

Memorandum

Date: December 20, 2024

To: Eli Glazier, Montgomery County Planning Department

From: Meredith Milam, Ron Milam, Mike Wallace, and Eric Womeldorff

Subject: **VMT Best Practices Literature Review, Lessons Learned, and Recommendations**

DC24-0136

Executive Summary

This memorandum provides a comprehensive review of best practices, lessons learned, and recommendations for Montgomery County's potential adoption of Vehicle Miles Traveled (VMT) as a transportation impact metric. Drawing on case studies from jurisdictions in California, it identifies the considerations, tools, and methodologies needed to transition from traditional metrics such as Level of Service (LOS) to VMT. This transition offers an opportunity to align transportation impact analysis with broader environmental, equity, and development goals. The most important decisions are listed below and addressed in detail in Appendix C.

- What form of VMT metric should be used?
- What methodology to use in monitoring VMT?
- What methodology to use in estimating and forecasting VMT?
- What is the VMT performance standard or threshold for projects?
- What VMT reduction mitigation strategies are effective and feasible?

Key lessons learned from the review emphasize both the features and limitations of adopting VMT as an impact metric:

Features	Limitations
• VMT analysis captures the effects of driving. • VMT mitigation aligns with improving walking, bicycling, and transit networks. • VMT analysis can be less costly and time-consuming than conventional level of service (LOS) analysis.	• VMT analysis requires the use of models or tools. • Current models may not be sufficiently suitable and sensitive for VMT analysis. • Setting VMT thresholds for what constitutes an impact is a difficult decision for jurisdictions.



Based on these insights, the memorandum offers the following recommendations for Montgomery County, organized into four key areas:

1. Establish the foundation and purpose:

- **Right-size the adoption effort and timing.** Transition gradually with a phased approach to address challenges incrementally.
- **Engage the public and stakeholders.** Involve the public and key groups early to build consensus and reduce resistance.
- **Establish clear thresholds.** Develop thresholds aligned with County goals and broader environmental objectives.

2. Develop and tailor the tools:

- **Right-size the tool.** Balance simplicity and comprehensiveness; use land use and trip purpose categories appropriate for County needs.
- **Favor local data.** Incorporate granular, localized data where you can for accurate VMT calculations.
- **Focus on daily VMT.** Prioritize daily metrics while calibrating models for peak-period or hour analyses when necessary

3. Align with regional models and standards:

- **Understand your model needs.** Prepare for MWCOC's transition to an activity-based model (ABM) and align County tools.
- **Choose context-sensitive metrics.** Ensure VMT metrics account for the County's unique land use and multijurisdictional context.

4. Consider implementation, maintenance, and Refinement:

- **Consider screening projects.** Streamline reviews for low-VMT areas to encourage desired development.
- **Determine the users and distribution.** Identify tool users (staff or consultants) and develop a rollout and training plan.
- **Integrate periodic updates to the tool.** Schedule regular updates to maintain tool relevance and reliability.
- **Consider pilot projects.** Test metrics, thresholds, and tools in specific areas to refine processes before full implementation.

Montgomery County's adoption of VMT is not mandated by law or regulation, allowing the flexibility to design a tailored and effective framework. A transition to VMT is not required if the main goal is to change the mitigation for vehicle delay-driven impacts. The County will ultimately



need to develop and communicate their why for wanting to adopt VMT. It is a desired outcome from this memo to inform the eventual framework for how to reach those decisions.



Introduction

This technical memorandum consists of a best practices literature review that focuses on the lessons learned by other jurisdictions nationwide that have used VMT as a measure of transportation impact. Key features of the review included the following elements.

1. Finding regions or jurisdictions with a similar land use and transportation context as Montgomery County that use VMT for development impact review and evaluating travel demand management (TDM) effectiveness.
2. Identifying the data, metrics, methodology, and tools used in VMT impact analysis while also assessing emerging new data sources or methods for estimating and forecasting VMT by time of travel and trip purpose.
3. Assessing the potential costs incurred.
4. Summarizing the features and limitations of actual VMT applications for impact review purposes.

The final section of this memorandum is a set of lessons learned that would be applicable to Montgomery County.

Best Practices Literature Review

In identifying jurisdictions nationwide that have used VMT to measure transportation impacts, jurisdictions in California were clearly on the forefront for use of VMT metrics for transportation impact review due to the passage of Senate Bill (SB) 743 that mandated the replacement of vehicle level of service (LOS). The state selected VMT as the replacement metric to better capture the environmental effects of driving and to encourage desired outcomes related to increased infill housing, more active transportation, and less greenhouse gas (GHG) emissions. Each city and county is required to select a specific VMT metric, adopt thresholds for when a change constitutes a significant impact requiring mitigation, and then decide what mitigation actions are feasible.

Public agencies in states such as Maryland, Massachusetts, Oregon, Virginia, and Washington are investigating VMT impact applications but have not advanced to the level of California jurisdictions. The states of Oregon and Washington have initiated a rollout of VMT as a metric and are in the early stages of incorporating new state legislation into local and regional agency processes.



Since California jurisdictions have been actively implementing SB 743 since 2018, their experience and learning curve is valuable for other jurisdictions to avoid or minimize mistakes and to understand what data, tools, and models are necessary for effective use of VMT impact metrics. The specific case studies are listed below.

- City/County Association of Governments of San Mateo County (C/CAG)
- City of Los Angeles (LA)
- Fresno Council of Governments (Fresno COG)
- Butte County Association of Governments (BCAG)

Three of the case studies are regional agencies that have similar land use and transportation contexts to Montgomery County. Key shared features include a land use context consisting of urban, suburban, and rural land uses where multiple jurisdictions rely on a shared regional transportation system. Hence, decisions about how to perform transportation impact analysis are not made in isolation but consider regional influences. The final case study from the City of LA is included given their focus on streamlining development review through their VMT impact analysis process.

Appendix A contains the master summary of the literature review findings while key takeaways are summarized in the following sections.

Considerations from VMT Adoption

Incorporating VMT into transportation impact analysis is a transformative change that shifts the focus from measuring impacts to drivers to measuring the impact of driving. VMT helps describe the environmental consequences of land use and transportation network decisions while LOS describes traffic operations effects. Public agencies long focused on single locations and the delay experienced by people in cars must increase their knowledge and ability to communicate about VMT specific data, metrics, methodology, and tools.

VMT measures the number of miles traveled by vehicles and is a function of how many vehicle trips are taken and the distance of those trips. In general, lower VMT results in less impact on the geographic extent and overall transportation system. The more distance traveled utilizes more of the roadway infrastructure, therefore, higher VMT can be a surrogate metric for location efficiency.

Typically, development located farther from retail, office and other uses and with poor access to transit, generates more driving than development situated close to complementary uses and transit. Estimating and forecasting VMT involves the use of data, tools, and models that require clear definitions of the VMT metrics to be analyzed. Up to nine VMT metrics have been identified for potential use as impact metrics as shown in the lexicon below (refer to Appendix B for a detailed description of each metric).



VMT Lexicon



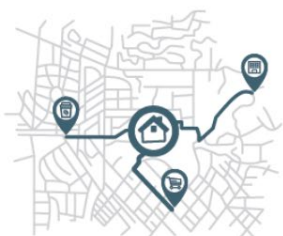
Total VMT



Total VMT Generated
by a Project



Total VMT per
Employee



Home-Based VMT per
Resident



Total VMT per Service
Population



Work Tour VMT per
Employee



Residential VMT per
Resident



Total VMT per Land Use
Unit



Home-Based Work
(HBW) VMT





For transportation impact analysis of land use projects, VMT is commonly measured as an efficiency metric in the case studies and expressed as the VMT generated per resident or per employee. The preferred metric form depends on what technical questions the jurisdiction is trying to answer with respect to VMT and its associated effects on things like emissions, energy consumption, safety, etc. **Table 1 LOS Versus VMT: Measurement Matrix** lists the types of effects that can be captured using VMT and compares it against the traditional LOS metric. Understanding these differences are important in the transition to VMT.

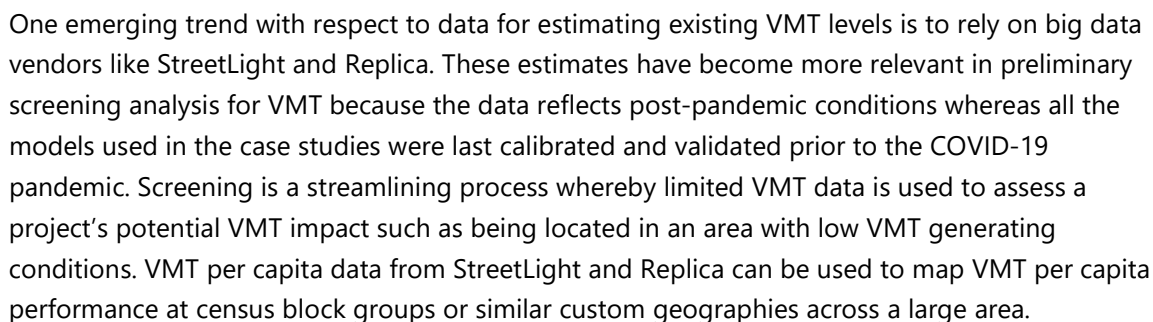
Table 1 LOS Versus VMT: Measurement Matrix

LOS	VMT
☐ Emissions (Greenhouse Gases)	☒ Emissions (Greenhouse Gases)
☐ Emissions (Air Pollutants)	☒ Emissions (Air Pollutants)
☐ Fuel Consumption	☒ Fuel Consumption
☐ Energy Consumption	☒ Energy Consumption
☒ Driver Delay (Speed)	☐ Driver Delay (Speed)
☒ Driver Delay (Intersection Wait Time)	☐ Driver Delay (Intersection Wait Time)
☒ Safety (Speed)	☐ Safety (Speed)
☐ Safety (Collisions)	☒ Safety (Collisions)

The use of VMT changes the focus of transportation impact analysis and mitigation. In some cases, this change could be substantial for jurisdictions and developers comfortable with current practice where transportation impacts and mitigation largely affect the external roadway network. With the impact spotlight shining on VMT, more attention will be on the project's physical design and whether it incorporates strategies to reduce vehicle use and encourage active transportation and transit use.

For all the case studies, the metric selection was influenced by the availability of data and models to estimate and forecast VMT. VMT impact analysis requires the ability to forecast project effects on VMT and compare those results against impact thresholds. Common thresholds in California are tied to existing VMT per capita performance of cities, counties, or regions. This necessitated the use of the same modeling methodology to estimate and forecast VMT for the thresholds and individual projects to avoid false impact results. The two most common VMT metrics are listed below and do require the use of models that can produce VMT by land use type and trip purpose.

- **Residential Projects:** Home Based VMT per Resident
- **Office Projects:** Home Based Work VMT per Employee



An important aspect of VMT analysis for all the case studies was the ability to predict VMT reductions associated with impact mitigation measures. Common VMT mitigation measures include VMT reduction strategies associated with built environment effects (i.e., land use density, diversity, and transit accessibility) and TDM actions. While TDM actions are similar across states, California requires verification that TDM actions reduce VMT. This verification has been performed and documented in the *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity* (California Air Pollution Control Officers Association, 2021). This Handbook contains about 30 VMT reduction strategies that have sufficient substantial evidence to verify their effectiveness. Each strategy contains a fact sheet detailing the specific reduction potential and calculation methodology. Each of the case studies rely on the Handbook as the source for their recommended mitigation measures.

TRANSPORTATION I



While the above information highlights important and common elements of VMT impact analysis, the review also revealed the use of analysis tools to help facilitate VMT impact analysis. The tools rely on input from the travel demand models related to specific VMT metrics and allow for quick testing of VMT impacts for individual land use projects without having to re-run the travel demand model. Some tools also allow for mitigation evaluation. The tools range from Excel-based spreadsheet tools to web applications largely built within the ESRI platform. Tool development costs ranged from about \$100k to \$250k and require on-going maintenance costs.

More details about the specific use of tools are summarized in **Table 2** and the case studies locator map is shown in **Figure 1**.

Table 2 Case Study VMT Tool Assessment

Parameters	CCAG	LA	FCOG	BCAG
Do they have a tool?	✓	✓	✓	✓
Do they still use the tool?	✓	✓	✓	✓
Do they use local data?	✓	✓	✓	✓
Are the outputs expansive?	✓			
Are they in the higher level of effort than most jurisdictions?	✓			
Are there multiple geographies considered?	✓		✓	✓



Figure 1 Case Studies Locator Map



Figure 1



Case Studies Locator Map



For more details about each case study, descriptions are provided below. These are followed by the review's key findings with respect to the features and limitations of using VMT as a transportation impact metric and what lessons are most relevant to Montgomery County.

City/County Association of Governments of San Mateo County (C/CAG)

C/CAG has embraced VMT to measure transportation impacts by providing support for their member agencies through technical guidance, an impact analysis tool, and continued research into mitigation programs.

C/CAG supports member agencies as they implement VMT and does not adopt VMT analysis practices for its own purposes. Instead, C/CAG has taken the role of establishing a consistent methodological approach for project analysis in San Mateo County, indicating and reporting baseline and future VMT metrics, developing a standardized VMT impact screening tool, and helping member agencies navigate the SB 743 VMT implementation process. Adoption of this methodological approach, or development of alternative approaches, is a decision left to individual member agencies. Ultimately, individual agencies have to make formal decisions about their preferred choice of VMT metric, methodology, thresholds, and mitigation (see Appendix C for a summary of specific decisions). By establishing a standard methodological approach, C/CAG strives to simplify the process for member agencies in adopting transportation impact analysis guidelines that comply with SB 743.

The VMT impact screening tool was developed on the ESRI platform and takes advantage of geographic information systems (GIS) tools to assess potential VMT impacts for land use projects. If a project fails the screening tests, a complete VMT analysis is required.

In October 2024, C/CAG furthered their VMT efforts when C/CAG took the lead to develop a VMT/Greenhouse Gas (GHG) Model Mitigation Program for project sponsors and developers to identify feasible options for mitigating the VMT and GHG emission impacts of land use and VMT-inducing transportation projects in San Mateo County. The goal of the VMT/GHG Model Mitigation Program is to allow project sponsors to fund off-site VMT/GHG-reducing transportation improvements and programs that could mitigate VMT/GHG impacts identified through CEQA studies.

The C/CAG VMT impact analysis supporting materials are available on-line at:

[https://ccag.ca.gov/sb-743-los-to-vmt/#:~:text=Senate%20Bill%20743%20\(SB%20743,Level%20of%20Service%20\(LOS\)\)](https://ccag.ca.gov/sb-743-los-to-vmt/#:~:text=Senate%20Bill%20743%20(SB%20743,Level%20of%20Service%20(LOS)))



City of Los Angeles (LA)

LA is the largest city in California based on population. The city is mostly built out and most new developments are infill or redevelopment projects. LA has historically been known for being an auto-oriented city, but in recent decades, a strong public transit component has been added that includes extensive commuter rail service as well as a heavy-rail/subway system, several light rail lines, BRT service, and extensive rapid bus service. Further, the city has prioritized building more infill and affordable housing and is using VMT as an impact metric to help facilitate the process.

LA incorporated VMT metrics into its transportation impact study process in August 2019 and documented specific guidance in the City of Los Angeles Transportation Assessment Guidelines (TAG). As part of this effort, the city developed a VMT Calculator tool that could be used to evaluate typical land use projects (e.g., residential, retail, office, etc.). As part of the preparation of this version of the TAG, LA updated its travel forecasting model (TFM) and transportation impact thresholds to be consistent with the VMT impact methodology.

LA requires the preparation and submission of a transportation assessment for development projects or transportation projects that meet the following criteria:

- If the development project is estimated to generate a net increase of 250 or more daily vehicle trips and requires discretionary action, a transportation assessment for a development project is required.
- If a transportation project is likely to either: (1) induce additional VMT by increasing vehicle capacity; or (2) reduce roadway through-lane capacity on a street that exceeds 750 vehicles per hour per lane for at least two (2) consecutive hours in a 24-hour period after the project is completed, a transportation assessment is generally required.
- A transportation assessment is required by City ordinance or regulation.

The preparation of a transportation assessment requires analysis and prediction of impacts or deficiencies to the circulation system generated by development or transportation projects as well as the identification of feasible measures or corrective conditions to offset any impacts or deficiencies identified through a transportation assessment. The criteria, guidelines, objectives, and standards are intended for use by the public, private consultants, and City staff in the preparation and review of a transportation assessment in the city.

The LA VMT impact analysis supporting materials are available on-line at:

<https://ladot.lacity.gov/documents/transportation-assessment>



Fresno Council of Governments (Fresno COG)

Fresno COG is in the central valley of California and has a mostly suburban and rural land use context with the exception of downtown Fresno. Fresno COG has developed a technical report, regional guidance, a mitigation study, and a screening tool to assist its member agencies with VMT impact analysis. Similar to the other case studies, the guidance covers the key decisions related to metric, methodology, thresholds, and mitigation.

Part of the focus for Fresno COG was to tailor their recommendations to their land use context and regional setting. As such, their methodology and thresholds reflect the specific VMT output available from their regional TFM and how Fresno's regional VMT/GHG reduction goals fit within those of the state. They also identify mitigation strategies that Fresno COG members identified as feasible given their land use and transportation context.

The Fresno COG VMT impact analysis supporting materials are available on-line at:
<https://www.fresnocog.org/project/sb743-regional-guidelines-development/>

Butte County Association of Governments (BCAG)

BCAG is the MPO for Butte County and has developed technical guidance and a VMT impact screening tool to assist member agencies implement SB 743. BCAG's guidance is similar to that of Fresno COG although it provides more details about how the technical and legal expectations related to the implementation decisions about metrics, methodology, thresholds, and mitigation feasibility. This is an important aspect of technical guidance in California because CEQA involves the risk of legal challenges related to technical adequacy.

Given the legal perspective, the BCAG materials explain that the use of VMT impact screening as a streamlining approach to analysis is a discretionary decision for each jurisdiction. As part of selecting thresholds, lead agencies need to decide if they will allow the use of VMT impact screening since it involves the use of 'partial analysis' that may be challenged for not providing a complete review of a project's potential VMT impacts.

In anticipation that some jurisdictions would want to use screening, BCAG developed a web-based VMT impact screening tool in the ESRI platform and also developed static maps of low VMT generating areas to simplify screening efforts.

On-site and off-site VMT mitigation actions were evaluated within the land use and transportation context of Butte County. These actions considered both the built environment (e.g., land use density, diversity, etc.) and TDM strategies. A limited number of mitigation actions were identified as being applicable in Butte County given the land use context especially in rural areas. To expand mitigation actions and their effectiveness, information was provided about developing a VMT mitigation program such as an impact fee program.



The BCAG VMT impact analysis supporting materials are available on-line at:
<https://www.bcag.org/PlansProgramsModel/SB-743-Implementation-Study/index.html>



Lessons Learned

Implementing or transitioning VMT impact analysis to the development review process necessitates key decisions by the implementing agency as outlined in Appendix C. Each of the case studies developed guidance around these decisions that were then either partially or fully implemented along with the creation of new VMT impact screening tools to help facilitate quick response impact assessments. The case studies also revealed that agencies needed to continue investing in the evolution of their VMT analysis process especially with regard to developing mitigation strategies and maintaining analysis tools.

In reviewing the case studies and considering our other work throughout California and with other states like Oregon and Washington, some clear benefits of using VMT as an impact metric have emerged when the focus is related to environmental impacts as outlined below.

- **VMT analysis captures the effects of driving.** This includes effects like land use efficiency, energy consumption, air pollutant and GHG emissions, and safety. The connection between VMT and emissions (as well as energy consumption) is relatively well understood in practice since the more VMT, the more fuel consumed, and the more emissions produced. The connection to safety may not be as well understood. Evidence collected by the California Governor's Office of Planning and Research shows that areas with low VMT per capita tend to have lower collision rates and less severe collisions (see Appendix B - https://lci.ca.gov/docs/OPR_COMPLETE_7.31.17.pdf).

The Fresno COG and BCAG case studies emphasized that incorporating VMT metrics helped identify projects with potential to improve regional GHG and safety outcomes by focusing on land use density, diversity, and transit accessibility.

- **VMT mitigation aligns with improving walking, bicycling, and transit networks.** In mature communities where roadway expansion needs are limited, the focus for transportation network improvement tends to be on developing complete streets for all modes and users with special attention for vulnerable users like pedestrians and bicyclists. Use of VMT as an impact metrics aligns with mitigation focused on improving walking, bicycling, and transit use, which are key areas for new analyses and mitigation requirements in recent revisions of Montgomery County's Growth Policy.

The City of LA case study highlights how the adoption of VMT metrics aligns with policies to prioritize infill development and expand multimodal transportation infrastructure, such as transit-oriented developments and complete streets projects. Similarly, BCAG



emphasized TDM strategies that directly encourage walking and biking to reduce VMT in rural areas.

- **VMT analysis can be less costly and time-consuming than conventional LOS analysis.**

Through the use of 'screening', relatively simple analysis tools can be developed to facilitate VMT impact analysis. These are typically designed to quickly screen out of analysis those projects that are likely to be low VMT generating due to location, design, or both. This reduces the cost of transportation impact studies for developers and jurisdictions, with the effect of helping the latter 'steer' development into transportation-rich or efficient locations. Screening tools like those developed by LA and BCAG have proven invaluable in reducing the time and cost associated with VMT impact analysis, particularly for small-scale projects in low VMT zones.

The GIS-based screening tools like those developed by City of LA and BCAG have proven invaluable in reducing the time and cost associated with VMT impact analysis, particularly for small-scale projects in low VMT zones.

VMT impact analysis is not without limitations. The case studies identified several key issues:

- **VMT analysis requires the use of models.** VMT impact analysis typically requires the use of TFMs for estimates and forecasts of VMT. While screening tools can be developed for some projects, TFMs will likely be needed for larger or more complex projects. Not all jurisdictions have an established model user base across agencies and consultants.

Fresno COG relies on its Activity-Based Travel Demand Model to produce detailed VMT metrics for residential and office projects, but this model requires significant calibration and maintenance.

- **Current models may not be sufficiently suitable and sensitive for VMT analysis.** TFMs may not be fully calibrated and validated for VMT impact analysis and may not produce the desired form of analysis metrics. A common limitation of typical local and regional models is that they have not been 'dynamically' validated. This means they have not been sensitivity tested with respect to how VMT outputs change in response to model input variables. Another issue is that the model input variables related to land use and socioeconomics may not align with the typical planning inputs provided in development applications. This creates the need for a crosswalk between development application land use plans and the model input variables that may be subjective or prone to errors until a formal methodology can be created.



BCAG's guidance explicitly acknowledged the above points – that typical local models are often not dynamically validated for VMT sensitivity, leading to potential inaccuracies in forecasting VMT impacts.

- **Setting VMT thresholds for what constitutes an impact is a difficult decision for jurisdictions.** This essentially requires agency staff and elected officials to determine what is 'good' versus 'excessive' VMT and, by definition, what the bright line separating the two is. Nuance about the levels of travel that are sustaining to individuals, economies, communities, etc. are typically lost in making this distinction. In California, excessive VMT must be mitigated to the extent feasible, and feasibility is determined by substantial technical evidence versus agency discretion about what mitigation is desirable.

The C/CAG case study emphasized the importance of aligning thresholds with regional averages and using consistent methodologies to avoid false impact determinations. In contrast, BCAG highlighted that thresholds are inherently subjective.

Reflecting on the lessons learned in relation to Montgomery County, the essential steps and decisions for implementing a VMT impact analysis process are outlined in the Appendix C questions. Each decision regarding metrics, methodology, and thresholds are essential for informing the process and the models or tools used in the VMT impact analysis. Tools have clearly been beneficial to the case study agencies as they helped simplify and streamline the VMT impact analysis process and would be an important component for Montgomery County's development review process.

An important takeaway - neither a benefit nor a limitation - is that transitioning to VMT-based analysis is not required if a jurisdiction's main goal is adjust mitigation for LOS impacts. California's transition to VMT was driven by state-level action, but jurisdictions that value adequate traffic operations can still shift their mitigation focus on reducing demand. This can be achieved by limiting roadway capacity expansion as a mitigation measure and replacing or augmenting it with TDM strategies. These strategies should align with those vetted through the CAPCOA Handbook, which have been shown to effectively reduce vehicle trips and VMT.

The choice of thresholds is another component of a VMT-based approach that warrants careful consideration. California jurisdictions benefited from clear recommendations tied to statewide GHG reduction goals, which provided guidance on what constitutes 'good' versus 'excessive' VMT. Even then, jurisdictions needed to make decisions about how to interpret this guidance through the lens of their community, in the broadest sense of the term, goals and values. In the absence of similar state guidance, Montgomery County would need to determine what level of VMT change is significant, which often involves subjective judgements rooted in community values. This subjectivity can create challenges, particularly from the development community, among others, if



new developments are expected to outperform existing ones in terms of VMT per capita. In California, achieving better VMT performance typically requires development in transit-rich or highly efficient locations. Otherwise, higher VMT mitigation costs are necessary to compensate for developments in less efficient areas.



Recommendations

To successfully implement VMT as a transportation impact metric for land use and transportation projects, Montgomery County must navigate a series of strategic, technical, and procedural decisions. These include defining the purpose and scope of VMT adoption, aligning tools and methodologies with regional and local contexts, and ensuring stakeholder engagement and practical implementation. The recommendations below provide a structured framework to help guide the County through these decisions, suggesting a phased approach that balances ambition with feasibility while addressing the unique needs and goals of the County.

1. Establish the foundation and purpose:

- **Right size the adoption effort and timing.** The County's potential transition to VMT-based transportation analysis should be thoughtful and right-sized the ambition and appetite for change. Additionally, a phased implementation will allow the County to refine the approach while addressing challenges incrementally.
- **Engage the public and stakeholders.** The County should engage the public and key stakeholders, including the developer community organizations, early in the process. Transparent communication about the goals, benefits, and trade-offs of VMT adoption will help foster buy-in and reduce resistance. Many roadways in Montgomery County are owned by Maryland Department of Transportation State Highway Administration (SHA), SHA would need to buy in on VMT.
- **Establish clear thresholds.** To assess impacts effectively, VMT metrics should be compared against thresholds tailored to County goals, such as reducing emissions or encouraging multimodal transportation. Thresholds should reflect local values while aligning with broader environmental and transportation objectives.

2. Develop and tailor the tools:

- **Right-size the tool.** The County will need to determine the complexity of the tool, balancing the desire for simplicity and the need for comprehensiveness informed by goals. While the City of LA uses 32 land use types, many jurisdictions achieve effective results with as few as 3 land use types. Although the case studies include Home and Work trip purposes, with additional purposes or analysis methods for specific land use types (i.e. Industrial, Retail, Regional Serving). The County has expressed interest in including a separate School trip purpose. The County should consider how the number of land use types and trip purposes will streamline or complicate development review.
- **Favor local data.** Incorporating granular, localized data ensures accurate VMT calculations. The City of LA VMT tool uses the city's traffic count database to provide



more granular data. Absent current or comprehensive local data, agencies typically use TFMs to calculate VMT, which incorporate regional and national data such as Institute of Transportation (ITE) Trip Generation rates, households travel surveys, and are calibrated to reflect local travel. Emerging technologies like connected vehicle data and location-based services (e.g., StreetLight and Replica) can provide precise, real-time insights into transportation patterns. These should complement traditional sources like TFMs, ITE trip generation rates, and household travel surveys.

- **Focus on daily VMT.** Most TFMs are calibrated to daily conditions, which align well with land use impact evaluations. For specific peak-period or peak-hour analyses, additional calibration may be necessary to ensure accuracy.

3. Align with regional models and standards:

- **Understand your model needs.** The County should assess the effect of MWCOC's upcoming migration to an activity-based model (ABM), planned for 2025. Transition considerations include upfront development and training costs, ongoing maintenance, and ensuring internal expertise for effective use. Aligning the County's model with the regional ABM will improve consistency and accuracy across jurisdictions, but will constitute an investment in time and resources.
- **Choose context-sensitive metrics.** VMT metrics must account for Montgomery County's specific land use context, such as Transportation Management Districts (TMDs) and Growth Policy Areas (GPAs).

4. Consider implementation, maintenance, and refinement:

- **Consider screening projects.** The County should consider streamlined reviews for projects in high-priority, low-VMT areas. This approach would encourage desired development while reducing administrative burdens.
- **Determine the users and distribution.** The County must identify the primary users of the tool, whether internal staff, external consultants, or both. A clear rollout and training plan is necessary to ensure effective implementation and use.
- **Integrate periodic updates to the tool.** Regular updates to the tool are essential to ensure its reliability and relevance. For example, BCAG updates its VMT screening tool every four years alongside TFM updates. Montgomery County should determine how often to evaluate the tool based on staffing, data availability, and new technologies.
- **Consider pilot projects.** The County could consider launching a pilot project or effort to test VMT metrics, thresholds, and the tool that will come from this effort in specific areas. Pilots can identify challenges and help the County refine their processes before full implementation.



APPENDIX A

The Best Practices Literature Review includes how other jurisdictions nationwide have used Vehicles Miles Traveled (VMT) as a measure of various types of transportation impacts, particularly for development review and Transportation Demand Management (TDM) purposes. This review includes an analysis of the data sources used, metrics developed, potential costs incurred, and features and limitations jurisdictions have experienced using Vehicle Miles Traveled for these purposes as well as information on new data sources or technologies for obtaining VMT by time of travel and trip purpose. This matrix will be finalized in the memorandum detailing lessons learned based on this review as applicable to Montgomery County and present findings and takeaways for Montgomery County implementation.

Attributes	The City/County Association of Governments of San Mateo County (C/CAG)	City of Los Angeles	Fresno Council of Governments (Fresno COG)	Butte County Association of Governments (BCAG)
VMT Metrics				
Data Source	Utilizes regional and state travel forecasting models and household travel surveys. • C/CAG-Santa Clara Valley Transportation Authority (VTA)-Bi-County Model ("C/CAG-VTA travel forecasting model") • 2012 California Household Travel Survey (CHTS) • California State Travel Demand Model (CSTDm)	Utilizes traffic count databases, travel behavior zones, and local forecasting model. • LADOT Traffic Count Database • City of Los Angeles Travel Demand Forecasting (TDF) Model • City of Los Angeles Travel Behavior Zones (TBZ) • Institute of Transportation Engineers (ITE) Trip Generation Manual (9th and 10th Edition)	Utilizes regional forecasting model and trip generation manuals. • Fresno COG Activity Based Travel Demand Model (2019) • Institute of Transportation Engineers (ITE) Trip Generation Manual	Utilizes the regional forecasting model. • Modified Version 1.1-3.17.21 of the BCAG RTP/SCS Model



Attributes	The City/County Association of Governments of San Mateo County (C/CAG)	City of Los Angeles	Fresno Council of Governments (Fresno COG)	Butte County Association of Governments (BCAG)
Land Use and VMT Metric	The C/CAG tool measures VMT for land use projects. • Residential Projects: Home Based VMT per Resident • Office Projects: Home Based Work VMT per Employee • Industrial Projects: Total Project Generated VMT per Service Population	The City of LA tool measures VMT for land use projects and plans. • Residential Projects: Daily household VMT per capita • Office Projects: Daily work VMT per employee • Regional Serving Projects: Net increase in VMT • Land Use Plans: Average total VMT per service population	The FCOG tool measures VMT for land use projects. • Residential Projects: VMT per Capita • Office Projects: VMT per employee • Retail Projects: Total VMT • Other Projects: VMT per employee	The BCAG tool measures VMT for land use projects. • Residential Projects: Home Based VMT per Resident • Office Projects: Home Based Work VMT per Employee
VMT Tool				
VMT Tool	GIS WebApp Spatial-Based VMT Estimation Tool	Excel-based VMT Calculator Tool	Excel-based VMT Calculator Tool	GIS WebApp Spatial-Based VMT Estimation Tool
Costs incurred	~\$250k	~\$150k	~\$250k	~\$100k



Attributes	The City/County Association of Governments of San Mateo County (C/CAG)	City of Los Angeles	Fresno Council of Governments (Fresno COG)	Butte County Association of Governments (BCAG)
Tool Parameters	This tool offers a user-friendly map interface with customizable VMT metrics and localized data, designed for small communities to comply with CEQA regulations. • Intuitive map interface for easy navigation. • Provides both baseline and cumulative VMT data. • Includes multiple VMT metrics and land use types, tailored to localized data. • Customizable tool for smaller communities to ensure CEQA State law compliance.	The tool offers predefined land use types using localized data, providing cost-effective solutions for small projects while ensuring CEQA compliance. • Intuitive interface for easy navigation. • Includes 32 predefined land use types based on localized data. • Cost-effective, especially for small-scale projects. • Ensures compliance with CEQA state law to simplify environmental analyses.	The tool provides an intuitive map interface, cost-effective solutions for small-scale projects, localized data integration, and customization for smaller communities to ensure compliance with CEQA State law. • Intuitive interface for easy navigation. • Cost-effective, especially for small-scale projects. • Localized data integration. • Customizable tool for smaller communities to ensure CEQA State law compliance.	The web-based tool simplifies screening by offering an intuitive interface, efficient cost and time management, and localized data. • Intuitive map interface for easy navigation. • Cost-effective, especially for small-scale projects. • Localized data integration.



Attributes	The City/County Association of Governments of San Mateo County (C/CAG)	City of Los Angeles	Fresno Council of Governments (Fresno COG)	Butte County Association of Governments (BCAG)
Considerations	• The tool provides some, but not all, screening capabilities and may require additional analysis for larger or more complex projects. • The tool uses estimates from the regional travel forecasting model, which may not fully reflect land use types outside the model. Additional analysis may be needed for such projects. • Larger, mixed-use, or long-range land use plans should be analyzed using the C/CAG VTA forecasting model for more detailed estimates. • The VMT estimates account for a portion of the total VMT related to specific trip purposes and are limited to light-duty vehicles.	• The tool includes common predefined land use types, which may not fully capture special or unique land uses or developments. • The Excel-based tool can be susceptible to user error and challenges with version control. • Results may be misinterpreted if not properly understood. • Larger or more complex projects may need additional analysis.	• The tool can be used for projects up to 500 DU. • The tool can be used for projects up to 375 Office employees. • For projects outside these parameters, users must use the Fresno COG Activity-Based Model (ABM). • The Excel-based tool can be susceptible to user error and challenges with version control. • There is potential for misinterpretation of the results.	• The tool provides some, but not all, screening capabilities and may require additional analysis for larger or more complex projects. • The tool uses estimates from the regional travel forecasting model, which may not fully reflect land use types outside the model. Additional analysis may be needed for such projects.
Geographic Scale	The tool uses project location and details, alongside the C/CAG-VTA forecasting model, to estimate VMT generation based on TAZ-level rates.	The City of Los Angeles uses the Travel Behavior Zone (TBZ) categorization to assign VMT and trip reductions, considering factors like population density and proximity to transit stations.	The tool estimates project-generated VMT based on detailed location information and project description, including unit or employee counts.	The BCAG RTP/SCS model utilizes county TAZs to identify and screen out projects located in low VMT zones.



Purpose of Tool	The tool helps C/CAG member agencies evaluate transportation impacts under CEQA, offering both VMT screening and detailed analysis for projects that exceed thresholds. • The countywide, web-based, and Geographic Information Systems (GIS)-based tool is designed to evaluate the transportation effects of land use projects under the CEQA for C/CAG member agencies. • The tool assists agencies in conducting baseline VMT screening analysis for proposed projects. If a project fails the screening, a more detailed VMT analysis is required to evaluate cumulative conditions and the project's effect on boundary VMT within a specific geographic area. This comprehensive VMT analysis is then used as input for the air quality, GHG, and energy impact analyses.	The VMT Calculator was developed to forecast VMT for land use development projects and utilizes the City of Los Angeles Transportation Assessment Guidelines (TAG). • The VMT Calculator forecasts VMT for residential and office projects in Los Angeles, but is not applicable for regional retail or entertainment projects. The tool also applies the screening criteria described in the TAG for determining whether a VMT analysis is required for a project. • The VMT Calculator is intended for evaluation of residential and office projects in accordance with the TAG and reports daily vehicle trips, daily VMT, daily household VMT per capita, and daily work VMT per employee.	The VMT Tool estimates the VMT generated by land use projects, ensures compliance with CEQA, and supports regional planning by evaluating their potential effects on traffic and sustainability. • This tool uses detailed location and project-specific data, including the number of units or employees, to estimate the project-generated VMT. The combination of the project's location within a jurisdiction, parcel number, or Traffic Analysis Zone (TAZ) helps determine the VMT generated by the development. • The tool applies this information to estimate how much VMT is produced by the project, providing essential data for further analysis and decision-making related to transportation impacts	The tool screens out projects that meet VMT thresholds, ensuring that projects exceeding the limits undergo more detailed impact analysis. • The primary purpose of the tool is to streamline the evaluation of land use projects by screening out those that meet specific VMT thresholds. For projects that surpass these thresholds, a more comprehensive VMT analysis is conducted. • This process helps identify which projects require further study and ensures that transportation impacts are properly assessed in line with CEQA regulations.
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Attributes	The City/County Association of Governments of San Mateo County (C/CAG)	City of Los Angeles	Fresno Council of Governments (Fresno COG)	Butte County Association of Governments (BCAG)
Why did they do this?	The tool was developed to help jurisdictions in San Mateo County comply with CEQA under SB 743 by establishing VMT thresholds and providing clear guidelines for conducting VMT analysis.	The tool helps streamline environmental reviews and promote sustainable development by offering localized VMT reduction strategies and TDM solutions.	The tool compares VMT outputs with thresholds to identify potential impacts and offers mitigation strategies, including TDM measures, to address transportation effects.	The tool's screening approach accelerates the review process but may lack detailed evidence, which is why four case studies were evaluated to assess the outcomes for projects that fail screening.



APPENDIX B

VMT Lexicon

Metric	Model Types Used to Produce Metric (1)	Definition	Example
Total VMT	ABM, TOUR, TRIP	All vehicle-trips (i.e., passenger and commercial vehicles) assigned on the network within a specific geographic boundary (i.e., model-wide, region-wide, city-wide). Vehicle volume on each link is multiplied by link distance.	
Total VMT generated by a project	ABM, TOUR, TRIP	All vehicle-trips are traced to the zone or zones of study. This includes internal to internal (II), internal to external (IX), and external to internal (XI) trips. May use final assignment origin-destination (OD) trip tables or production (P) and attraction (A) estimates multiplied by distance skims. When the model has multiple assignment periods, OD trip tables and congested skims from each period should be used.	



Metric	Model Types Used to Produce Metric (1)	Definition	Example
Total VMT per service population	ABM, TOUR, TRIP	• Same method as above (Total VMT generated by a project) to estimate VMT and then divide by the population and employment of the zone(s) of study. If the model generates vehicle trips from other sources like students, then include those variables in the service population. Note that employment is often used as the independent variable for total vehicle trip generation associated with non-residential land uses. This means that vehicle trips made by people other than the employees are accounted for in the trip rate including visitors, customers, vendors, and delivery companies. Use of this metric should be limited to scenarios comparing full model runs focused on changes at the city, county, or regional scale. • Some trip-based models may not use population and employment as trip generation variables. Instead, they rely on land uses. A 'correspondence' between the model land use input variables and population and employment rates is required for these types of models.	



Metric	Model Types Used to Produce Metric (1)	Definition	Example
Residential VMT per resident	ABM, TOUR	• All automobile (i.e., passenger cars and light-duty trucks) vehicle-trips are traced back to the residence of the trip-maker, even non-home-based (NHB) trips. • Not applicable for trip-based models since NHB trips aren't tied to the households making them. • Can be calculated either by averaging the daily VMT of all residents or by calculating total VMT, counting total residents, and dividing. • Allocation of responsibility within a jurisdiction (e.g., cities within a county) is straight-forward, since each trip is attached to a resident and each resident has a single home location. • Requires household size determination, which can be subject to debate for different housing types (i.e., single-family, multi-family, and age-qualified housing products). • Commercial vehicle trips are not included.	



Metric	Model Types Used to Produce Metric (1)	Definition	Example
Home-Based VMT per resident	ABM, TOUR, TRIP	- All home-based automobile vehicle trips are traced back to the residence of the trip-maker; non-home-based trips are excluded. - Similar to Total VMT per service population.	
Total VMT per employee	ABM, TOUR	- All automobile vehicle-trips made by employed persons are traced back to the workplace of the trip-maker, even trips that aren't part of the work tour (i.e., all trips from home to work location and the return to home). - Allocation of responsibility within a jurisdiction is straight-forward, since each trip is attached to a worker. But if some workers have multiple work locations then deciding which to count may be an issue. - Commercial vehicle trips are not included.	



Metric	Model Types Used to Produce Metric (1)	Definition	Example
Total VMT per land use unit (e.g., KSF)	TRIP	All vehicle trips are traced to the zone or zones of study. This includes internal to internal (II), internal to external (IX), and external to internal (XI) trips. Use trip estimates or trip tables multiplied by distance skims similar to total VMT generated by a project.	
Work Tour VMT per employee	ABM, TOUR	- All automobile trips which are part of home-work tours or work-based tours are counted. - Allocation of responsibility within a jurisdiction is straight-forward since each tour should be attached to a specific workplace. - Commercial vehicle trips are not included.	



Metric	Model Types Used to Produce Metric (1)	Definition	Example
Home-Based Work (HBW) VMT per employee	ABM, TOUR, TRIP	• All automobile trips between home and work are counted. (A variant might also count work-based other trips.) • Allocation of responsibility within a jurisdiction should be straight-forward except for work-based other trips from one work location to another; even in this case it should be possible to decide which to count. • Commercial vehicle trips are not included.	

NOTES: (1) ABM = Activity-Based Model, TOUR = Tour-Based Model, TRIP = Trip-Based Model



APPENDIX C

Summary of Agency Decisions, Options, and Considerations

The following table provides a framework for thinking about the available options for using VMT to evaluate the effects and impacts of land use projects/plans and transportation network modifications. VMT is a recommended metric for environmental impacts as well as system performance because it is an indicator of mobility (for automobile trips), land use efficiency, and emissions from the transportation system. It is also correlated with other key outcomes, such as accessibility, safety, and traffic congestion. VMT tends to rise with incomes and with reliance on automobiles; it tends to decline with improved proximity to destinations and access to multimodal transportation options.

Decisions	Land Use Projects/Plans	Transportation Projects	Common Limitations	Recommendations
What form of VMT metric should be used?	Evaluate both absolute VMT and an efficiency metric version of VMT: 1 Total VMT (by speed bin) for the model area. 2 VMT per capita (or appropriate denominator) to evaluate land use projects and plans: Total VMT per capita (or service population), home-based VMT per resident, home-based work VMT per employee	Evaluate both absolute VMT and an efficiency metric: 1 Total VMT on the corridor 2 Total VMT for the area of effect including by speed bin for emissions analysis.	Metrics other than total VMT, such as home-based VMT per resident, represent only partial VMT (i.e., some vehicle types and trip purposes may be excluded). This helps analysts understand how much VMT may be generated by a plan or project, but does not evaluate a plan or project's overall effect on VMT.	Project/Area analysis 1 Total VMT (by speed bin) 2 Total VMT per capita 3 Home-based VMT per resident 4 Home-based work VMT per employee Corridor-level 1 Total VMT (by speed bin) for the area of effect



Decisions	Land Use Projects/Plans	Transportation Projects	Common Limitations	Recommendations
What methodology to use in monitoring VMT?	1 Mobile device data within a defined boundary 2 Household travel survey responses 3 Highway Performance Monitoring System (HPMS) data (example: https://www.oregon.gov/odot/data/pages/road-assets-mileage.aspx)	1 Same as land use.	Mobile device data can vary in its accuracy, particularly at the project or corridor level. Household travel surveys are conducted every 10-15 years; data is often aggregated at higher geographic scale than may be desired; access to disaggregated data is limited. Observed data may appear to overestimate VMT when compared to travel models, which truncate trips at model boundaries.	Validate big data products against household travel surveys and corridor-level counts. ○ https://www.streetlightdata.com/sb-743-vmt-solutions/
What methodology to use in estimating and forecasting VMT?	1 Regional travel demand model 2 City travel demand model 3 Sketch planning tool or spreadsheet (e.g. VisionEval - https://visioneval.org/)	1 Same as land use. 2 Elasticity methods based on lane mile changes. Resource: https://ncst.ucdavis.edu/research-product/induced-travel-calculator	Regional models have limited sensitivity and accuracy for local scale applications off the shelf. Regional and local models often truncate trips at model boundaries. Sketch and spreadsheet tools do not capture the 'project effect on VMT.' Models commonly have limited sensitivity to active transportation project effects on VMT.	Statically and dynamically validate models and make refinements to improve sensitivity and reasonableness within the study area and for the type of project under analysis. For transportation projects, also include elasticity methods to compensate for any model limitations.



Decisions	Land Use Projects/Plans	Transportation Projects	Common Limitations	Recommendations
What is the VMT performance standard for projects?	1 Agency discretion consistent with comprehensive plan. 2 Set based on agency's goals for emissions or energy consumption reduction. 3 Any increase above baseline for the study area. 4 Identify specific project types that are required to conduct VMT analysis.	Same as land use.	Difficult for agencies to determine what level of VMT change is unacceptable when viewed solely through a transportation lens. Uncertainty of VMT trends contributes to difficulty in setting thresholds. Connecting a VMT reduction expectation to baseline helps to reduce uncertainty associated with future conditions.	If VMT is already used in air quality, GHG, and energy impact analysis, review thresholds for those analyses to inform new thresholds exclusively for transportation purposes. Consider national and regional VMT trends and the potential influence of new and emerging mobility options such as autonomous vehicles (AVs).
What VMT reduction mitigation strategies are effective and feasible?	Data on efficacy of specific built-environment and transportation demand management (TDM) mitigation strategies: http://www.airquality.org/air-quality-health/climate-change/ghg-handbook-caleemod Local and regional travel models may have some sensitivity to these strategies.	Same as land use.	Models may lack full sensitivity to built-environment and TDM. Sensitivity testing through dynamic validation may be required prior to model application. Some demand management strategies are building tenant dependent that may require off-model processing along with on-going monitoring to verify performance.	Strategies applied at a regional or community level offer greater VMT reduction potential than on-site only strategies. As such, develop a VMT mitigation program at the city, county, or regional scale. More details available at https://www.fehrandpeers.com/wp-content/uploads/2020/04/VMT-Fees-Exchanges-Banks-White-Paper-Apr2020.pdf