A Tool for the Assessment of Local Land Use Decisions on VMT and Resulting Air Quality

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Abstract

In 2009, the Minnesota Legislature passed a bill directing the Metropolitan Council of the Twin Cities to prepare a Land Use and Planning Resources Report and that the report:

- Identify and assess the effectiveness of local level and regional level land use and transportation planning strategies and processes for reducing air pollution, mitigating congestion, and reducing infrastructure costs.
- Emphasize approaches that reduce or manage travel demand through land use and access to transportation options.

As one of the elements of the report, the Council began development of an air quality assessment tool that local jurisdictions could use to assess the impacts of local development decisions on transportation use and the resulting mobile source air quality emissions.

The air quality assessment tool uses data from the regional travel demand model and MOVES2010, along with VMT reduction elasticities identified through a literature review. VMT was aggregated for various trips for home based trips, non-home based trips, truck trips, and through trips. The VMT tabulations were then converted to generation rates by dividing the aggregated VMT totals by households and employees.

A short selection of land use density and design related VMT reduction elasticities were included in the model. These include: household density, land use mix, jobs/housing balance, intersection/street density, percent 4-way intersection, job accessibility, and distance to transit. The first five are oriented towards measures that could be implemented by the communities, and the last two by the region/transit operator.

The elasticities are applied to the changes proposed by land use scenarios and the resulting VMT adjustment factors applied to the VMT generation rates and the resulting change in VMT estimated. Pollutant emission rates (generated with the EPA model MOVES2010 using local input parameters derived from existing sources) are then applied to the VMT reduction to quantify the potential impacts on air quality and fuel consumption. Preliminary tests of the tool show that land use changes can be expected to impact air pollution to a very limited degree.

Background

The Minnesota Legislature established the Metropolitan Council in 1967 to coordinate planning and development within the Twin Cities metropolitan area and to deal with issues that could not be adequately addressed with existing governmental arrangements. Additional legislative acts in 1974, 1976 and 1994 strengthened the Council's planning and policy roles, and merged the functions of three agencies (the Metropolitan Transit Commission, the Regional Transit Board and the Metropolitan Waste Control Commission) into one — the Metropolitan Council. The

Metropolitan Council is the regional planning agency serving the Twin Cities seven-county metropolitan area and providing essential services to the region. The Council works with local communities to provide these critical services:

- operates the region's largest bus system
- collects and treats wastewater
- engages communities and the public in planning for future growth
- provides forecasts of the region's population and household growth
- provides affordable housing opportunities for low- and moderate-income individuals and families
- provides planning, acquisitions and funding for a regional system of parks and trails
- provides a framework for decisions and implementation for regional systems including aviation, transportation, parks and open space, water quality and water management.

In 2009, the Minnesota State Legislature directed the Metropolitan Council of the Twin Cities to prepare a Land Use and Planning Resources Report and that the report:

- Identify and assess the effectiveness of local level and regional level land use and transportation planning strategies and processes for reducing air pollution, mitigating congestion, and reducing infrastructure costs.
- Emphasize approaches that reduce or manage travel demand through land use and access to transportation options.

As part of that work the Council's administration decided to provide local decision makers a tool they could use to assess potential impacts of local land-use decisions on vehicle use and the resulting mobile source air pollutants. All work developing the tool was to be conducted by Council staff using existing models or existing data. To the maximum extent possible, the tool was to use locally derived data. To meet this requirement for local data, the regional travel demand model was used to estimate average VMT generation rates for each community in the region.

In simplified terms, the process followed these steps:

1. Estimate 2005 vehicle miles traveled (VMT) as a measure of travel using the regional travel demand forecast model.
2. Aggregate 2005 VMT by community.
3. Convert to rates of VMT generated per household and per employee.
4. Select strategies that affect the impact of alternative development or land use scenarios on VMT.
5. Calculate changes in VMT for alternative development or land use scenarios.
6. Estimate changes in air quality pollutant emissions.

The final outcome is a comparison of emissions for "Before" and "After" scenarios. The "Before" scenario needs to be developed by the community using the tool through either their normal planning process or from recent typical developments in their area. The "After" scenario would be the intensity or design developed to implement travel reduction.

The air quality assessment tool is designed to estimate air pollutants from only mobile transportation sources. It estimates emissions for all air pollutants for which EPA's MOVES2010a emission rates model provides data. The tool does not estimate total air pollutants or total greenhouse gases for a community, nor does it estimate full life-cycle carbon emissions. At this point, it only addresses the base year of 2005. Its value comes from comparing a 2005 baseline measure to emissions from a different type of development or land use that produces a different total vehicle miles traveled (either more or less).

Air pollutants from aviation and private rail traffic are not included. The Council's regional transportation model does not include commercial rail, and the Council has no data to forecast travel behavior for a transportation mode run by private rail operators, such as Amtrak. Air traffic is not part of the tool because there is little relationship between land use and aircraft flights. However, ground transportation trips for airport passenger access and freight distribution are included in the regional travel demand model.

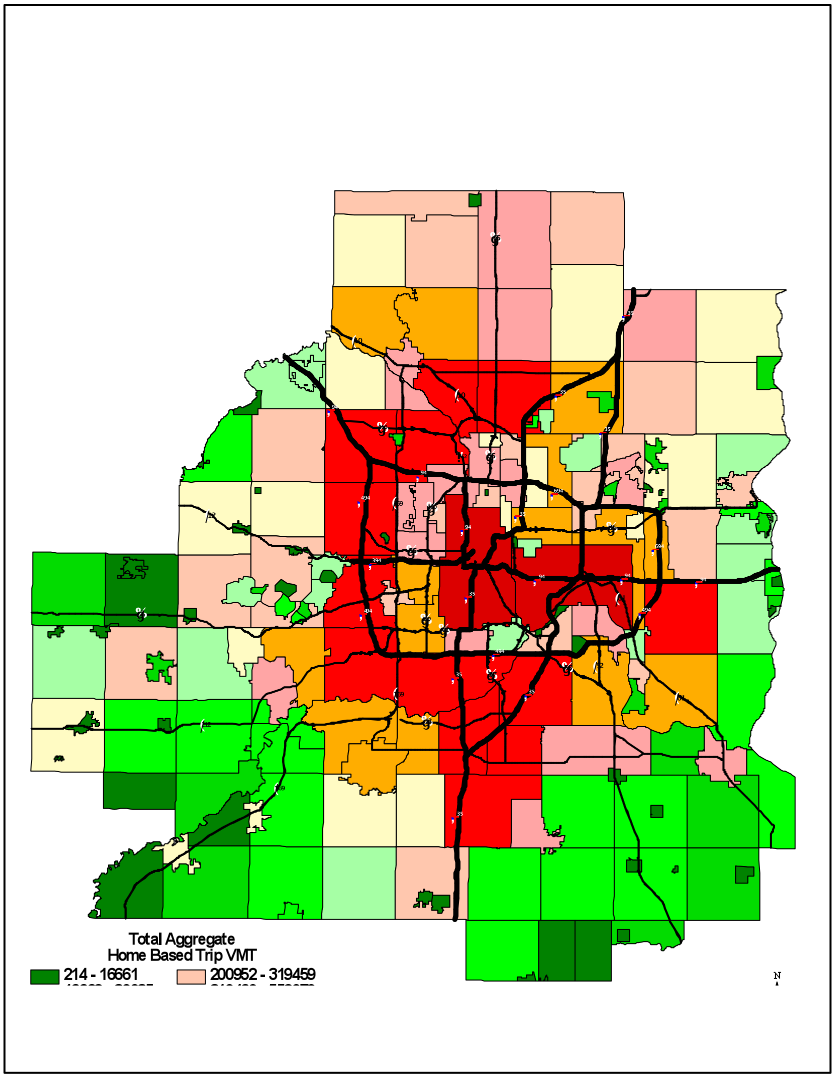
Regional Travel Demand Model – VMT Tabulations

The travel demand model produces vehicle miles traveled (VMT) by trip purpose for geographic areas in the region. Model generated VMT results were aggregated by Transportation Analysis Zones (TAZs) at the smallest scale, individual communities, and the region as a whole. VMT was also classified by Home-Based and Non-Home Based for trips beginning or ending in each of the communities. VMT from trips passing through the communities was not categorized by trip.

Home-Based VMT Tabulations by Community

To produce the community level aggregations, GIS was used to determine the area of each TAZ that was in a community and calculate a proportional split. Vehicle trips were converted to VMT by multiplying them by skimmed values of distance between TAZ pairs along the shortest time path. To reduce the number of files and computational time, the model's 24 highway assignment time periods were collapsed to five time periods: Early Morning Period, AM Peak Period, Midday Period, PM Peak Period, and Evening Period. Average link travel times were calculated for each of these time periods and used for the path tracing. VMT of home-based trips were aggregated by the community of residence, while VMT of non-home based trips were aggregated at both ends by the communities of trip origin and trip destination.

Figure 1 illustrates the pattern of VMT generated by the communites of the Twin Cities region. As expected, the two central cities of Minneapolis and St. Paul generate the greatest numbers of miles traveled. But it should also be noted that a significant number of the communties along or containing principal arterials show a pattern of greater VMT generation.

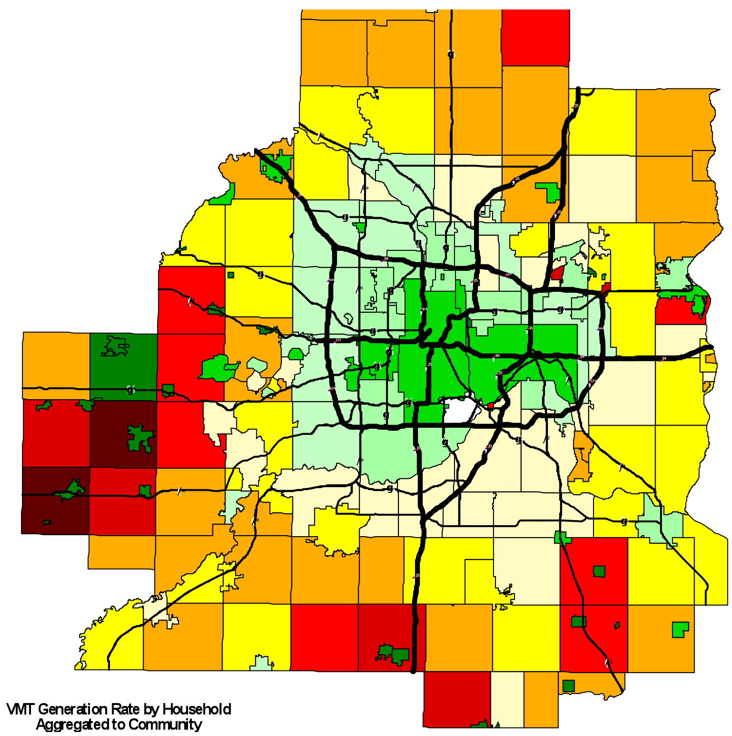


Once vehicle miles traveled (VMT) were produced and aggregated by community and trip purpose, results were then combined with the number of households or the number of employees in a TAZ or community to develop base VMT generation rates. These rates serve as the basis for comparing vehicle miles traveled generated by an alternative development pattern and were generated for each community in the region (182 communities). Averages by community type are listed below in Table 1.

Table 1: Range of VMT Generation Rates by Community Type

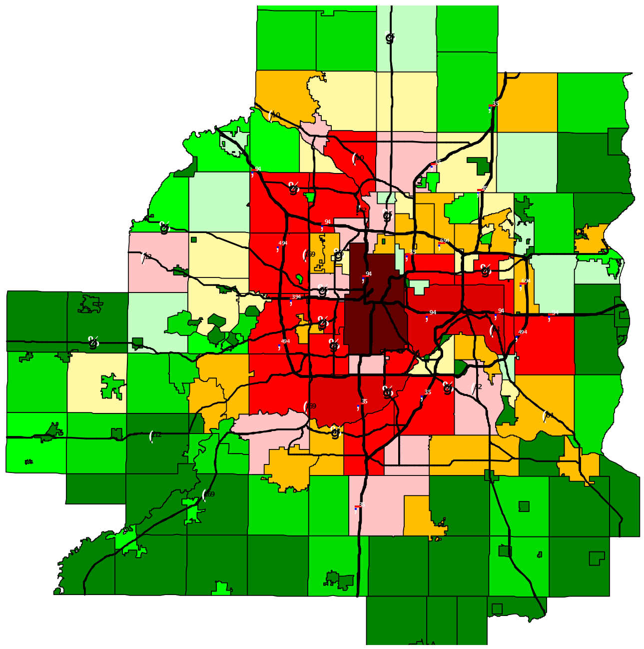
Type of Community	Home Based VMT per Household	Non-Home Based VMT per Employee
Regionwide	51	25
Central City	32	19
Suburb	55	27
Free Standing Growth Center	42	22
Rural Community	93	65
Township	115	84

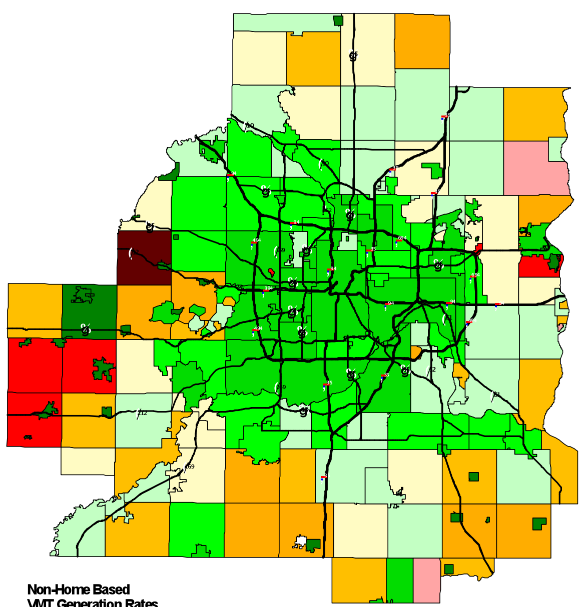
However, when the VMT is converted to generation rates by dividing by the number of households in a community, a different picture and related implication appears. Now the central cities and inner suburbs, communities that generated high levels of VMT, show that they actually generate lower rates of VMT per household compared to more remote communities. This is reasonable given the denser development pattern in those inner communities which provides opportunities to satisfy needs with shorter trips. These communities also are densely enough developed to support higher levels of transit, providing an alternative mode not readily available in the out suburbs and townships.



Non-Home Based VMT Tabulations by Community

The pattern of non-home based trip VMT shows a similar pattern, though not as well defined, as illustrated in Figures 3 and 4. Once again, the communities showing the greatest amount of non-home based VMT are the central cities and those communities containing or in proximity to highways. But when normalized by the number of employees in a community, those communities show the lowest generation rates, while some of the more remote township and communities of the region exhibit the highest rates of non-home based VMT generation.





Non-Home Based
VMT Generation Rates

Land Use Development and VMT Elasticities

Council research staff conducted a literature search to locate applicable land use/transportation elasticities that could be used to assess different land use development patterns and their impacts on travel. They found one set of documents and one journal article to be particularly useful in this research:

TCRP Report 95: Traveler Response to Transportation System Changes; Ch. 15 – Land Use and Site Design, 2003

Travel and the Built Environment; Reid Ewing and Robert Cervero; Journal of the American Planning Association; Vol. 76, No. 3, Summer 2010.

Applicable elasticities were identified in 5 categories: diversity, design, accessibility, transit, and density, as shown in Table 2.

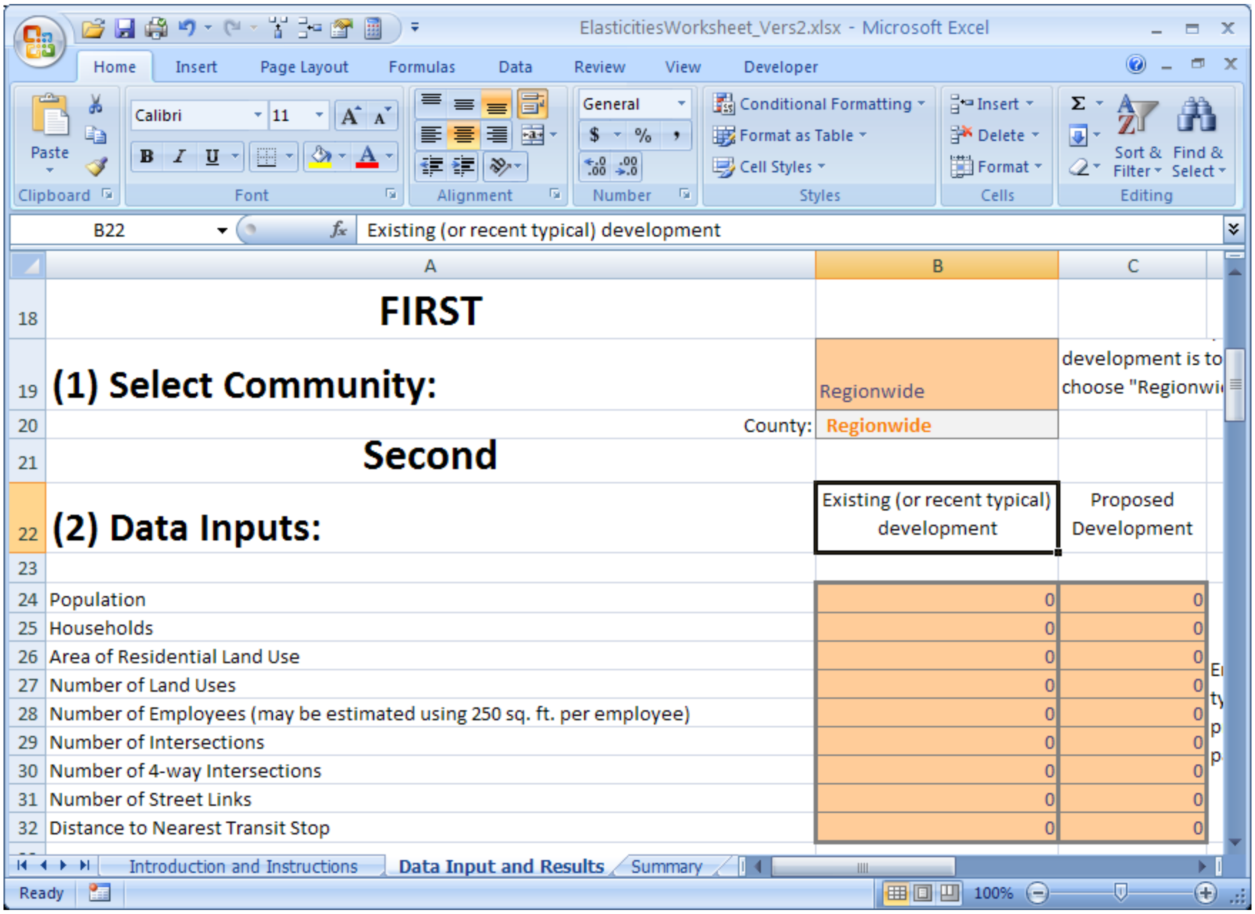
Table 2
Land Use/Transportation Elasticities

Strategy	Build Environment Variable	Elasticity
Diversity	Land Use Mix	-9%
	Jobs/Housing Balance	-2%
Design	Intersection/Street Density	-12%
	Percent 4-Way Intersections	-12%
Accessibility	Job Accessibility by Auto	-20%
	Job Accessibility by Transit	-5%
Transit	Distance to Nearest Transit Stop	-5%
Density	Population or HH Density	-4%

Air Quality Assessment Tool Implementation

The tool is currently implemented as a stand-alone spreadsheet, though the intent is to convert it to a web-based application that will be maintained and freely accessible on the Metropolitan Council web-site. The data requirements have been kept as minimal as possible to maximize ease of use. The intended audience consists of local decision makers (local planning commissions, city councils, and city planners). Data for both the land use scenario designed to reduce VMT and data for a "base" case are required. The need that the data for both scenarios be developed in the same manner is paramount for the successful application of the tool. In situations where only data for the build alternative is available, it is recommended that data for a typical recent development in the area of the scenario under evaluation be used as a surrogate for the "base" case.

The first step in the application of the tool is for the user to select the community of interest and then enter the available data pieces. The following illustration shows the data input screen:



Selecting the appropriate community automatically selects the appropriate county, county based air pollutant emission rates, and the community specific home-based and non-home based VMT generation rates. The completed cells in the data inputs section will use the elasticities previously listed in Table 2 and calculate the total maximum potential change in VMT given the size of the development. The availability of data from the data input section will determine which elasticities can be applied and the spreadsheet will do so automatically without any required user intervention.

The application of the density elasticities raised an issue of comparability between the “base” case and the alternative build scenario. As it is assumed that the area of development is constant, different densities of households or population would result in different total numbers of households or residents. The application of the density related elasticity (-4%) would produce a decrease in the rate of VMT generation, however, the base increase in the land use (i.e. number of households) would result in an increase in overall VMT and air pollutants.

For example, a 10 acre parcel could hold 30 households at 3 units per acre or 100 households at 10 units per acre. The elasticity applied to the 300+% increase in density would suggest a 13+% decrease in the VMT. However, the number of trips and amount of VMT produced by 100 households, compared to 30, would far overshadow the decrease in VMT. To remedy this, the same number of households are assumed to occur in both the “base” case and the alternative build scenario, under the assumption that those household will be developed somewhere and that on a regional scale it would be batter to develop in a manner resulting in less travel would be a net.

Example

A suburban 120 acre parcel is to develop with residential uses and a school. The design could be at a typical density and design of 3 units per acre with a curvi-linear street pattern predominantly of cul-de-sacs and off-set intersection to calm traffic. The alternative is a denser 10 unit per acre land use with a more urban grid street pattern. Table 3 shows the inputs are as follows:

Table 3: Example Input Data

Input Type	"Base" Case Data	Alternative Scenario Data
Number of Households	360	1200
Area of Residential Land Use in Acres	120	120
Number of Intersections	15	38
Number of 4-way Intersection	4	37
Number of Street Links	31	60

Given the available input data, the tool will assess the following strategies. Table 4 shows the percent change in the assessment criteria along with the predicted change in VMT generation rate based on the elasticities in Table 2.

Table 4: Example Strategies Implemented and Results

Strategy	Percent Change in Strategy	Predicted Percent in VMT Rate
Change in Household Density	233%	-9%
Change in Intersection/Street Density	31%	4%
Change in Percent of 4-way Intersections	265%	-32%
Total	NA	-44.9%

The suburb used in this example generates 75.4 vehicle-miles-of-travel from Home-Based trips each day and 35.8 from Non-Home Based trips. With the total percent change from Table 4, these rates become 41.6 and 19.8 respectively, for a net reduction of 40,607 vehicle-miles-traveled from a "base" case VMT generation. However, the community and region will experience an overall increase of 49,921 vehicle-miles traveled compared to a scenario where those 1,200 households are not constructed anywhere in the region.

Conclusions

With growth (increase in households, population and employment) comes the need for people to make trips. There are ways for land use to influence the length and mode of those trips, and in so doing, reduce the related amount of travel. The Air Quality Assessment Tool provides local decision makers and their staffs a tool to add this consideration of the land use -transportation linkage into their deliberations. Land use changes will not be the silver bullet to quickly eliminate air quality concerns (whether they cover CO, CO_2, $PM_{2.5}$ or ozone), but efforts to use land use decisions as one more tool to affect air quality improvements can be effective in the long term. After all, that is how our land use decisions of the past exacerbated the problems essentially based in the combustion of hydrocarbons to move vehicles.