TERNER CENTER FOR HOUSING INNOVATION UC BERKELEY

TERNER CENTER COMMENTARY - APRIL 2025

Aligning Housing with Climate Goals: The Importance of Measuring VMT

AUTHORS

Rachel Strangeway, Assistant Specialist

Zack Subin, Associate Research Director

CONTENTS

Introduction

California has undertaken two challenging housing and climate goals: to **build 2.5 million new homes by 2030** and to **reduce climate pollution 40 percent by 2030**.[1] Especially given that passenger travel represents the single **largest source** of climate pollution from California households, geographically defined transportation criteria are increasingly being used in California housing policy to promote state goals for reducing climate pollution (**Table 2**). **These goals** target reductions in the amount of daily driving by California residents, as measured in a metric known as vehicle miles traveled (VMT) per person.[2]

Previous Terner Center commentaries have investigated the **mechanisms** by which, and **to what extent**, building more housing in walkable neighborhoods could reduce VMT by enabling future residents to drive less while accomplishing their daily activities. In general, research **suggests** infill housing—building new housing within existing neighborhoods—tends to reduce carbon pollution by avoiding more carbon-intensive development in new suburban neighborhoods.

Following Senate Bill **(SB) 226** (2011), the Office of Land Use and Climate Innovation (LCI—formerly the Office of Planning and Research) developed **statutory** guidance defining "low vehicle travel areas" (i.e., neighborhoods with relatively low VMT per person). In addition, LCI developed **technical** guidance expanding on this definition for the implementation of **SB 743** (2013). Both documents offer criteria for streamlined

impact assessment under the California Environmental Quality Act (CEQA),[3] meaning that housing development in these areas may proceed somewhat more quickly, or at less expense, through local environmental review.

LCI defined low-VMT neighborhoods by comparing neighborhood-level VMT patterns to a regional or city average. LCI's **reasoning** was that new housing development in low-VMT neighborhoods would enable future residents to also drive less. California State Governor Gavin Newsom's August 2024 **executive order** encouraging infill housing recommended the use of **LCI's Site Check tool**, a web-based mapping platform launched by LCI in 2023, to identify opportunities for streamlined development, including low-VMT neighborhoods under LCI's definition.

All of this suggests that how "low-VMT" is defined, as well as the data and models that are used to measure local VMT patterns, are increasingly important to where new housing is incentivized. Methodological changes can alter which neighborhoods are defined as low-VMT, thereby influencing which developments may be provided streamlined CEQA entitlement processes.

In this analysis, we compare the low-VMT layer from LCI's Site Check tool (a composite of state and regional models described below: "the State's low-VMT layer") with two other modelled approaches to measuring VMT, to note differences in which neighborhoods are identified as having low-VMT under different approaches.

We find large differences in the low-VMT maps depending on which VMT model is used, as well as whether neighborhood-level VMT is compared with a regional or state VMT baseline.

Importantly, the State's low-VMT layer may be overlooking many higher-resource and job-rich neighborhoods that have the potential to reduce VMT and support the state's fair housing goals when building new housing.[4] We recommend that the State further invest in developing and validating VMT models for use in housing policy, and consider expanding the criteria for defining low-VMT to include larger areas for streamlining housing development.

Existing VMT Models

VMT per person for a certain geographic area can be measured in two different ways: based on total driving *occurring within* the area, or on total driving done by people *living within* the area. For example, you could measure the VMT in San Francisco using the miles driven within the city limits, including incoming commuters for the portions of their trips occurring in the city's boundary. Or, you could measure the VMT based on how much San Francisco residents drive in a typical day, including their miles driven outside the city's boundaries. The first metric is more common and easier to measure since it can be observed directly by counting vehicles using highways and major roadways. This approach is how the Federal Highway Administration (FHWA) reports VMT for each county. However, the second metric ("residential VMT") is more relevant for housing policy, since it accounts for whether people are able to live close to their work and/or easily access other daily needs such as grocery stores or schools. Residential VMT is used under the LCI guidance, as well as in the models assessed below.

LCI's **Site Check** tool is designed to help developers identify sites that could qualify a development for CEQA exemption or streamlining (above), including VMT criteria, as well as other policy criteria such as minimizing exposure to environmental hazards. The Site Check tool compiles VMT estimates from regional or state agencies and identifies areas in which VMT is **below the regional average** and **15 percent below the regional average** at a traffic analysis zone (TAZ) level.[5] These VMT estimates are not actual measurements of residential travel, but rather composites of model outputs from either regional Metropolitan Planning Organization (MPO) VMT models or the California Statewide Travel Demand Model (CSTDM), depending on the region (**Appendix 3**).

To understand the implications of using alternative VMT estimates for housing policy, we compare the areas contained in the State's low-VMT layer to those similarly defined using two other models: Replica and Local Area Transportation Characteristics for Households Data (LATCH). **Replica** is a private company that uses a proprietary model calibrated using data from mobile devices, such as cell phone locations, to estimate U.S. travel patterns. **LATCH** is a federal model incorporating 2017 National Household Travel Survey (NHTS) data and American Community Survey (ACS) data. **Previous research** has compared LATCH and Replica, finding modest evidence that Replica's estimates are realistic and appropriate for housing policy analysis.[6] In this analysis, we map neighborhoods with an average VMT 15 percent below each model's respective regional averages.

We also attempt to validate the VMT models in Site Check, Replica, and LATCH with two additional sets of VMT estimates: those from FHWA and from Fehr and Peers' **VMT+** model (model details can be found in **Appendix 3**). Neither of these can be compared directly at a neighborhood scale with the three VMT models;[7] instead, we compare regional- and state-average VMT estimates.

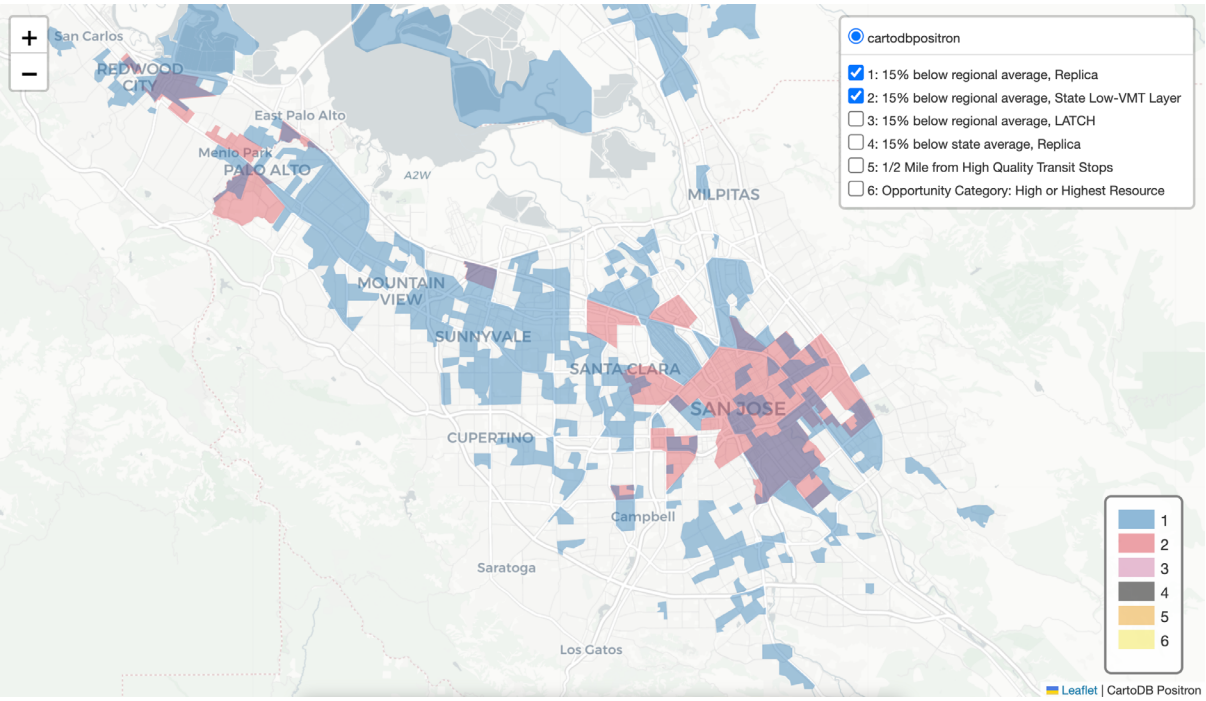
It is important to note that in all three of these model layers (the State's low-VMT layer, Replica, and LATCH), the actual miles travelled are not directly observed (e.g., from vehicle count data, trip diaries, or household travel surveys), but are instead modeled estimates of resident trips and aggregated VMT. These tools rely on modelling because of the lack of fine geographic-scale, residential VMT datasets; collecting this type of data would be challenging.[8] However, each model also comes with its own underlying assumptions and limitations, which is why understanding differences in how they designate low-VMT areas is important.

Findings

Effects of VMT Model Selection

Our analysis shows that the choice of model influences which neighborhoods are designated as low-VMT, with implications for where new housing would be streamlined. In coastal urban areas, more neighborhoods are designated low-VMT according to Replica than using either the State's low-VMT layer or LATCH, while in less dense inland cities there are more neighborhoods designated low-VMT according to the State than using Replica (Figures **1** and **2**; Tables **A8** and **A9**).

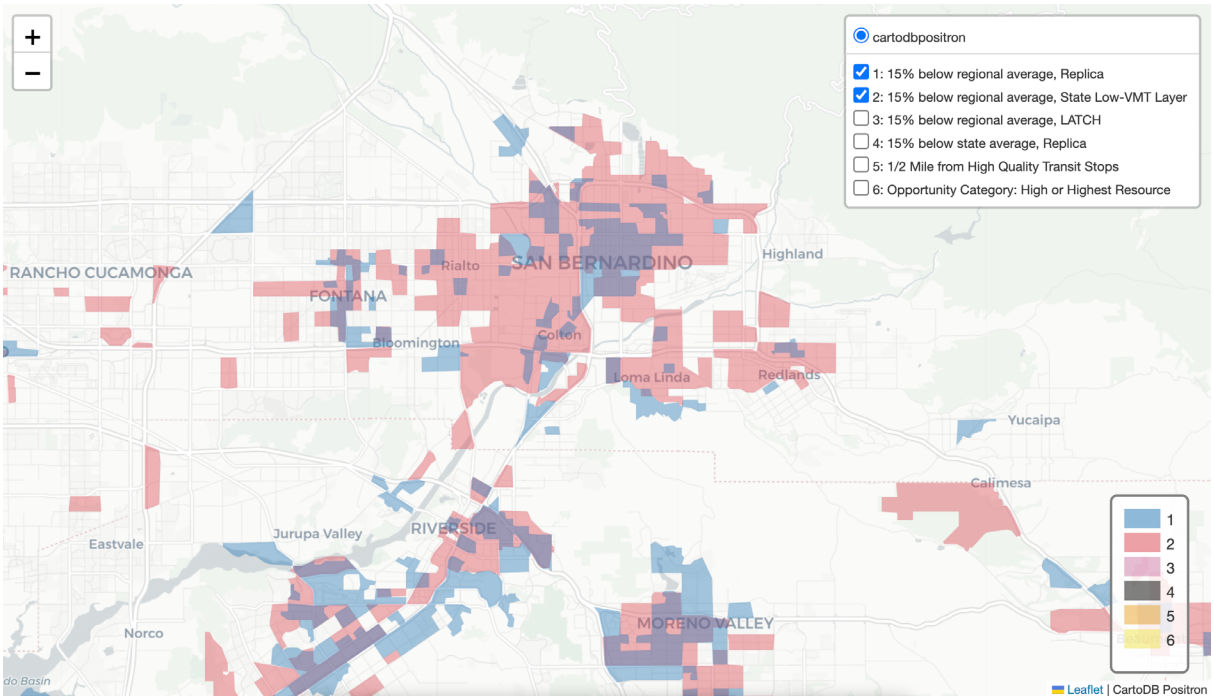
Figure 1: Map of the South Bay comparing Replica low-VMT areas (blue) to the State's low-VMT layer (red)



Source for Figures: Terner Center analysis of models in Appendix 3 and other State map layers noted.

There are more low-VMT areas in the South Bay with Replica (shown in blue) than with the State's low-VMT layer (shown in red).

Figure 2: Map of San Bernardino comparing Replica low-VMT areas (blue) to the State's low-VMT layer (red)



There are more low-VMT areas in San Bernardino with the State's low-VMT layer (shown in red) than with Replica (shown in blue).

For example, Replica designates 62 percent of Los Angeles' city population as living in low-VMT neighborhoods, while the State designates 40 percent. Overall, Replica designates 1.9 times as many Los Angeles *County* residents' neighborhoods as low-VMT as the State does. In contrast, the State designates about 71 percent of San Bernardino's city population as living in low-VMT neighborhoods, while Replica designates 29 percent; overall, Replica designates half as much of San Bernardino *County* as low-VMT as the State does.

We find that the State's low-VMT layer identifies fewer coastal urban neighborhoods and more inland city neighborhoods for streamlined housing development than if Replica's model were used.

Building more in coastal urban areas would help reduce carbon pollution and provide access to job-rich urban centers. However, development in inland areas may provide new housing at lower cost. The State's **housing plan** envisions all regions of the state contributing to overall housing production, so developing more infill housing in both areas would be ideal.

Effects of VMT Baseline Definition

Additionally, we find that the identification of low-VMT neighborhoods is sensitive to the baseline used, with implications for different regions of the state.

For example, the Bay Area region has a relatively low average VMT compared to the statewide average in all three models (as well as both of the additional data sources used for validation; **Table 1**). According to Replica's modeling, people in several neighborhoods next to downtown Mountain View average 17 VMT per person, per day[9]—more than 15 percent less than Replica's state average of 21, but not its regional average of 19 VMT per person, per day.

If low-VMT neighborhoods were defined relative to the state average, about 40 percent more residents' neighborhoods in the Bay Area would be identified for housing development streamlining (**Figure A6**; **Table A8**). Since the goal is to reduce statewide carbon pollution, using the state, rather than the regional, average as the baseline would lead to overall greater reductions in VMT.[10]

In contrast, using a statewide baseline would yield fewer neighborhoods for streamlining in higher-VMT regions of the state, such as the Central Valley. Using a statewide baseline may also require changing LCI's **statutory guidance** implementing SB 226. In these cases, it could make sense to use the existing regional, rather than state, baseline.

Relationship with Transit Proximity

LCI guidance suggests streamlining for locations within a half-mile of "high-quality transit" under SB 743.[11] We compare these locations to neighborhoods designated in

the State's low-VMT layer and Replica. In coastal cities, the State tends to designate fewer neighborhoods low-VMT, so most of these would already be covered by the high-quality transit definition (**Figure A4**). In Replica, however, including low-VMT neighborhoods expands streamlining modestly in coastal cities (**Figure A3**). Inland, the State designates many neighborhoods low-VMT but *not* within a half-mile of high-quality transit (**Figure A5**).

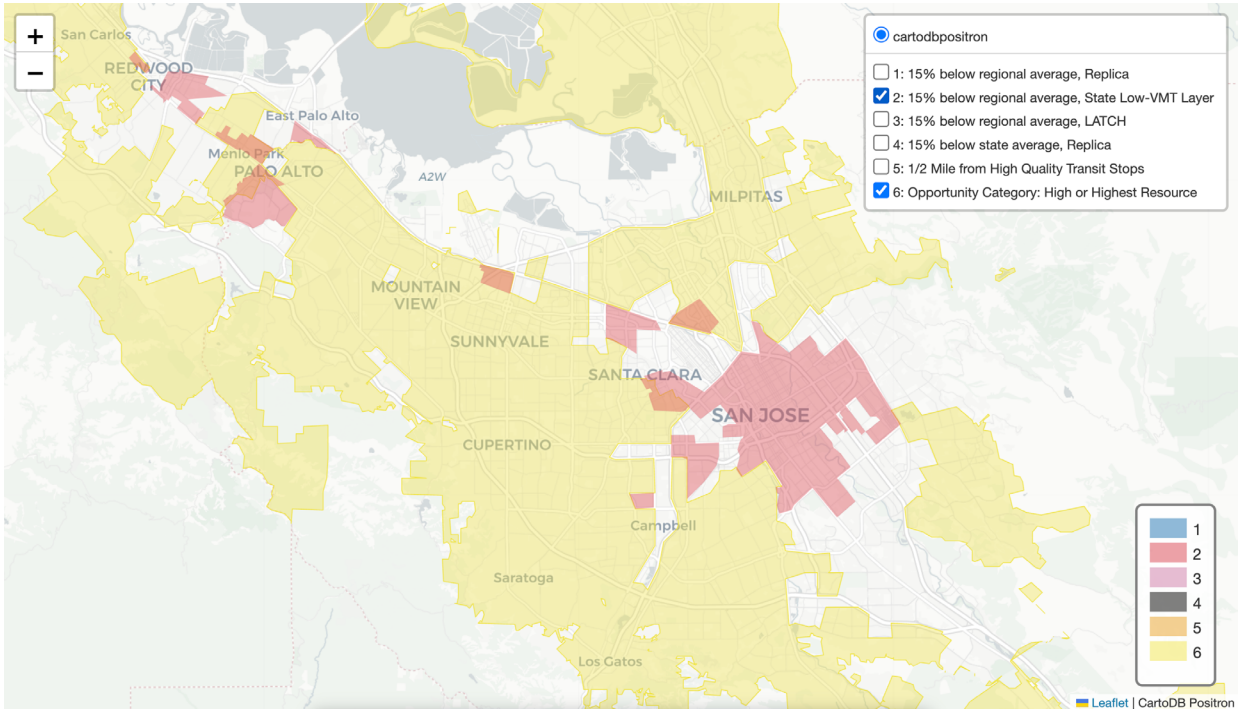
Overall, the expansion of eligibility for CEQA streamlining from transit-proximate to also include low-VMT may modestly expand the areas streamlined, but for different locations in the State's low-VMT layer and Replica.

Relationship with Opportunity Maps

Neighborhoods that are low-VMT (which tend to be in more dense, urban areas) may differ from those that have better schools and other resources to support economic mobility (which tend to be wealthier, single-family suburbs). To explore this relationship, we overlay the low-VMT models with the higher-resourced neighborhoods defined by the state's **2024 Opportunity Maps**.[12] We find that using Replica instead of the State's low-VMT layer (or LATCH) would enhance overlap between low-VMT areas and higher-resource areas (**Figure 3**, **Figure 4**).

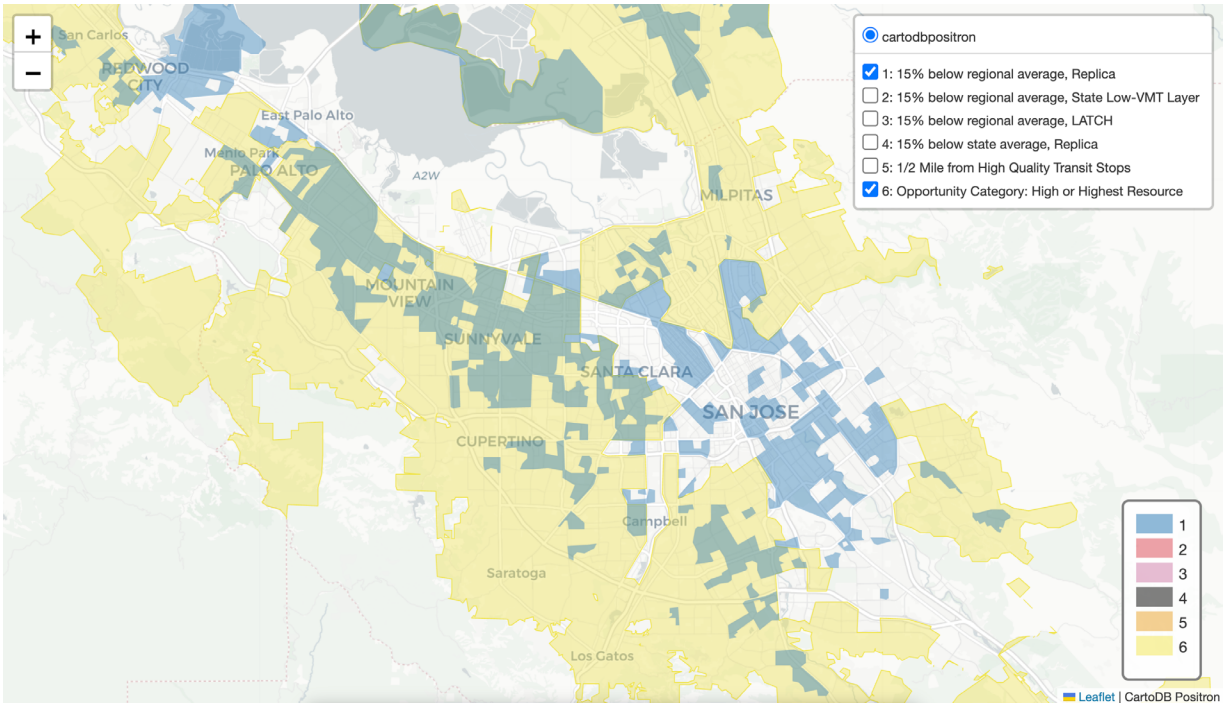
The choice of VMT model would affect how much area is identified as satisfying both environmental and fair housing criteria for housing development.

Figure 3: Map of the San Jose area comparing the State's low-VMT layer (red) to higher-resource areas (yellow)



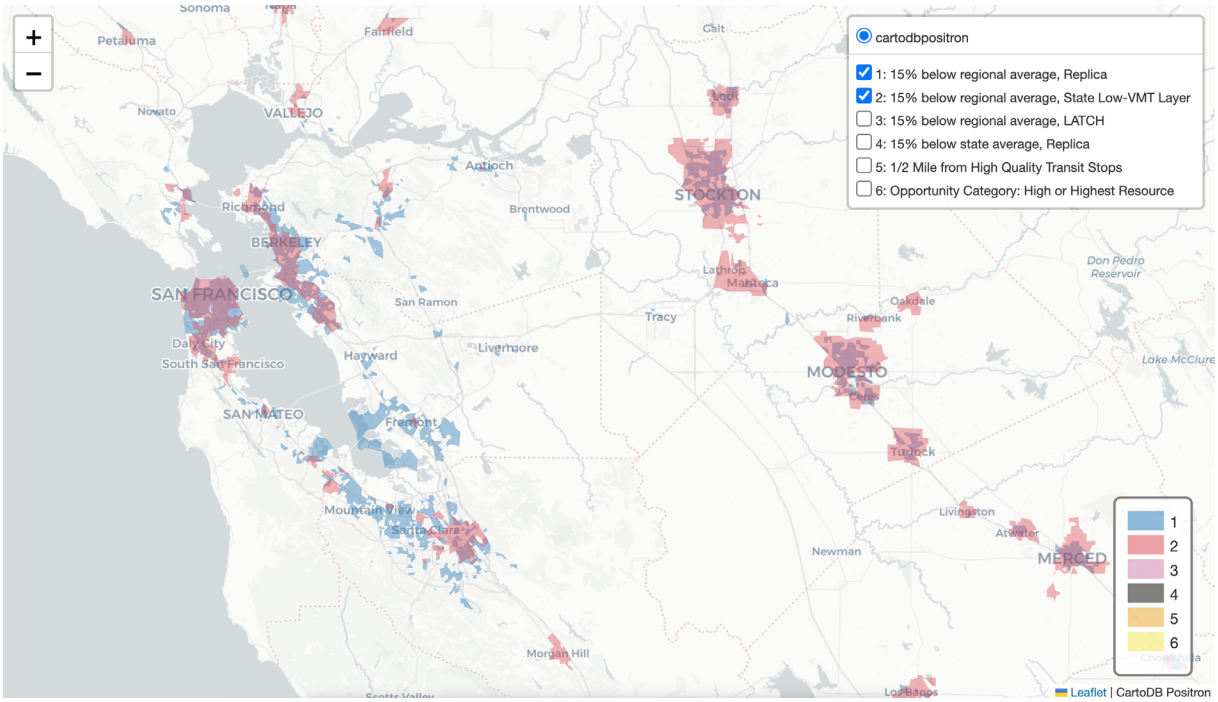
There is very little overlap between higher-resource areas and the State's low-VMT layer.

Figure 4: Map of the San Jose area comparing Replica low-VMT areas (blue) to higher-resource areas (yellow)



There is more overlap between higher-resource areas and low-VMT areas from Replica.

Interactive Statewide Map of Transportation and Housing Policy Criteria



Access an interactive map illustrating how low-VMT neighborhoods may vary depending on the model estimates used across the state. The map also illustrates High-Quality Transit Areas[13] and higher-resource areas (i.e., "high" or "highest" resource areas) defined in the state's **2024 Opportunity Map**.

Policy Implications

Given the urgency of both addressing climate change and the state's housing shortage, this analysis suggests that policymakers should pay more attention to how "low-VMT" areas are defined. We recommend that the State allocate additional research and technical assistance funds to make high-quality, transparent, and comprehensive VMT estimates available to the public.[14] Given the challenges of validating VMT models (**Appendix 1**), the State may first commission detailed expert review of the various existing approaches to measuring VMT (including acquiring proprietary datasets). Then, technical assistance funding could be used to either: (1) support regional transportation planning agencies, prioritizing lower-resourced regions, to improve and harmonize their models; or (2) to enhance the validation and transparency of the California State Travel Demand Model to promote consistency of VMT modelling across the state.

In the face of imperfect measurements of residential VMT, policymakers could also develop broader transportation criteria to expand where new housing is streamlined or otherwise encouraged. For example, they could enable streamlining for neighborhoods that are either designated low-VMT or have characteristics associated with lower VMT such as **high residential density** and high **walkability** scores: enabling housing projects located in neighborhoods satisfying *any* of these three criteria.

Given the State's climate goals, policymakers should consider revising guidance to use the statewide VMT average as the baseline in regions with low average VMT, rather than using their regional average as the baseline. To avoid reducing housing production in regions with higher average VMT, policymakers may continue to use the existing baseline there. Using different baselines in different regions of the state may help balance state greenhouse gas reduction and housing production goals.

The use of VMT estimates to guide planning and policy decisions is important for building a sustainable California. However, policymakers should avoid letting imperfect information obscure opportunities for much-needed housing development. Considering the holistic environmental **benefits** of infill and/or dense housing beyond reducing VMT, they should err on the side of streamlining more existing neighborhoods for new housing.

References

Bureau of Transportation Studies. (2024). Methodology for 2017 Local Area Transportation Characteristics for Households. Bureau of Transportation Statistics. **https://www.bts.gov/latch/latch-methodology-2017**

California Environmental Quality Act (CEQA) Appendix M: Performance Standards for Infill Projects Eligible for Streamlined Review, Public Resources Code Sections 21094.5 and 21094.5.5. (2016). California Governor's Office of Land Use and Climate Innovation. **https://resources.ca.gov/CNRALegacyFiles/ceqa/docs/2016_CEQA_Statutes_and_Guidelines_Appendix_M.pdf**

California Governor's Office of Planning and Research (OPR). (2018). Technical Advisory: On Evaluating Transportation Impacts in CEQA. **https://lci.ca.gov/docs/20190122-743_Technical_Advisory.pdf**

California Tax Credit Allocation Committee (CTCAC). (2024). Methodology for Opportunity and High-Poverty & Segregated Area Mapping Tools. **https://www.treasurer.ca.gov/ctcac/opportunity/2024/draft-2024-opportunity-mapping-methodology.pdf**

CTCAC, & California Department of Housing and Community Development (HCD). (2024). Final 2024 CTCAC HCD Opportunity Map [Dataset]. **https://belonging.berkeley.edu/final-2024-ctcac-hcd-opportunity-map**

Environmental Protection Agency (EPA). (2025). National Walkability Index [Dataset]. **https://epa.maps.arcgis.com/home/item.html?id=f16f5e2f84884b93b380cfd4be9f0bba**

Federal Highway Administration (FHWA). (2025). Highway Statistics Series: Annual Vehicle Distance Traveled in Miles and Related Data by Highway Category and Vehicle Type (VM–1; Version 2022) [Dataset]. Highway Statistics Series. **https://www.fhwa.dot.gov/policyinformation/statistics/2022/vm1.cfm**

Fehr & Peers. (n.d.). SB 743 Policy Adoption Technical Assistance Program: Establishing an Infill and Affordable Housing Screen (VMT Policy Adoption Technical Assistance Memo Template). Association of Bay Area Governments. Retrieved March 14, 2025, from **https://abag.ca.gov/sites/default/files/documents/2024-04/MTC_Infill_Housing_VMT_White_Paper.pdf**

Heyerdahl, J., & Conservation Biology Institute. (2023a). 15% Below Regional Average Vehicle Miles Traveled (VMT) Per Capita, California (Version 2.1) [Dataset]. Data Basin. **https://databasin.org/datasets/4e189c878e094cbfb0a000ae8ad04948/**

Heyerdahl, J., & Conservation Biology Institute. (2023b). Below Regional Average Vehicle Miles Traveled (VMT) Per Capita, California (Version 2.1) [Dataset]. Data Basin. **https://databasin.org/datasets/d155d4bec8774c7db030ab090bd86359/**

Jones, C., & Kammen, D. M. (2014). Spatial distribution of U.S. household carbon footprints reveals suburbanization undermines greenhouse gas benefits of urban population density. Environmental Science and Technology, 48(2), 895–902. **https://doi.org/10.1021/es4034364**

Kim, J. H., et al. (2024). Assessing the Potential for Densification and VMT Reduction in Areas Without Rail Transit Access. **https://doi.org/10.7922/G22V2DGJ**

Little Hoover Commission. (2024). CEQA: Targeted Reforms for California's Core Environmental Law (279). **https://lhc.ca.gov/wp-content/uploads/Report279.pdf**

Manville, M. (2024). Induced Travel Estimation Revisited. UCLA Institute for Transportation Studies. **https://escholarship.org/uc/item/8m98c8j1**

Marantz, N. J., et al. (2024). Evaluating the Potential for Housing Development in Transportation-Efficient and Healthy, High-Opportunity Areas in California (20STC009; pp. 1–178). California Air Resources Board. **https://www.law.virginia.edu/node/2182176**

Miller, E. (2023). The current state of activity-based travel demand modelling and some possible next steps. Transport Reviews, 43(4), 565–570. **https://doi.org/10.1080/01441647.2023.2198458**

Office of Governor of California Gavin Newsom. Executive Order N-2-24 (2024). **https://www.gov.ca.gov/wp-content/uploads/2024/07/infill-EO.pdf**

Othering and Belonging Institute (OBI). (2024, January 18). California renews adoption of OBI opportunity map | Othering & Belonging Institute, University of California, Berkeley. **https://belonging.berkeley.edu/california-renews-adoption-obi-opportunity-map**

Reid, C., Subin, Zack, & McCall, J. (2024). Housing + Climate Policy: Building Equitable Pathways to Sustainability and Affordability. Terner Center for Housing Innovation, University of California, Berkeley. **https://ternercenter.berkeley.edu/research-and-policy/climate-housing-overview/**

Replica. (2024, January). Seasonal Mobility Model Methodology Extended (Places). Replica. **https://documentation.replicahq.com/docs/seasonal-mobility-model-methodology-extended-places**

Subin, Z. (2024, October 9). How much can new housing contribute to state climate action? Terner Center for Housing Innovation, UC Berkeley. **https://ternercenter.berkeley.edu/blog/how-much-can-new-housing-contribute-to-state-climate-action/**

Subin, Z. (2024, March 12). Understanding the Role of New Housing in Reducing Climate Pollution. Terner Center for Housing Innovation, UC Berkeley. **https://ternercenter.berkeley.edu/research-and-policy/role-of-new-housing-in-reducing-climate-pollution/**

Subin, Z., et al. (2024). US urban land-use reform: A strategy for energy sufficiency. Buildings & Cities, 5(1). **https://doi.org/10.5334/bc.434**

Wallace, M., McDonough, P., & Milam, R. (2023, December 5). Fehr & Peers 2019 VMT per Capita Estimates. Fehr & Peers. **https://storymaps.arcgis.com/stories/e9fb17d33a2c4d60a6747071be3d5b4a**

Endnotes

1. **SB 32**, passed in 2016, requires the California Air Resources Board (CARB) to ensure that statewide greenhouse gas (GHG) emissions are reduced to 40 percent below 1990 levels by 2030.

2. VMT is particularly an index of greenhouse gas emissions, as these approximately relate to the product of miles driven and the fuel consumed per mile. **Researchers have argued** that while VMT is an important and commonly referenced index of transportation GHG emissions, it is imperfect. Other metrics, such as road space, might track more closely to pollution caused by transportation while not discounting the benefits of improving access to destinations for California residents.

3. CEQA exemptions or streamlined reviews occur as a result of studies of environmental impact. Projects in areas 15 percent or more below regional average VMT ("low-VMT" here) may be presumed to have "less than significant" transportation impact according to the LCI technical guidance for SB 743, though ultimately this decision rests with the "lead agency." Projects in "low vehicle travel" areas (below regional average VMT) may also qualify for streamlining as an infill project under the SB 226 statutory guidance. The lead agency is the public entity carrying out the project or responsible for approving the project and that is also responsible for performing or approving the CEQA analysis. In some cases, lawsuits are brought against project developers and their corresponding CEQA analysis and lead agency, which may result in litigation that requires judicial interpretation of the environmental impact of a project. For more details, see **Little Hoover Commission, 2024**.

4. Researchers focused on the Southern California region recently conducted a **study** with similar findings.

5. These two definitions correspond to the SB 226 statutory guidance, and the SB 743 technical guidance, respectively. Per the **Site Check methodology**: "Region is defined as either the jurisdictional boundary of a Municipal Planning Organization (MPO), or in cases where no MPO exists, the region is instead defined as the county boundary."

6. Replica's VMT outputs more closely matched FHWA's estimates of national VMT than LATCH's model. In addition, Replica generally had a more realistic statistical distribution. The two models had modest correlation at the census tract level and differed substantially in their representation of rural areas, but the two models had a very similar relationship with population density in suburban and urban areas. For more details, see **Subin et al. (2024)**.

7. FHWA measures VMT within a geographic boundary, rather than from people living within a boundary, and counties are the finest geographic scale for which it provides VMT estimates. VMT+ develops neighborhood VMT estimates but these are not publicly available for download.

8. Gathering fine geographic-scale, residential VMT datasets would require directly collecting a large enough sample of all resident trips in every neighborhood that the samples could be considered representative and used directly without use of an intermediate statistical model.

9. Specifically, census block groups numbered 5003, 6002, and 6003.

10. As discussed in previous Terner Center **research** and **Subin et al. (2024)**, the most appropriate baseline would consider *where housing would otherwise be built* if not in the streamlined locations; this could be different from the state average if recent housing development has been trending toward higher-VMT locations, or if the California housing shortage is displacing residents from the state entirely.

11. The LCI guidance also suggests locations near "major transit stops" for streamlining. Some other State policies refer to either or both of these definitions (**Table 2**). We analyzed proximity to "high-quality transit" here, as these locations tend to be broader than "major transit stops."

12. The state's Opportunity Map is **designed** to identify priority areas for affordable family housing development, in order to overcome decades of exclusionary housing policies that have concentrated affordable housing in high-poverty, racially segregated neighborhoods. The maps identify census tracts that are considered to be high- and highest-resourced areas in order to increase access to opportunity and reduce segregation **(OBI, 2024)**. (Here, we define "higher-resource" as either "high" or "highest" resource.) Note that prior to 2024, transit proximity was included as a criterion in the Opportunity Map, so it would be less appropriate to make the comparisons shown here with prior versions. Other maps have been proposed to identify priority areas for housing development that satisfy fair housing and transportation objectives, such as **Marantz et al. (2024)**.

13. A High-Quality Transit Area is defined in PRC § 21155 as an area less than half a mile from a corridor with fixed-route bus service with service intervals no longer than 15 minutes during peak commute hours. Note that proximity to "major transit stops" has a different definition, recently updated by 2024 Assembly Bill 2553, and is used in other legislation such as Assembly Bill 2097 (2022), which removed parking requirements within half a mile of these stops.

14. Additional research is also needed to better understand why differences shown in this analysis exist between the models. However, the downloadable low-VMT layer from Site Check provides insufficient supporting information to enable complete cross-comparison and validation (see below).

15. The regional average estimates for Replica and LATCH have a correlation coefficient of 54 percent (statistically significant at a 5 percent threshold). The State's low-VMT layer is not significantly correlated with any of the other models, including **VMT+** and FHWA.

16. The average is calculated as a population-weighted average of all areas of the state within an MPO.

17. The comparison of statewide average is between FHWA 2022 VMT and Replica's 2023 VMT. In addition, FHWA includes all vehicle trips, while Replica's VMT estimates used here exclude most heavy-duty and commercial vehicle trips. Nationally, heavy-duty trucks comprise about 10 percent of VMT (**FHWA, Table VM-1**).

18. The State's downloadable low-VMT layer is currently challenging for researchers to use or validate against other models, due to limited information provided: the inability to download files for areas with greater than regional average VMT (making comprehensive assessment of the State's VMT distribution and comparisons with other VMT models impossible); post-processing that excludes areas outside urbanized areas; and use of non-standard geographies (model-specific transportation analysis zones are used instead without associated metadata such as enclosed housing stock and population). Again, these limitations make quantitative comparisons to other models very difficult.

19. For additional benchmarking, we include regional average VMT estimates from **VMT+**, a tool that, like Replica, incorporates mobile device data. Underlying census block group-level VMT estimates used in the VMT+ dashboard are not publicly available for statewide download; however, we have manually retrieved the 18 MPO averages from the public dashboard for this comparison.

20. This total excludes the population outside an MPO, about 2 percent of the state, based on authors' calculations of ACS data.

Acknowledgments

We would like to thank the Wells Fargo Foundation for supporting the Terner Center's Housing + Climate research initiative, including this work. We would like to thank Sarah Karlinsky, Ben Metcalf, Carolina Reid, Dan Chatman, and several peer reviewers for their comments on previous drafts. We would like to thank Quinn Underriner for his assistance with data analysis and map presentation.

This research does not represent the institutional views of the University of California, Berkeley or of Terner Center's funders. Funders do not determine research findings or recommendations in Terner Center's research and policy reports.

Appendix 1: Validation of VMT Estimates

To contextualize the differing low-VMT areas identified by each model, we compared the regional average VMT per person inferred in each model with each other and with FHWA estimates (**Table 1**). FHWA regional estimates for VMT, based on measuring total driving *occurring* in an area (above), are uncorrelated with any of the three VMT model layers measuring driving by *residents* in an area (the State's low-VMT layer, Replica, and LATCH)—illustrating the difference between the two approaches. However, while Replica estimates *are* statistically similar to those of LATCH, the State's composite estimates are not correlated with any of the other models'.[15]

While the results of measuring VMT based on miles driven in an area versus the miles driven by residents of an area differ greatly at the local level, they become more similar when focusing on larger geographic areas, as their included trips overlap more. For example, commuters frequently cross city lines but rarely cross state lines, especially in a large state like California.

Comparing the statewide averages for all five models, LATCH estimates appear to be systematically lower then FHWA estimates, while Replica and the State's estimates match more closely on average,[16] within the margin expected from year-to-year variation and differences in model scope.[17]

The statewide averages mask larger regional differences between the State's low-VMT layer and the other models: the State's VMT estimates are lower than those of other models for MPOs with small populations (**Table 1**). For example, the State's low-VMT layer estimates Madera County's average to be 10.0 VMT per person per day, lower than the other models for any region. We attempted to understand the differences between the State's low-VMT layer and the other estimates more closely, but the downloadable layer does not provide sufficient information to enable direct, quantitative validation and cross-comparison; key missing information includes VMT estimates covering the entire state (not just areas designated low-VMT) and geographic metadata for the transportation analysis zones.[18]

Table 1: Regional Average of Daily Vehicle Miles Traveled Per Capita according to State (2019-2021), Replica (2023), LATCH (2017), VMT+ (2024),[19] and FHWA (2022).

MPO (Year Represented)	State (2019-2021)	Replica (2023)	LATCH (2017)	VMT+ (2019)	FHWA (2022)	Population (ACS 5-year estimates, 2022)
AMBAG	15.7	22.9	13.5	22.8	22.2	770,933
BCAG	14.9	22.5	14.4	22.3	19.8	213,605
FCOG	16.1	21.3	12.0	20.9	22.4	1,008,280
KCAG	18.1	24.6	13.0	23.1	29.2	152,515
KCOG	17.1	21.6	12.5	22.4	28.0	906,883
MCAG	17.6	20.7	12.4	25.7	27.9	282,290
MCTC	10.0	27.6	12.1	27.4	31.6	157,243
MTC	15.5	18.9	14.1	19.4	19.4	7,685,888
SACOG	20.8	21.1	14.0	23.1	21.3	2,537,783
SANDAG	19.0	21.9	13.6	21.2	21.9	3,289,701
SBCAG	11.5	21.1	13.2	19.3	20.5	445,213
SCAG	20.8	20.6	12.4	20.6	21.6	18,743,554
SJCOG	19.5	21.8	12.5	26.6	23.2	779,445
SLOCOG	15.4	25.8	16.2	22.9	30.3	281,712
SRTA	18.8	26.2	15.2	22.3	27.9	181,852
StanCOG	17.5	20.5	12.7	24.2	22.0	552,063
TCAG	15.1	20.4	12.4	22.7	23.3	473,446
TMPO	19.0	35.4	15.7		14.7	55,771
Statewide totals[20]	18.9	20.7	13.0	21.0	21.6	38,518,177

Appendix 2: California Policies

Table 2: Selected California Housing Policies and Proposed Policies with Requirements Involving Transit Proximity or Low-VMT

Policy, Date	Description	Requirements Related to Transit Proximity	Requirements Related to VMT
SB 375, 2008	Mandates that Metropolitan Planning Organizations (MPOs) include a Sustainable Communities Strategy (SCS)—a regional land use plan—within their Regional Transportation Plans (RTPs). The combined RTP/SCSs must demonstrate that they will reduce VMT and greenhouse gases (GHGs) from automobiles and light trucks in the region by state-mandated, targeted amounts over the plan duration. SB 375 also requires that RTP/SCSs be aligned with Regional Housing Needs Allocation (RHNA) plans. It also provided a new "Sustainable Communities Project Exemption" for Transit Priority Projects (TPPs) that are declared Sustainable Community Projects, as well as streamlined CEQA analysis for TPPs and certain residential or mixed-use projects.	Projects designated as both TPPS and Sustainable Community Projects are exempt from CEQA analysis. (Among other requirements are that it must be located within a half-mile of a rail transit station included in a regional transportation plan or within one-quarter mile of a high-quality transit corridor included in a regional transportation plan). Projects designated only as TPPs and that meet other requirements are eligible for a streamlined CEQA process (three requirements, one of which is to be within a half-mile of a major transit stop or high-quality transit corridor included in a regional transportation plan.)	RTPs are required to demonstrate that they will reduce vehicle miles traveled (VMT) and GHGs from automobiles and light trucks in the region by state-mandated, targeted amounts over the plan duration.

SB 226, 2011	Expands the provisions for CEQA streamlining and categorical exemption of infill development. For infill development that meets several criteria, including performance criteria pertaining to transportation impacts, CEQA review of significant effects may be limited or not required, depending on a prior Environmental Impact Review (EIR) and whether any uniformly applicable development policies or standards would substantially mitigate those effects.	To be eligible for streamlining pursuant to Section 15183.3, among other requirements, a project must satisfy one of the following: Projects achieving below average regional per capita vehicle miles traveled (VMT). A residential project is eligible if it is located in a "low vehicle travel area" within the region. **Projects located within [to be determined] miles of an Existing Major Transit Stop or High-Quality Transit Corridor. A residential project is eligible if it is located within [to be determined] miles of an existing major transit stop or an existing stop along a high-quality transit corridor.** Low-Income Housing. A residential or mixed-use project consisting of 300 or fewer residential units, all of which are affordable to low-income households, is eligible if the developer of the project provides sufficient legal commitments to the lead agency to ensure the continued availability and use of the housing units for lower-income households, as defined in Section 50079.5 of the Health and Safety Code, for a period of at least 30 years, at monthly housing costs, as determined pursuant to Section 50053 of the Health and Safety Code.	To be eligible for streamlining pursuant to Section 15183.3, among other requirements, a project must satisfy one of the following: **Projects achieving below average regional per capita vehicle miles traveled (VMT). A residential project is eligible if it is located in a "low vehicle travel area" within the region.** Projects located within [to be determined] miles of an Existing Major Transit Stop or High-Quality Transit Corridor. A residential project is eligible if it is located within [to be determined] miles of an existing major transit stop or an existing stop along a high-quality transit corridor. Low-Income Housing. A residential or mixed-use project consisting of 300 or fewer residential units, all of which are affordable to low-income households, is eligible if the developer of the project provides sufficient legal commitments to the lead agency to ensure the continued availability and use of the housing units for lower-income households, as defined in Section 50079.5 of the Health and Safety Code, for a period of at least 30 years, at monthly housing costs, as determined pursuant to Section 50053 of the Health and Safety Code.

SB 743, 2013	Shifts the focus of analysis and mitigation required under CEQA of transportation impacts of development from maintaining level of service (LOS) standards for vehicular throughput, to considering impacts on reducing VMT.	Aesthetic and parking impacts of a residential, mixed-use residential, or employment center project, on an infill site, within a transit priority area, shall not be considered significant impacts on the environment. Any project that includes in its geographic bounds a portion of an existing or planned Transit Priority Area (i.e., the project is within a half-mile of an existing or planned major transit stop or an existing stop along a high-quality transit corridor) may employ VMT as its primary metric of transportation impact for the entire project.	The California Governor's Office of Planning and Research (OPR), now the Office of Land Use and Climate Innovation (LCI), recommends that a per capita or per employee VMT that is 15 percent below that of existing development may be a reasonable significance threshold for transportation environmental impact (**OPR, 2018**).

Affordable Housing and Sustainable Communities Program, 2014 **(Round 8 Guidelines - most recent)**	Twenty percent of funds are allocated on an ongoing basis from California's GHG Cap-and-Trade Program to the Affordable Housing and Sustainable Communities (AHSC) Program to fund affordable housing projects, combined with transit and/or active transport facilities upgrades.	Eligible project areas: 1. Transit-Oriented Development (TOD) project areas must include at least one Transit Station/Stop that is served by High-Quality Transit at the time of application submittal; 2. Integrated Connectivity Project (ICP) Areas must include at least one Transit Station/Stop that is served by the Qualifying Transit at the time of application submittal. At the time of application, it must not include: a Transit Station/Stop that is served by High-Quality Transit located within one-half (0.50) mile of the Affordable Housing Development along a Pedestrian Access Route; 3. Rural Innovation Project Areas (RIPAs) must demonstrate all the following: a. Include at least one existing or planned Transit Station/Stop that is served by the Qualifying Transit or High-Quality Transit that is located no farther than one-half (0.5) mile from the Affordable Housing Development along a Pedestrian Access Route b. Must be located within a Rural Area, as defined in California Health and Safety Code 50199.21.	All projects, regardless of project area type, must demonstrate VMT reduction through fewer or shorter vehicle trips or through mode shift to transit use, bicycling, or walking within transit areas.
AB 2097, 2022	Prohibits public agencies or cities from imposing a minimum automobile parking requirement on most development projects located within a half-mile radius of a major transit stop, with some narrow exceptions.	Development projects within a half-mile of a major transit stop are subject to this bill.	None

AB 2334, 2022	AB 2334 amends State Density Bonus Law to include several changes and clarifications. These include expanding the locations where significant concessions are provided for 100 percent affordable housing developments to include very low vehicle travel areas, an update to the definition of maximum allowable residential density, a change to the resident age requirement to allow for the elimination of parking, and a clarification regarding the maximum rent levels in 100 percent affordable projects. (**Memo, Implementation of 2022 State Density Bonus Laws, City of Los Angeles**)	Previous density bonus law AB 1763 considered areas within a half-mile of major transit stops.	AB 2334 expands the ministerial development bonuses created by AB 1763 (2019) for 100 percent affordable housing developments, as defined in § 65915(b)(1)(G). The area where these incentives can be utilized has been significantly expanded from areas within a half-mile of a major transit stop to now also include developments within a "very low vehicle travel area."
SB 886, 2022	A student housing project or a faculty and staff housing project carried out by a public university on real property owned by the public university can qualify for a CEQA exemption, but only if it meets several labor, building design, environmental, and planning criteria.	Projects must be located within a **half-mile of a major transit stop**, a half-mile of the campus boundary, or have 15 percent lower per capita Vehicle Miles Traveled (VMT) than that for the jurisdiction in which the university housing development project is located.	Projects must be located within a half-mile of a major transit stop, a half-mile of the campus boundary, or have **15 percent lower per capita Vehicle Miles Traveled (VMT) than that for the jurisdiction in which the university housing development project is located.**

AB 68, Proposed 2022, not adopted	This bill would require ministerial approval of infill multifamily units in walkable, transit-accessible, and low vehicle miles traveled (VMT) neighborhoods that are close to services and under specified conditions. It would also preserve natural and working landscapes outside of existing communities that are critical for climate resilience, storing carbon, and keeping people out of harm's way. It would fast-track approval of more naturally affordable multi-family housing in high-opportunity neighborhoods located in Climate Smart Parcels. (**Factsheet, March 16, 2023**)	"Climate Smart Parcel" means a parcel located in a high-resource, or moderate-resource area, that satisfies at least one mobility indicator: A. **The parcel is located within a half-mile walking distance of either a high-quality transit corridor or a major transit stop.** B. The parcel is located in a very low vehicle travel area. C. The parcel is located within one mile from a cluster of six or more of the following: restaurant, bar, coffee shop, supermarket, grocery store, hardware store, park, pharmacy, or drugstore.	"Climate Smart Parcel" means a parcel located in a high-resource or moderate-resource area, that satisfies at least one mobility indicator: A. The parcel is located within a half-mile walking distance of either a high-quality transit corridor or a major transit stop. B. **The parcel is located in a very low vehicle travel area** C. The parcel is located within one mile from a cluster of six or more of the following: restaurant, bar, coffee shop, supermarket, grocery store, hardware store, park, pharmacy, or drugstore.
SB 423, 2023	Formerly known as SB 35, this bill provides a streamlined and ministerial review path for projects in jurisdictions that are not meeting State housing goals (Regional Housing Need Allocation, or RHNA) at both lower-income levels and market-rate income levels.	A local government shall not impose automobile parking standards for a streamlined development that was approved pursuant to this section in any of the following instances: A. **The development is located within a half-mile of public transit.** B. The development is located within an architecturally and historically significant historic district. C. When on-street parking permits are required but not offered to the occupants of the development. D. When there is a car-share vehicle located within one block of the development.	None

Appendix 3: VMT Model Details

State: VMT estimates were compiled by the Conservation Biology Institute (CBI), and they are a combination of estimated VMT outputs from regional travel demand models (TDMs) created by various Metropolitan Regional Organizations (MPOs) within California. In areas where MPOs either did not provide TDM output or the output did not pass CBI's quality testing, VMT estimates were generated from the Caltrans' 2020 statewide travel demand model. According to **CBI documentation** and the data provided in the downloadable VMT layers, MPOs that contributed VMT estimates to the Site Check tool and their respective source data years were: MaderaTC (2021), MTC (2021), BCAG (2020), SACOG (2020), FCOG (2020), SCAG (2021), and SANDAG (2019). Of these MPO TDMs, only MCTC's and BCAG's are trip-based models; all others, including Caltrans', use a **more complete** activity-based approach. Because most of these models use source data from before or during the start of the COVID-19 pandemic, VMT estimates may differ from those of Replica, which uses source data from Spring 2023 in the VMT estimates referenced in this piece.

Replica: Replica uses "location-based services (LBS) data (collected from personal mobile devices, vehicle in-dash GPS data, and point-of-interest aggregates)," as well as demographic, built environment, and economic data as inputs to their **activity-based model**. This model generates synthetic populations and trips in order to estimate residential VMT at various geographic scales. The inclusion of mobile location data as an input to the model is a key difference between Replica and many other TDMs. For some activity-based models, such as those of the **Metropolitan Transportation Commission** (MTC) and the **Southern California Association of Governments** (SCAG), Census journey-to-work, aggregated vehicle flow data, and travel surveys are the main form of travel input data informing travel preferences, with ground truth data such as vehicle counts used for calibration and validation.

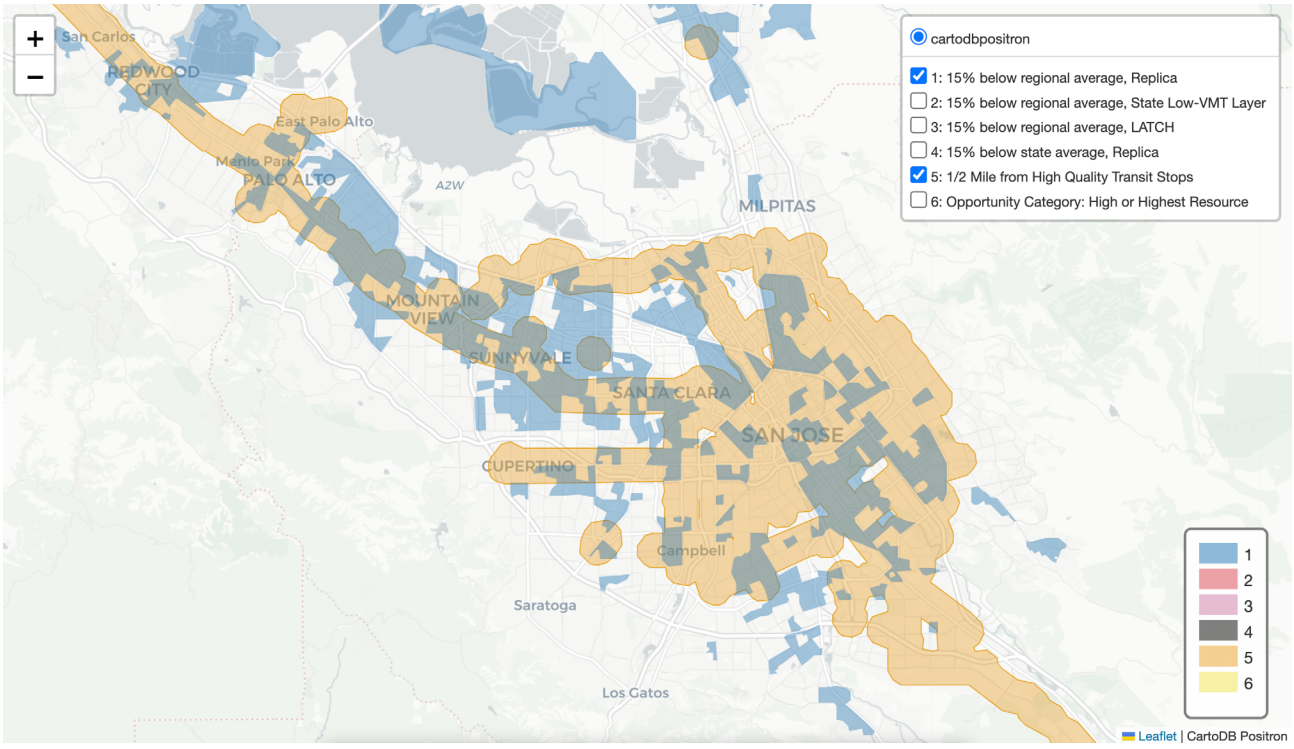
LATCH: The **model** was created by the federal Bureau of Transportation Statistics (BTS) based on 2017 National Household Travel Survey (NHTS) household characteristic and travel data estimates at large geographic levels (such as a Metropolitan Statistical Area). There are 18 different model equations based on "regional group categories," created by dividing California into six regions (e.g., the Northeast region), and each of those regions is divided into three urban groups (urban, suburban, and rural). Inputs to generate the multiple linear regression model equation include 12 independent household characteristic variables (such as household income, number of household vehicles available, etc.), as well as four dependent travel variables, all at the smallest geographic level available from the 2017 NHTS (typically larger than a city). The model then generates estimates for the four travel variables at a census tract level, based on the 12 independent variable values of the census tract determined from equivalent data from ACS tables. BTS validated the model in two ways. First, means of each of the 12 independent variables of one of the six regions were calculated. Those regional means were inputted into the model, and the resulting four travel variable outputs were used to calculate a model regional mean value for each variable. Those model regional means were com-

pared to the regional mean of the travel variables calculated from the 2017 NHTS data. Second, BTS used non-public census tract-level NHTS data to compare the predicted mean value of each of the four travel variables of the census tract to the one calculated from NHTS data, where available.

FHWA: VMT estimates provided by the FHWA are derived from Highway Performance Monitoring System data. Vehicle count data (Annual Average Daily Traffic) are collected on federal highways and roadways, and are multiplied by the length of a roadway section to generate **VMT estimates**. For rural minor collectors and rural/urban local functional systems, travel is estimated by states and provided to the **FHWA** on a summary basis. The resulting estimate is of all travel that occurs within a specific geographic area, distinct from travel of individuals whose origins or destinations are within that geographic area (e.g., the area's residents). Total VMT estimates are indirectly constrained by total fuel consumption and vehicle fleet average fuel efficiency, with cross-comparison enabled by the development of Energy Information Agency data products, such as the State Energy Data System and the Annual Energy Outlook.

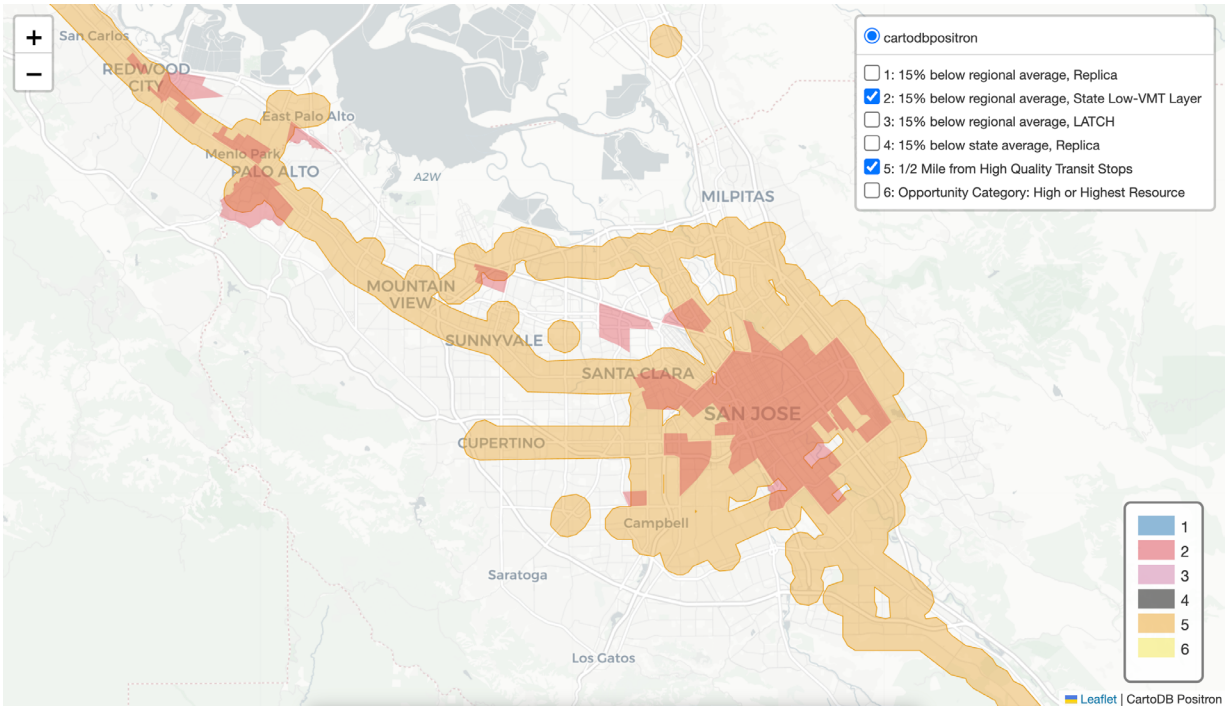
Appendix 4: Additional Figures and Result Tables

Figure A3: Map of the South Bay comparing Replica low-VMT areas (blue) to High-Quality Transit areas (orange)



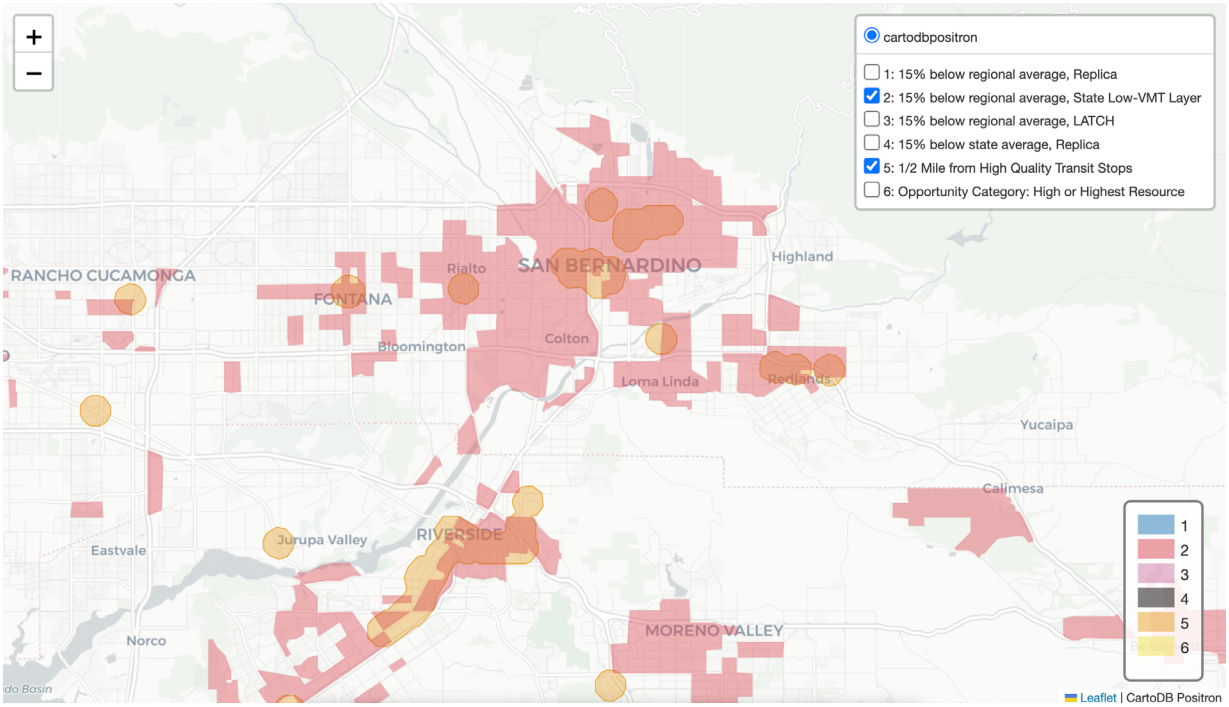
According to Replica, a small number of areas are low-VMT that are not also transit-proximate.

Figure A4: Map of the South Bay comparing the State low-VMT areas (red) to High-Quality Transit areas (orange)



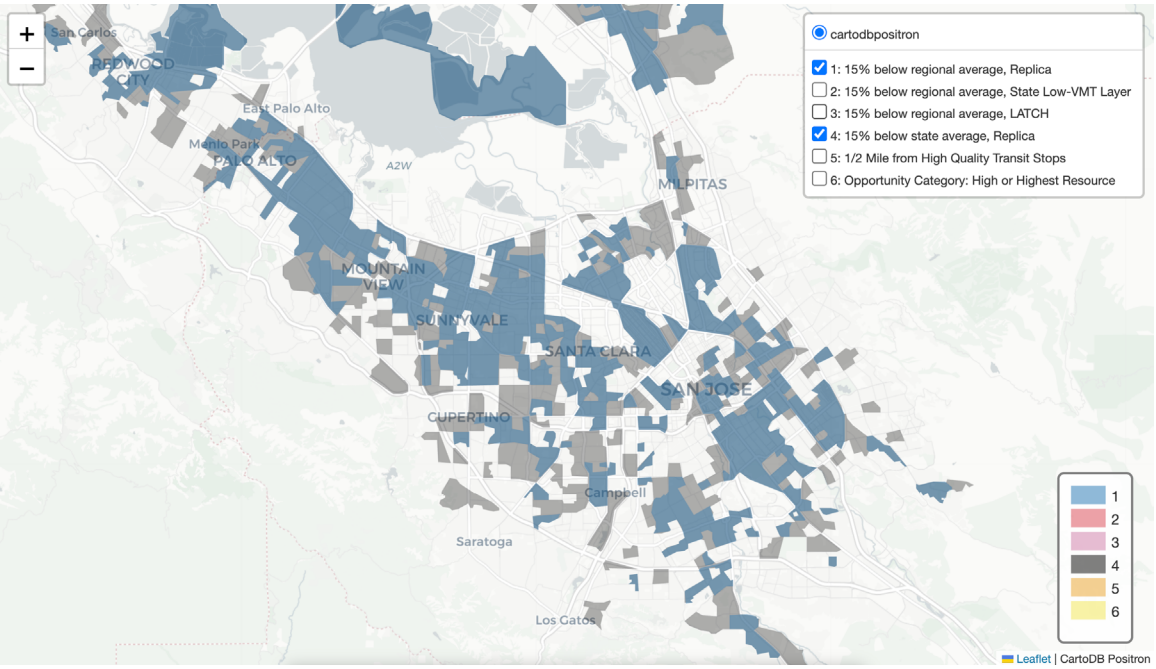
According to the State, almost no area is low-VMT that is not also transit-proximate in the South Bay.

Figure A5: Map of San Bernardino comparing State low-VMT areas (red) to High-Quality Transit areas (orange)



According to the State, a considerable amount of area is low-VMT that is not also transit-proximate in the less dense area around San Bernardino.

Figure A6: Map of San Jose comparing Replica low-VMT areas as defined by a regional average (blue, with overlap appearing as a darker blue) to low-VMT areas as defined by the state average (grey).



The grey areas show additional areas that would be considered low-VMT according to Replica if the state average VMT, as opposed to the regional average, is used as the baseline in defining "low-VMT."

Table A8: Population calculations for low-VMT areas by MPO based on different VMT models and baselines (utilizing 2022 five-year ACS block group population estimates)

Note about the State's low-VMT layer population calculations: We approximated the population for each TAZ in the State's low-VMT layer from 2022 ACS block group population data, since population data are not included in the State's low-VMT layer. We took a weighted average of the population of each block group that lies within each TAZ, weighted by the fraction of area of each block group within the TAZ, to approximate the population of each TAZ. These calculations were used for both Table A8 and A9.

	Population Share (% of Total Population)				**Population Ratio**	
MPO	Replica Low-VMT Using Regional Average Baseline	Replica Low-VMT Using State Average Baseline	State Low-VMT Layer Using Regional Average Baseline	Total Population (millions)	Replica Using Regional Average / Replica Using State Average	Replica Using Regional Average / State Layer Using Regional Average
AMBAG	37%	28%	59%	0.77	1.3	0.6
BCAG	39%	32%	40%	0.21	1.2	1.0
FCOG	41%	40%	41%	1.01	1.0	1.0
KCAG	36%	17%	69%	0.15	2.1	0.5
KCOG	32%	29%	61%	0.91	1.1	0.5
MCAG	26%	26%	52%	0.28	1.0	0.5
MCTC	37%	27%	35%	0.16	1.4	1.0
MTC	33%	45%	29%	7.69	0.7	1.1
SACOG	22%	21%	26%	2.54	1.0	0.8
SANDAG	30%	25%	28%	3.29	1.2	1.1
SBCAG	29%	29%	56%	0.45	1.0	0.5
SCAG	32%	35%	24%	18.74	0.9	1.3
SJCOG	33%	31%	60%	0.78	1.1	0.6
SLOCOG	26%	10%	43%	0.28	2.7	0.6
SRTA	44%	22%	59%	0.18	2.0	0.7
StanCOG	32%	34%	67%	0.55	0.9	0.5
TCAG	31%	35%	59%	0.47	0.9	0.5
TMPO	41%	8%	49%	0.04	5.2	0.8
Total	32%	34%	30%	38.50	0.9	1.0

Table A9: Population calculations for low-VMT areas by county based on different VMT models and VMT baselines (based on 2022 five-year ACS block group population estimates)

County	Replica / State	Replica Population Share	State Population Share
Alameda	1.4	41%	29%
Butte	1.0	39%	40%
Calaveras	0.9	2%	2%
Colusa	0.8	28%	37%
Contra Costa	1.3	16%	13%
Del Norte	0.7	10%	15%
El Dorado	0.8	9%	12%
Fresno	1.0	41%	41%
Glenn	0.3	12%	35%
Humboldt	0.9	36%	38%
Imperial	0.5	31%	61%
Inyo	1.3	20%	15%
Kern	0.5	32%	61%
Kings	0.5	36%	69%
Lake	1.0	25%	25%
Lassen	0.3	9%	31%
Los Angeles	1.9	42%	22%
Madera	1.0	37%	35%
Marin	1.3	11%	8%
Mendocino	1.0	25%	25%
Merced	0.5	26%	52%
Modoc	1.2	17%	14%
Mono	0.9	39%	44%
Monterey	0.7	47%	70%
Napa	0.5	15%	30%
Nevada	0.4	10%	25%
Orange	2.3	32%	14%
Placer	1.1	20%	18%
Riverside	0.4	15%	38%
Sacramento	0.8	24%	29%
San Benito	0.0	2%	58%
San Bernardino	0.5	14%	28%
San Diego	1.1	30%	28%
San Francisco	1.0	94%	90%
San Joaquin	0.6	33%	60%
San Luis Obispo	0.6	26%	45%

San Mateo	1.0	22%	22%
Santa Barbara	0.5	29%	56%
Santa Clara	1.8	28%	16%
Santa Cruz	0.7	29%	44%
Shasta	0.7	44%	59%
Siskiyou	1.0	25%	24%
Solano	0.2	6%	31%
Sonoma	0.4	12%	28%
Stanislaus	0.5	32%	67%
Sutter	0.3	17%	53%
Tehama	1.1	27%	24%
Tulare	0.5	31%	59%
Tuolumne	0.8	5%	7%
Ventura	0.5	17%	32%
Yolo	1.4	31%	21%

Appendix References

Bay Area Metro Input Files. GitHub. Last modified May 21, 2021. **https://github.com/BayAreaMetro/modeling-website/wiki/InputFiles**

Conservation Biology Institute. 15% Below Regional Average Vehicle Miles Traveled (VMT) Per Capita, California (Version 2.1). Data Basin. Last modified August 1, 2023. **https://databasin.org/datasets/4e189c878e094cbfb0a000ae8ad04948/**

Federal Highway Administration. (2024, January 12). Table VM-2—Highway Statistics 2022. **https://www.fhwa.dot.gov/policyinformation/statistics/2022/vm2.cfm**

Federal Highway Administration. (2018, August). Traffic Data Computation Method Pocket Guide. **https://www.fhwa.dot.gov/policyinformation/pubs/pl18027_traffic_data_pocket_guide.pdf**

Miller, E. (2023). The current state of activity-based travel demand modelling and some possible next steps. Transport Reviews, 43(4), 565–570. **https://doi.org/10.1080/01441647.2023.2198458**

Replica. (2024, January). Seasonal mobility model methodology extended (places). Replica. **https://documentation.replicahq.com/docs/seasonal-mobility-model-methodology-extended-places**

Southern California Association of Governments. (2013, January). CEMSELTS & CEMDAP Final Report 4: A SimAGENT Application. Last modified November 16, 2020. **https://scag.ca.gov/sites/main/files/file-attachments/simagent_final_report_4_cemselts_cemdap.pdf?1605574594**

About the Terner Center for Housing Innovation

The Terner Center formulates bold strategies to house families from all walks of life in vibrant, sustainable, and affordable homes and communities. Our focus is on generating constructive, practical strategies for public policy makers and innovative tools for private sector partners to achieve better results for families and communities. The Terner Center is housed within the College of Environmental Design at the University of California, Berkeley.

For more information, please visit: **ternercenter.berkeley.edu**