Appendix C

Fehr & Peers VMT Memo

Model Development Report and VMT Methodology

May 31, 2023

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Prepared for

City of Elk Grove

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1 Introduction

The report presents the Activity-Based Travel Demand Model (ABM) built for the City of Elk Grove. This report describes the following elements of the model development process:

- Base Year Model Development
- Model Calibration
- Model Validation
- Future Year Model Development
- Vehicle Miles of Travel (VMT) Threshold Development

Activity-Based Travel Demand Model

A travel demand model is a computer program that estimates traffic levels and travel patterns for a specific geographic area. Travel demand models use current travel behavior to predict future travel patterns from a sample of travel behavior data. Activity-based models are based on the principle that travel demand is derived from people's daily activity patterns. Activity-based models predict which activities are conducted when, where, for how long, for and with whom, and the travel choices they will make to complete them. ABMs use a tour-based structure to represent and model travel patterns. Tours are defined as chains of trips beginning and ending at the same location.

The model consists of input files that summarize the area's population and household characteristics, roadway network, travel characteristics, and other key factors. Using this data, the model performs a series of calculations to determine the activities that are generated throughout the day, number of trips generated, the beginning and ending location of each trip, and the route taken by the trip. The model's output includes projections of trip details for individuals in the model area, VMT, traffic volumes on roadways, and peak hour turning movements at selected intersections.

Benefits of Activity-Based Models

Travel demand models are valuable tools for preparing long-range transportation planning studies, like the City's General Plan. The travel model can be used to estimate the average daily and peak hour traffic volumes on the major roads in response to planned population and employment growth, changes in transportation infrastructure, policy assumptions, and provides a consistent platform to analyze different land use and transportation scenarios.

Activity based models represent an emerging practice in regional transportation planning. The genesis and continued support for ABM development is derived from the challenges of modern transportation planning, especially for distinguishing between the social outcomes of transportation policy and the underlying

choices made by travelers[1]. ABMs account for value-of-time distribution among the population and account for the full range of costs and utilities associated with travel. ABMs account for changes in travel behavior due to person-level attributes of an individual (age, gender, race, occupation status, etc.). As a result, ABMs allow for evaluating the effect of alternative policies on individuals travel behavior such VMT mitigation strategies.

EGSIM20

EGSIM20 is the city of Elk Grove Travel Demand Model, which is a modified version of the latest ABM developed by Sacramento Area Council of Governments (SACOG) known as SACSIM19. EGSIM20 can be used for many purposes related to the planning and design of the City of Elk Grove's transportation system. The following lists potential uses of the model.

- Update the land use and circulation elements of planning documents such as City's General Plan and transportation mitigation fee program.
- Evaluate the impacts of land development proposals.
- Support the development of transportation sections of CEQA documents.
- Support the preparation of project development reports for Caltrans.

In the near term, EGSIM20 will be used for the following purposes:

- Update the land use and circulation elements of General Plan Amendment (Kammerer Urban Design Study)
- Evaluate VMT and design of Whitelock Parkway Interchange
- Evaluate impacts of Elk Grove Zoo
- Evaluate impacts of Elk Grove Crossing (Annexation Project)
- Evaluate impacts of Bilby Ridge (Annexation Project)
- Evaluate impacts of Other land use and transportation projects

Scenario Years for the City of EGSIM20

The model has two scenario years:

- Base Year Model – 2019/2020 Pre-Pandemic Conditions
- Future Year Model – General Plan Buildout Model (Beyond 2040)

[1] Activity Based Models, Travel Forecasting Resource, https://tfresource.org/topics/Activity_based_models.html

2 Base Year Model Development

The EGSIM20 base year (2020) travel demand model development began with the 2019 version of the SACSIM model that has a base year of 2016. Refinements to the model in the city included adding a more detailed traffic analysis zones (TAZ), adding detail to the roadway network, and updating the base year land use inputs to 2020 conditions. The model's activity generation process was unchanged.

This chapter discusses the methodology used to update the roadway network, TAZs, and land use inputs.

2.1 Roadway Network Development

The 2020 base year roadway network was developed from the SACSIM19 base year network. SACSIM19 is a regional model and hence only includes roadways designated as major collectors and above (i.e., arterials, highways, and freeways). Therefore, more detail in the City of Elk Grove was needed to better replicate travel in the city. The roadway network detail added in the city included many collector roadways, local roadways (represented by TAZ connections), and new arterial and collector roadways constructed since 2016. We added the roadway details using the following sources:

- Previous General Plan and Fee Program models
- Latest Maps and Areal imagery (Google Earth and Open streets maps)
- Field Review

Where necessary, the number of directional travel lanes, roadway capacity, free-flow speeds, and permitted turning movements (particularly for special link connections to TAZs call centroids) were updated to replicate 2020 conditions. Chapter 3 (Model Calibration) includes additional discussion of model network refinements. The following model input files were modified:

1. *2016_base.net*
2. *2016_tranline.txt*

Figure 1 shows the "off-the-shelf" SACSIM19 base year model roadway network in the City of Elk Grove and **Figure 2** shows the final base year model network after refinements. The refinements resulted in an increase of 440 lane mile of roadway.

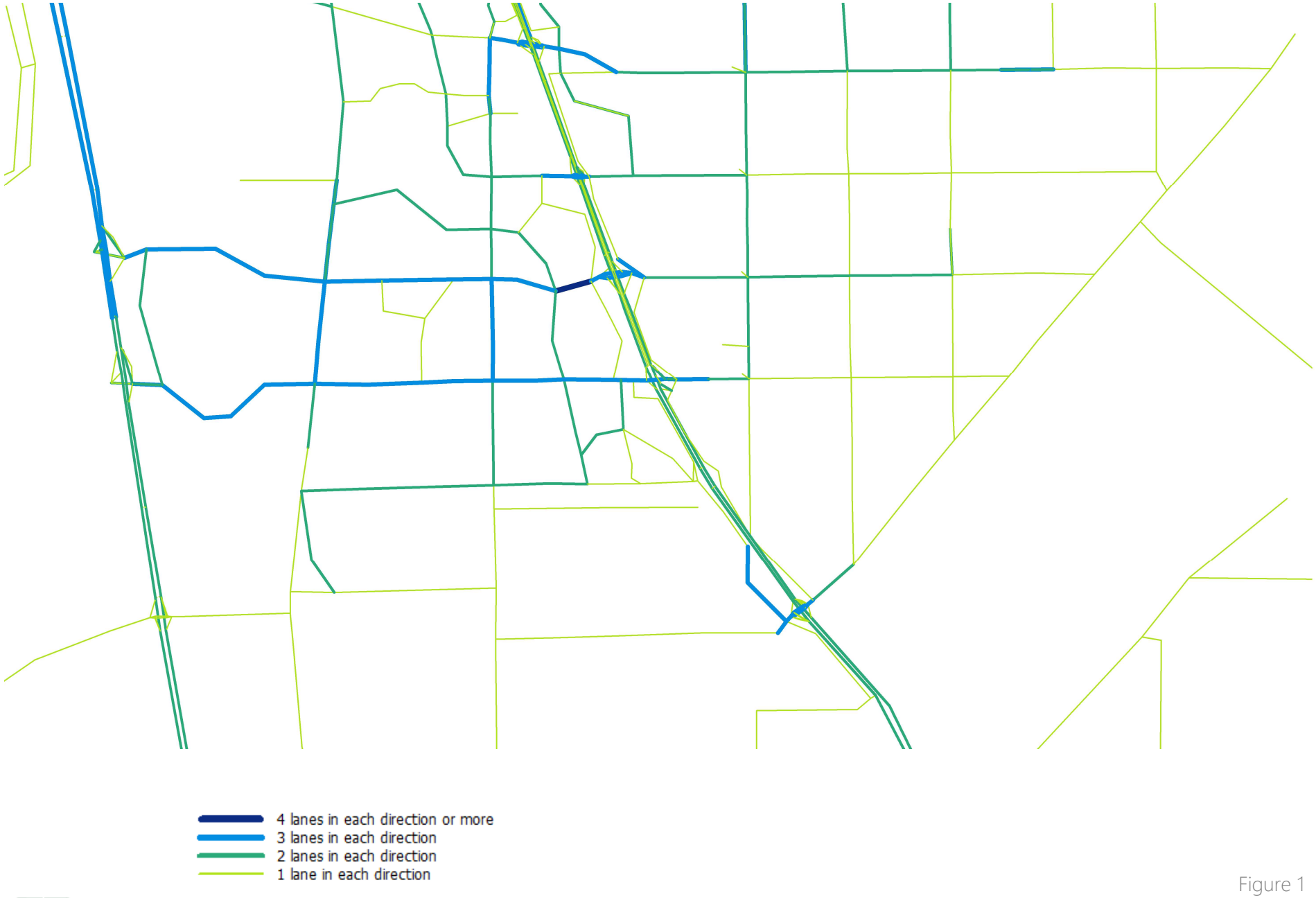


Figure 1

SACSIM19 - Base Year
Roadway Network

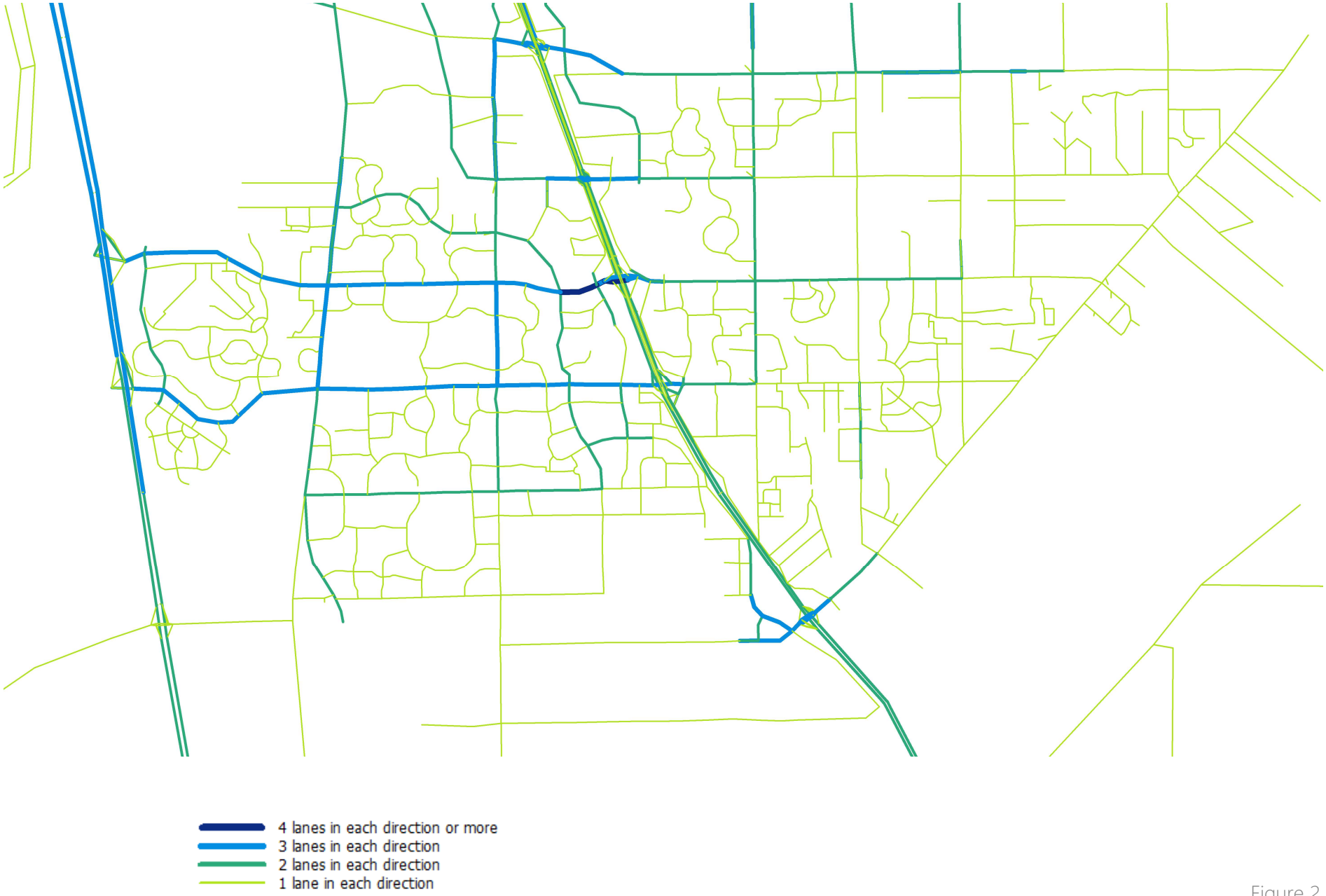


Figure 2

EGSIM20 - Updated Base Year Roadway Network

2.2 Traffic Analysis Zones (TAZ)

In travel demand models, the model area is split into many smaller spatial units or zones. These are called traffic analysis zones (TAZ). Depending on how a travel model is structured, TAZs have several uses, including: storing information about the people and places in each zone, serving as origins and destinations of trips, and calculating travel times between (and within) destinations.

In activity-based models, the activity generation operates on individual people and trips instead of zones, yet TAZs are still very important especially for vehicle trip assignments. Since SACSIM19 uses a multi-step static assignment at a TAZ level, it is important to have TAZs that adequately represent the analysis area. Therefore, the SACSIM 19 TAZ geography were split to add more detail within and around the City. This ensures more realistic assignment of trips onto the model network, which improves the model's estimate of VMT. See more details in Chapter 3 (Model Calibration).

Figure 3 shows the off-the-shelf SACSIM19 model TAZ structure in the City of Elk Grove. **Figure 4** shows the final updated TAZ structure for EGSIM20. The modification resulted in the addition of 684 TAZs to the model.

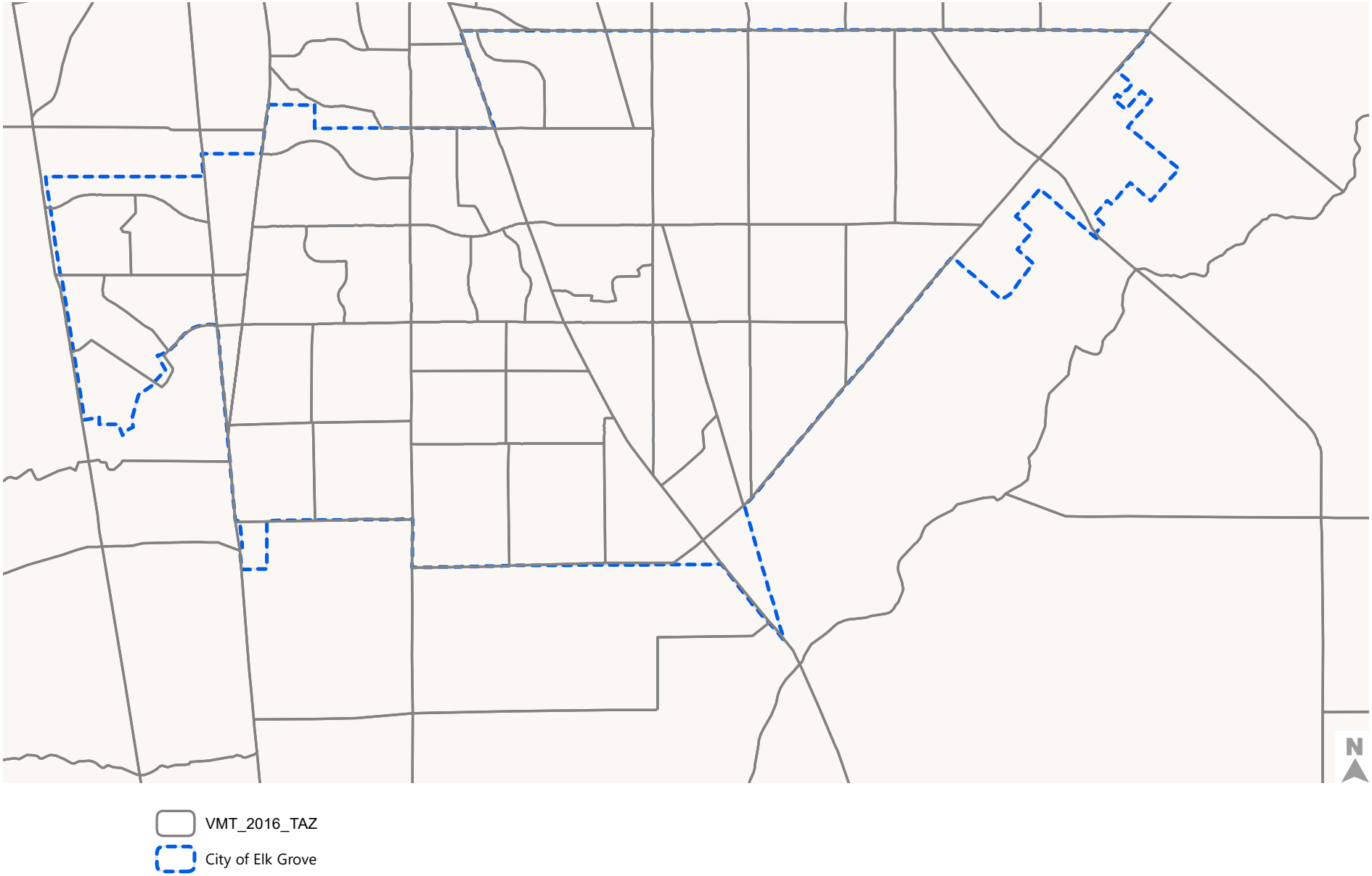


Figure 3

SACSIM19 TAZ Structure in Elk Grove

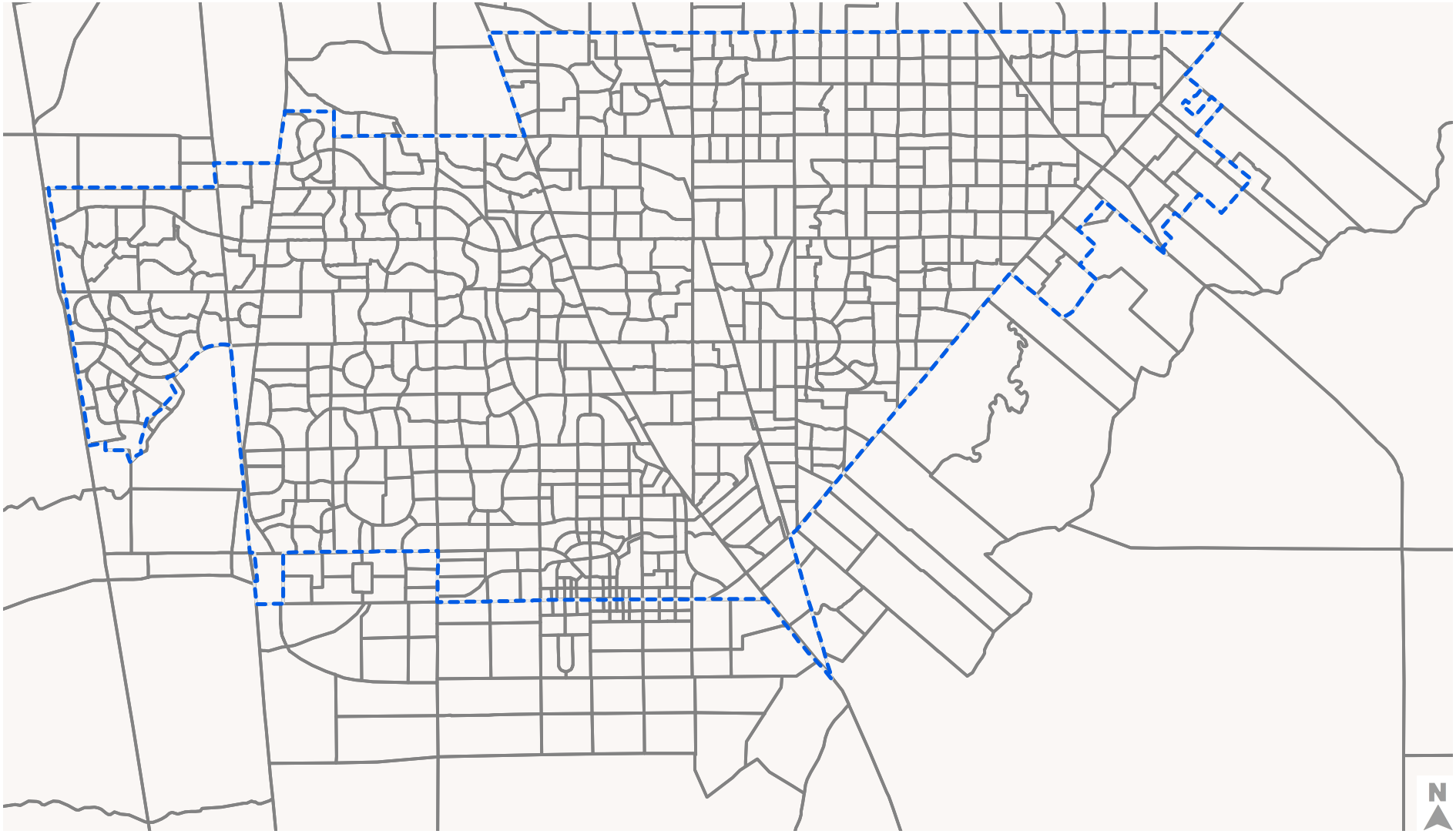


Figure 4

Updated TAZ - EGSIM20

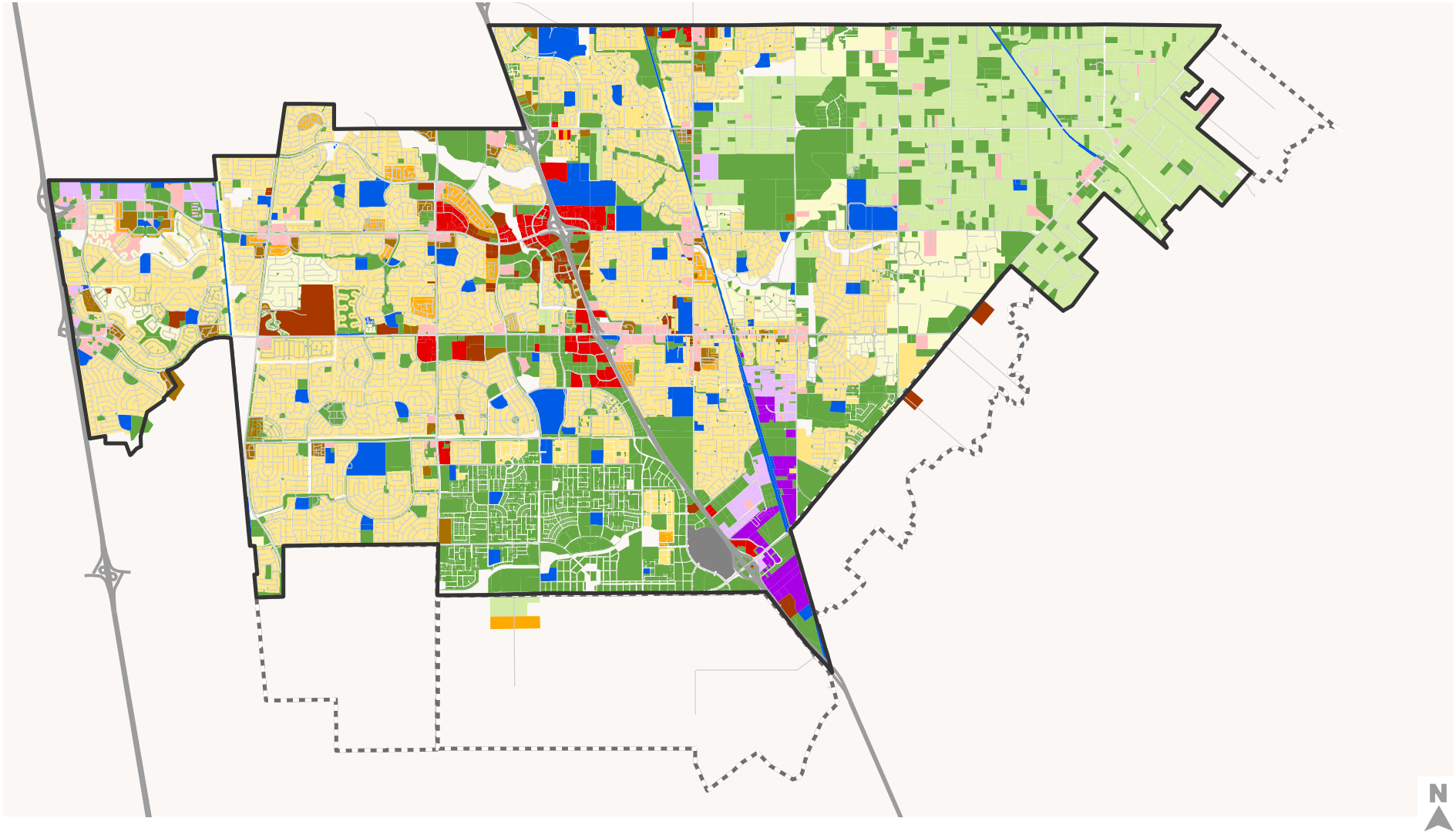
2.3 Land Use Development

The approach for developing pre-pandemic (2020) land uses within the City of Elk Grove was to collect a variety of available data, and then add this data to existing (2016) parcels. The following sources were used to estimate the residential dwelling units and occupied non-residential space within the City limits.

- SACSIM19 Data – SACSIM19 includes land use data by parcel for the year 2016. This was used as the base parcel land use information.
- Occupied Parcel Data – Occupied parcel data was provided by the City for the timeframe April 2018-June 2019. Projected occupied parcel data was also provided for the pre-pandemic base year timeframe. These were used to update the land use parcel data.
- Other Sources – Aerial imagery from Google Earth was reviewed and field investigations were performed to confirm built / occupied buildings in various parts of the City. Additionally, investigations were conducted to determine the proper designation for several developed land use parcels and were classified as a different land use designation (Example- more office employees vs more industrial employees).

Using these sources, we updated the number of dwelling units, number of employees, number of students, and the land use designations. SACSIM 19 uses nine different employment categories, which are different than the City's General Plan land use designations. Therefore, a land use crosswalk developed by SACOG (Attached in **Appendix A**) was used to generate model employee inputs based on the City's General Plan land designation. **Figure 5** shows the modified parcel by land use designations. The City of Elk Grove has 54,791 total dwelling units and 45,840 total jobs and an overall job-housing ratio of 0.83. This new validated new model has 2,074 more dwelling units and 10,287 more jobs compared to the SACSIM19 model.

Table 1 displays the base year (2020) land use totals within the current City of Elk Grove boundaries by General Plan land use designation.



City of Elk Grove

Study Areas

Base Year Land Use Designations

Commercial/Employment Land Use

- Community Commercial
- Regional Commercial
- Employment Center
- Light Industrial
- Heavy Industrial

Residential Land Use

- Rural Residential
- Estate Residential
- Low Density Residential
- Medium Density Residential
- High Density Residential

Other

- Public Services
- Tribal Trust Lands
- Parks and Open Space

Figure 5

Updated Base Year Parcel by Land Use Category – EGSIM20

Table 1: Base Year (2020) Land Use by Designation Type

Land Use Type		Land use Totals within City of Elk Grove Plus Study Area [1]		
		Households	Students	Employees
Residential	Estate Residential	2,557	0	0
	Rural Residential	1,226	0	0
	Low Density Residential	43,371	0	0
	Medium Density Residential	2,443	0	0
	High Density Residential	5,194	0	0
Commercial/ Employment	Community Commercial	0	0	11,641
	Employment Center	0	0	9,853
	Heavy Industrial	0	0	1,831
	Light Industrial	0	0	8,525
	Regional Commercial	0	0	9,633
Public Services		0	38,948	4,057
Tribal Trust Lands		0	0	300
Total		**54,791**	**38,948**	**45,840**

Notes:
[1] Land use totals include 15 households and 58 employees outside the current city boundary.
Source: Fehr & Peers 2023

3 Model Calibration

3.1 Network Modification

The following modifications were made to the model network (2016_base.net) to calibrate it to the existing conditions.

1. Added missing collectors and residential streets.
2. Added missing or newly constructed links. Examples include –
    a. Extended Bilby Road east of Bruceville Road to connect to Big Horn Boulevard
    b. Extended Big Horn Boulevard south of Whitelock Parkway to connect to Bilby Road
3. Updated number of lanes to match existing lanes. Examples include –
    a. Elk Grove Boulevard eastbound (EB) link updated from 2 to 3 lanes between SR 99 southbound (SB) ramps and SR 99 northbound (NB) on ramp.
    b. Emerald Vista Drive link updated from 2 to 4 lanes between Elk Grove Boulevard and E Stockton Boulevard
4. Reviewed interchange configurations.
5. Added NB-off ramp at SR 99/Sheldon Road Interchange
6. Updated interchange configuration to accurately model permitted turning movements at the following interchanges:
    a. SR 99 & Elk Grove Boulevard
    b. SR 99 & Sheldon Road
    c. SR 99 & Bond Road
7. Updated speed at locations when appropriate using the following sources:
    a. Posted speed limits from Google street view and field review.
    b. Wejo travel speed data that uses data from connected cars to create speed database over the course of the day for specific roadway segments.
8. Updated capacity class or roadway classification using the General Plan Circulation element diagram when appropriate.

3.2 TAZ Structure and Centroid Connections

As described in Section 2.2, TAZ structure was modified so that the vehicle loading onto the collector and arterial streets replicate land use access. The following model files were updated to incorporate the new TAZ structure.

- *2016_taz.dbf*
- *tazrad07.txt*
- *sacog_taz_indexes.dat*
- *2016_ixxi.dbf*

- *2016_station_links.csv*
- *worker_ixxifractions.dat*
- *2016_PNR.dbf*

Centroid connectors that connected directly to intersections were also moved to more appropriate locations.

3.3 Model File Updates

EGSIM20 requires detailed parcel, household, and population data inputs to run DAYSIM[2] at a parcel zone level. Preparing these files is not part of the model itself, but a necessary step to create and format the inputs needed to model a scenario. These three files are interdependent; they require specific relationship identification fields to link between data such as parcel point locations, household, and person characteristics.

3.3.1 Parcel File

As discussed earlier, as this is an activity-based model, the land use inputs are added at a parcel level. Using the sources discussed in Section 2.3, the following parcel level attributes (i.e., ptype16 and Res_Code) were updated in the parcel table:

1. Number of households
2. Number of students enrolled in schools (k-8, high school, and university)
3. Number of employees in non-residential parcels (education, food, retail, office, service, government, industrial, other, and total employees)

The output for this step is a database (*sacog_parcel_2016.dbf*) file with parcel level data used in the buffering step.

3.3.2 Buffering

The Buffering process calculates the relative attractiveness between land uses to ensure that the relationship between land uses is accurately accounted for in the model's activity/tour generation and mode choice. The buffering process is equivalent to the "D Variables" in a four-step model that accounts for the built environment. EGSIM20 uses a "circuity-based measure for each parcel" as an attractiveness input that is stored in the Parcel-Point DAYSIM file. The buffering process[3] is conducted after the update in Step 3.3.1 and includes the following steps:

[2] Refer to SACOG's User Guide and Model Documentation for SACSIM19 for more information regarding DaySIM https://www.sacog.org/sites/main/files/file-attachments/000_all_test_draft_sacsim19_model_documentation_full.pdf?1601588553

[3] Refer to SACOG's User Guide and Model Documentation for SACSIM19 for more information regarding Buffering process.

1. Prepare Inputs – Updated the following files in the Parcel-Point DAYSIM file.
    - Intersections (*sacog_intersections_2016.dbf*) - A list of intersections, with node ID, XY coordinates, and number of links terminating at the node.
    - Transit Stops (*sacog_transitstops_2016.dbf*) - A list of transit stops, with stop ID, XY coordinates, and the type of transit serving the stop.
    - Open Space (*sacog_openspace_2016.dbf*) - A list of parks, sports fields and other public recreational areas, with an ID and the size, in square feet
    - Circuity Factors (*sacog_parcel_2016_cir.dbf*) – A factor associated with each parcel. 24 radially distributed points (8 directions at 3 distinct distance bands 0.5-mile, 1 mile and 1.5 mile) represent the distances from a walkable streets network. For a parcel, a circuity factor or ratio is calculated based on the shortest path distance to destination parcels and straight-line distance for all 24 radial points to destination parcels.
2. Develop Control File (*sacogbuffering2016_cir_decay.ctl*) – Refers to the input and output file names and location for buffering run.
3. Execute Buffering – *DaySimParcelBufferingV3.exe* produces the buffering inputs.

The output for this step is a buffered parcel file (*2016_raw_parcel.txt*), which is the main land use input for the model.

3.3.3 Household and Population File

EGSIM20 requires a detailed household and population file with representation of key demographics, such as household size, income, ethnicity, and age of the population. PopGen[4], software developed by the Mobility Analytics Research Group alongside multiple universities and Metropolitan Planning Organizations (MPO), was used to generate a representative synthetic population with person and household-level attributes. The model's existing household and population files were calibrated for the new land use added to the model. The following steps highlight this process:

1. Developed Marginal Totals – Used a spreadsheet-based tool (Create Marginal Files.xlsx) to create marginal totals for new land use areas, using the Sacramento County demographics distribution by land use type. Marginal totals are population and household distribution targets for specific geographic areas such as Census Tracts. Four files are updated in this step-
    - *HH Marginal.csv*
    - *Pop Marginal.csv*
    - *GQ Marginal.csv*
    - *Corrospondence.csv*
1. Execute PopGen – Run Popgen software to create the synthetic household and population data.
2. Expand Data – Use ArcGIS to expand synthetic household and population data.
3. Update Control File – Prepare parcels with new land use for allocation.

[4] More information and PopGen software can be downloaded from the Mobility Analytics webpage https://www.mobilityanalytics.org/popgen.html

4. Allocate Land Use to Parcels – *Run parcelAllocationModel1.exe*
5. Update Household/Population File – Update the model household and population file (*2016_raw_household.txt* and *2016_raw_population.txt*) with new synthetic data.

3.3.4 Turn Penalties

Turn penalties are used to prohibit or add delay to certain turning movements. EGSIM20 prohibits traffic from making restricted turn movements. The *TurnProhibitions.csv* file specifies prohibited movements.

3.3.5 External Travel Update

Like SACSIM19, EGSIM20 uses an external sub module outside of DAYSIM to estimate Internal-External and External-Internal (I-X and X-I) travel to/from areas external the SACOG region. Highway network links used during the assignment are used to represent roadway connections outside the SACOG region. These roadway links are called "gateways." SR 99 and I-5 gateway weights were adjusted for SR 99 & I5 (south of Elk Grove), based on traffic flow data from Caltrans Performance Measurement System (PeMS).

4 Model Validation

This section discusses the results of the validation tests of the updated EGSIM20 base year (2020) travel demand model. The intent is for the model to be validated so that it accurately predicts conditions observed from the data collection.

Model validation is the term used to describe model performance in terms of how closely the model's output matches existing travel data in the base year. The extent that the model outputs match existing travel data validates the assumptions of the inputs.

Traditionally, most model validation guidelines have focused on the performance of the trip assignment function in accurately assigning trips to the roadway network. This metric is called static validation, and it remains the most common means of measuring model accuracy.

A more rigorous type of validation is Dynamic Validation which focuses on model's response to changing inputs.

4.1 Static Validation

The *2010 Regional Transportation Plan (RTP) Guidelines* specify that travel demand models to be used in the preparation of RTPs should undergo a series of diagnostic tests to determine their ability to accurately estimate traffic volumes and other travel parameters. Fehr & Peers interprets this guidance to also extend to travel demand models being developed for other purposes such as fee programs, CIPs, policy development, infrastructure studies, etc. In accordance with this guidance, the model's performance was evaluated using criteria described in the Caltrans *Travel Forecasting Guidelines*, 1992, *Travel Model Improvement Program (TMIP) Model Validation and Reasonableness Checking Manual*, 1997, and Fehr & Peers' internal standards. In particular, the following validation measures were evaluated:

- Volume-to-Count Ratio – Divides the model volume by the actual traffic count for individual roadways throughout the model.
- Percent of Links Within Caltrans Deviation Allowance – Calculated as the difference between the model and actual traffic count divided by the actual traffic count. The result is then evaluated against prescribed deviation thresholds.
- Correlation Coefficient – estimates the correlation (strength and direction of the linear relationship) between the actual traffic counts and the estimated volumes from the model.
- Percent Root Mean Square Error (% RMSE) – is the square root of the model volume minus the actual count squared divided by the number of counts. It is a measure like standard deviation in that it assesses the accuracy of the entire model.

The model validation tests are performed for Daily conditions for a typical weekday. Fehr & Peers identified **70** roadway segments within the City of Elk Grove and nine highway segments for use in the validation

tests. The segments within the city consist primarily of arterial roadways, which are situated at the City entry/exit points, across geographic boundaries (e.g., railroad or freeway overpasses), or on otherwise critical travel corridors throughout the City (e.g., overcrossings).

Appendix B displays the existing weekday Daily, AM peak hour and PM peak hour volume on each segment along with the predicted traffic volume from the base year traffic model. It also includes detailed validation tests and results. **Table 2** summarizes the results of the validation tests including the applicable validation targets. As shown, the EGSIM20 (2020) base year travel demand model passes all four validation tests that have measurable acceptance criteria. Validation was performed on 70 roadway segments in the City of Elk Grove and 18 directional freeway segments on SR 99 and I-5. As shown in **Table 2**, the model satisfies the validation tests specified in *Travel Forecasting Guidelines*, Caltrans, 1992.

Table 2: Base Year (2020) Travel Demand Model Validation Tests

Validation Test	Validation Targets	Validation Periods		
		Daily	AM	PM
Volume-to-Count Ratio	+/-10% [1]	0.99	1.01	0.94
Percent of Links Within Allowable Deviation	≥ 75%	88%	86%	89%
Percent Root Mean Squared Error (%RMSE)	≤ 40%	14%	26%	22%
Correlation Coefficient	≥ 0.88	0.97	0.94	0.95

Source: Travel Forecasting Guidelines, Caltrans, 1992.
2017 Regional Transportation Plan Guidelines for Regional Transportation Planning Agencies, Caltrans, 2017
Fehr & Peers, 2023
Notes: (1) The guidelines don't specify a criterion for acceptance for Volume-to-Count Ratio. +/-10% is a general travel demand modeling guideline.

4.2 Dynamic Validation

Static validation provides information on a model's ability to reproduce a static condition. Dynamic validation tests, recommended in the 2017 California Regional Transportation Plan Guidelines, evaluate a model's response to changing inputs. Dynamic Validation was not exclusively performed for EGSIM20 given the extensive dynamic validation that has been conducted for SACSIM19, the parent model. The dynamic validation or elasticity of SACSIM has been tested by SACOG and through project application of the model, meaning that the model performs as expected in the correct direction and magnitude based on dynamic validation with changes to network or land use input[5].

[5] Refer to SACOG's Sensitivity tests for SACSIM19 to learn more about model elasticity and validation https://www.sacog.org/sites/main/files/file-attachments/11_model_calibration_and_validation.pdf?1593568047

5 General Plan Buildout Model

The General Plan Buildout Model represents conditions beyond 2040. As discussed in Section 1, the future year EGSIM20 model will be used to analyze several planned developments including the Kammerer Urban Design Strategy. The Buildout model includes the following four study areas that are shown on **Figure 6** in relation to the City limits.:

1. East Study Area
2. North Study Area
3. South Study Area
4. West Study Area

5.1 Transportation Network

The transportation network for the buildout model is consistent with the general plan circulation element, the latest information available for the study areas, and the Kammerer Road Urban Design Strategy. Where roadway layouts were not available in the study areas, a general roadway network was developed that follows a generalized network grid like existing and planned facilities in the City limits, in terms of number of lanes, capacity, travel speed, and spacing. **Figure 7** shows the SACSIM19 cumulative network and **Figure 8** shows the new network for the EGSIM20 buildout model. Model input files - *pa40_base.net* and *pa40_tranline.txt* were modified as part of this step. The transit network for the model consists of local and regional buses and light rails. The transit network was mostly kept the same as the network assumed in the SACOG MTP/SCS except for the inclusion of the planned extension of Regional Transit Light Rail to Elk Grove. This extension of blue line extends beyond its current end point at Cosumnes River Boulevard and Bruceville Road to Kammerer Road and Lotz Parkway through the KUDS study area,

5.2 Traffic Analysis Zones (TAZ)

The TAZ structure for the buildout model is the same as base year model in the City limits, for consistency. The TAZ for new study areas were created using the most up-to-date land use and circulation plans available. The changes made for the base year model were carried over to the buildout network. The files listed in Section 3.2 were also updated for the buildout model.

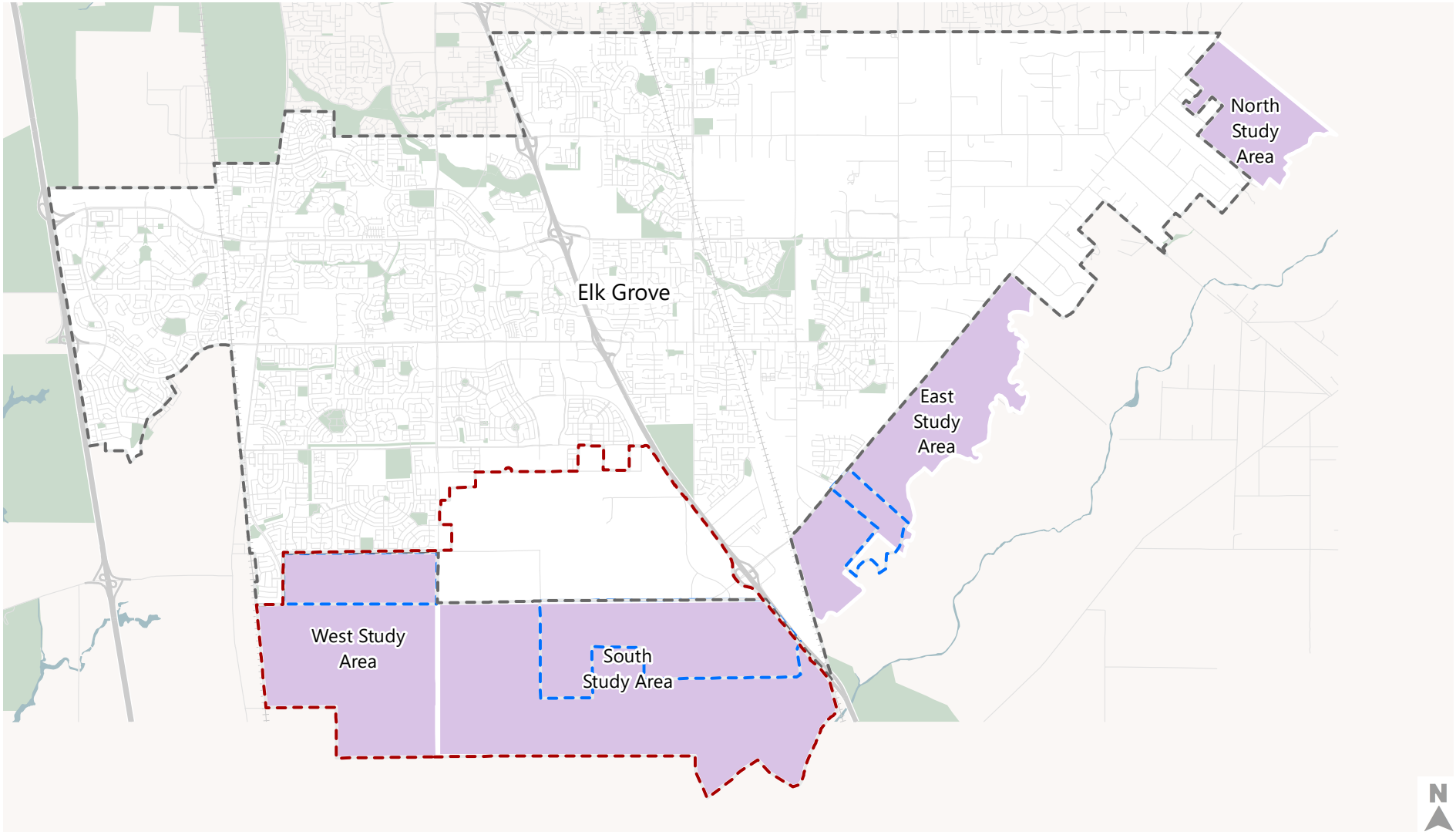


Figure 6

City Boundary and Study Areas
General Plan Buildout

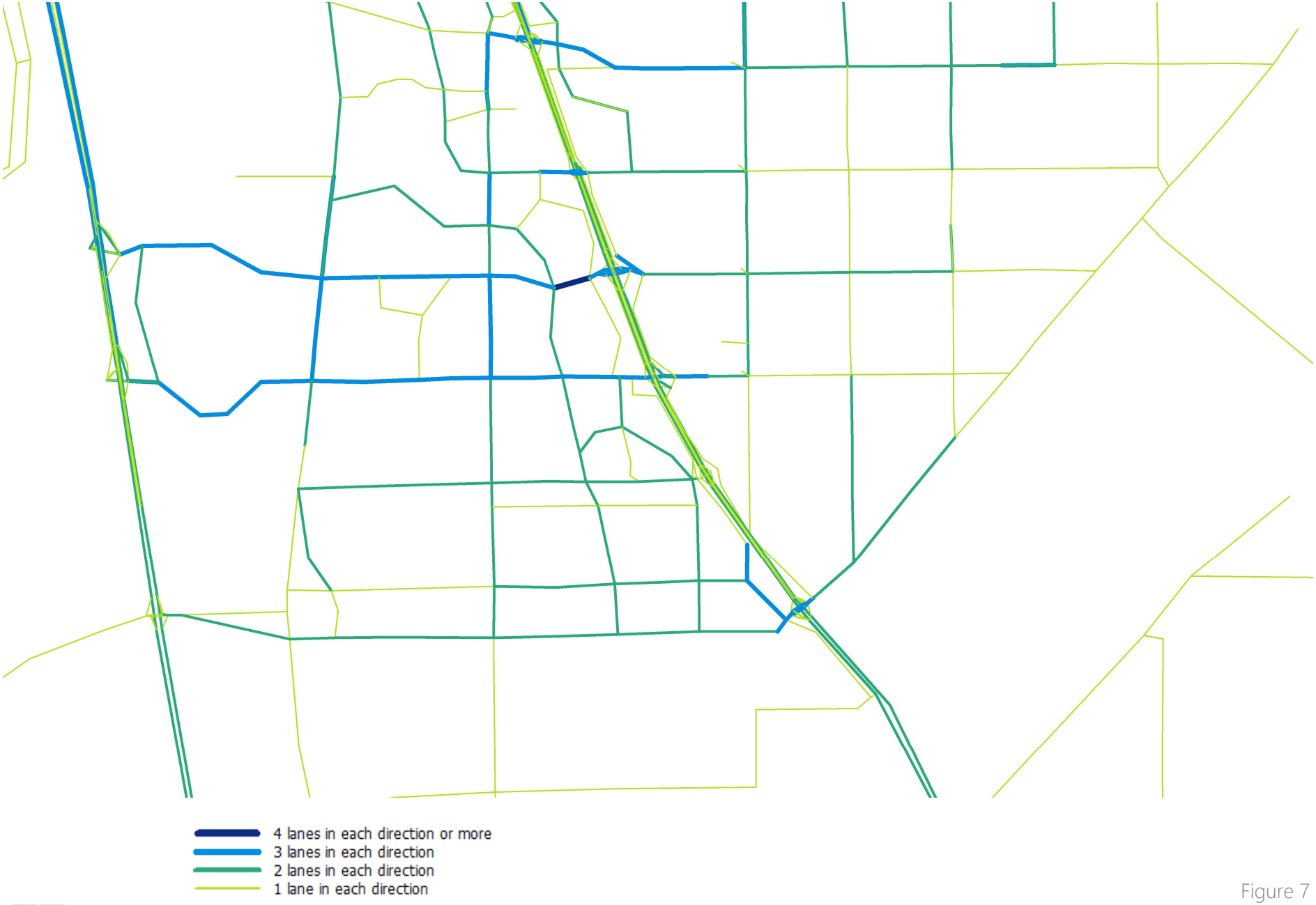


Figure 7

SACSIM19 - Cumulative Year Roadway Network

Figure 8

EGSIM20 - General Plan Buildout Roadway Network

5.3 Land Use Assumptions

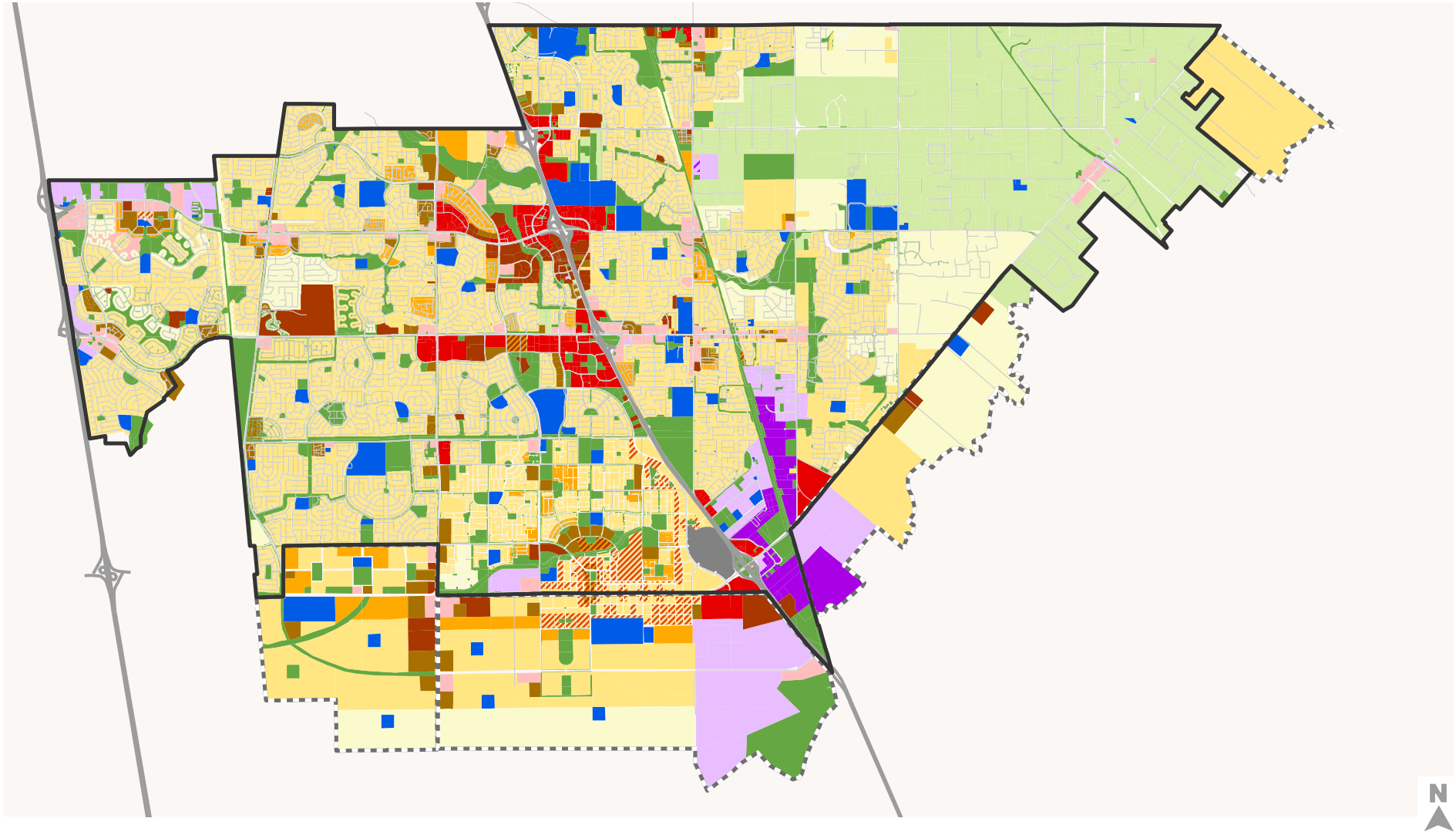
Land use for the buildout model was updated using the following sources:

- Elk Grove Fee Program Model – A modified version of the 2018 City of Elk Grove General Plan model developed for the update of the City of Elk Grove Fee Program. This model included an update to the base year model, representative of late 2019/early 2020 pre-pandemic conditions.
- Kammerer Urban Design Study (KUDS) Land Use – includes the land use assumptions for the Kammerer Urban Design Study.
- Study Area Land Use Updates – Updated land use for portions of the South, East, and West Study Areas.

Using the methodology discussed in Section 3.3, the following model files were updated:

- *Pa40_raw_parcel.txt*
- *Pa40_raw_household.txt*
- *Pa40_raw_population.txt*

Figure 9 shows the buildout parcels by land use type. **Table 3** shows the land use totals and growth by study area. **Table 4** displays the land use totals within the City for the primary trip-generating land use types under General Plan Buildout.



City of Elk Grove

Study Areas

General Plan Buildout Land Use Designations

Commercial/Employment Land Use

- Community Commercial
- Regional Commercial
- Employment Center
- Light Industrial
- Heavy Industrial

Residential Land Use

- Rural Residential
- Estate Residential
- Low Density Residential
- Medium Density Residential
- High Density Residential

Other

- Public Services
- Tribal Trust Lands
- Parks and Open Space

Figure 9

General Plan Buildout Parcel by Land Use Category – EGSIM20

Table 3: Buildout Model Land Use by Study Area

Plan Area	Base Year Model			Buildout Model			Growth		
	Households	Students	Employees	Households	Students	Employees	Households	Students	Employees
East Study Area	0	0	58	4,806	0	9,183	4,806	0	9,125
North Study Area	0	0	0	323	0	0	323	0	0
South Study Area	15	0	0	12,325	7,200	36,332	12,310	7,200	36,332
West Study Area	0	0	0	10,361	5,540	5,620	10,361	5,540	5,620
City Limit (Excluding East Study Area)	54,776	38,948	45,782	76,697	53,483	75,032	21,921	14,535	29,250
Total	**54,791**	**38,948**	**45,840**	**104,512**	**66,223**	**126,167**	**49,721**	**27,275**	**80,327**

Source: Fehr & Peers, 2023

Table 4: Buildout Year Land Use Designation

Land Use Type	Base Year Land Use			Buildout Land Use			Growth		
	Households	Students	Employees	Households	Students	Employees	Households	Students	Employees
Residential									
Estate Residential	2,557	-	-	10,686	-	739	8,129	-	739
Rural Residential	1,226	-	-	1,933	-	835	707	-	835
Low Density Residential	43,371	-	-	61,155	-	6,525	17,784	-	6,525
Medium Density Residential	2,443	-	-	7,689	-	206	5,246	-	206
High Density Residential	5,194	-	-	16,235	-	700	11,041	-	700
Commercial/ Employment									
Community Commercial	-	-	11,641	-	-	15,939	-	-	4,298
Employment Center	-	-	9,853	-	-	26,121	-	-	16,268
Heavy Industrial	-	-	1,831	-	-	4,650	-	-	2,819
Light Industrial	-	-	8,525	-	-	28,874	-	-	20,349
Light Industrial/Flex	-	-	-	-	-	188	-	-	188
Regional Commercial	-	-	9,633	-	-	16,218	-	-	6,585
Mixed Use									
Residential Mixed Use	-	-	-	382	-	143	382	-	143
Village Center Mixed Use	-	-	-	48	-	1,256	48	-	1,256
Transect-3	-	-	-	2,460	-	3,404	2,460	-	3,404
Transect-3R	-	-	-	1,881	-	1,302	1,881	-	1,302
Transect-4	-	-	-	1,059	-	3,422	1,059	-	3,422
Transect-5	-	-	-	759	-	7,327	759	-	7,327
Other									
Public Services	-	38,948	4,057	-	66,223	6,567	-	27,275	2,510
Tribal Trust Lands	-	-	300	-	-	1,750	-	-	1,450
Total	**54,791**	**38,948**	**45,840**	**104,287**	**66,223**	**126,167**	**49,496**	**27,275**	**80,327**

Source: Fehr & Peers, 2023

6 Vehicle Miles of Travel (VMT)

Vehicle miles traveled (VMT) is defined as miles driven by a vehicle (regardless of the number of occupants). SB 743, passed in 2013, required the California Governor's Office of Planning and Research (OPR) to develop new CEQA guidelines that address traffic metrics under CEQA. In December 2018, OPR published Technical Advisory on Evaluating Transportation Impacts in CEQA ("Technical Advisory"), which provided guidance for implementing SB 743. On December 28, 2018, the Resources Agency adopted CEQA Guidelines Section 15064.3. Under this guideline, VMT is the primary metric used to identify transportation impacts. On July 1, 2020, the provisions of Section 15064.3 became effective statewide.

6.1 Origin-Destination VMT

Origin-Destination VMT (total VMT) refers to VMT based on all trips that have one end in a specific location. This is calculated multiplying model origin- destination trip matrix with congested distance matrix for each location. This accounts for the entire trip length within SACOG region for II, IX and XI trips. Buildout year VMT for the city and the study areas are listed in table.

Table 5: VMT Limit by Study Area

City Limit and Study Areas	VMT Limit (Buildout)
City	8,039,802
North Study Area	27,132
East Study Area	574,028
South Study Area	1,769,671
West Study Area	751,049

Source:
Fehr & Peers, 2023

6.2 VMT Performance Metrics

The EGSIM20 Travel Demand Model is a tool for implementing the General Plan (i.e., like General Plan policy and actions). Consistent with CEQA Guidelines, § 15064.7, the City selected VMT per service population as the preferred performance metric, for implementing its VMT policy. Of the performance metrics considered, VMT per service population was the most intuitive to the decision makers and supported implementation of the General Plan by incentivizing development in the City's core and not in sensitive resource areas that the community values. A key emphasis of the General Plan was to plan and develop a better job-to-housing balance so residents can work where they live, and to support more mixed-use development to reduce the

need to travel by car for goods and services. The VMT per service population metric is useful since it captures these trip reduction benefits and accounts for travel from the full range of users and not just residents or just workers. In addition, unique to the City of Elk Grove is the use of VMT performance targets by General Plan land use category, which is an additional step to ensure consistency with the General Plan.

6.3 VMT Efficiency Components – Definitions

6.3.1 Trips

Trip is defined as a travel between two points using a certain mode of travel. In an activity-based model, individuals make multiple trips per day. The model tracks each trip, including their characteristics (e.g., trip length, purpose, time, location etc.). The model includes four major types of trips that are included in various VMT calculations:

- Trips by SACOG residents to destinations within the SACOG region. These are known as internal-internal, or II trips. These trips are modeled by the DAYSIM submodel.
- Trips by SACOG residents to destinations outside the SACOG region, known as internal-external, or IX trips. These trips are modeled by the IX-XI submodel.
- Trips by non-SACOG residents to destinations in the SACOG region, known as external-internal, or XI trips. These trips are modeled by the IX-XI submodel.
- Trips that do not stop within the SACOG region are known as external-external (XX) or through trips. These are generally not included in VMT efficiency calculations but are typically included in VMT estimates used for emissions analysis. They offer the full picture of VMT within a certain region.

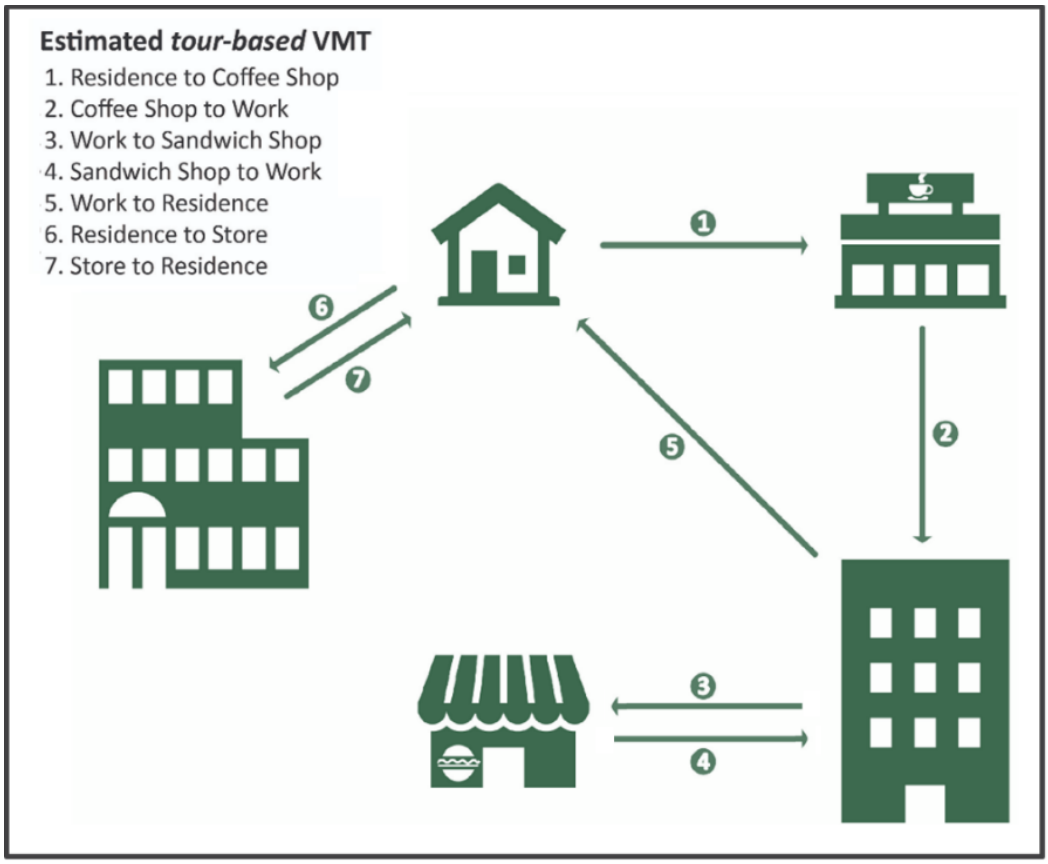
6.3.2 Tours

A tour is defined as a chain of trips that, typically occurring in sequence, which start and end at a specific location. By definition, tours in activity-based models refer to chain of trips that begin and end at a home location. Any trip-chaining that doesn't begin or end at home location are called subtours.

6.3.3 Travel Diary

As mentioned earlier, activity-based models create a travel diary for each individual in the model area. **Figure 10** shows a travel diary of a typical day for a household member within the SACOG region. Each leg of the arrow indicates an individual trip. This example includes 7 trips and 2 tours between home, coffee shop, work, and store location. Work location can be Office/Industrial/Retail/Public facilities etc. Trips 1-2-5 is a home-based tour. Trip 3-4 is a work-based subtour.

Figure 10: Example Travel Diary – EGSIM20



6.3.4 Full Accounting

Full Accounting of VMT accounts for vehicle travel that occurs outside of the model area. This is done in the EGSIM20 by using IX-XI trips and average trip distance outside SACOG region. The average trip length outside of the SACOG region was calculated using Replica (Spring 2019) mobility data.

6.3.5 Household Generated VMT

Household Generated VMT applies to all residential land uses. This includes All VMT from vehicle tours (both work/commute vehicle tours and non-work vehicle tours) that start and end at residential units. Tours ***1-2-5*** and ***6-7*** in **Figure 10** are examples of such tours. Trips made by a household resident that do not begin or end at home (e.g., midday travel from a worksite for lunch or personal business) are also included in the household generated VMT estimates. Subtour ***3-4*** from **Figure 10** is an example of non-home-based tour.

6.3.6 Employment Center Generated Work Tour VMT

Employment Center Generated Work Tour VMT applies to office/business professional and industrial employment land uses. This VMT includes all work/commute vehicle tours that start and end at the worksite (including intermediate stops). Tour ***1-2-5*** in **Figure 10** is an example of commute tour. Work-based subtours tours that start and end at employment locations are also included. Tour ***3-4*** in **Figure 10** is an example of work based sub-tour.

6.3.7 Retail/Public facilities Generated VMT

Retail/Public facilities Generated VMT applies to retail or public facilities projects. This VMT includes all work/commute vehicle tours that start and end at the retail/public facility site (including intermediate stops). Tour ***1-2-5*** in **Figure 10** is an example of commute tour. Work based subtours tours that start and end at employment location are also included. Tour ***3-4*** in **Figure 10** is an example of work based sub-tour. VMT associated with retail/public facility uses that are not commute tours are also included. Tour ***6-7*** in **Figure 10** is an example of "Other" tours. Other tours are only included for the following trip purposes only:

- Shopping
- Meal
- Personal Business/ Medical

6.3.8 VMT Efficiency by Land Use Category

VMT Efficiency by Land Use Category is the ratio of total VMT for each parcel containing a specific land use designation and total service population for that parcel. For example, sum all the VMT from parcels designated as "Low density household" within City of Elk Grove and divide it by the total service population within the City for the same parcels to get VMT per service population for the Low-Density Household category.

6.4 VMT Efficiency Metric Calculation Methodology

Internal-Internal (II) VMT for EGSIM20 is calculated by using the trip and tour diaries created through the activity generation portion of the model (DaySIM) and added to IX-XI VMT, calculated using additional processes outside of DaySIM. The main steps in calculating the VMT efficiency metrics are discussed below.

6.4.1 Run Scripts

When the EGSIM20 run completes, it produces the *_trips.tsv* file, which is a table of all internal-internal trips. However, because the trip distance in the original table is estimated based on the congested speed prior to the last global iteration, the user must run a Cube Voyage script[6], to estimate the distance based on the

[6] SACOG, VMT Computation Procedures – DRAFT, https://www.sacog.org/sites/main/files/file-attachments/draft_sacsim_vmt_calculation_procedures_0.pdf?1601488966

final iteration network congestion. The output of this supplementary Cube script is a CSV file, "_trip_1_1.csv," which has the same table as _trips.tsv but with the following attributes added to each trip:

- timeau – Updated travel time by auto
- distau – Updated trip distance by auto
- distcong – Congested distance

After running the first script, another Cube Voyager script[6] is run to compute VMT and other variables for both IX-XI and commercial trips. The following files are the output of the second script:

- *ixxi_taz.dbf* – This includes trips and VMT on Gateways for each TAZ.
- *cveh_taz.dbf* – This includes commercial vehicle trips for each TAZ

6.4.2 Internal-Internal VMT

Using the trips_1_1.csv file, each vehicle trip's VMT is calculated using the following formulas. Factors are applied to the trip distance based on trip MODE.

- If MODE = 3 (DA), $VMT = distau$
- If MODE = 4 (HOV2), $VMT = distau * 0.5$
- If MODE = 5 (HOVE3+), $VMT = distau * 0.3$

Where,

distau = updated trip distance by auto
DA = Drive Alone
HOV2 = High Occupancy Vehicle or Shared Drive 2
HOV3+ = High Occupancy Vehicle or Shared Drive 3 or more

6.4.3 IX-XI VMT by TAZ

SACOG methodology for calculating VMT outside the region[7] were followed for this process. The file Outside_sacog_vmt_estimation_steps_0_new_method.xlsx excel tool created by SACOG[8] was modified to incorporate new TAZ, land use, and external worker data. The output of this tool includes the following:

- Total IX-XI VMT by TAZ for external household generated VMT. This is completed by multiplying all external trips for each TAZ with the average estimated trip distance outside the region, which was estimated using Replica (Spring 2019) mobility data.

- Household generated IX-XI VMT or External Travel by residents for each TAZ is calculated using the following formula:

[7] SACOG, SACOG Outside the Region VMT Estimation, https://www.sacog.org/sites/main/files/file-attachments/draft_vmt_ixxi_documentation_0.pdf?1622243676
[8] https://www.sacog.org/sites/main/files/file-attachments/outside_sacog_vmt_estimation_steps_0_0.xlsx?1626798833

$$IXXI_{VMT_{RES}} = \left(IX_{VMT\_I} + XI_{VMT\_I}\right) * \left(\frac{HH}{(1 + HH + 1.1 * (EMPTOT - FOOD - RET - 0.25 * SVC))}\right.$$

Where:

$IXXI_{VMT\_RES}$ = internal-external VMT made by SACOG residents
IX_{VMT_I} = VMT originating at zone I
IX_{VMT_I} = VMT ending at zone I
HH = Households in zone I
EMPTOT = Jobs in zone I
FOOD = Jobs in Food sector in zone I
RET = Retail jobs in zone I
SVC = Service Jobs in zone I

- Work tour IX-XI VMT by TAZ for external employment/retail VMT. This is completed by multiplying the vehicle trips by external worker for each TAZ with the average estimated trip distance outside the region using Replica (Spring 2019) mobility data. Vehicle trips by external worker is calculated using the following formula:

$$Vehicle\ Trips\ by\ External\ Worker\ =\ External\ Worker\ *\ 1.7\ *\ (0.89 + 0.11/2.34)$$

Where:

1.7 – Person to Vehicle Trip Factor
0.89 – drive alone trip mode share
0.11 – shared ride trip mode share
2.34- shared ride vehicle occupancy factor

6.4.4 Household Generated VMT by parcel

- All household generated II VMT are summed for each parcel as described in Section 6.3.5
- All household generated IX-XI VMT or external travel by residents for each TAZ (as described in section 6.4.3) is divided by total population of each TAZ to calculate Household generated IX-XI VMT per person per TAZ.
- Household generated IX-XI VMT for each parcel is then calculated multiplying household size for the parcel and Household generated IX-XI VMT rate for the TAZ that the parcel belongs to.
- Finally, the II and IX-XI VMT for each parcel is summed to get total household generated VMT.

6.4.5 Employment Center Generated Work Tour

- VMT from II work tours as described in Section 6.3.6 are summed for each employment parcel.
- Work tour IX-XI or VMT by external workers (as described in Step 6.4.3) for each TAZ is divided by external employees for respective TAZ. This results in the rate of IX-XI VMT by external workers for each TAZ.

- Employment center generated IX-XI work VMT for each parcel is then calculated multiplying the number of employees and rate of IX-XI VMT by external workers for the respective TAZ that the parcel belongs to.
- Finally, the II and IX-XI VMT for each employment center parcel is summed to get total employment center generated VMT.

6.4.6 Retail/Public facilities Generated VMT

- VMT from II tours as described in Section 6.3.7 are summed for each retail or public facilities parcel.
- Work tour IX-XI or VMT by external workers (as described in Step 6.4.3) for each TAZ is divided by external employees for respective TAZ. This results in the rate of IX-XI VMT by external workers for each TAZ.
- Retail/public facilities generated IX-XI work VMT for each parcel is then calculated multiplying number of employees and rate of IX-XI VMT by external workers for respective TAZ that the parcel belongs to.
- Finally, the II and IX-XI VMT for each retail/public facility parcel is summed to get total retail/public facilities generated VMT.

Appendix C includes python scripts used for these metrics.

Table 6 compares the three major types of VMT metrics calculated using EGSIM20. **Appendix D** shows VMT methodology comparison between SACOG, Sacramento County, and City of Elk Grove.

Table 6: VMT Methodology Comparison by Project Type

VMT Analysis		Residential Projects	Office/ Industrial Projects	Retail/ Public Facilities Projects
Analysis Methodology		Household generated VMT per service population	Work Tour VMT per service population [1]	Retail/Public facilities Generated VMT per service population
HBW [2]	1-2-5	Y	Y	Y
HBO [3]	6-7	Y	N	Y [8]
NHB [4]	3-4	Y	Y	Y
IX-XI [5]	External travel by residents	Y	N	N
	Travel by external workers	N	Y	Y
XX [6]		N	N	N
Commercial Vehicle [7]		N	N	N

Notes
[1] Service Population = Residents + Employees + Students
[2] HBW = Home-based work tour, includes intermediate stops
[3] HBO = Home-based other tour (shopping, personal business, medical, school, recreational etc.), includes intermediate stops
[4] NHB = Non-Home-based tour (tour that begin and end at a non-home location i.e., subtours), includes intermediate stops
[5] IX-XI = Internal-External / External-Internal,
External work travel by residents who reside within SACOG but work outside the region.
Travel by workers that reside outside SACOG region but work within the region.
[6] XX = External-External Travel, Trips that don't have any stops within SACOG region
[7] Commercial Vehicle = Trips by commercial vehicles (small-large trucks)
[8] Only includes Customer/Visitor Tour (Tours at employment location by people who don't work there). The following trip purposes are included:
-- Personal Business/ Medical
-- Shop
-- Meal

6.4.7 VMT Per Service Population by Land Use types

All the VMT generated by the three types of projects are summed to get total VMT by each parcel. Then the total VMT is divided by service population to get VMT per service population or each parcel. The data is then summarized by land use type to get the VMT per service population by LU type. Error! Not a valid bookmark self-reference. shows the VMT limits by LU type.

Table 7: VMT Per Service Population by Land Use Designation

Land Use Designation	Base Year			Buildout Land Use			VMT Limit [1]	Percent Change (Buildout to VMT Limit)
	Service Pop	Total VMT	VMT per Service Pop	Service Pop	Total VMT	VMT per Service Pop		
Commercial and Employment Land Use Designations								
Community Commercial	10,373	325,768	31.4	15,939	463,466	29.4	26.7	10.1%
Regional Commercial	9,639	305,755	31.7	16,218	480,513	29.4	27.0	8.9%
Employment Center	8,590	204,220	23.8	27,321	530,222	19.3	20.2	-4.0%
Light Industrial/Flex[2]	-	-	-	188	3,442	24.2	-	-
Light Industrial	8,525	225,168	26.4	28,874	701,975	24.2	22.5	7.6%
Heavy Industrial	1,831	57,138	31.2	4,650	107,870	23.4	26.5	-11.7%
Mixed Use Land Use Designations[2]								
Village Center Mixed Use	-	-	-	1,381	25,750	19.3	19.3	-
Residential Mixed Use	-	-	-	1,144	22,572	19.4	19.4	-
Transect-3	-	-	-	10,648	225,191	21.4	21.4	-
Transect-3R	-	-	-	6,794	135,587	20.1	20.1	-
Transect-4	-	-	-	6,342	133,730	20.9	20.9	-
Transect-5	-	-	-	9,443	160,441	16.6	16.6	-
Public/Quasi Public and Open Space Land Use Designations								
Parks and Open Space	-	-	-	-	-	-	-	-
Resource Management and Conservations	-	-	-	-	-	-	-	-
Public Services	-	-	-	-	-	-	-	-
Residential Land Use Designations								
Rural Residential	4,995	147,890	29.6	6,992	174,752	24.9	25.2	-1.2%
Estate Residential	8,573	207,440	24.2	35,847	797,248	22.3	20.6	8.2%
Low Density Residential	142,284	3,230,237	22.7	200,337	4,045,908	20.2	19.3	4.7%
Medium Density Residential	7,208	151,469	21.0	22,633	443,033	19.7	17.9	10.0%
High Density Residential	15,168	316,033	20.8	46,180	860,116	18.6	17.7	5.3%
Other Land Use Designations								
Agriculture	-	-	-	-	-	-	-	-

Notes:

[1] VMT limit is – 85% of average base year VMT per service population for parcels with land use designation

[2] VMT limit is - average buildout VMT per service population for parcels with mixed land use designation

Appendix A

SACOG Employment Crosswalk

FEHR PEERS

Land use crosswalk developed by SACOG

Land Use Designation	Type	Max Units/Acre	Max Jobs/Acre	EMPEDU	EMPFOOD	EMPGOV	EMPIND	EMPMED	EMPOFC	EMPRET	EMPSER
Rural Residential	Residential	1	0								
Very Low Density Detached Residential		4	0								
Low Density Detached Residential		8	0								
Medium Density Residential		12	0								
Medium-High Density Residential		24	0								
High Density Attached Residential		42	0								
Very High Density Attached Residential		81	0								
Urban Attached Residential	Mixed Use	120	6	0.0%	17.5%	0.0%	0.0%	0.0%	53.2%	29.3%	0.0%
Mixed Use Center/Corridor		20	12	0.0%	20.0%	0.0%	0.0%	0.0%	33.0%	21.0%	26.0%
Sac CBD Mixed Use		103	603	0.0%	0.0%	55.5%	0.0%	0.0%	44.5%	0.0%	0.0%
Sac High Density Mixed Use		100	103	0.0%	10.0%	20.0%	0.0%	0.0%	60.0%	0.0%	10.0%
Residential/Retail Mixed Use High		57	41	0.0%	7.1%	0.0%	0.0%	0.0%	43.1%	23.7%	26.1%
Residential/Retail Mixed Use Low		25	74	0.0%	7.1%	0.0%	0.0%	0.0%	43.1%	23.7%	26.1%
Employment Focus Mixed Use Center/Corridor		9	92	0.0%	17.5%	0.0%	0.0%	0.0%	53.2%	29.3%	0.0%
K-12 School	Institution	0	18	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
College/University		0	95	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Heavy Industrial	Employment	0	14	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
Regional Retail		0	16	0.0%	32.1%	0.0%	0.0%	0.0%	0.0%	53.8%	14.1%
Civic/Institution		0	21	0.0%	0.0%	16.8%	0.0%	0.0%	0.0%	0.0%	83.2%
Public/Quasi-Public		0	21	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Community/Neighborhood Retail		0	22	0.0%	32.1%	0.0%	0.0%	0.0%	0.0%	53.8%	14.1%
Light Industrial		0	27	0.0%	3.6%	0.0%	60.0%	0.0%	22.1%	0.0%	14.3%
Community/Neighborhood Commercial		0	28	0.0%	14.9%	0.0%	0.0%	0.0%	45.3%	24.9%	14.9%
Community/Neighborhood Commercial/Office		0	37	0.0%	13.9%	0.0%	0.0%	0.0%	42.3%	23.3%	20.5%
Low-Intensity Office		0	39	0.0%	0.0%	0.0%	0.0%	0.0%	80.0%	0.0%	20.0%
Light Industrial/Office		0	46	0.0%	4.2%	0.0%	10.0%	0.0%	67.0%	0.0%	18.7%
Medical Office		0	123	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Medical Facility		0	178	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Moderate-Intensity Office		0	179	0.0%	0.9%	28.6%	0.0%	0.0%	60.2%	0.0%	10.3%

Appendix B

Static Validation – EGSIM 20

FEHR & PEERS

Elk Grove Fee Program Update **Elk Grove Base Year Model**

Daily **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
1	Laguna Boulevard	From Harbour Point Drive to Franklin Boulevard	31,660	32,228	0.98	2%	24%	Acceptable	-568	323,003
2	Laguna Boulevard	From Franklin Boulevard to Bruceville Road	33,230	34,048	0.98	2%	24%	Acceptable	-818	669,124
3	Laguna Boulevard	From Bruceville Road to Big Horn Boulevard	42,744	38,936	1.10	10%	22%	Acceptable	3,808	14,500,864
4	Laguna Boulevard	From Big Horn Boulevard to Laguna Springs Drive	64,849	53,155	1.22	22%	20%	High	11,694	136,749,636
5	Bond Road	From E. Stockton Boulevard to Emerald Crest Drive	45,857	35,751	1.28	28%	23%	High	10,106	102,131,236
6	Bond Road	From Elk Grove Florin Road to Waterman Road	31,614	25,454	1.24	24%	26%	Acceptable	6,160	37,941,493
7	Bond Road	From Waterman Road to Bradshaw Road	19,213	12,614	1.52	52%	33%	High	6,599	43,542,402
8	Bond Road	From Bradshaw Road to Grant Line Road	5,350	5,215	1.03	3%	48%	Acceptable	135	18,135
9	Elk Grove Boulevard	From Harbour Point Drive to Franklin Boulevard	30,338	33,498	0.91	9%	24%	Acceptable	-3,160	9,985,600
10	Elk Grove Boulevard	From Franklin Boulevard to Bruceville Road	27,356	35,168	0.78	22%	23%	Acceptable	-7,812	61,032,552
11	Elk Grove Boulevard	From Bruceville Road to Big Horn Boulevard	36,573	39,576	0.92	8%	22%	Acceptable	-3,003	9,020,011
12	Elk Grove Boulevard	From Laguna Springs Drive to SR 99	43,662	47,423	0.92	8%	21%	Acceptable	-3,761	14,142,614
13	Elk Grove Boulevard	From E. Stockton Boulevard to Elk Grove Florin Road	31,967	31,451	1.02	2%	24%	Acceptable	516	265,912
14	Elk Grove Boulevard	From Elk Grove Florin Road to Waterman Road	16,682	17,687	0.94	6%	29%	Acceptable	-1,005	1,009,355
15	Elk Grove Boulevard	From Bradshaw Road to Grant Line Road	2,986	3,385	0.88	12%	58%	Acceptable	-399	159,467
16	Bilby Road	From Willard Parkway to Bruceville Road	7,373	6,915	1.07	7%	44%	Acceptable	458	209,459
17	Kammerer Road	From Bruceville Road to Promenade Parkway	7,719	8,729	0.88	12%	41%	Acceptable	-1,010	1,019,427
18	Kammerer Road	From Promenade Parkway to SR 99	15,565	18,915	0.82	18%	28%	Acceptable	-3,350	11,222,500
19	Grant Line Road	From E. Stockton Boulevard to Waterman Road	28,375	28,692	0.99	1%	25%	Acceptable	-317	100,278
20	Sheldon Road	From Lewis Stein Road to SR 99	30,436	38,454	0.79	21%	22%	Acceptable	-8,018	64,293,669
21	Sheldon Road	From Elk Grove Florin Road to Waterman Road	8,331	14,786	0.56	44%	31%	Low	-6,455	41,662,722
22	Franklin Boulevard	From Big Horn Boulevard to Laguna Boulevard	28,109	24,893	1.13	13%	26%	Acceptable	3,216	10,340,512
23	Franklin Boulevard	From Laguna Boulevard to Elk Grove Boulevard	29,239	20,858	1.40	40%	28%	High	8,381	70,241,161
24	Franklin Boulevard	From Elk Grove Boulevard to Whitelock Parkway	22,189	22,114	1.00	0%	27%	Acceptable	75	5,575
25	Bruceville Road	From Big Horn Boulevard to Laguna Boulevard	29,517	31,345	0.94	6%	24%	Acceptable	-1,828	3,340,365
26	Bruceville Road	From Laguna Boulevard to Elk Grove Boulevard	23,662	27,065	0.87	13%	25%	Acceptable	-3,403	11,582,678
27	Bruceville Road	From Elk Grove Boulevard to Whitelock Parkway	25,708	26,639	0.97	3%	25%	Acceptable	-931	866,761
28	Bruceville Road	From Whitelock Parkway to Bilby Road	10,396	8,599	1.21	21%	41%	Acceptable	1,797	3,230,407
29	Big Horn Boulevard	From Lewis Stein Road to Laguna Boulevard	15,366	15,950	0.96	4%	30%	Acceptable	-584	340,667
30	Big Horn Boulevard	From Laguna Boulevard to Longleaf Drive	27,588	22,745	1.21	21%	27%	Acceptable	4,843	23,454,649
31	Big Horn Boulevard	From Elk Grove Boulevard to Civic Center Drive	13,273	16,278	0.82	18%	29%	Acceptable	-3,005	9,028,022
32	Big Horn Boulevard	From Lotz Parkway to Whitelock Parkway	8,049	11,316	0.71	29%	34%	Acceptable	-3,267	10,675,467
33	Power Inn Road	From Auburry Drive to Sheldon Road	9,311	9,348	1.00	0%	38%	Acceptable	-37	1,394
34	Elk Grove Florin Road	From Calvine Road to Sheldon Road	34,014	29,835	1.14	14%	24%	Acceptable	4,179	17,461,255
35	Elk Grove Florin Road	From Sheldon Road to Bond Road	29,274	24,553	1.19	19%	26%	Acceptable	4,721	22,287,841
36	Elk Grove Florin Road	From Bond Road to Elk Grove Boulevard	19,091	18,363	1.04	4%	29%	Acceptable	728	529,984
37	Elk Grove Florin Road	From Valley Oak Lane to E. Stockton Boulevard	7,018	6,203	1.13	13%	48%	Acceptable	815	664,768
38	Waterman Road	From Sheldon Road to Bond Road	11,662	12,996	0.90	10%	33%	Acceptable	-1,334	1,780,445
39	Waterman Road	From Bond Road to Elk Grove Boulevard	11,858	12,843	0.92	8%	33%	Acceptable	-985	969,568
40	Waterman Road	From Mosher Road to Grant Line Road	6,450	7,690	0.84	16%	41%	Acceptable	-1,240	1,538,427

Elk Grove Fee Program Update **Elk Grove Base Year Model**

Daily **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
41	Bradshaw Road	From Sheldon Road to Bond Road	21,326	16,466	1.30	30%	29%	High	4,860	23,619,600
42	Bradshaw Road	From Elk Grove Boulevard to Grant Line Road	11,094	8,417	1.32	32%	41%	Acceptable	2,677	7,166,329
43	Harbour Point Drive	From Laguna Boulevard to Babson Drive	11,617	13,347	0.87	13%	33%	Acceptable	-1,730	2,994,053
44	Willard Parkway	From Whitelock Parkway to Blossom Ridge Drive	6,335	8,139	0.78	22%	41%	Acceptable	-1,804	3,255,619
45	Willard Parkway	From Blossom Ridge Drive to Bilby Road	7,181	7,199	1.00	0%	44%	Acceptable	-18	312
46	Bilby Road	From Franklin Boulevard to Willard Parkway	7,373	7,336	1.01	1%	44%	Acceptable	37	1,394
47	Civic Center Drive	From Bruceville Road to Wymark Drive	3,948	5,431	0.73	27%	48%	Acceptable	-1,483	2,200,278
48	Civic Center Drive	From Wymark Drive to Big Horn Boulevard	3,694	6,218	0.59	41%	48%	Acceptable	-2,524	6,372,259
49	Civic Center Drive	From Big Horn Boulevard to Laguna Springs Drive	1,115	2,955	0.38	62%	58%	Low	-1,840	3,386,827
50	Lotz Parkway	From Big Horn Boulevard to Laguna Springs Drive	6,081	5,684	1.07	7%	48%	Acceptable	397	157,344
51	Lotz Parkway	From Laguna Springs Drive to Whitelock Parkway	4,334	4,491	0.96	4%	52%	Acceptable	-157	24,754
52	Whitelock Parkway	From Franklin Boulevard to Bruceville Road	14,247	14,970	0.95	5%	31%	Acceptable	-723	523,211
53	Whitelock Parkway	From Bruceville Road to Big Horn Boulevard	7,877	13,650	0.58	42%	33%	Low	-5,773	33,323,680
54	Whitelock Parkway	From Big Horn Boulevard to Lotz Parkway	4,290	6,138	0.70	30%	48%	Acceptable	-1,848	3,416,336
55	W. Stockton Bouelvard	From Lewis Stein Road to Michener Way	3,312	5,572	0.59	41%	48%	Acceptable	-2,260	5,107,600
56	W. Stockton Bouelvard	From Dunisch Road to Laguna Boulevard	3,178	5,587	0.57	43%	48%	Acceptable	-2,409	5,804,887
57	W. Stockton Bouelvard	From Whitelock Parkway to Kyler Road	9,513	8,447	1.13	13%	41%	Acceptable	1,066	1,135,645
58	Poppy Ridge Road	From Bruceville Road to Cosby Way	999	1,696	0.59	41%	63%	Acceptable	-697	486,274
59	Promenade Parkway	From Kyler Road to Kammerer Road	7,960	9,349	0.85	15%	38%	Acceptable	-1,389	1,930,247
60	Laguna Springs Boulevard	From Laguna Boulevard to Longleaf Drive	15,165	19,544	0.78	22%	28%	Acceptable	-4,379	19,175,641
61	Laguna Springs Boulevard	From Longleaf Drive to Elk Grove Boulevard	8,625	8,909	0.97	3%	38%	Acceptable	-284	80,656
62	Laguna Springs Boulevard	From Elk Grove Boulevard to Civic Center Drive	8,413	8,021	1.05	5%	41%	Acceptable	392	153,403
63	Auto Center Drive	From Elk Grove Boulevard to W. Stockton Bouelvard	15,501	13,900	1.12	12%	31%	Acceptable	1,601	2,563,201
64	Lewis Stein Road	From Sheldon Road to W. Stockton Bouelvard	17,110	15,045	1.14	14%	30%	Acceptable	2,065	4,264,225
65	E. Stockton Boulevard	From Marketplace 99 South to Bond Road	10,278	12,206	0.84	16%	34%	Acceptable	-1,928	3,718,469
66	E. Stockton Boulevard	From Bond Road to Banff Vista Drive	6,503	8,921	0.73	27%	38%	Acceptable	-2,418	5,846,724
67	E. Stockton Boulevard	From Elk Grove Boulevard to SR 99 NB Ramps	19,911	26,749	0.74	26%	25%	Low	-6,838	46,753,685
68	E. Stockton Boulevard	From Elk Grove Florin Road to Grant Line Road	9,447	7,748	1.22	22%	41%	Acceptable	1,699	2,886,601
69	Emarld Vist Drive	From E. Stockton Bouelvard to Elk Grove Boulevard	16,021	10,384	1.54	54%	36%	High	5,637	31,775,769
70	Mosher Road	From Waterman Road to Grant Line Road	1,824	1,674	1.09	9%	63%	Acceptable	150	22,600
101	SR99 NB	North of Sheldon Road	72,395	65,521	1.10	10%	17%	Acceptable	6,874	47,251,876
102	SR99 SB		76,782	75,184	1.02	2%	15%	Acceptable	1,598	2,553,604
103	SR99 NB	Between Sheldon Road and Bond Road	66,354	64,250	1.03	3%	18%	Acceptable	2,104	4,426,816
104	SR99 SB		74,015	72,106	1.03	3%	16%	Acceptable	1,909	3,644,281
105	SR99 NB	Between Bond Road and Elk Grove Boulevard	48,468	43,323	1.12	12%	21%	Acceptable	5,145	26,471,025
106	SR99 SB		51,372	57,675	0.89	11%	19%	Acceptable	-6,303	39,727,809
107	SR99 NB	Between Elk Grove Boulevard and Grant Line Road	40,942	42,617	0.96	4%	21%	Acceptable	-1,675	2,805,625
108	SR99 SB		39,937	41,808	0.96	4%	22%	Acceptable	-1,871	3,500,641
109	SR99 NB	South of Grant Line Road	38,547	36,475	1.06	6%	23%	Acceptable	2,072	4,293,184
110	SR99 SB		48,656	44,086	1.10	10%	21%	Acceptable	4,570	20,884,900

Elk Grove Fee Program Update **Elk Grove Base Year Model**

Daily **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
111	SR99 NB	South of Boessow Road (Closest to Gateway)	33,950	39,080	0.87	13%	22%	Acceptable	-5,130	26,316,900
112	SR99 SB		34,977	39,343	0.89	11%	22%	Acceptable	-4,366	19,061,956
113	I5 NB	Betweeen Consumnus River and Laguna Boulevard	47,643	53,436	0.89	11%	20%	Acceptable	-5,793	33,558,849
114	I5 SB		42,890	54,641	0.78	22%	20%	Low	-11,751	138,086,001
115	I5 NB	Between Laguna Boulevard and Elk Grove Boulevard	29,684	32,296	0.92	8%	24%	Acceptable	-2,612	6,822,544
116	I5 SB		29,939	32,093	0.93	7%	24%	Acceptable	-2,154	4,639,716
117	I5 NB	Between Elk Grove Boulevard and Hood Franklin Rd	32,352	34,240	0.94	6%	24%	Acceptable	-1,888	3,564,544
118	I5 SB		30,674	33,256	0.92	8%	24%	Acceptable	-2,582	6,666,724
		Total	**2,027,503**	**2,057,342**						

EXCLUDING FREEWAYS	
Model/Count Ratio	0.99
Percent Within Caltrans Maximum Deviation (>75%)	86%
Percent Root Mean Square Error (<40%)	22%
Correlation Coefficient (>0.88)	0.96
Notes: 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations	
Total Count	70
Links Within Deviation	60
Links Outside Deviation	10

INCLUDING FREEWAYS	
Model/Count Ratio	0.99
Percent Within Caltrans Maximum Deviation (>75%)	88%
Percent Root Mean Square Error (<40%)	14%
Correlation Coefficient (>0.88)	0.97
Notes: 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations	
Total Count	88
Links Within Deviation	77
Links Outside Deviation	11

Data Sources:

- For arterials and collector Streets, counts were averaged over three mid-weekdays for either of the following date ranges:
  1. August 2, 2019 – August 22, 2019
  2. August 27, 2019 – August 29, 2019
  3. September 10, 2019 – September 12, 2019
- For freeways, counts were collected from PeMS data source and averaged for the month of August - October, 2019. Only the data points with good quality (% obsereved> 95%) were selected.

Elk Grove Fee Program Update **Elk Grove Base Year Model**

AM Peak Hour **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
1	Laguna Boulevard	From Harbour Point Drive to Franklin Boulevard	2,713	1,869	1.45	45%	29%	High	844	712,395
2	Laguna Boulevard	From Franklin Boulevard to Bruceville Road	2,520	2,328	1.08	8%	27%	Acceptable	192	36,899
3	Laguna Boulevard	From Bruceville Road to Big Horn Boulevard	2,997	2,329	1.29	29%	27%	High	668	446,256
4	Laguna Boulevard	From Big Horn Boulevard to Laguna Springs Drive	4,233	2,880	1.47	47%	24%	High	1,353	1,829,823
5	Bond Road	From E. Stockton Boulevard to Emerald Crest Drive	3,199	2,359	1.36	36%	27%	High	840	705,372
6	Bond Road	From Elk Grove Florin Road to Waterman Road	2,389	2,091	1.14	14%	28%	Acceptable	298	89,081
7	Bond Road	From Waterman Road to Bradshaw Road	1,500	1,136	1.32	32%	34%	Acceptable	364	132,143
8	Bond Road	From Bradshaw Road to Grant Line Road	302	454	0.67	33%	52%	Acceptable	-152	23,105
9	Elk Grove Boulevard	From Harbour Point Drive to Franklin Boulevard	2,555	2,558	1.00	0%	26%	Acceptable	-3	8
10	Elk Grove Boulevard	From Franklin Boulevard to Bruceville Road	2,103	2,658	0.79	21%	25%	Acceptable	-555	308,368
11	Elk Grove Boulevard	From Bruceville Road to Big Horn Boulevard	2,497	2,695	0.93	7%	25%	Acceptable	-198	39,107
12	Elk Grove Boulevard	From Laguna Springs Drive to SR 99	3,060	2,822	1.08	8%	25%	Acceptable	238	56,551
13	Elk Grove Boulevard	From E. Stockton Boulevard to Elk Grove Florin Road	2,337	2,048	1.14	14%	28%	Acceptable	289	83,697
14	Elk Grove Boulevard	From Elk Grove Florin Road to Waterman Road	1,273	1,282	0.99	1%	33%	Acceptable	-9	84
15	Elk Grove Boulevard	From Bradshaw Road to Grant Line Road	219	255	0.86	14%	58%	Acceptable	-36	1,264
16	Bilby Road	From Willard Parkway to Bruceville Road	596	598	1.00	0%	48%	Acceptable	-2	4
17	Kammerer Road	From Bruceville Road to Promenade Parkway	653	792	0.82	18%	41%	Acceptable	-139	19,217
18	Kammerer Road	From Promenade Parkway to SR 99	1,257	1,520	0.83	17%	30%	Acceptable	-263	69,015
19	Grant Line Road	From E. Stockton Boulevard to Waterman Road	2,027	2,385	0.85	15%	26%	Acceptable	-358	128,405
20	Sheldon Road	From Lewis Stein Road to SR 99	2,582	2,615	0.99	1%	26%	Acceptable	-33	1,058
21	Sheldon Road	From Elk Grove Florin Road to Waterman Road	933	1,452	0.64	36%	31%	Low	-519	269,108
22	Franklin Boulevard	From Big Horn Boulevard to Laguna Boulevard	2,287	1,749	1.31	31%	29%	High	538	289,916
23	Franklin Boulevard	From Laguna Boulevard to Elk Grove Boulevard	2,301	1,510	1.52	52%	30%	High	791	625,844
24	Franklin Boulevard	From Elk Grove Boulevard to Whitelock Parkway	1,876	1,772	1.06	6%	29%	Acceptable	104	10,768
25	Bruceville Road	From Big Horn Boulevard to Laguna Boulevard	2,525	2,132	1.18	18%	27%	Acceptable	393	154,475
26	Bruceville Road	From Laguna Boulevard to Elk Grove Boulevard	1,916	1,784	1.07	7%	29%	Acceptable	132	17,313
27	Bruceville Road	From Elk Grove Boulevard to Whitelock Parkway	1,781	1,720	1.04	4%	29%	Acceptable	61	3,661
28	Bruceville Road	From Whitelock Parkway to Bilby Road	711	636	1.12	12%	44%	Acceptable	75	5,664
29	Big Horn Boulevard	From Lewis Stein Road to Laguna Boulevard	1,309	1,209	1.08	8%	34%	Acceptable	100	9,957
30	Big Horn Boulevard	From Laguna Boulevard to Longleaf Drive	1,873	1,881	1.00	0%	28%	Acceptable	-8	71
31	Big Horn Boulevard	From Elk Grove Boulevard to Civic Center Drive	1,104	1,466	0.75	25%	31%	Acceptable	-362	131,209
32	Big Horn Boulevard	From Lotz Parkway to Whitelock Parkway	670	948	0.71	29%	38%	Acceptable	-278	77,077
33	Power Inn Road	From Auburry Drive to Sheldon Road	1,027	1,106	0.93	7%	36%	Acceptable	-79	6,287
34	Elk Grove Florin Road	From Calvine Road to Sheldon Road	2,653	2,447	1.08	8%	26%	Acceptable	206	42,571
35	Elk Grove Florin Road	From Sheldon Road to Bond Road	2,302	2,059	1.12	12%	28%	Acceptable	243	59,104
36	Elk Grove Florin Road	From Bond Road to Elk Grove Boulevard	1,574	1,554	1.01	1%	30%	Acceptable	20	385
37	Elk Grove Florin Road	From Valley Oak Lane to E. Stockton Boulevard	555	748	0.74	26%	44%	Acceptable	-193	37,225
38	Waterman Road	From Sheldon Road to Bond Road	1,107	1,336	0.83	17%	33%	Acceptable	-229	52,585
39	Waterman Road	From Bond Road to Elk Grove Boulevard	929	1,135	0.82	18%	34%	Acceptable	-206	42,240

Elk Grove Fee Program Update **Elk Grove Base Year Model**

AM Peak Hour **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
40	Waterman Road	From Mosher Road to Grant Line Road	577	619	0.93	7%	48%	Acceptable	-42	1,767
41	Bradshaw Road	From Sheldon Road to Bond Road	1,359	1,593	0.85	15%	30%	Acceptable	-234	54,762
42	Bradshaw Road	From Elk Grove Boulevard to Grant Line Road	644	805	0.80	20%	41%	Acceptable	-161	25,976
43	Harbour Point Drive	From Laguna Boulevard to Babson Drive	954	894	1.07	7%	38%	Acceptable	60	3,572
44	Willard Parkway	From Whitelock Parkway to Blossom Ridge Drive	533	734	0.73	27%	44%	Acceptable	-201	40,502
45	Willard Parkway	From Blossom Ridge Drive to Bilby Road	588	698	0.84	16%	44%	Acceptable	-110	12,094
46	Bilby Road	From Franklin Boulevard to Willard Parkway	596	862	0.69	31%	41%	Acceptable	-266	70,790
47	Civic Center Drive	From Bruceville Road to Wymark Drive	353	386	0.91	9%	52%	Acceptable	-33	1,121
48	Civic Center Drive	From Wymark Drive to Big Horn Boulevard	316	497	0.64	36%	52%	Acceptable	-181	32,799
49	Civic Center Drive	From Big Horn Boulevard to Laguna Springs Drive	73	258	0.28	72%	58%	Low	-185	34,241
50	Lotz Parkway	From Big Horn Boulevard to Laguna Springs Drive	487	742	0.66	34%	44%	Acceptable	-255	64,891
51	Lotz Parkway	From Laguna Springs Drive to Whitelock Parkway	350	465	0.75	25%	52%	Acceptable	-115	13,184
52	Whitelock Parkway	From Franklin Boulevard to Bruceville Road	1,244	1,186	1.05	5%	34%	Acceptable	58	3,363
53	Whitelock Parkway	From Bruceville Road to Big Horn Boulevard	692	1,111	0.62	38%	36%	Low	-419	175,420
54	Whitelock Parkway	From Big Horn Boulevard to Lotz Parkway	300	551	0.54	46%	48%	Acceptable	-251	62,952
55	W. Stockton Bouelvard	From Lewis Stein Road to Michener Way	303	397	0.76	24%	52%	Acceptable	-94	8,789
56	W. Stockton Bouelvard	From Dunisch Road to Laguna Boulevard	268	350	0.77	23%	58%	Acceptable	-82	6,743
57	W. Stockton Bouelvard	From Whitelock Parkway to Kyler Road	728	755	0.96	4%	41%	Acceptable	-27	716
58	Poppy Ridge Road	From Bruceville Road to Cosby Way	50	91	0.55	45%	68%	Acceptable	-41	1,647
59	Promenade Parkway	From Kyler Road to Kammerer Road	616	805	0.77	23%	41%	Acceptable	-189	35,751
60	Laguna Springs Boulevard	From Laguna Boulevard to Longleaf Drive	1,170	1,304	0.90	10%	33%	Acceptable	-134	17,857
61	Laguna Springs Boulevard	From Longleaf Drive to Elk Grove Boulevard	635	629	1.01	1%	44%	Acceptable	6	33
62	Laguna Springs Boulevard	From Elk Grove Boulevard to Civic Center Drive	758	654	1.16	16%	44%	Acceptable	104	10,776
63	Auto Center Drive	From Elk Grove Boulevard to W. Stockton Bouelvard	1,055	981	1.08	8%	38%	Acceptable	74	5,417
64	Lewis Stein Road	From Sheldon Road to W. Stockton Bouelvard	1,575	1,101	1.43	43%	36%	High	474	224,561
65	E. Stockton Boulevard	From Marketplace 99 South to Bond Road	829	836	0.99	1%	41%	Acceptable	-7	52
66	E. Stockton Boulevard	From Bond Road to Banff Vista Drive	537	785	0.68	32%	41%	Acceptable	-248	61,650
67	E. Stockton Boulevard	From Elk Grove Boulevard to SR 99 NB Ramps	1,333	1,754	0.76	24%	29%	Acceptable	-421	177,207
68	E. Stockton Boulevard	From Elk Grove Florin Road to Grant Line Road	690	674	1.02	2%	44%	Acceptable	16	249
69	Emarld Vist Drive	From E. Stockton Bouelvard to Elk Grove Boulevard	1,174	992	1.18	18%	38%	Acceptable	182	33,116
70	Mosher Road	From Waterman Road to Grant Line Road	146	201	0.73	27%	63%	Acceptable	-55	3,014
		Total	91,377	90,028						

Model/Count Ratio	1.01
Percent Within Caltrans Maximum Deviation (>75%)	86%
Percent Root Mean Square Error (<40%)	26%
Correlation Coefficient (>0.88)	0.94

Notes: 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations

Total Count	70
Links Within Deviation	60

Elk Grove Fee Program Update **Elk Grove Base Year Model**

AM Peak Hour **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
Links Outside Deviation					10					

Data Sources:

- For arterials and collector Streets counts were averaged over three mid-weekdays for either of the following date ranges:
  1. August 2, 2019 – August 22, 2019
  2. August 27, 2019 – August 29, 2019
  3. September 10, 2019 – September 12, 2019
- For freeways, counts were collected from PeMS data source and averaged for the month of August - October, 2019. Only the data points with detector health > 95% were selected.

Elk Grove Fee Program Update **Elk Grove Base Year Model**

PM Peak Hour **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
1	Laguna Boulevard	From Harbour Point Drive to Franklin Boulevard	1,939	2,571	0.75	25%	26%	Acceptable	-632	399,210
2	Laguna Boulevard	From Franklin Boulevard to Bruceville Road	2,658	2,713	0.98	2%	25%	Acceptable	-55	3,018
3	Laguna Boulevard	From Bruceville Road to Big Horn Boulevard	3,252	2,962	1.10	10%	24%	Acceptable	290	84,344
4	Laguna Boulevard	From Big Horn Boulevard to Laguna Springs Drive	4,799	3,647	1.32	32%	23%	High	1,152	1,326,041
5	Bond Road	From E. Stockton Boulevard to Emerald Crest Drive	3,297	2,705	1.22	22%	25%	Acceptable	592	350,613
6	Bond Road	From Elk Grove Florin Road to Waterman Road	2,358	2,072	1.14	14%	28%	Acceptable	286	82,057
7	Bond Road	From Waterman Road to Bradshaw Road	1,448	1,220	1.19	19%	34%	Acceptable	228	52,121
8	Bond Road	From Bradshaw Road to Grant Line Road	328	486	0.68	32%	52%	Acceptable	-158	24,845
9	Elk Grove Boulevard	From Harbour Point Drive to Franklin Boulevard	2,672	2,878	0.93	7%	24%	Acceptable	-206	42,278
10	Elk Grove Boulevard	From Franklin Boulevard to Bruceville Road	2,276	3,024	0.75	25%	24%	Low	-748	559,159
11	Elk Grove Boulevard	From Bruceville Road to Big Horn Boulevard	2,779	3,023	0.92	8%	24%	Acceptable	-244	59,681
12	Elk Grove Boulevard	From Laguna Springs Drive to SR 99	3,619	3,444	1.05	5%	24%	Acceptable	175	30,714
13	Elk Grove Boulevard	From E. Stockton Boulevard to Elk Grove Florin Road	2,467	2,422	1.02	2%	26%	Acceptable	45	2,012
14	Elk Grove Boulevard	From Elk Grove Florin Road to Waterman Road	1,331	1,390	0.96	4%	31%	Acceptable	-59	3,482
15	Elk Grove Boulevard	From Bradshaw Road to Grant Line Road	247	298	0.83	17%	58%	Acceptable	-51	2,632
16	Bilby Road	From Willard Parkway to Bruceville Road	625	633	0.99	1%	44%	Acceptable	-8	60
17	Kammerer Road	From Bruceville Road to Promenade Parkway	657	845	0.78	22%	41%	Acceptable	-188	35,270
18	Kammerer Road	From Promenade Parkway to SR 99	1,347	1,716	0.79	21%	29%	Acceptable	-369	136,083
19	Grant Line Road	From E. Stockton Boulevard to Waterman Road	2,267	2,436	0.93	7%	26%	Acceptable	-169	28,507
20	Sheldon Road	From Lewis Stein Road to SR 99	2,370	3,097	0.77	23%	24%	Acceptable	-727	528,774
21	Sheldon Road	From Elk Grove Florin Road to Waterman Road	843	1,397	0.60	40%	31%	Low	-554	306,698
22	Franklin Boulevard	From Big Horn Boulevard to Laguna Boulevard	2,266	1,987	1.14	14%	28%	Acceptable	279	77,647
23	Franklin Boulevard	From Laguna Boulevard to Elk Grove Boulevard	2,378	1,780	1.34	34%	29%	High	598	357,809
24	Franklin Boulevard	From Elk Grove Boulevard to Whitelock Parkway	1,777	1,951	0.91	9%	28%	Acceptable	-174	30,420
25	Bruceville Road	From Big Horn Boulevard to Laguna Boulevard	2,597	2,540	1.02	2%	26%	Acceptable	57	3,196
26	Bruceville Road	From Laguna Boulevard to Elk Grove Boulevard	1,960	2,259	0.87	13%	27%	Acceptable	-299	89,394
27	Bruceville Road	From Elk Grove Boulevard to Whitelock Parkway	1,817	2,163	0.84	16%	27%	Acceptable	-346	119,816
28	Bruceville Road	From Whitelock Parkway to Bilby Road	858	718	1.20	20%	44%	Acceptable	140	19,647
29	Big Horn Boulevard	From Lewis Stein Road to Laguna Boulevard	1,232	1,419	0.87	13%	31%	Acceptable	-187	34,795
30	Big Horn Boulevard	From Laguna Boulevard to Longleaf Drive	1,944	2,051	0.95	5%	28%	Acceptable	-107	11,545
31	Big Horn Boulevard	From Elk Grove Boulevard to Civic Center Drive	1,048	1,445	0.73	27%	31%	Acceptable	-397	157,715
32	Big Horn Boulevard	From Lotz Parkway to Whitelock Parkway	641	1,118	0.57	43%	36%	Low	-477	227,367
33	Power Inn Road	From Auburry Drive to Sheldon Road	918	888	1.03	3%	38%	Acceptable	30	870
34	Elk Grove Florin Road	From Calvine Road to Sheldon Road	2,579	2,410	1.07	7%	26%	Acceptable	169	28,706
35	Elk Grove Florin Road	From Sheldon Road to Bond Road	2,244	1,924	1.17	17%	28%	Acceptable	320	102,438
36	Elk Grove Florin Road	From Bond Road to Elk Grove Boulevard	1,562	1,545	1.01	1%	30%	Acceptable	17	279
37	Elk Grove Florin Road	From Valley Oak Lane to E. Stockton Boulevard	594	591	1.01	1%	48%	Acceptable	3	10
38	Waterman Road	From Sheldon Road to Bond Road	1,051	1,193	0.88	12%	34%	Acceptable	-142	20,202
39	Waterman Road	From Bond Road to Elk Grove Boulevard	952	1,071	0.89	11%	36%	Acceptable	-119	14,170

Elk Grove Fee Program Update **Elk Grove Base Year Model**

PM Peak Hour **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
40	Waterman Road	From Mosher Road to Grant Line Road	636	685	0.93	7%	44%	Acceptable	-49	2,354
41	Bradshaw Road	From Sheldon Road to Bond Road	1,418	1,683	0.84	16%	29%	Acceptable	-265	70,211
42	Bradshaw Road	From Elk Grove Boulevard to Grant Line Road	756	771	0.98	2%	41%	Acceptable	-15	219
43	Harbour Point Drive	From Laguna Boulevard to Babson Drive	1,002	1,126	0.89	11%	34%	Acceptable	-124	15,360
44	Willard Parkway	From Whitelock Parkway to Blossom Ridge Drive	521	687	0.76	24%	44%	Acceptable	-166	27,437
45	Willard Parkway	From Blossom Ridge Drive to Bilby Road	603	611	0.99	1%	48%	Acceptable	-8	69
46	Bilby Road	From Franklin Boulevard to Willard Parkway	625	609	1.03	3%	48%	Acceptable	16	265
47	Civic Center Drive	From Bruceville Road to Wymark Drive	425	524	0.81	19%	48%	Acceptable	-99	9,896
48	Civic Center Drive	From Wymark Drive to Big Horn Boulevard	345	624	0.55	45%	48%	Acceptable	-279	78,042
49	Civic Center Drive	From Big Horn Boulevard to Laguna Springs Drive	85	337	0.25	75%	58%	Low	-252	63,513
50	Lotz Parkway	From Big Horn Boulevard to Laguna Springs Drive	632	696	0.91	9%	44%	Acceptable	-64	4,120
51	Lotz Parkway	From Laguna Springs Drive to Whitelock Parkway	363	491	0.74	26%	52%	Acceptable	-128	16,429
52	Whitelock Parkway	From Franklin Boulevard to Bruceville Road	1,143	1,421	0.80	20%	31%	Acceptable	-278	77,025
53	Whitelock Parkway	From Bruceville Road to Big Horn Boulevard	722	1,323	0.55	45%	33%	Low	-601	360,808
54	Whitelock Parkway	From Big Horn Boulevard to Lotz Parkway	375	561	0.67	33%	48%	Acceptable	-186	34,416
55	W. Stockton Bouelvard	From Lewis Stein Road to Michener Way	347	468	0.74	26%	52%	Acceptable	-121	14,754
56	W. Stockton Bouelvard	From Dunisch Road to Laguna Boulevard	331	466	0.71	29%	52%	Acceptable	-135	18,290
57	W. Stockton Bouelvard	From Whitelock Parkway to Kyler Road	845	765	1.10	10%	41%	Acceptable	80	6,397
58	Poppy Ridge Road	From Bruceville Road to Cosby Way	86	117	0.73	27%	68%	Acceptable	-31	971
59	Promenade Parkway	From Kyler Road to Kammerer Road	704	854	0.82	18%	41%	Acceptable	-150	22,642
60	Laguna Springs Boulevard	From Laguna Boulevard to Longleaf Drive	1,125	1,791	0.63	37%	29%	Low	-666	443,647
61	Laguna Springs Boulevard	From Longleaf Drive to Elk Grove Boulevard	661	812	0.81	19%	41%	Acceptable	-151	22,661
62	Laguna Springs Boulevard	From Elk Grove Boulevard to Civic Center Drive	750	759	0.99	1%	41%	Acceptable	-9	87
63	Auto Center Drive	From Elk Grove Boulevard to W. Stockton Bouelvard	1,211	1,175	1.03	3%	34%	Acceptable	36	1,297
64	Lewis Stein Road	From Sheldon Road to W. Stockton Bouelvard	1,409	1,276	1.10	10%	33%	Acceptable	133	17,820
65	E. Stockton Boulevard	From Marketplace 99 South to Bond Road	870	999	0.87	13%	38%	Acceptable	-129	16,607
66	E. Stockton Boulevard	From Bond Road to Banff Vista Drive	642	782	0.82	18%	41%	Acceptable	-140	19,735
67	E. Stockton Boulevard	From Elk Grove Boulevard to SR 99 NB Ramps	1,578	1,920	0.82	18%	28%	Acceptable	-342	117,248
68	E. Stockton Boulevard	From Elk Grove Florin Road to Grant Line Road	784	720	1.09	9%	44%	Acceptable	64	4,119
69	Emarld Vist Drive	From E. Stockton Bouelvard to Elk Grove Boulevard	1,357	996	1.36	36%	38%	Acceptable	361	130,241
70	Mosher Road	From Waterman Road to Grant Line Road	170	127	1.34	34%	63%	Acceptable	43	1,885
		Total	94,519	100,208						

Model/Count Ratio	0.94
Percent Within Caltrans Maximum Deviation (>75%)	89%
Percent Root Mean Square Error (<40%)	22%
Correlation Coefficient (>0.88)	0.95

Notes: 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations

Total Count	70
Links Within Deviation	62

Elk Grove Fee Program Update **Elk Grove Base Year Model**

PM Peak Hour **Static Model Validation - Two-Way Total**

ID	Roadway	Segment	Model Volume	Count Volume	Model / Count	% Deviation	Max Allowable % Deviation	Within Deviation	Model - Count	Difference Squared
Links Outside Deviation					8					

Data Sources:

- For arterials and collector Streets counts were averaged over three mid-weekdays for either of the following date ranges:
  1. August 2, 2019 – August 22, 2019
  2. August 27, 2019 – August 29, 2019
  3. September 10, 2019 – September 12, 2019
- For freeways, counts were collected from PeMS data source and averaged for the month of August - October, 2019. Only the data points with detector health > 95% were selected.

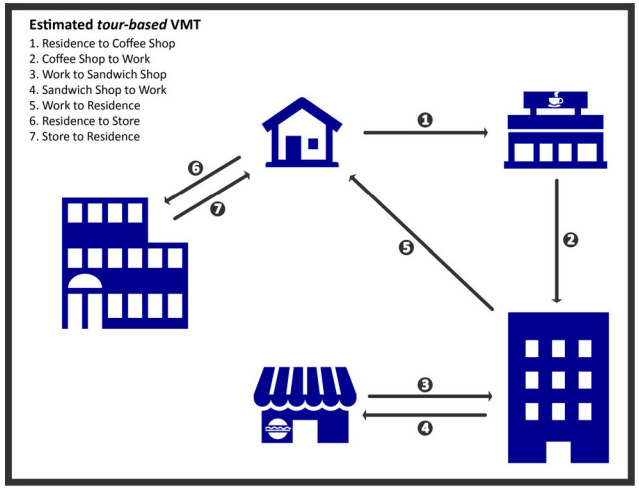
Appendix C

VMT Scripts

FEHR & PEERS

Household VMT Calculation

VMT per Capita is used to evaluate residential projects. It includes all vehicle "tours" (both work/commute vehicle tours and non-work vehicle tours) that start and end at residential units. VMT from these tours are summed to the home location. VMT for each home is then summed by TAZ and divided by the total population in that TAZ to arrive at VMT per Capita.



Process.docx file includes the full documentation.

Input files required :

1. _trips_1_1.csv
2. _houehold.tsv
3. 2016_raw_parcel.dbf
4. ixxi_taz.dbf
5. Outside_sacog_vmt_estimation_steps_0.xlsx

Input Files

In [ ]:
```
import pandas as pd
from dbfread import DBF
import numpy as np
```

In [ ]:
```
pd.set_option('display.max_rows', 5)
pd.set_option('display.max_columns', 50)
import warnings
warnings.filterwarnings ('ignore')
```

In [ ]:
```
TAZ_Jurisdiction = pd.read_csv("parcel_taz_juris.csv")
```

In [ ]:
```
trips_input = pd.read_csv("_trip_1_1.csv")
household_input = pd.read_csv("_household.tsv", delimiter = "\t")
taz_rad_input = pd.read_csv("tazrad07.txt", delimiter = "\s+" ,header = None)
parcel_id = DBF("pa40_raw_parcel.dbf")
parcel_id = pd.DataFrame(parcel_id)
ixxi_input = DBF("ixxi_taz.dbf")
ixxi_input = pd.DataFrame(ixxi_input)
IXXI_VMT_by_TAZ_input = pd.read_excel('Outside_sacog_vmt_estimation_steps_0_new_method.xlsx', sheet_name='IXXI_VMT_by_TAZ', index_col=None)
```

In [ ]:
```
def vmt_gen(row):
    if row["mode"] == 5:
        return row["distau"] * 0.3
    elif row["mode"] == 4:
        return row["distau"] * 0.5
    else:
```

```
        return row["distau"] * 1

veh_trips = trips_input[(trips_input["mode"] == 3) | (trips_input["mode"] == 4) | (trips_input["mode"] == 5)]
veh_trips["VMT"] = veh_trips.apply(vmt_gen, axis =1)
```

Summarize II VMT by Parcel

In [ ]:
```
trip_hh_merge = pd.merge(veh_trips, household_input, how = "left", on = "hhno")
trip_hh_merge_vmt = trip_hh_merge.groupby("hhparcel")["VMT"].sum().reset_index()
trip_hh_merge_vmt = trip_hh_merge_vmt.rename(columns={"hhparcel": "HHPARCEL", "VMT": "VMT_II"})
```

In [ ]:
```
trip_hh_merge['hhsize'].sum(),len(trip_hh_merge),trip_hh_merge_vmt['VMT_II'].sum()
```

Summarize II VMT by TAZ

In [ ]:
```
## Summarize II VMT by Parcel
ii_vmt_all_parcel = pd.merge(parcel_id, trip_hh_merge_vmt, how='left',left_on ="PARCELID", right_on = "HHPARCEL")
ii_vmt_all_parcel = ii_vmt_all_parcel.sort_values('PARCELID')
ii_vmt_all_parcel = ii_vmt_all_parcel.fillna(0)
ii_vmt_parcel = ii_vmt_all_parcel[['PARCELID','TAZ','HH_P','VMT_II']]
```

In [ ]:
```
ii_vmt_taz = ii_vmt_parcel.groupby("TAZ")["VMT_II"].sum().reset_index()
ii_vmt_taz = ii_vmt_taz.rename(columns={ "VMT_II": "VMT_II_TAZ"})
```

In [ ]:
```
ii_vmt_taz["VMT_II_TAZ"].sum(), veh_trips["VMT"].sum(), trip_hh_merge_vmt['VMT_II'].sum()
```

In [ ]:
```
taz_pops = household_input.groupby("hhtaz")["hhsize"].sum().reset_index()
taz_pops = taz_pops.rename(columns={'hhtaz':'TAZ', "hhsize": "POP"})
```

IXXI VMT by TAZ

In [ ]:
```
ixxi_taz_input_LU = ixxi_input[["I", "HHS", "EMPTOT", "FOOD", "RET", "SVC"]]
ixxi_taz_VMT_w_LU = pd.merge(IXXI_VMT_by_TAZ_input,  ixxi_taz_input_LU, how = "left", on = "I" )
ixxi_taz_VMT_w_LU["IX_VMT_RES"] = (ixxi_taz_VMT_w_LU["IX_VMT_I"] + ixxi_taz_VMT_w_LU["IX_VMT_J"]) * ((ixxi_taz_VMT_w_LU["HHS"])/ (1+ ixxi_taz_VMT_w_LU["HHS"] + 1.1*(i
```

In [ ]:
```
ixxi_VMT_taz = ixxi_taz_VMT_w_LU[["I", "IX_VMT_RES"]]
ixxi_VMT_taz = ixxi_VMT_taz.rename(columns={'I':'TAZ', "IX_VMT_RES": "VMT_ixxi"})
```

In [ ]:
```
len(ixxi_VMT_taz)
```

In [ ]:
```
ixxi_vmt_taz_2 = pd.merge(ixxi_VMT_taz, taz_pops, how='left', on = "TAZ")
ixxi_vmt_taz_2['VMT_ixxi_per_cap_taz'] = np.where(ixxi_vmt_taz_2["POP"]>0, ixxi_vmt_taz_2["VMT_ixxi"] / ixxi_vmt_taz_2["POP"], 0)
```

In [ ]:
```
ixxi_vmt_taz_2['POP']=ixxi_vmt_taz_2['POP'].fillna(0)
```

In [ ]:
```
len(ixxi_vmt_taz_final)
```

In [ ]:
```
TAZ_RAD = TAZ_Jurisdiction[['TAZ', 'RAD']]
```

In [ ]:
```
TAZ_RAD = TAZ_RAD.drop_duplicates()
```

In [ ]:
```
ixxi_vmt_taz_final = pd.merge(ixxi_vmt_taz_2, TAZ_RAD, on = "TAZ", how='left')
```

In [ ]:
```
ixxi_vmt_taz_final['RAD']=ixxi_vmt_taz_final['RAD'].fillna(0)
```

IXXI VMT by RAD

In [ ]:
```
ixxi_vmt_taz_rad = ixxi_vmt_taz_final[ixxi_vmt_taz_final['RAD']>0]
```

In [ ]:
```
ixxi_vmt_rad = ixxi_vmt_taz_rad.groupby(['RAD']).agg({'VMT_ixxi':'sum','POP':'sum'}).reset_index()
```

In [ ]:
```
ixxi_vmt_rad['VMT_ixxi_per_cap_rad'] = np.where(ixxi_vmt_rad["POP"]>0, ixxi_vmt_rad["VMT_ixxi"] / ixxi_vmt_rad["POP"], 0)
```

In [ ]:
```
ixxi_vmt_rad = ixxi_vmt_rad.drop(columns={'VMT_ixxi','POP'})
```

Parcel Level Calculation

In [ ]:
```
household_pop = household_input.groupby('hhparcel')['hhsize'].sum().reset_index()
```

In [ ]:
```
hh_VMT_II = pd.merge(ii_vmt_parcel, TAZ_Jurisdiction, on = 'PARCELID', how="left")
```

In [ ]:
```
hh_VMT_II_pop = pd.merge(hh_VMT_II, household_pop, left_on='PARCELID', right_on = 'hhparcel', how="left")
```

In [ ]:
```
hh_VMT_II_pop['POP'] = hh_VMT_II_pop['hhsize']
```

In [ ]:
```
hh_VMT_II_pop = hh_VMT_II_pop.drop(columns=['TAZ_y'])
hh_VMT_II_pop = hh_VMT_II_pop.rename(columns={"TAZ_x": "TAZ"})
```

In [ ]:
```
hh_VMT_II_pop = hh_VMT_II_pop[['PARCELID','TAZ','JURIS','RAD','VMT_II','HH_P','POP']]
```

In [ ]:
```
HH_VMT_by_parcel_rad = pd.merge(hh_VMT_II_pop, ixxi_vmt_rad, on = "RAD", how = "left")
HH_VMT_by_parcel_rad = HH_VMT_by_parcel_rad.fillna(0)
```

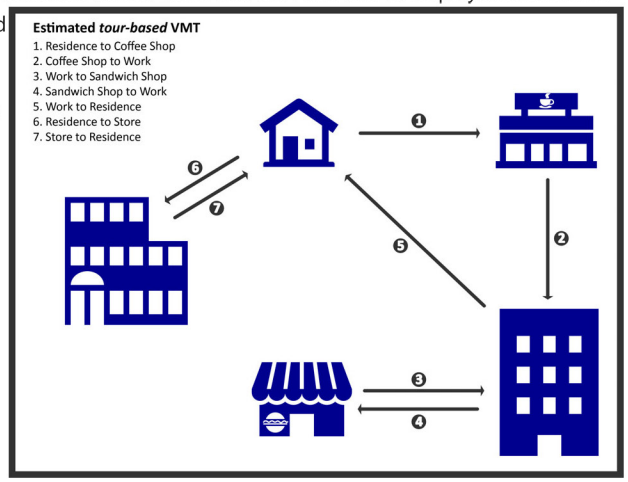
In [ ]:
```
HH_VMT_by_parcel_rad ['VMT_IXXI'] = HH_VMT_by_parcel_rad['VMT_ixxi_per_cap_rad']*HH_VMT_by_parcel_rad['POP']
HH_VMT_by_parcel_rad ['VMT_TOT'] = HH_VMT_by_parcel_rad ['VMT_II'] + HH_VMT_by_parcel_rad ['VMT_IXXI']
HH_VMT_by_parcel_rad ['VMT_TOT_PER_CAP'] = np.where(HH_VMT_by_parcel_rad["POP"]>0, HH_VMT_by_parcel_rad["VMT_TOT"] / HH_VMT_by_parcel_rad["POP"], 0)
```

In [ ]:
```
Household_VMT_by_parcel_rad = HH_VMT_by_parcel_rad[['PARCELID', 'TAZ', 'RAD','HH_P','POP','VMT_II', 'VMT_IXXI', 'VMT_TOT', 'VMT_TOT_PER_CAP']]
```

In [ ]:
```
Household_VMT_by_parcel_rad.to_csv("Household_VMT_by_parcel.csv", index=False)
```

Work Tour VMT by parcel Calculation

VMT per Employee is used to evaluate commercial and industrial employment projects. VMT per Employee includes all work/commute vehicle tours that start and end at employment location. VMT from these tours are summed to the employment parcels. VMT for each employment parcel is then summed by TAZ and divided by the total employment of that TAZ to arrive at VMT per Employee per TAZ.



The work/commute vehicle tours estimated by SACSIM19 include intermediate stops. VMT from these tours must include the full mileage of the entire round-trip work/commute tour including all stops based on the SACSIM19 model. \ From SACOG guidelines, Work-tour VMT includes trips **#1, 2, 5, 3**, and **4** from the image.

Process.docx file includes the full documentation.

Input files required :

1. _trips_1_1.csv
2. _houehold.tsv
3. _tour.tsv
4. pa40_raw_parcel.dbf
5. tazhhsums.txt
6. worker_ixxifractions.dat
7. Outside_sacog_vmt_estimation_steps_0.xlsx

Import packages

In [1]:
```
import pandas as pd
from dbfread import DBF
import numpy as np
```

In [2]:
```
pd.set_option('display.max_rows', 5)
pd.set_option('display.max_columns', None)
import warnings
warnings.filterwarnings('ignore')
```

Input Files

In [3]:
```
tour_input = pd.read_csv("_tour.tsv", delimiter = "\t")
trips_input = pd.read_csv("_trip_1_1.csv")
household_input = pd.read_csv("_household.tsv", delimiter = "\t")
parcel_input = DBF("pa40_raw_parcel.dbf")
parcel_input = pd.DataFrame(parcel_input)
worker_ixxi_fractions = pd.read_csv("worker_ixxifractions.dat", sep = "\s+", header = None)
```

In [4]:
```
work_tour_ixxi = pd.read_excel('Outside_sacog_vmt_estimation_steps_0_new_method.xlsx', sheet_name='work_tour_ixxi', index_col=None)
```

In [5]:
```
```

```
TAZ_Jurisdiction = pd.read_csv("parcel_taz_juris.CSV")
```

In [6]:
```
trips_input_c = trips_input
def vmt_gen(row):
    if row["mode"] == 5:
        return row["distau"] * 0.3
    elif row["mode"] == 4:
        return row["distau"] * 0.5
    else:
        return row["distau"] * 1

trips_input_c = trips_input_c[(trips_input_c["mode"] == 3) | (trips_input_c["mode"] == 4) | (trips_input_c["mode"] == 5)]
trips_input_c["VMT"] = trips_input_c.apply(vmt_gen, axis =1)
```

Filter Work Trips ii VMT by parcel

- Merge trips and tour files
- Filter by pdpurp = 1 (Destination purpose = work)
- Summazire (groupby) data by destination parcels (tdpcl) to get VMT for each trip

In [7]:
```
trip_tour_merge = pd.merge(trips_input_c, tour_input, how = "left", left_on = "tour_id" , right_on = "id")
trip_tour_merge = trip_tour_merge[['opcl',"pdpurp", "parent", "tdpcl", "topcl", "VMT" ]]
work_trip_tour = trip_tour_merge[trip_tour_merge["pdpurp"] == 1]
work_trips_dest = work_trip_tour.groupby("tdpcl")["VMT"].sum().reset_index()
```

Add Work Subtours by parcel

- Filter data by parent>0 (subtour)
- Summarize VMT data by origin parcel (topcl). Origin parcel of a work based subtour will be the work location.
- Add this to the work tours calculated in the previous step
- This will be total II work VMT

In [8]:
```
work_subtour = trip_tour_merge[trip_tour_merge["parent"]>0]
work_subtour_origin_parcel = work_subtour.groupby("topcl")["VMT"].sum().reset_index()

ii_work_vmt = pd.merge(work_trips_dest, work_subtour_origin_parcel, left_on = "tdpcl", right_on = "topcl", how = "outer" )
ii_work_vmt["VMT_x"] = ii_work_vmt["VMT_x"].fillna(0)
ii_work_vmt["VMT_y"] = ii_work_vmt["VMT_y"].fillna(0)
ii_work_vmt["VMT_II"] = ii_work_vmt["VMT_x"] + ii_work_vmt["VMT_y"]
```

Separate Internal-External Worker By Parcel

In [9]:
```
worker_ixxi_fractions.columns = ["taz", "residents_ix", "workers_xi"]
parcel_jobs = parcel_input[["PARCELID", "TAZ", "EMPTOT_P"]].copy()
parcel_workers = pd.merge(parcel_jobs, worker_ixxi_fractions, left_on = "TAZ",right_on = "taz", how = "left")
parcel_workers["External_Workers"] = parcel_workers["EMPTOT_P"] * parcel_workers["workers_xi"]
parcel_workers["Internal_Workers"] = parcel_workers["EMPTOT_P"] - parcel_workers["External_Workers"]
```

In [10]:
```
parcel_work_vmt = pd.merge(parcel_workers, ii_work_vmt, how = "left", left_on = "PARCELID", right_on = "tdpcl" )
```

In [11]:
```
parcel_work_vmt = pd.merge(parcel_workers, ii_work_vmt, how = "left", left_on = "PARCELID", right_on = "tdpcl" )
parcel_work_vmt["VMT_II"] = parcel_work_vmt["VMT_II"].fillna(0)
parcel_work_vmt["VMT_II_Per_Worker"] = parcel_work_vmt["VMT_II"]/ parcel_work_vmt["Internal_Workers"]
parcel_work_vmt["VMT_II_Per_Worker"] = parcel_work_vmt["VMT_II_Per_Worker"].fillna(0)
```

In [12]:
```
parcel_work_vmt = parcel_work_vmt[['PARCELID','TAZ','EMPTOT_P','External_Workers','Internal_Workers','VMT_II','VMT_II_Per_Worker']]
```

Summarize II VMT and workers by TAZ

In [13]:
```
taz_work_vmt_ii = parcel_work_vmt.groupby("TAZ")[("VMT_II",'EMPTOT_P','Internal_Workers')].sum().reset_index()
```

In [14]:
```
taz_work_vmt_ii['VMT_II_Per_Emp'] = taz_work_vmt_ii["VMT_II"]/ taz_work_vmt_ii["Internal_Workers"]
```

Add IXXI VMT by TAZ

In [15]:
```
## Add IXXI VMT by TAZ# This step is tricky - have not fully figures out yet, but we need another input here

VMT_work_tour_ixxi = work_tour_ixxi[["I","F_exW_VMT(XI)", "F_exW_VMT(IX)",'external_workers']]
VMT_work_tour_ixxi = VMT_work_tour_ixxi[VMT_work_tour_ixxi['I']>30]
VMT_work_tour_ixxi["VMT_IXXI"] = VMT_work_tour_ixxi["F_exW_VMT(XI)"] + VMT_work_tour_ixxi["F_exW_VMT(IX)"]
VMT_work_tour_ixxi['VMT_IXXI_per_Emp'] = np.where(VMT_work_tour_ixxi['external_workers']>0,VMT_work_tour_ixxi['VMT_IXXI']/VMT_work_tour_ixxi['external_workers'],0)
```

TAZ Level Calculation

In [16]:
```
VMT_work_tour = pd.merge(VMT_work_tour_ixxi, taz_work_vmt_ii, how = "left", left_on = "I", right_on = "TAZ")
VMT_work_tour["VMT_II"] = VMT_work_tour["VMT_II"].fillna(0)
```

In [17]:
```
VMT_work_tour["VMT_Total"] = VMT_work_tour["VMT_II"] + VMT_work_tour["VMT_IXXI"]
```

In [18]:
```
VMT_work_tour['VMT_Per_Emp'] = np.where(VMT_work_tour['EMPTOT_P']>0, (VMT_work_tour["VMT_Total"] / VMT_work_tour["EMPTOT_P"]), 0)
```

In [19]:
```
VMT_work_tour = VMT_work_tour.drop(columns=['TAZ'])
VMT_work_tour = VMT_work_tour.rename(columns={"I": "TAZ"})
```

In [20]:
```
VMT_work_tour2 = pd.merge(VMT_work_tour, TAZ_Jurisdiction, how = "left", on = "TAZ")
```

In [21]:
```
VMT_work_tour3 = VMT_work_tour2[['TAZ','RAD','EMPTOT_P','external_workers','VMT_II','VMT_IXXI','VMT_Total','VMT_Per_Emp','JURIS']]
```

In [22]:
```
#VMT_work_tour3.to_csv('Work_Tour_VMT_by_taz.csv', index=False)
```

IX-XI VMT by RAD

In [23]:
```
rad_VMT_IXXI = VMT_work_tour2.groupby('RAD')[('VMT_IXXI','external_workers')].sum().reset_index()
```

In [24]:
```
rad_VMT_IXXI["VMT_IXXI_per_worker_rad"] = rad_VMT_IXXI["VMT_IXXI"] / rad_VMT_IXXI["external_workers"]
```

In [25]:
```
rad_VMT_IXXI = rad_VMT_IXXI.drop(columns={'external_workers','VMT_IXXI'})
```

Parcel level Calculation

In [26]:
```
VMT_Parcel_rad = pd.merge(parcel_work_vmt,TAZ_Jurisdiction, left_on = "PARCELID", right_on = "PARCELID", how = "left" )
```

In [27]:
```
Work_Tour_VMT_parcel_rad = pd.merge(VMT_Parcel_rad, rad_VMT_IXXI, left_on = 'RAD', right_on = 'RAD', how="left")
```

In [28]:
```
Work_Tour_VMT_parcel_rad['VMT_IXXI_per_worker_rad'] = Work_Tour_VMT_parcel_rad['VMT_IXXI_per_worker_rad'].fillna(0)
```

In [29]:
```
Work_Tour_VMT_parcel_rad['VMT_IXXI'] = Work_Tour_VMT_parcel_rad['VMT_IXXI_per_worker_rad']*Work_Tour_VMT_parcel_rad['External_Workers']
```

In [30]:
```
Work_Tour_VMT_parcel_rad['VMT_TOT'] = Work_Tour_VMT_parcel_rad['VMT_II']+Work_Tour_VMT_parcel_rad['VMT_IXXI']
```

In [31]:
```
Work_Tour_VMT_parcel_rad['VMT_TOT_per_emp'] = np.where(Work_Tour_VMT_parcel_rad['EMPTOT_P']>0,Work_Tour_VMT_parcel_rad['VMT_TOT'] / Work_Tour_VMT_parcel_rad['EMPTOT_P
```

In [32]:
```
Work_Tour_VMT_parcel_rad = Work_Tour_VMT_parcel_rad.drop(columns=['TAZ_y'])
Work_Tour_VMT_parcel_rad = Work_Tour_VMT_parcel_rad.rename(columns={"TAZ_x": "TAZ"})
```

In [33]:
```
Work_Tour_VMT_parcel_rad = Work_Tour_VMT_parcel_rad[['PARCELID','TAZ','JURIS','RAD','EMPTOT_P','External_Workers','Internal_Workers','VMT_II','VMT_IXXI','VMT_TOT','VM
```

In [34]:
```
Work_Tour_VMT_parcel_rad.to_csv('Work_Tour_VMT_by_parcel.csv', index=False)
```

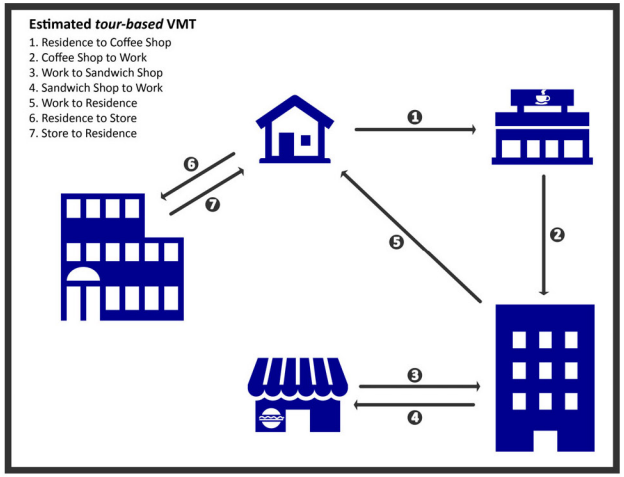
Other VMT by parcel Calculation

Other-tour VMT includes trip **#6-7** from the image.

Process.docx file includes the full documentation.

Input files required :

1. _trips_1_1.csv
2. _houehold.tsv
3. _tour.tsv
4. pa40_raw_parcel.dbf
5. tazhhsums.txt
6. worker_ixxifractions.dat
7. Outside_sacog_vmt_estimation_steps_0.xlsx



Import packages

In [1]:
```
import pandas as pd
from dbfread import DBF
import numpy as np
```

In [2]:
```
pd.set_option('display.max_rows', 5)
pd.set_option('display.max_columns', None)
import warnings
warnings.filterwarnings('ignore')
```

Input Files

In [3]:
```
tour_input = pd.read_csv("_tour.tsv", delimiter = "\t")
trips_input = pd.read_csv("_trip_1_1.csv")
```

In [4]:
```
parcel_input = DBF("pa40_raw_parcel.dbf")
parcel_input = pd.DataFrame(parcel_input)
```

In [5]:
```
TAZ_Jurisdiction = pd.read_csv("parcel_taz_juris.csv")
```

In [6]:
```
trips_input_c = trips_input
def vmt_gen(row):
    if row["mode"] == 5:
        return row["distau"] * 0.3
    elif row["mode"] == 4:
```

```
        return row["distau"] * 0.5
    else:
        return row["distau"] * 1

trips_input_c = trips_input_c[(trips_input_c["mode"] == 3) | (trips_input_c["mode"] == 4) | (trips_input_c["mode"] == 5)]
trips_input_c["VMT"] = trips_input_c.apply(vmt_gen, axis =1)
```

Filter Other Tours and VMT - II VMT by Parcel

- Merge trips and tour files
- Filter by pdpurp:
  - 4 - personal bussiness/medical
  - 5 - shop
  - 6 - meal
- Summazire (groupby) data by destination parcels (tdpcl) to get VMT for each trip

In [7]:
```
trip_tour_merge = pd.merge(trips_input_c, tour_input, how = "left", left_on = "tour_id" , right_on = "id")
trip_tour_merge = trip_tour_merge[['opcl',"pdpurp", "parent", "tdpcl", "topcl", "VMT" ]]
Other_trip_tour = trip_tour_merge[(trip_tour_merge["pdpurp"] == 4)|(trip_tour_merge["pdpurp"] == 5)|(trip_tour_merge["pdpurp"] == 6)]
Other_trips_dest = Other_trip_tour.groupby("tdpcl")["VMT"].sum().reset_index()
```

In [8]:
```
parcel_Other_vmt = pd.merge(parcel_input, Other_trips_dest, how = "left", left_on = "PARCELID" , right_on = "tdpcl")
```

In [9]:
```
parcel_Other_vmt = parcel_Other_vmt[['PARCELID','TAZ','EMPTOT_P','VMT']]
```

Parcel Level Calculation

In [11]:
```
VMT_Parcel = pd.merge(parcel_Other_vmt,TAZ_Jurisdiction, on = "PARCELID", how = "left" )
VMT_Parcel = VMT_Parcel.fillna(0)
```

In [12]:
```
VMT_Parcel.to_csv('Other_VMT_by_parcel.csv', index=False)
```

VMT by Service Population

Import Files

In [1]:
```
import pandas as pd
from dbfread import DBF
import numpy as np
import warnings
warnings.filterwarnings ('ignore')
```

In [2]:
```
parcel = pd.read_csv('pa40_raw_parcel.txt')
parcel_jurisdiction = pd.read_csv("parcel_taz_juris.csv")
```

In [3]:
```
hh_VMT = pd.read_csv('Household_VMT_by_parcel.csv')
work_VMT = pd.read_csv('Work_Tour_VMT_by_parcel.csv')
retail_VMT = pd.read_csv('Other_VMT_by_parcel.csv')
```

Toatal VMT and VMT per Service population _ By Parcel

In [4]:
```
parcel2 = pd.merge(parcel_jurisdiction, parcel, how='left', left_on= 'PARCELID',right_on='parcelid')
parcel2['STUDENT'] =  parcel2['stugrd_p']+parcel2['stuhgh_p']+parcel2['stuuni_p']
student = parcel2[['PARCELID','STUDENT','TAZ','JURIS','LUTYPE']].fillna(0)
```

In [5]:
```
hh_VMT = hh_VMT[['PARCELID','POP','HH_P','VMT_TOT']]
work_VMT = work_VMT[['PARCELID','EMPTOT_P','VMT_TOT']]
retail_VMT = retail_VMT[['PARCELID','VMT']]
```

In [6]:
```
all_parc_hh_work_VMT = pd.merge(hh_VMT,work_VMT,how='left', on= 'PARCELID')
all_parc_all_VMT = pd.merge(all_parc_hh_work_VMT,retail_VMT,how='left', on= 'PARCELID')

all_parc_service_pop_VMT = pd.merge(all_parc_all_VMT,student,how='left', left_on='PARCELID', right_on='PARCELID')
all_parc_service_pop_VMT = all_parc_service_pop_VMT.fillna(0)
```

In [7]:
```
all_parc_service_pop_VMT = all_parc_service_pop_VMT.rename(columns={'VMT_TOT_x':'RES_VMT','VMT_TOT_y':'WORK_VMT','VMT':'OTHER_VMT','EMPTOT_P':'EMPLOYEE','JURIS':'Juri
```

In [8]:
```
all_parc_service_pop_VMT = all_parc_service_pop_VMT.round(2)
```

In [9]:
```
all_parc_service_pop_VMT['TOTAL_VMT'] = all_parc_service_pop_VMT['RES_VMT']+all_parc_service_pop_VMT['WORK_VMT']+all_parc_service_pop_VMT['OTHER_VMT']
all_parc_service_pop_VMT['SERVICE_POP'] = all_parc_service_pop_VMT['POP']+all_parc_service_pop_VMT['EMPLOYEE']++all_parc_service_pop_VMT['STUDENT']
all_parc_service_pop_VMT['VMT_SERVICE_POP'] = np.where(all_parc_service_pop_VMT["SERVICE_POP"]>0, all_parc_service_pop_VMT["TOTAL_VMT"]/all_parc_service_pop_VMT["SERV
```

In [10]:
```
all_parc_service_pop_VMT = all_parc_service_pop_VMT[['PARCELID','TAZ','Jurisdiction','LUTYPE','HH_P','POP','EMPLOYEE','STUDENT','RES_VMT','WORK_VMT','OTHER_VMT','TOTA
```

Total VMT & VMT per Service Population by Land Use Type

In [11]:
```
LUTYPE_service_pop_VMT = all_parc_service_pop_VMT.groupby('LUTYPE')[('POP','EMPLOYEE','STUDENT','RES_VMT','WORK_VMT','OTHER_VMT','TOTAL_VMT','SERVICE_POP')].sum().res
```

In [12]:
```
LUTYPE_service_pop_VMT['VMT_SERVICE_POP'] = np.where(LUTYPE_service_pop_VMT["SERVICE_POP"]>0, LUTYPE_service_pop_VMT["TOTAL_VMT"]/LUTYPE_service_pop_VMT["SERVICE_POP"
```

Output

In [17]:
```
writer = pd.ExcelWriter('VMT_by_Service_Pop.xlsx', engine='xlsxwriter')

all_parc_service_pop_VMT.to_excel(writer, sheet_name='VMT_by_parcel', index=False)
TAZ_service_pop_VMT.to_excel(writer, sheet_name='VMT_by_TAZ')
Jurisdiction_service_pop_VMT.to_excel(writer, sheet_name='VMT_by_Jurisdiction')
LUTYPE_service_pop_VMT.to_excel(writer, sheet_name='VMT_by_LandUse')

writer.save()
```

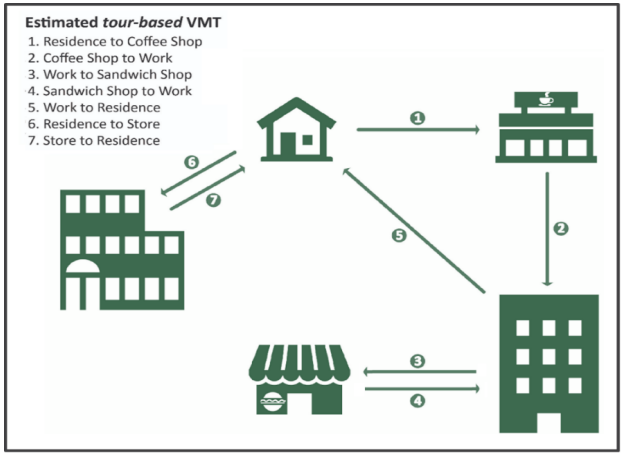
Appendix D

VMT Methodology Comparison for Jurisdictions

FEHR & PEERS

Types of Project	VMT Analysis		SACOG	Sacramento County	City of Elk Grove
Residential Projects	**Analysis Methodology**		Household generated VMT	Homebased tour VMT	Household generated VMT
	SB 743 Threshold		Household generated VMT per resident for new projects – 15% below regional Average	Homebased tour VMT per resident for new projects– 15% below regional Average	Total VMT[1] per service population[2] for new projects – 15% below **Citywide** Average
	HBW[3] Tour	1-2-5	Y	Y	Y
	HBO[4] Tour	6-7	Y	Y	Y
	NHB[5] (Work Based Subtour)	3-4	Y	N	Y
	IX-XI[6] (External work travel by residents)		Y	Y	Y
	IX-XI[7] (Work travel by external workers)		N	N	N
	XX[8]		N	N	N
	Commercial Vehicle[9]		N	N	N
Office/ Industrial Projects	**Analysis Methodology**		Work Tour VMT	Work Tour VMT	Work Tour VMT
	SB 743 Threshold		Work Tour VMT per employee for new projects – 15% below regional Average	Work Tour VMT per employee for new projects – 15% below regional Average	Total VMT[1] per service population[2] for new projects – 15% below **Citywide** Average
	HBW[3] Tour	1-2-5	Y	Y	Y
	NHB[5] (Work Based Subtour)	3-4	Y	N	Y
	IX-XI[6] (External work travel by residents)		N	N	N
	IX-XI[7] (Work travel by external workers)		Y	Y	Y
	XX[8]		N	N	N
	Commercial Vehicle[9]		N	N	N
Retail/ Public Facilities Projects	**Analysis Methodology**		Regional Change in VMT	Regional Change in VMT	Total VMT
	SB 743 Threshold		Total regional VMT with the project should not exceed baseline total VMT	Total regional VMT with the project should not exceed baseline total VMT	Total VMT[1] per service population[2] for new projects – 15% below **Citywide** Average
	HBW[3] Tour	1-2-5	Y	Y	Y
	HBO[4] Tour	6-7	Y	Y	Y[10]
	NHB[5] (Work Based Subtour)	3-4	Y	Y	Y
	IX-XI[6] (External work travel by residents)		Y	Y	N
	IX-XI[7] (Work travel by external workers)		Y	Y	Y
	XX[8]		N	N	N
	Commercial Vehicle[9]		Y	Y	N

The figure below shows a travel diary of a typical day for a household member within the SACOG region. Each leg of the arrow indicates an individual trip. This example includes 7 trips and 2 tours. Tours are defined as a chain of trips that begin and end at the household location (trips 1-2-5 is a home-based work tour). Tours that begin and end at a location other than home are called sub-tours (trip 3-4 is a work-based subtour).



Work location can be Office/Industrial/Retail/Public facilities etc.

[1] Total VMT = calculated by adding household generated VMT and employment generated VMT for each parcel

[1] Service Population = Residents + Employees + Students

[3] HBW = Home-based work tour, includes intermediate stops

[4] HBO = Home-based other tour (shopping, personal business, medical, school, recreational etc.), includes intermediate stops

[5] NHB = Non Home-based tour (tour that begin and end at a non-home location i.e., subtours), includes intermediate stops

[6] IX-XI = Internal-External / External-Internal, External work travel by residents who reside within SACOG but work outside the region

[7] IX-XI = Internal-External / External-Internal, Travel by workers that reside outside SACOG region but work within the region

[8] XX = External-External Travel, Trips that don't have any stops within SACOG region

[9] Commercial Vehicle = Trips by commercial vehicles (small-large trucks)

** [10] Only includes Customer/Visitor Tour (Tours at employment location by people who don't work there). Trip purposes included in for this are the following:*

-- Personal Business/ Medical

-- Shop

-- Meal

All trips/tours are from the SACSIM19 Activity based model travel diary (DaySim travel diary)

IX-XI VMT accounts for vehicle travel that occurs outside of the SACSIM model area by using SACSIM IX-XI trips and average trip distance outside SACOG region, calculated using Replica (Spring 2019) mobility data.