness is derived from looking at the effects of increasing destination accessibility in the urban and suburban contexts. The effectiveness in rural contexts was negligible. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects.

Land Use / Location 5 – Increase transit accessibility – Range of effectiveness: 0.5– 24.6%

The range of effectiveness is derived from looking at the effects of increasing transit accessibility in the urban and suburban contexts. The effectiveness in rural contexts was appropriate if development site is adjacent to commuter rail station with convenient rail service to a major employment center. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects. Project would need to provide the distance to transit station.

Parking Policy / Pricing 1 - Limit Parking Supply – Range of effectiveness: 5 – 12.5%

The range of effectiveness is derived from looking at the effects of limiting parking supply in urban and suburban contexts. The effectiveness in rural contexts was negligible. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects. The reduction in VMT can only be counted if spillover parking is controlled via residential permits and on-street metering.

Parking Policy / Pricing 2 - Unbundle parking costs from property cost – Range of effectiveness: 2.6 - 13%

The range of effectiveness is derived from looking at the effects of limiting parking supply in urban and suburban contexts. The effectiveness in rural contexts was negligible. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects. A complimentary strategy is Workplace Parking Pricing. Though not required, implement workplace parking pricing ensures the market signal from unbundling parking is transferred to the employee.

Parking Policy / Pricing 3 - Implement Market Price Public Parking (on-street) – range of effectiveness: 2.8 – 5.5%

The range of effectiveness is derived from looking at the effects of limiting parking supply in urban and suburban contexts. The effectiveness in rural contexts was negligible. The strategy is appropriate for retail, office, and mixed-use projects. The strategy is only applicable in an area or general plan context, usually in downtown areas, and reductions can only be counted if spillover parking is controlled via residential permits in surrounding neighborhoods.

Parking Policy / Pricing 4 - Require Residential Area Parking Permits – range of effectiveness: Grouped strategy, see 1-3.

The range of effectiveness is derived from looking at the effects of limiting parking supply in urban context. The strategy is appropriate for residential, retail, office, industrial, and mixed-use projects.

3. Guo Zhan, Residential Street Parking and Car Ownership. *Journal of the American Planning Association*, 79:1, 32-48, May 9 2013.

   Zhan reviews the oversupply of on-street parking and resident travel and parking behavior. Using various aerial and street-level publicly available online mapping programs, the author identified off-street parking supply and on-street parking supply and crowding.

   The author found that residential proximity to a train station was associated with a reduction in car ownership at the levels of one or two cars, but not for households with three or more cars. Furthermore, excess off-street parking encourages a higher level of car ownership: the relationship between increased availability of on-street parking (less crowded street parking) and increased car ownership is statistically significant (even when off-street parking is available).

   On-street parking increases total parking supply for a household, thus households are able to buy more cars than just the off-street parking would allow. Finally, having on-street parking readily available in front of one's residence may provide some advantages that off-street parking is unable to offer: households use their garages as an extension of their home square footage, for storage or other non-vehicle storage purposes, and use the on-street parking for their vehicle as an additional amenity.

4. Daniel Chatman, Does Transit-Oriented Development Need the Transit?, *Access*, Fall 2015.

Chatman questions whether the transit oriented development (TOD) necessarily requires transit (defined as rail), or whether other variables (such as dense urban form or residential choice) account for lower car ownership. The author conducted a household survey within two mile radius of ten rail stations in New Jersey. Households with less than one off-street parking space per adult had 0.16 fewer vehicles per adults. Households with both low on- and off-street parking availability had 0.29 fewer vehicles per adult. The other significant variable was the number of bus stops within a mile of the home (doubling the number of bus stops within a mile radius around the average home was associated with 0.08 fewer vehicles per adult). When the effects of more bus stops and low on- and off-street parking availability were combined, they reduce auto ownership by 44 percent.

> *If access to rail is not a primary factor in reducing auto use, it could be a blessing, not only because rail infrastructure is expensive, but also because the amount of available land near rail stations is limited. That said, allowing higher housing density and scarce on- and off-street parking everywhere could increase congestion if not carefully managed (Chatman, p. 21).*

5. Chris McCahill, et al., Effects of Parking Provision on Automobile Use in Cities: Inferring Causality, *Transportation Research Board*, November 13, 2015.

McCahill examines whether a causal relationship between parking and driving exists, asking: does the provision of parking over time influence driving to work or are minimum parking requirements an appropriate response to rising auto use for workers? Using Census 'Journey to Work' mode split data and aerial photos of nine cities from 1960 to 2000, McCahill applied the Bradford Hill general theory of causality (a method from the field of epidemiology) to assess changes in parking availability and mode choice over time.

At the city scale, the authors found that an increase in parking provision from 0.1 to 0.5 parking spaces per resident and employee is associated with an increase in commuter automobile mode share of roughly 30 percentage points. The authors conclude that the findings suggest that polices to restrict and reduce parking capacity in cities are warranted.

6. Fehr and Peers, Parking Analysis and Methodology Memo to San Francisco Planning – Final, April 2015.

The relationship between parking availability or automobile orientation and auto mode share was examined for three different land use types in San Francisco: residential, retail, and office. Fehr and Peers utilized survey data collected at three land use types to develop the linear regression statistical model.

- The researchers found that the AM residential model predicts the absence of parking to be associated with a 60% reduction in auto mode share; and the PM residential predicts the absence of parking to be associated with a 50% reduction in auto mode share.
- For office use at a site with moderate auto orientation, the absence of free or subsidized parking is associated with a 65% reduction in auto mode share.
- For the retail use, the AM morning model predicts that for a site with moderate auto orientation, the absence of parking is associated with 12% reduction in auto mode share; the PM evening retail model predicts that for a site with moderate auto orientation, the absence of parking is associated with a 25% reduction in auto mode share.

ATTACHMENT D

Guidance on Quantitative Analysis for Transportation Projects

The following methodology is based on OPR's Technical Advisory and provides an estimate of VMT effects of lane mile additions can be used to estimate the VMT effects of proposed roadway expansions (or other capacity increasing transportation projects)

Projects should first analyze the percent change in lane miles is calculated by dividing project lane miles by the total lane miles of the applicable functional classes to yield a percent change in lane miles (in %). This percentage is multiplied by the baseline VMT on those facilities and elasticity from the academic studies (typically 1.0) to yield the total induced travel.

Formula:

Elasticity = [% change in VMT] / [% change in lane-miles]

or

VMT Impact = [% change in lane-miles] * [baseline VMT on those lane-miles] * [elasticity]

Attachment E

Transportation Demand Management Measures

The following are a list of Transportation Demand Management measures identified by the Planning Department that can be used by projects to meet their Transportation Demand Management target. More information can be found at http://sf-planning.org/transportation-demand-management-program.

- Provide streetscape improvements to encourage walking (ACTIVE-1)
- Provide secure bicycle parking, more spaces given more points (ACTIVE-2)
- Provide on-site showers and lockers (ACTIVE-3)
- Provide a bike share membership to residents and employees for one point, another point given for each project within the bike share network (ACTIVE-4)
- Provide on-site bicycle repair station (ACTIVE-5A)
- Provide on-site bicycle maintenance services (ACTIVE-5B)
- Provide fleet of bicycles (ACTIVE-6)
- Provide bicycle valet parking (ACTIVE-7)
- Offer car-share parking and membership (CSHARE-1)
- Provide delivery supportive amenities (DELIVERY-1)
- Provide delivery services (DELIVERY-2)
- Offer family TDM amenities (FAMILY-1)
- Provide on-site childcare (FAMILY-2)
- Provide Family TDM package (FAMILY-3)
- Provide contributions or incentives for sustainable transportation (HOV-1)
- Provide shuttle bus service (HOV-2)
- Offer vanpool programs (HOV-3)
- Provide multimodal wayfinding signage (INFO-1)
- Provide real time transportation information display (INFO-2)
- Provide tailored transportation marketing services (INFO-3)
- Provide healthy food retail in underserved area (LU-1)
- Provide on-site affordable housing (LU-2)
- Offer unbundled parking (PKG-1)
- Offer short term daily parking provision (PKG-2)
- Offer parking cash out: non-residential tenants (PKG-3)
- Reduce parking supply (PKG-4)