

APPENDIX G

VMT Spreadsheet Tool

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Results**

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August 6, 2012

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1. Overview of VMT Spreadsheet Tool

The VMT spreadsheet tool is intended to give the user a sketch level comparison of different land use and transportation scenarios. It conducts a sketch level analysis of the land use and transportation relationships using 7 Ds: density, diversity, distance, design, destination, demographics, and development scale. It looks at how a land use scenario differs from an established or modeled land use scenario, comparing the two on land use metrics like number and types of jobs and households, densities, and the mix of uses. The tool also compares the scenarios on travel behavior, and - depending on the scale of the project - can provide estimates of vehicle miles traveled (VMT).

In the regional context, the tool provides VMT estimates that can be useful in scenario planning and evaluation. The project level evaluation compares land use variables as a “sketch” of whether an alternative scenario may perform better or worse than a base scenario. This level of use is not intended to replace the type of analysis better suited for more robust travel models or analysis tools, but to provide planners, developers, analysts, and elected officials a way of quickly comparing an alternative scenario to a base scenario.

The tool contains two parts. The main component of is a spreadsheet, Sketch7, built in Microsoft Excel. This is where all of the calculations take place. The other part is a web based GIS application, built in Microsoft Silverlight. The GIS portion is for making land use changes, and feeding the spreadsheet the appropriate land use data.

The rest of this documentation outlines the steps necessary to install, calibrate, and use the VMT spreadsheet tool.

2. Code Documentation

A. Silverlight Web GIS

A zip file with the custom GIS application, written in Silverlight, is available at <http://downloads.ice.ucdavis.edu/ultrans/statewidetools/StatewideToolsWebFiles.zip>. The contents of the file should be unzipped into a new folder. Visual Studio 2010 is required to open the project by selecting the *.sln file. Once the project is opened, the solution explorer will reveal a web section and a Silverlight section. All changes in the code should be performed in the Silverlight portion of the site. Finally, the site will need to be published to a web server using Visual Studio. To see an example of the application, please visit <http://mapping.sacog.org/landusebuffer/>.

3. User Guide

B. Sketch7

This documentation is for the standalone “Sketch7” tool created for the “Improved Data and Tools for Integrated Land Use-Transportation Planning” study. It uses Microsoft Excel as the platform for conducting a series of calculations to derive travel behavior from a change in land use(s). The elasticities used in the calculations are derived from the “Ds analysis modules” that were produced in the study. While the tool is defaulted to use elasticities for the Sacramento region, a series of elasticities were produced for each region to be used in this tool, see Appendix D for a list of regions and related elasticities. Calibration of the tool should be conducted to local conditions.

Work flow

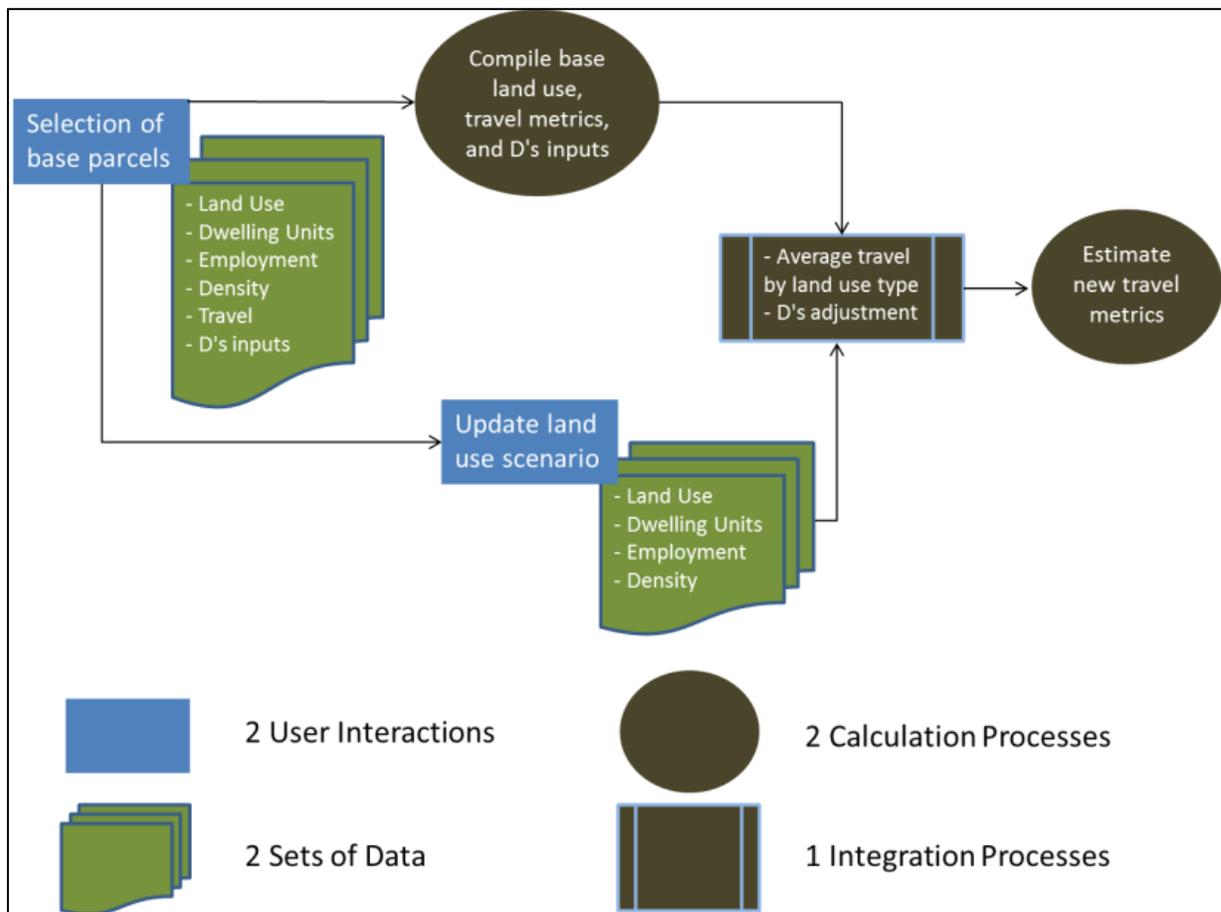


Figure 1

The figure above shows the flow of the process used in the estimation of travel based on a change in land use in the Sketch7 land use-transportation standalone estimation tool. It begins with the selection of a base set of parcels, the creation of a land use scenario, and estimation of final metrics. Between each step, the tool conducts several calculations to create base and context area averages for comparison purposes. The next sections of this document outline the steps within Sketch7, organized by tabs within the spreadsheet.

start

There are three user actions or options on the *start* tab:

Project Name,

A button labeled “Map”, which opens the web based GIS application and allows the user to enter the land use scenario, and

A button labeled “Import”, which allows the user to browse to the location of a saved version of the mapped land use scenario.

There are also three buttons that take the user to a screen to enter base data:

Regional Land Use and Travel Data

Elasticities

Place Types

The user first enters the name of the project. The user then clicks on the Map button to open the Silverlight GIS mapping application. Sketch7 opens a web browser for the Silverlight GIS mapping tool, which allows the user to select parcels, buffer them ¼ mile, change land uses, and export the new scenario to the spreadsheet tool (see prior documentation on this functionality). The Silverlight GIS map sets the context area for the analysis by assigning a transportation analysis zone (TAZ) to the project location. This TAZ becomes the base for all land use and travel metrics that are then adjusted using the elasticities set in the tool.

Once a land use scenario is created, the tool computes two sets of data. The first set is the place type average land use and travel metrics to be used for the base scenario and the newly created scenario. This includes the following:

Totals by Place Types: Household Population, Households, Retail
Jobs, Non-Retail Jobs,

HH-Generated Person Trips: Transit, Bike, Walk, HOV, Vehicle Trips

HH-Generated Travel: Household Generated VMT

Other: Net Acres w/ Dwelling Units, Net Acres with Employment

The other set of data is the land uses and travel metrics for the context area. These data are used for the D variables to adjust the base travel metrics up or down. This includes the same set of data as the place type averages, but instead of data from the selected parcels, it estimates data from a larger context area. For the custom mapping application, these are buffered within the tool. For the spreadsheet option, these data are TAZ averages.

After the land use scenario is generated, and the base and context variables are estimated, the user has the opportunity to adjust a few of the Ds variables up or down. These include the level of transit, the street pattern, and income and age variables of the project.

Transit

The transit adjustment is simply “high, medium, and low” level of transit service, which are defined below. The adjustment made to the base travel metrics is from a comparison of the base to the context area. The context level is determined by the following: greater than 80% of the maximum average for percent transit of all trips in all RADs is High, lower than 20% of the minimum average for percent transit of all trips in all RADs is Low, everything else is Moderate.

- Low: Little or no transit service available within 1/4 mile. If available, it is infrequent service (1 hour +) with limited connections available.
- Medium: Some transit service available within 1/4 mile, but fairly infrequent (30 minutes +) headways.
- High: Multiple transit options available within 1/4 mile, with at least one frequent (~ 15 minutes) option.

Figure 7 below shows the default elasticities that are applied to the base VMT in order to estimate the new values.

Transit Access	-0.02
-----------------------	-------

Figure 7

Street

Similar to the adjustment for transit service, street connectivity or Design is set to Low, Moderate, and High; see below for an explanation. These values are then compared to the context value, which is determined by the following: greater than 80% of the maximum average for percent walk and bike trips of all trips in all counties is High, lower than 20% of the minimum average for percent walk and bike trips of all trips in all counties is Low, everything else is Moderate.

- Cul-De-Sac style street design with limited 4-way intersections and large block faces.
- Mixed Block style street design with some 4-way intersections and some smaller block faces.
- Grid style street design with many 4-way intersections and smaller block faces.



Figure 8

Figure 8 above shows the default elasticities prior to updates resulting from the land use project.

Demographics

There are two demographic variables that the user can set for the area, age and income. How the variables are set for the project is described below.

Age:

Fewer people 55 and older

Average amount of people 55 and older

More people 55 and older

Income:

Fewer households above median income

Households near median income

More households above median income



Figure 9

Figure 9 above shows the default elasticities prior to updates resulting from the land use project.

The other Ds variables are set by the location and the combination of land uses selected by the user. These include: Destination (Accessibility), Density, Diversity, and Development Scale. These are described below.

There are two types of accessibility measures: transit and auto accessibility. Transit accessibility is defined by the number of jobs that can be reached with a 45 minute transit trip, and auto accessibility is the number of jobs accessible within a 20 minute drive. The context is defaulted to the RAD average, and the project adjusts that number up or down depending on the number of jobs added to the scenario.

Figure 10 below shows the default elasticities for the Accessibility variables.

Accessibility	-0.26
----------------------	-------

Figure 10

The Diversity adjustment is based on the difference between the context average for each specific component: Retail Employee per Dwelling Unit, Total Jobs per Dwelling Unit, and K-12 Employees per Dwelling Unit; and the optimal value in order to receive maximum travel benefit. Figure 11 shows the optimal value, and the elasticity used for each.

Diversity/Mix	-0.02
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Figure 11

The Density adjustment is the gross density (jobs + dwelling units / gross acres) for the project area compared to the context area. The base is adjusted up or down depending on whether density in the project area increases density in the context area or not. The calculation is simply project divided by context – 1.

Density	-0.11
----------------	-------

Figure 12

Figure 12 above shows the elasticity for this variable.

Development scale is the total amount of jobs and dwelling units within the project area. The higher the number, the bigger the adjustment will be on the travel metrics. Figure 13 shows the elasticities from the various scale of growth.

Development Scale	
Scale	Adjustment
0	0
500	0
1000	0
2000	0
5000	0
15000	-0.00001
50000	-0.0001
200000	-0.001
1000000	-0.01

Figure 13

Input

Once a user has created a land use scenario, adjusted Ds variables, and the tool has estimated travel demand, the user can alter the land uses to either optimize the scenario or better reflect observed results.

On this tab, the user simple adjusts the dwelling units, total employees, retail employees, and non-retail employees. The tool will automatically adjust the travel metrics to reflect the changes in land use.

These data are then compared to the TAZ averages calculated above to set the unadjusted land use and travel metrics for the scenario. The next step is for the user to adjust the “Ds” variables to estimate the change in travel.

The final report produced by this tool performs an assessment of each Ds variable for the project as compared to the context area and the region. Based on this assessment, the base travel metrics are adjusted up or down using the above-stated elasticities. The base travel metrics are shown alongside the non-adjusted numbers for the project, as well as the final adjusted travel estimates.

Figure 14 below is an example of the tool’s final report.

Table 1. Assessment of Key Land Use and Travel Characteristics

Region	Context Area	Project Area Base Values	Assessment
1,212	2,795	Auto Accessibility (Jobs w/in 20 Minute Drive) 5,407	Higher than average in surrounding area, and higher than regional
453	1,637	Transit Accessibility (Jobs w/in 45 Minute Transit Trip) 4,249	Higher than average in surrounding area, and higher than regional
1.2	0.9	J/H Balance (Jobs per Household w/in 4 miles) 1.4	Higher than average in surrounding area, and near regional average
		Residential Mix (Entropy, 0.5 mile buffer)	
3.00	4.66	Residential Density (Dwellings per Net Res Acre, within a 0.5 mi buffer) #DIV/0!	#DIV/0!
\$60,000	\$37,547	Income (Median income) ➡	More households below median income
35	37	Age (Median Householder Age) ➡	Lower median householder age
16.57	19.26	VMT per Capita 17.24	Near average in surrounding area, and near regional average
0.05	0.04	Transit Trips Per Capita 0.04	Near average in surrounding area, and near regional average
0.35	0.25	B+W trips per capita 0.21	Near average in surrounding area, and lower than regional

Table 2. Summary of Adjustments to Base Travel Metrics

	Destination		Diversity		Density	Demographics		Development	Design	Distance	TOTAL
	Auto Access	Transit Access	J/H Balance	Res. Mix	Res. Density	Income	Age	Scale	Street Pattern	Transit Distance	
VMT per Capita	-6.26%	-4.79%	0.76%		#DIV/0!	0.00%	-0.20%	0.00%	0.00%	-0.20%	#DIV/0!
Transit Trips per Capita											
B+W Trips per Capita											

Table 3. Final Project VMT

	Regional	Context Area	Non-Adjusted Project	Adjusted Project
VMT Per Capita	16.57	19.26	17.24	#DIV/0!
Total VMT (1000s)	36,699	560.4	75.2	#DIV/0!
Transit Trips per Capita				
B+W Trips per Capita				

Print Start Over

Figure 24

In order for all calculations to take place, a set of land uses needs to be entered into the tool, and base set of data from a regional travel model using the same land uses needs to be loaded.

place types

The land uses, or place types within Sketch7, are defaulted to a generic set of land uses used in this study. The information that is needed within the place types tab includes:

Name	Order (sorting order)	Residential Density (dwellings per acre)
Employment Density (employees per acre)		% Retail (% of land for retail uses)

The place types used in Sketch7 must be consistent with those used in the Silverlight GIS mapping application as well as the travel model used to supply base metrics.

regional data

Regional data from a TAZ based travel model must be entered into the tool for each place type. By TAZ and place type, these data are:

Household Population	Dwelling Units	Employees	Retail Employees
Non-Retail Employees	Acres w/ DUs	Acres w/ Emps	Total Trips
Vehicle Trips	Walk Trips	Bike Trips	Transit Trips
VMT/HH	VMT/Capita	Jobs w/in 20 minute Drive	
Jobs w/in 45 transit trip			

B. Silverlight Web GIS

For the Sacramento region, the tool can be found by navigating to the following URL <http://mapping.sacog.org/landusebuffer>. The purpose of the website is to enable a user to select one or more parcel locations within the SACOG area on the map and produce a buffer from those points to retrieve all parcels within that buffer. A table then appears showing data for each parcel along with a highlighted selection of each parcels location. At this point the user can adjust the original data to fit the needs of a particular scenario. The **Employment, Dwelling Units, and Landuse Type** fields are all editable and can be changed to any value the user desires. Lastly, when all field value changes are completed the user can export the table into an xml spreadsheet onto their local computer to export into an Excel spreadsheet for further analysis.

Web server administrators have a few requirements to fulfill to host the application. The website utilizes ESRI's ArcServer GIS web mapping technology with data stored in an ArcSDE database for use over the internet. Data storage can also include shapefiles and file based geodatabases. A

copy of Microsoft Visual Studio will be needed to change URL parameters and publishing of the website onto an IIS based web server. Users of the website also have the requirement of installing the Microsoft Silverlight browser plugin before they can view the web site. Upon navigating the site, a script checks to see if the browser contains the plugin, and if not provides a link to install. The shapefile or geodatabase must include the following fields:

Landuse Type (must be consistent with the place types in Sketch7)

Dwelling Units

Employees

TAZ

The initial screen shows a map view of the Curtis Park area in Sacramento, CA and various elements including a toolbar, map navigation tool, scalebar, and an overview map. The map is navigable in a similar fashion to Google or Bing maps. The scroll button zooms in and out while click and dragging pans the map view. The navigation tool at the lower left section of the web site allows the user to perform the same actions as using mouse activities. The overview window shows the current map extent using a red outlined box and the surrounding area. Clicking and dragging the red box will pan the window to that location. The bottom center of the screen displays a scalebar that adjusts itself when zooming in or out.

A toolbar containing three tools appears at the top right corner of the website. A user will select the point tool in order to select a parcel that will be used in buffering. It is recommended that an actual parcel be selected otherwise a message will appear explaining a parcel does not exist at that location. This point then becomes the location where the buffer will originate. If another point is desired in the overall selection, then the user will have to select the point tool again and place a second point on the screen. This process can be repeated for as many points on the map as desired. When all points are placed on the map, the **Buffer Parcels** button is selected and the buffer will take place. A table will appear on the upper left corner of the screen showing all parcels that were selected in the buffer. The selected parcels will also appear highlighted in blue on the map. When hovering the mouse over each record in the table, it will highlight to a cyan color as well as highlight the parcel that corresponds to that record on the map. This will help the user identify which record corresponds with the desired parcel. The table is now available for attributes to be edited. A permanent change to the underlying database is not being performed, changes will only be noted when the table is exported. After all changes are made to the scenario, the user will click the **Save Results** button on the table and export to an xml file onto their local desktop. This file will then be used in the next step of the process. If an undesirable buffer was

performed or the user wishes to experiment with various buffers, the **Clear Tool** must be selected to reset the table and graphics in order to perform new buffers.

Navigation

Upon navigating to the website located at <http://mapping.sacog.org/landusebuffer>, a map appears showing the extent of the SACOG region. The map interacts similar to a Google map in that panning and zooming are controlled by the mouse and mouse wheel. An additional zoom tool exists as well by pressing the shift key and drawing a rectangle on the screen to zoom into the desired area. A navigation control is also available in the upper left corner of the map that interacts similar to Google maps.



Figure 3

Toolbar

The toolbar consists of 4 tools that include parcel selection, clear, buffer, and display help, respectively.

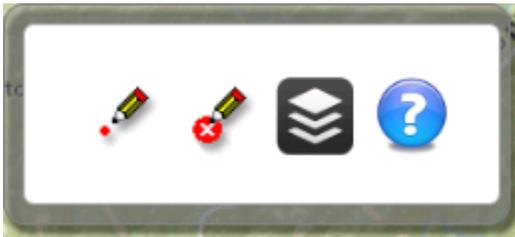


Figure 4



Parcel Selection = When zoomed in within a close enough scale, parcels will display on the screen. The user will click the parcel selection tool and begin to select parcels on the screen whose values will then be changed later in a table for the simulation. Once the tool is initiated, as many parcels as desired will be selected.



Clear = Clears all graphics and resets parcel selections from the screen. Useful if a parcel selection needs to be reselected to achieve a different buffer area.



Buffer = Once parcels are selected on the map, a buffer of 0.5 mile will be performed and all parcels within that buffer will become selected and highlighted on the map. A table will then appear in the lower left screen showing the parcel(s) selected before the buffer occurred. These values can then be edited directly in the table.



Help = Displays the help.

Basic Workflow – Below describes a basic workflow using the above tools

Zoom to desired area

Select parcel selection tool



Select parcel(s)

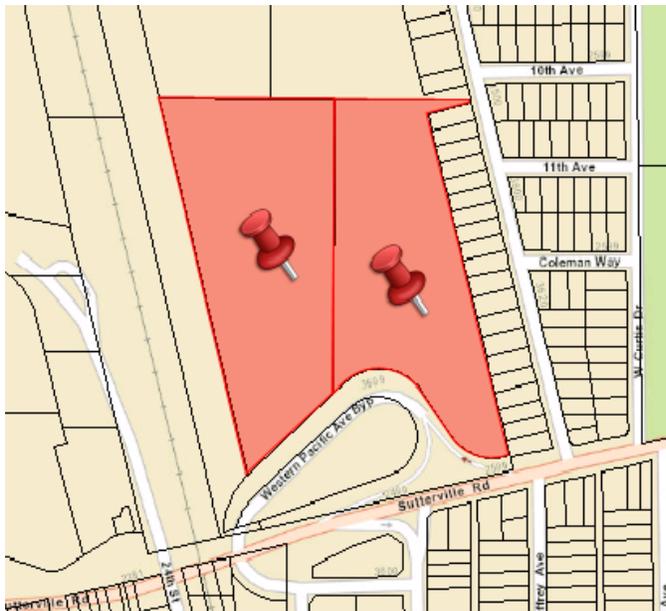


Figure 5



Click the Buffer button

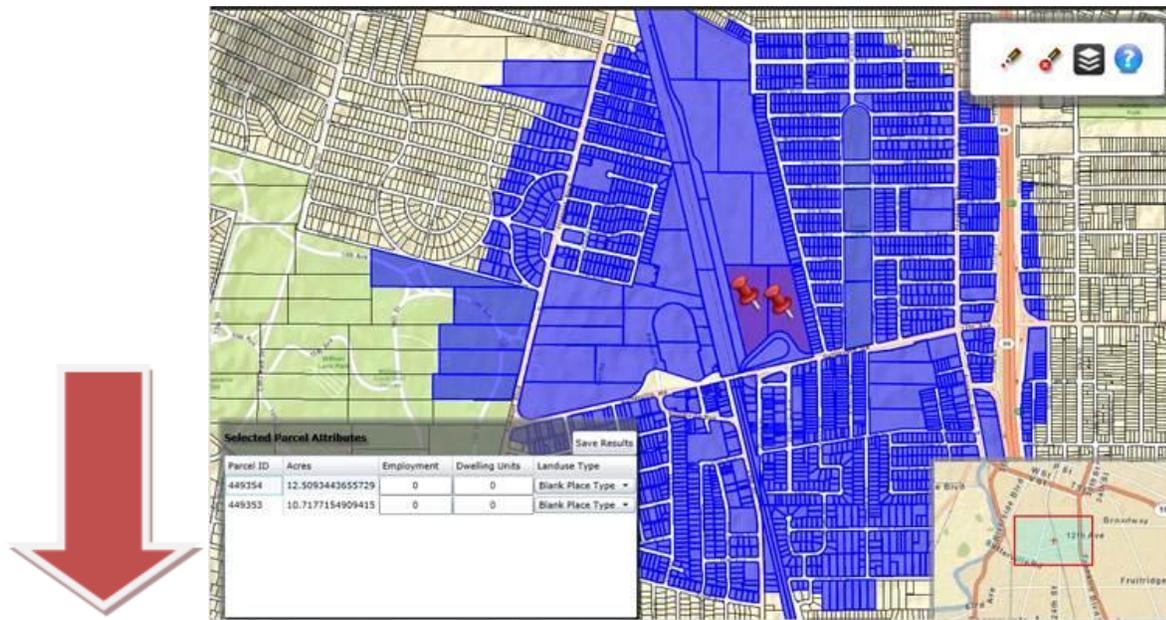


Figure 6

Edit values in the table

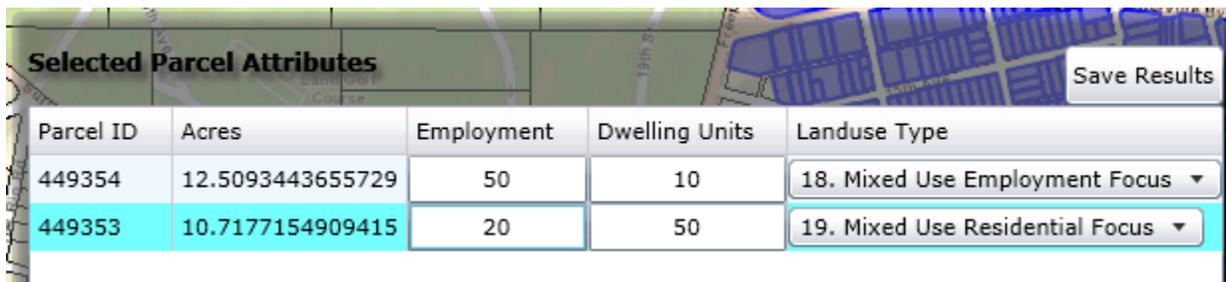


Figure 7

Click the **Save Results** button to save the edited records in the table and the buffered surrounding parcels to an excel file.

4. Validation Test Plan and Results

In order to test the effectiveness of the tool, several tests were conducted. These are:

- Testing the accuracy of the calculations
- Testing the reasonableness of the results

These tests area appropriate levels of testing for sketch tools, which are not intended to provide specific numbers to be used in more rigorous evaluations, but rather to give users a sense of magnitude and direction between different planning scenarios.

A. Calculation Accuracy

The calculation tests are a simple way to check if the tool is functioning in the way it is intended. It is not meant to determine if results are accurate, just whether the calculations in the tool are working appropriately. A simple test would be seeing if 1 + 1 in the tool equals 2.

In order to conduct this test, the model was fed a simple land use scenario: 10 dwelling units and 10 employees, 5 of which were retail. Beginning from the results page, each formula was traced throughout the spreadsheet to see if the results were based on the correct input cells. Figure 15 below shows the outcomes from that test. Adding 10 employees increases the context plus project area accessibility measures by 10 employees. In addition, the jobs housing balance measure, with the addition of 10 employees and 10 dwelling units, stays the same.

Table 1. Assessment of Key Land Use and Travel Characteristics

Region	Context Area		Context Area with Project	Assessment
164,895	528,521	Auto Accessibility (Jobs w/in 20 Minute Drive)	528,531	Near average in surrounding area, and higher than regional
133,667	339,770	Transit Accessibility (Jobs w/in 45 Minute Transit Trip)	339,780	Near average in surrounding area, and higher than regional
1.2	2.2	J/H Balance (Jobs per Household w/in 4 miles)	2.2	Near average in surrounding area, and higher than regional

Figure 85

The test for calculations showed that the calculations were functioning correctly, and that spreadsheet portion of the tool was calculating as intended.

B. Reasonableness

Once the calculations were found to be functioning properly, the next test was to see if the results were reasonable. In order to conduct this test, three projects were entered into the tool, and the results examined to see if:

1. Estimated VMT was not higher or lower than expected,
2. Estimated mode shares were not higher or lower than expected, and
3. Given the land uses, the Ds variables and the adjustments they were making to the base VMT made sense.

The three projects tested were: Curtis Park Village in the city of Sacramento, La Valentina in Downtown Sacramento, and a non-geographically specific low density neighborhood.

Curtis Park Village was selected as SACOG had conducted analysis for the city of Sacramento and the Sacramento Air Quality Management District on this project. The project version evaluated contains approximately 530 dwelling units and 450 employees over 95 acres. The context area for the project is a typical inner-ring suburb in Sacramento with an abundance of mostly retail jobs, and medium density residential that is well-served by transit. The project is proposing a mix of uses, with slightly more residential units at a higher density. One portion of the project is designed for senior housing.

The test of the tool resulted in a VMT/HH of 44.3. SACOG's evaluation of the project using its SACSIM activity-based travel demand model resulted in a VMT/HH of 44.5, a difference of less than 1 percent. The share of trips resulted in increases in all non-auto modes from the regional average, including a 4% increase in walk/bike trips and a 4.4% increase in transit trips. Given the context area around the project, the existing and proposed demographics, and the proposed uses on the site, these slight increases aligned with our expectations.

La Valentina is an urban project that consists of two parcels totaling just over 1 acre in size. The proposed project used in this analysis is a mixed-use development that consists of 81 dwelling units and 30 jobs, 15 of which are retail. The context area immediately surrounding the project is urban, with an abundance of jobs, retail jobs, and fewer dwelling units, most of which are of medium to medium-high density.

The test of the tool resulted in a VMT per capita of 11.3, which seemed reasonable for an urban mixed-use project. A SACSIM analysis of the surrounding ½ mile area resulted in an average VMT per capita of 13.4. While this is 15% higher, given the mixed land uses and improved jobs-to-housing ratio with the addition of more housing, it makes sense to see an improvement over the surrounding area.

In order to find out if the improvements to the project warranted a 15% decrease in per capita VMT, the project was changed to reflect the typical development found in the area. The two parcels were set to medium-high density residential with no employment. As shown in Figure 16, this resulted in a VMT per capita almost identical to the context area.

Scenario	Res VMT/ Capita
La Valentina	13.5
Base	23.1
<i>Context Area Avg:</i>	<i>13.4</i>

Figure 16

For sketch level planning, the results of the two scenarios are reasonable and trend in direction that is expected. Although the models created for this tool are not intended to be used at this small scale, SACOG will continue to work on calibrating the tool to reflect travel at this level.

The Low Density Neighborhood scenario was created to reflect a standard suburban neighborhood that could occur anywhere. These areas typically are not served by transit, are not accessible to many jobs in a short drive, and are fairly homogenous in land use characteristics. For this test the project consisted of 100 single family dwelling units of approximately 4 dwelling units per acre. For this test, the VMT per capita was 35.6. Given the characteristics of the land use and lack of transit and accessibility to jobs, it seems reasonable the VMT per capita would be this high.

An additional test was done, setting the design, destination, and transit variables to those near the regional average. For this test, the per capita VMT was 27.5, which is still 19% above regional average. However, given that the project contained no employment and was at a slightly lower density than the regional average, it seems reasonable that the per capita VMT would remain slightly higher than the regional average.