Wine Country Travel Demand Model Project

Model Development Report

Submitted to:

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1. INTRODUCTION

Background

The Wine Country Travel Demand Model (also known as the Wine Country Model or WC-TDM) is a tool for forecasting traffic on roads of regional significance in Lake, Mendocino, Napa, and Sonoma Counties. The model has been validated for use in forecasting the results of residential development, commercial development, and changes in the roadway network.

The development of the Wine Country Model was sponsored by Caltrans as part of its support for the Wine Country Inter-Regional Partnership. The partnership is one of eight partnerships statewide that were created in 2004 to study jobs-housing imbalances and to promote strategies for reducing long-distance commuting by car. The Wine Country Inter-Regional Partnership includes the Lake County/City Area Planning Council (acting as contracting agency for this project), Caltrans, the Mendocino Council of Governments, the Metropolitan Transportation Commission, the Napa County Transportation and Planning Agency, the Sonoma County Transportation Authority, and the Association of Bay Area Governments.

Purpose of this Report

The purpose of this report is to document the structure, input data, and validation results of the Wine Country Model. A companion document entitled Wine Country Model Users' Manual provides detailed instructions for setting up and using the model.

2. COMPONENTS OF THE MODEL

Overall Model Structure

The Wine County Model consists of a variety of components, only some of which will be used on any given model run. The model has different versions representing the Base Year (2009), 2020 and 2030. Within each version there are sub-components representing typical daily, peak hour (AM and PM), and Friday evening conditions, as shown in Figure 1.

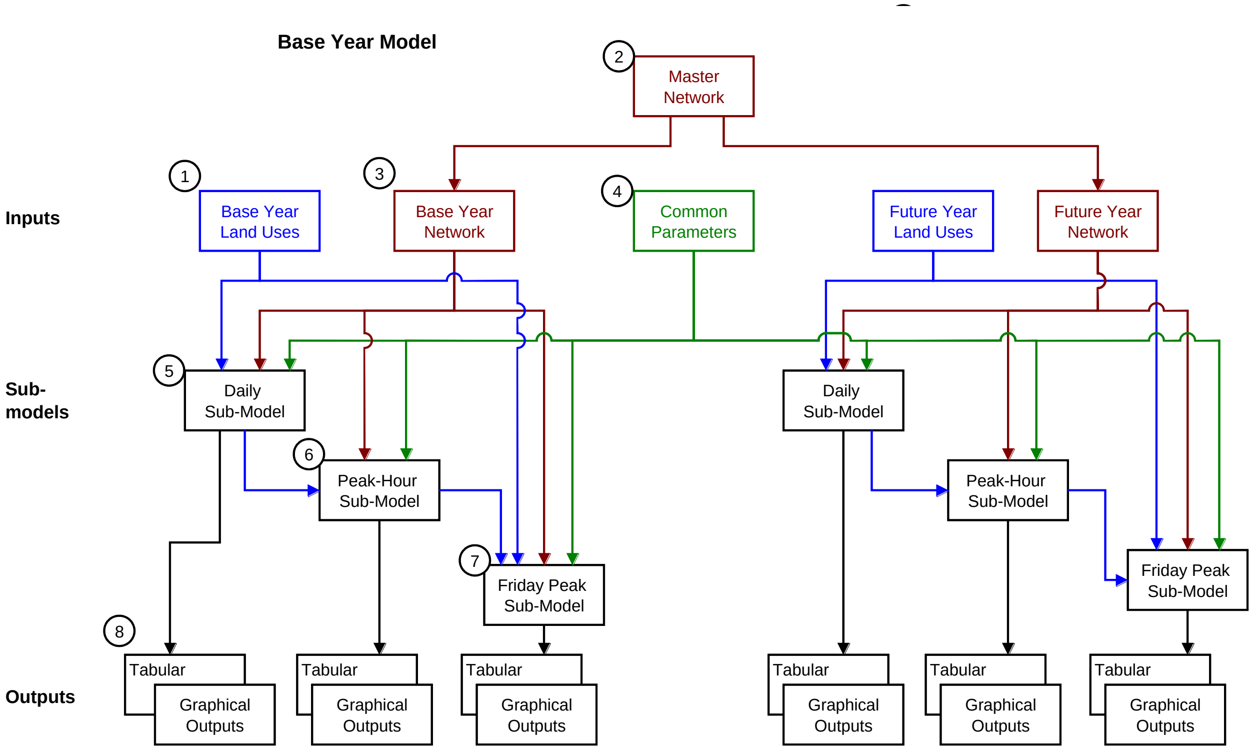

Figure 1: Overall Structure of the Wine Country Travel Demand Model

The major components of the model as shown in Figure 1 are described below using the Base Year as an example. These components will be further explained in the next section:

1) **Land Use Data:** Data on the assumed land uses is a major input for each scenario. Land use data is specified for Traffic Analysis Zones (TAZs) in the modeling area.
2) **Master Road Network:** This is a family[1] of files containing information on the length, location, free-flow speed, capacity, and other characteristics of the roadway system in the study area. The roadway network consists of nodes (used to represent points on the network such as intersections) and links (roadway segments). The master file contains information on the links used in all scenarios, including future scenarios.

[1] TransCAD stores some information in families of related files that share a name but not an extension, such as *Roads.dbd*, *Roads.bin*, *Roads.cdd*, etc.

3) **Scenario Network:** This network is a sub-set of links from the master network that represent roadways in the scenario to be tested in the model. It can be either a base-year scenario or a future-year alternative.
4) **Common Parameters:** These are miscellaneous model inputs, such as trip generation rates and the friction factors used for trip distribution, which are used in all model runs. It is considered best practice to leave these parameters unchanged for all model runs unless there is a specific defensible basis for making an adjustment.
5) **Daily Sub-Model:** Since much of our data on trip-making behavior is collected on the basis of a 24-hour period (census journey-to-work data, for example), the daily sub-model is the main forecast period of the model
6) **Peak-Period Sub-Models:** The AM and PM peak periods are developed as portions of the daily travel model.
7) **Friday Evening Sub-Model:** The Friday evening sub-model is a special case of the PM peak condition, with its own set of trip generation rates representing various types of recreational travel taking place in addition to normal commuting behavior.
8) **Model Outputs:** The model generates a variety of tabular and graphical outputs for each sub-model.

Now that the reader has a general idea of how the model is structured, the next section provides a much more detailed description of the files used by the model and how they interact with each other.

Model Stages and Files for Typical Model Runs

The Wine County Model consists of three kinds of components: input data, model steps, and model outputs. The input data are files prepared by the modeler to represent different aspects of traffic conditions. The model steps are the six processes that the model goes through in determining traffic flows. The model outputs are data files produced by the model. Some of the model output files are used as inputs into other steps in the model.

The components of the Wine Country Model and their relationship to each other are described below and in Figure 2. Annotated excerpts of many of these files can be found in Appendix A. The user has the option to cover one or more time periods in a given model run so some steps are shown as having more than one time period.

1) **Land Use Table *(Land_Use_2008.dbf)*:** Data regarding the land uses in each TAZ is stored in this file. This includes the number of single- and multi-family dwellings and the square footage or acreage of commercial, industrial, and other land uses. Other data associated with the TAZ stored in this file include terminal times, the percentage of dwellings that are seasonally occupied, etc.
2) **Trip Generation Rate Table *(CrossclassPA_2008.bin)*:** This file contains the daily trip production and attraction rates for each of the land uses listed in the land use table. These rates are disaggregated by trip purpose and area type. For example, one cell in the table contains the average daily number of home-based work (HBW) trips per single-family dwelling.

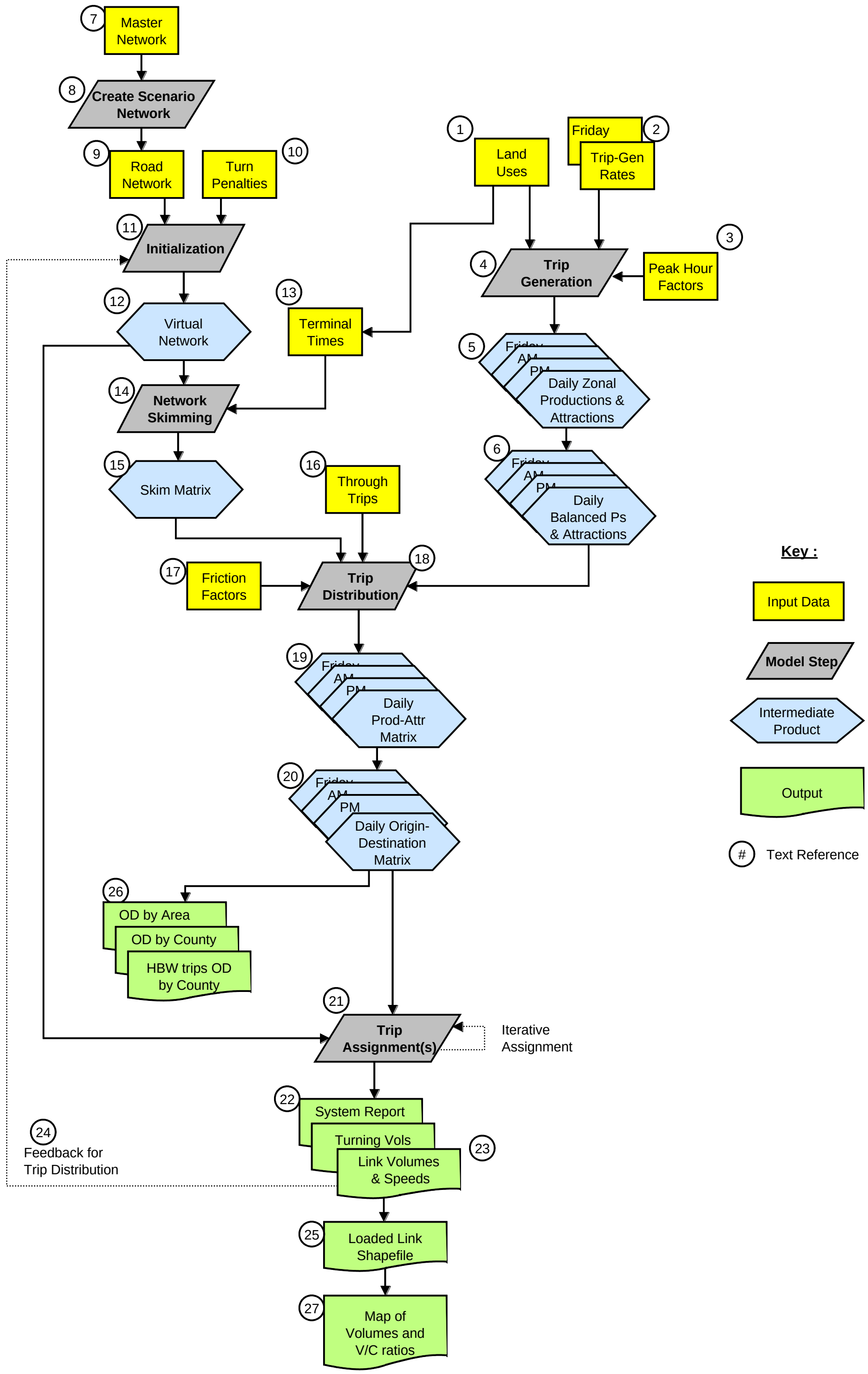

Figure 2: Components of the Wine Country Travel Demand Model

3) **Hourly Factors *(Hourly.bin)*:** This file identifies the percentage of trips that take place during the peak hours. The file is in the form of a matrix with one row for each hour of the day and two columns for each trip purpose, one for the departure trip and the other for the return trip. The daily trip-gen rates are multiplied by the hourly factors to produce trip rates for the AM and PM peak hours

4) **Trip Generation Step:** This step multiplies the demographic and trip generation tables together to produce a first estimate of trip ends.

5) **Production and Attraction Files *(PA_Unbalanced.bin)*:** This file contains the model's initial estimate of trips produced by and attracted to each TAZ, based on multiplying the demographic data by the cross classification data.

6) **Balanced P & A Trip Ends *(PA_Balanced.bin)*:** The model balances the trip production and attraction estimates based on instructions given in the model's resource file. Prior to running the model the modeler can select which estimate is more accurate (productions or attractions) and change the settings in the resource file as needed. The model then factors the other estimate up or down until it equals the selected estimate. In most cases the user should use the default values already stored in the model.

7) **Master Road Network (Master_Roads.dbd):** This is a family of files containing information on the length, location, free-flow speed, capacity, and other characteristics of the roadway links in the study area. The master file contains information on the links used in all scenarios, including future scenarios.

8) **Create Scenario Network Step**: This step creates a scenario-specific network from the master network file.

9) **Scenario Network *(Roads_Loaded_2008.dbd)*:** This is a family of files showing the length, location, free-flow speed, capacity, and other characteristics of the roadways in the study area. The scenario network will change depending on the assumptions used in a given scenario.

10) **Turn Penalty Table (*Turn_Penalities_2008.bin*):** This file contains information about delays incurred when vehicles make certain movements, such as left turns across major arterials. It also contains information on where turns are prohibited.

11) **Initialization Step:** In this step the model takes the highway data and converts it into a format used by the computer. Some basic characteristics of the input data are also checked (e.g., no two links can have the same ID number) and an error message may occur if problems are detected.

12) **Virtual Network *(Roads_Loaded_2008.net)*:** The output from the initialization step is a network file for use in later steps in the model. TransCAD stores this network in a format that cannot be seen or edited by the user.

13) **Terminal Times Matrix *(Terminal_Times_Temp.mtx)*:** The model reads the average travel times associated with the start and end of each trip, such as time spent looking for a parking place and parking, from the land use file. It then puts this into the form of a TAZ-to-TAZ matrix, so each cell contains the sum of the terminal times at the origin TAZ and destination TAZ. External trip ends do not have terminal times.

14) **Network Skimming Step:** The model examines the travel times for all of the possible routes between each origin TAZ and each destination TAZ, including the terminal times, and stores information on the quickest route.

15) **Skim Matrix *(Skim.mtx)*:** This file stores information on the quickest path between each origin-destination pair. The data is stored in the form of an origin-destination matrix with each cell showing the shortest travel time in minutes.

16) **Through Trips *(Through_Trips_2008.mtx)*:** This file informs the model of the number of through trips, in the form of an origin-destination matrix for external TAZs.

17) **Friction Factors *(Friction_Factors.dbf)*:** This file contains the friction factors that will be used in determining the relative attractiveness of potential destination TAZ's based on the travel time from the origin TAZ to the destination TAZ.

18) **Trip Distribution Step:** The model uses the four input files from Steps 6, 15, 16, and 17 to determine how trips are distributed among origin-destination pairs for the period.

19) **Production-Attraction Matrix *(PA.mtx)*:** The trip distribution step produces this file as an intermediate product. It is a trip table in production (home) to attraction (non-home) format.

20) **Origin-Destination Matrix *(OD_Daily.mtx)*:** The model produces an output file containing the number of trips between each origin-destination pair for the period.

21) **Trip Assignment Step:** The model uses an iterative assignment procedure whereby the quickest route is determined for each of the trips in the O-D matrix, taking into account congestion caused by other trips. The model runs a number of iterations based on instructions provided by the user.

22) **System Performance Report (*Report_VMT.txt*):** The model also generates a short text file that reports the total number of vehicle trips, vehicle miles traveled, and vehicle hours of travel for the entire four-county network for the period.

23) **Volumes and Speeds *(Volumes_Daily.bin, Volumes_Daily.dbf)*:** These files store information on the traffic volumes and speed on each link for the modeled period. TransCAD typically produces these outputs as *.bin files, but the Wine Country Model also produces *.dbf files with the same information since these are often easier to use when linking the model outputs to other software packages.

24) **Feedback Loop:** The congested speeds are then fed back into the virtual network, and Steps 11 through 21 are repeated. This simulates the effect of congestion on people's choice of where to work and shop (i.e. trip distribution). The number of feedback loops is set by the user as a model parameter. The default value is two feedback loops.

25) **Shapefile with Volumes and Speeds (*Shaped_Loaded_2008.shp*):** The model uses the link volumes and speeds from step 23 to create a shapefile in the form of a network map and database showing the final speeds and traffic volumes on each link in the network.

26) **Origin-Destination Summary Reports (*OD_Daily_by_County.mtx, OD_Daily_HBW_by_County.mtx, OD_Daily_by_Area_Type.mtx*):** The model aggregates the daily origin-destination matrix in three different ways to enable the user to check the reasonableness of the travel patterns in the model. This allows the user, for example, to

easily check whether the commute trips between counties increase or decrease under a particular set of land use assumptions, and by how much.

27) **Create Volume & V/C Ratio Graphic:** The final step is to automatically produce a network map showing the traffic volume as a bandwidth and congestion as a color code. Most users will find it useful to produce this graphic, which shows daily traffic volumes as a bandwidth and the volume/capacity ratio as a color code. This graphic can be saved as a jpeg or bmp file for use with other software packages, such as embedding it in a report done in Word.

3. ROAD NETWORK DATA

A key input to the model is information about the regional road network. This chapter describes how the road network file was developed.

Road Network

The process used to develop the draft road network file is outlined in Figure 3 and described in detail below:

1) The starting points for the network were road centerline files provided by the staff of the four counties in the study area.
2) The centerline layers were overlaid on aerial photographs from Google Earth Pro to determine the spatial accuracy of the centerline files. PB staff spot-checked forty-four locations in the study area and found only minor errors in the road centerline files, which were then corrected.
3) Next, attribute fields not used in modeling were deleted and all four files put into a common structure in preparation for the next step.
4) The four files were then combined into a single file by deleting any links that crossed outside of a county's boundary, bringing all four layers into a single layer, and then linking the roads that cross county boundaries.
5) Some of the centerline files include links that are not relevant to the Wine Country Model, such as railroads, fire trails, and unpaved roads. These links were deleted.
6) The centerline files represent most roads as a series of short segments. From a modeling standpoint it is much more efficient to work with the network if these links are aggregated so that each link represents the entire road length from one intersection to the next. For example, it takes less staff time to edit a single link than to edit ten links representing the same road segment, less storage space for the files, and less processing time when the model is run. We therefore deleted several thousand unneeded breaks in the network.
7) We then checked the connectivity of the network to make sure that no connections were inadvertently severed during link editing. We also checked places with grade separation, such as freeway interchanges, to make sure that the crossing links were not mis-represented as intersections.
8) Next we added attribute fields used by TransCAD (see Table 1).
9) The attribute fields created in the previous step were then populated with data from the original road centerline files as well as data from the four existing travel demand models to the extent possible. Some fields are intended for the storage of data that is created during a model run so those fields could not be populated in advance.
10) The TAZ structures from the four existing local models were used to determine the number and placement of centroid connectors, which were then added to the network file. A special set of centroid connectors was added to the network file to represent areas outside of the modeled area. There are fifteen such links representing the fifteen roads leading to other counties. These links are shown in Figure 4.

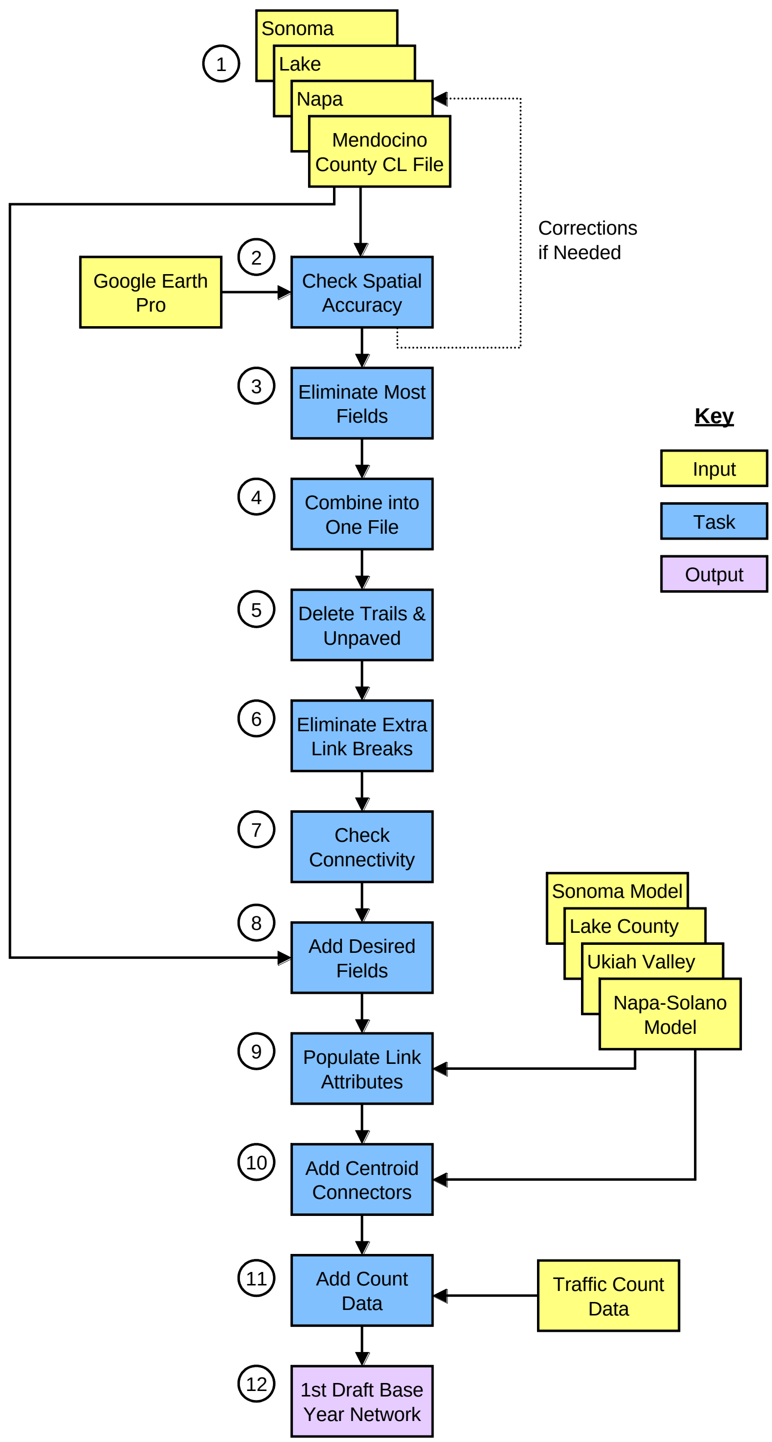

Figure 3: Development of Base Year Road Network

11) Additional fields were added for the storage of traffic count data.

12) The result was the Base Year network.

Table 1 – Attribute Fields in the Model Network

Field	Description
Input Link Layer Attributes	
CONST_YEAR	Construction year of each link. This is used to distinguish links that will be constructed in the future from existing roads. Future links will be available in future year scenarios.
FUNC_CLASS	Description of functional classification
CONNECTOR	Centroid connectors are coded as 1.
STRNAME	Name of streets for each link
HWY_NUM	This field is used to make graphics that display highway numbers on shields, such as  or 
LANE_CAPACITY	Hourly capacity per lane
ABLANE* / BALANE*	Number of lanes in AB and BA direction for each model year
AB_SPEED / BA_SPEED	Free-flow speed in AB and BA direction
ALPHA	These are the Alpha and Beta parameters used in the Bureau of Public Roads (BPR) equation. The BPR equation is a speed/flow curve, meaning that it is used to estimate the prevailing speed of traffic based on the volume of traffic and the lane capacity.
BETA	
FROM_ID / TO_ID	Manually populated A node / B node
CNT_*	Traffic counts (daily, AM peak hour, and PM peak hour)
Loaded Link Layer Attributes	
AB_TIME / BA_TIME	Free-flow travel time in minutes.
AB_CTT_TMP / BA_CTT_TMP	Congested travel time in minutes.
VOL*	Loaded link volumes for daily, AM, PM, and Friday PM peak hour.
Node Layer Attributes	
TAZ	TAZ number of each centroid
Study_Intersection	Identification of study intersections. The turning movement volumes will be populated for nodes with a numeric value.
Notes: **Bold** indicates the input network fields. Other fields in the model network are kept for informational purpose. An asterisk (*) indicates network attributes with AB and BA labels store directional information. If a link is drawn from point A to point B, the point A to point B direction is the AB direction, and it is also called topology direction.	

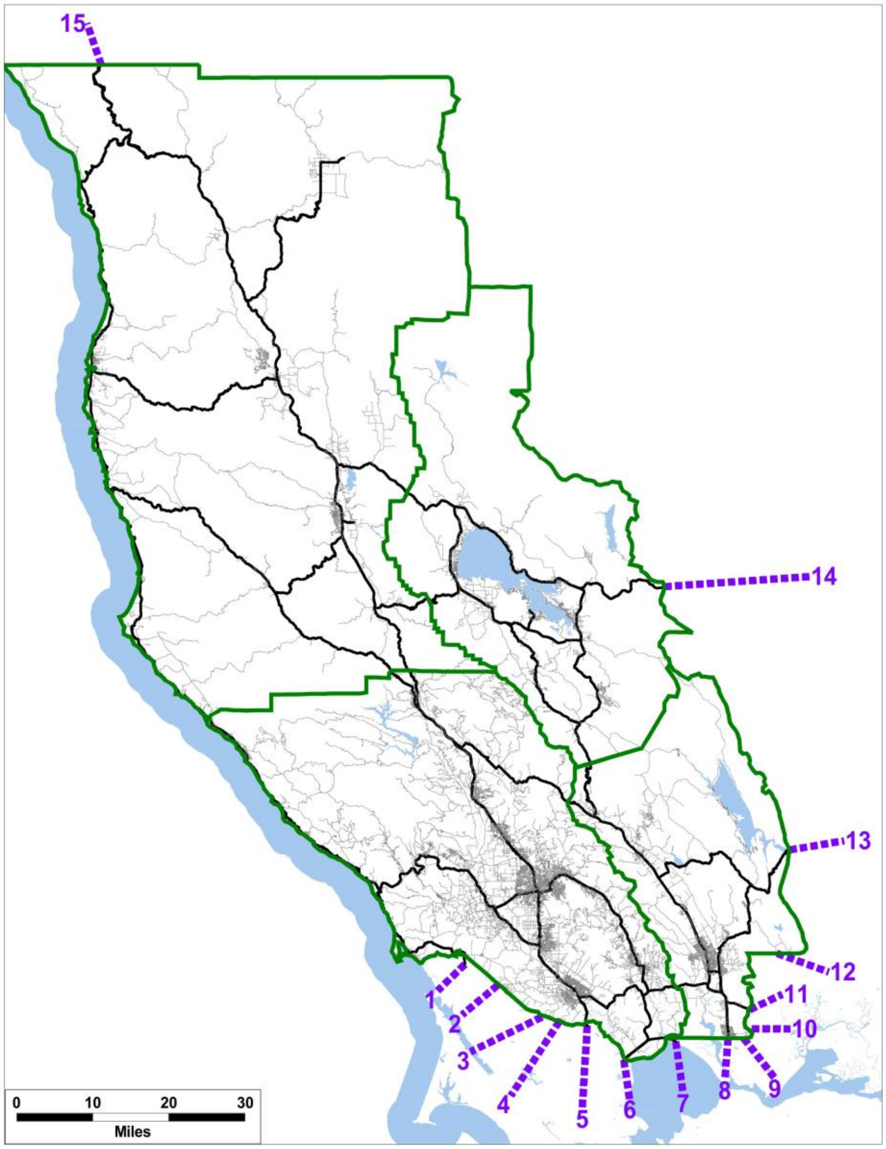

Figure 4: External TAZ Connectors

Nine functional classes were used (see Figure 5). The default characteristics of each classification are given in Table 2. The characteristics of individual links were revised whenever actual conditions were found to differ from the default values. Details of the free-flow speeds for different parts of the network can be found in Appendix B while details about the number of lanes is presented in Appendix C.

Table 2: Default Road Characteristics by Classification

Road Classification	Model Speed (mph)	Model Capacity per Lane (pc/lane/hr)
Freeway	60-65	1,800
Highway	50-55	1,500
Slip Ramp	40	800
Loop Ramp	25	800
Major Arterial	40-45	900
Minor Arterial	35-40	750
Major Collector	30-35	550
Minor Collector	25-30	550
Local Road	25	400
Centroid Connector	25	10,000

There is a variety of road classification systems used in the region; the system shown in Table is intended for modeling purposes only. There may be roads that are classified, for example, as a state highway for funding purposes but a rural arterial for modeling purposes. Similarly, the speeds and capacities associated with different road segments and that those used for modeling purposes may be different from what is used for other purposes. Level of service analysis, for example, often uses a capacity of 2000 vehicles/lane/hour for freeways. The speeds coded in the model network file are used by the model only for the purpose of selecting from among alternate routes between trip origins and destinations and so may reflect other factors besides the posted speed. For example when a freeway is used for a very short trip, such as between interchanges within a single town, the average speed for that user would be well below the posted speed because of the effects of weaving into and out of the traffic stream.

Centroid connectors are a special type of link used in the network to represent the place where trips first enter the road network. They do not correspond to actual roads.

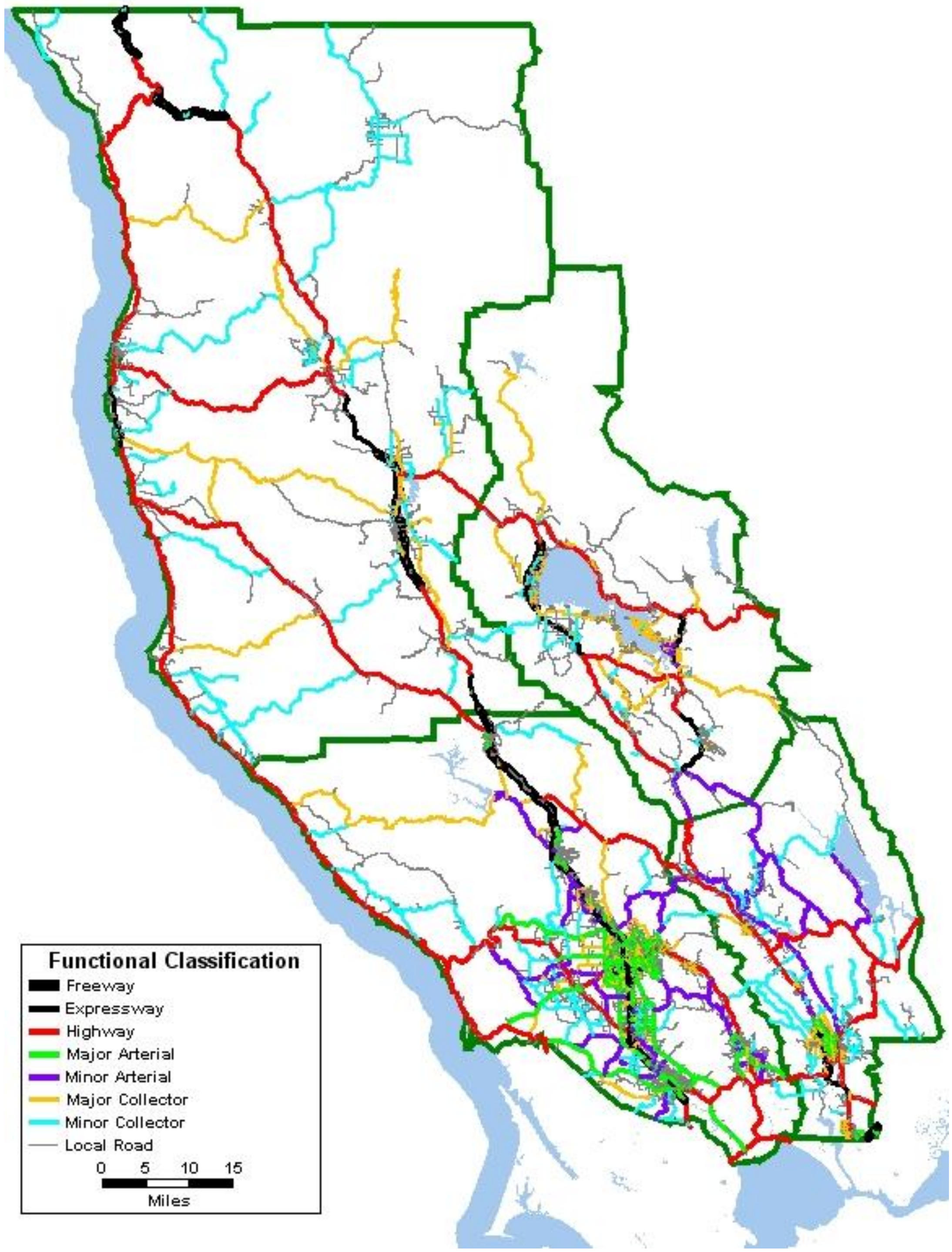

Figure 5: Functional Classifications in the Wine Country Model

4. LAND USE DATA

Another key input to the model is information about the land uses being served by the regional road network, including information about trips to and/or from land uses outside the modeled area. This chapter describes the land use information used in the Wine Country Model.

TAZ System

Traffic models store land use and other demand-related information in traffic analysis zones (TAZs), which the model uses to connect land uses to the road network. Devising a TAZ system involves a trade-off between providing sufficient detail to support detailed traffic studies, which implies a large number of small zones, and processing speed, which is best with a small number of zones.

In consultation with potential users of the model it was decided that the Wine Country Model would retain the TAZ structures of the four existing traffic models for the counties in the study region. This will facilitate the transfer of data between the regional and local models.

The numbering system used in the model was:

- Zones 1 through 20 (20 TAZs in all) are external zones representing areas outside the region that connect to the road system at the county boundaries.
- Zones 1100 through 1987 (391 TAZs in all) copy the TAZ system of the Lake County model except that one thousand has been added to every TAZ number (i.e. TAZ 100 in the Lake County model corresponds with TAZ 1100 in the Wine Country Model). This creates unique numbers in the Wine Country Model while preserving a clear link to the city model.
- Zones 2001 through 2218 (218 TAZs in all) copy the TAZ system of the Napa County traffic model, except that two thousand has been added to every TAZ number
- Zones 3001 through 3876 (711 TAZs in all) copy the TAZ system of the Sonoma County traffic model, except that three thousand has been added to every TAZ number
- Zones 4001 through 4944 (600 TAZs in all) copy the TAZ system of the Mendocino County traffic model, except that four thousand has been added to every TAZ number

In total there are 1940 TAZs in the model, or about one for every 150 households. Maps of the TAZ system for different parts of the modeled area can be found in Appendix D.

External Commute Areas

The journey-to-work data from the U.S. census indicates that some parts of the study area interact much more with areas outside the model than others (see Table 3).

Table 3: Out-Commuting from Study Area	
Area	**% of Work Trips out of the Region in Census**
Napa	20.7%
Petaluma	38.4%
Rohnert Park	22.7%
Santa Rosa	7.5%
Small Towns (northern part of region)	0.5%
Rural Areas (northern part of region)	0.5%

In order to enable the model to capture these differences the study area was divided into seven areas as follows (see Figure 6):

- Area 1: The City of Napa and its vicinity
- Area 2: Petaluma and its vicinity
- Area 3: Rohnert Park and its vicinity
- Area 4: Santa Rosa and Central Sonoma County
- Area 5: Lake and North Napa County
- Area 6: Mendocino and North Sonoma Counties
- Area 7: American Canyon

The in- and out-commuting characteristics of each area were incorporated into the trip generation rates used in the model.

Users should note that external zones were included in Area 1 as a convenience because the model script requires that each zone be included in one of the seven areas. It does not matter which area is listed for the external zones because they have no land uses and so they are unaffected by adjustments to trip generation rates.

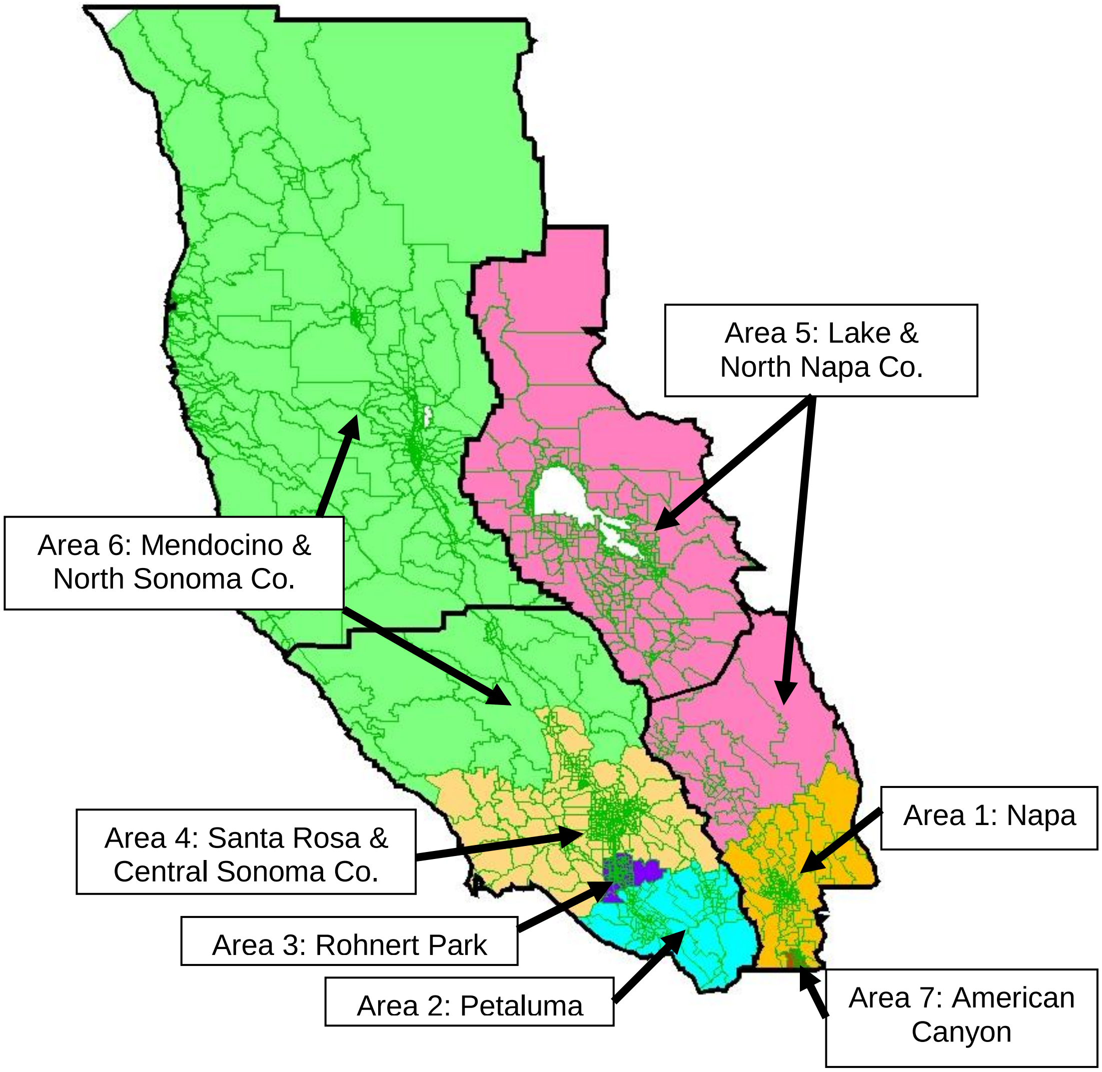

Figure 6: External Commute Areas

Residential Land Uses

To maintain consistency with local planning effort the number of dwelling units by TAZ was taken from the local models for use in the Wine Country Model. We then used census data to categorize the households into low-, middle- and high-household-income ranges in a way that makes sense both in the field and from a modeling standpoint. Again for the sake of consistency we used the income categories used in the MTC model, which are \$0-\$35,000 per year in household income for the low-income category, \$35,001-\$100,000 as the middle-income category, and \$100,001+ as the high-income category.

Seasonally-Occupied Housing

Due to its impact on traffic volumes, seasonal housing is an important aspect of land use in the study area. Seasonal houses generate little traffic on normal workdays but are trip attractors on Friday evenings. We used information obtained from the Census Bureau's website to estimate the percent of housing that is seasonal within different county subdivisions. A map of county subdivisions used in this analysis is shown in Figure 7 and the percent of housing that is seasonal in each subdivision is summarized in Table 4.

Several things can be learned from the data:

- Seasonal housing is an important land use factor in each of the four counties, but has the largest influence on Lake County.
- There is significant variation in seasonal housing rates within the counties, as shown by the circled values in Table 4. The largest percentages of seasonal housing being found in rural areas near bodies of water and the smallest percentages occurring near the urban centers.
- As a result of this distribution, one would expect large variations between weekday and weekend traffic volumes within the specified rural areas and smaller variations within the more urbanized parts of the counties.
- Since seasonal housing represents a major attractor for traffic from outside the study area the data can also be used to calibrate flows on outside gateway routes on the weekends.

Within much of the study area seasonal housing represents a significant aspect of land use that is likely to impact traffic flow patterns and intra-weekly variations. The data in Table 4 was used to create a seasonal housing land use category with a trip generation rate distinct from that of non-seasonal housing.

Figure 7: County Subdivisions in U.S. Census 2000

Table 4: Seasonal Occupancy by County Subdivision				
County	**Subdivision**	**Total Housing Units**	**Seasonal Units**	**% Seasonal**
Lake	Lakeport	12,465	2,427	19.5%
	Lower Lake-Middletown	12,561	1,897	15.1%
	Upper Lake-Clearlake Oaks	7,502	1,726	23.0%
Mendocino	Covelo	1,047	112	10.7%
	Fort Bragg	5,272	231	4.4%
	Hopland	863	52	6.0%
	Laytonville-Leggett	2,084	285	13.7%
	Mendocino-Anderson	5,418	695	12.8%
	Point Arena	2,299	473	20.6%
	Redwood-Potter	4,508	99	2.2%
	Ukiah	9,967	59	0.6%
	Willits	5,479	145	2.6%
Napa	Angwin	2,011	141	7.0%
	Berryessa	962	288	29.9%
	Calistoga	2,920	202	6.9%
	Napa	38,842	920	2.4%
	St. Helena	3,819	308	8.1%
Sonoma	Cloverdale-Geyserville	5,004	267	5.3%
	Healdsburg	14,872	425	2.9%
	Petaluma	45,153	250	0.6%
	Russian River-Coastal	15,476	4,008	25.9%
	Santa Rosa	73,213	713	1.0%
	Sebastopol	11,915	194	1.6%
	Sonoma	17,520	675	3.9%
	4 County Region	301,172	16,592	5.5%

Wide variations occur within the county

Wide variations occur within the county

Non-Residential Land Uses

The original approach to developing the Wine Country Travel Demand Model was based on adopting the land use information from the four existing local models in an effort to be as consistent as possible with the local models. This approach worked well for residential land uses but proved unworkable for non-residential uses. The reason is that the four local models use very different land use categories and different units of measurement so that the hoped-for consistency is not achievable; consistency with any one local model would automatically preclude consistency with the others.

Instead, non-residential land uses were incorporated into the model in units of employees for everything except educational institutions, which are in units of students. The approach is described below:

Data Sources

We used three sources of information regarding future non-residential land use:

<u>InfoUSA</u> - InfoUSA is a private vendor of information on employers. Their primary business is to assist their clients to develop targeted mailing lists of businesses. However, much of the data that they gather, on things like type of business, location, and number of employees, is very useful for traffic modeling purposes. The strength of this database is that it is continuously updated through periodic contact with employers, making it the most up-to-date dataset of its kind. Its weakness is that it provides no information about the future.

<u>Caltrans Office of Transportation Economics</u> – This unit in Caltrans develops employment forecasts for twelve economic sectors for use in travel demand planning. Their forecasts are not considered "official" Caltrans forecasts in that there is no requirement on the part of the Department for its use by any public or private agency. However, these forecasts are routinely updated, utilize sophisticated modeling techniques, and are done on a consistent basis for all 58 counties in California. The strength of this database is its consistency and the fact that it provides long-term (to 2030) forecasts, while its weaknesses are that it is done at the county level and so provides no information on spatial distribution within a county. Also, it lags several years behind the InfoUSA data.

<u>Local County Traffic Models</u> – Lake, Mendocino, Napa, and Sonoma Counties all have existing traffic models with forecasts of future land uses. The land use forecasts in these models incorporate data from the general plans of the local jurisdictions in their respective counties. The strength of these data sets is that they reflect the spatial distribution of future growth, while their weakness is that each county used a different system of land use categories, measured in different units, and in some cases different years.

Our approach is to combine the strongest features of each of the three data sources. That is, the accurate data on existing employment found in the InfoUSA data, Caltrans' well-developed growth rates for various employment sectors, and the local models' information about the spatial distribution of future growth.

General Approach

Our approach is shown in Figure 8 and is described in detail below:

1) We aggregated the many employment categories of the North American Industrial Classification System (NAICS) into six categories suitable for the Wine Country model. The relationships between the NAICS major categories, the Wine Country categories, and the Caltrans categories are shown in Table 5. Note that wineries, which are considered industrial establishments in the NAICS system, are considered a "leisure and recreation" use in the Wine Country in recognition of the trips they generate from tourism. Note also that Caltrans grouped wholesale and retail trades while the Wine Country model splits the two in recognition of their differences in trip generation.

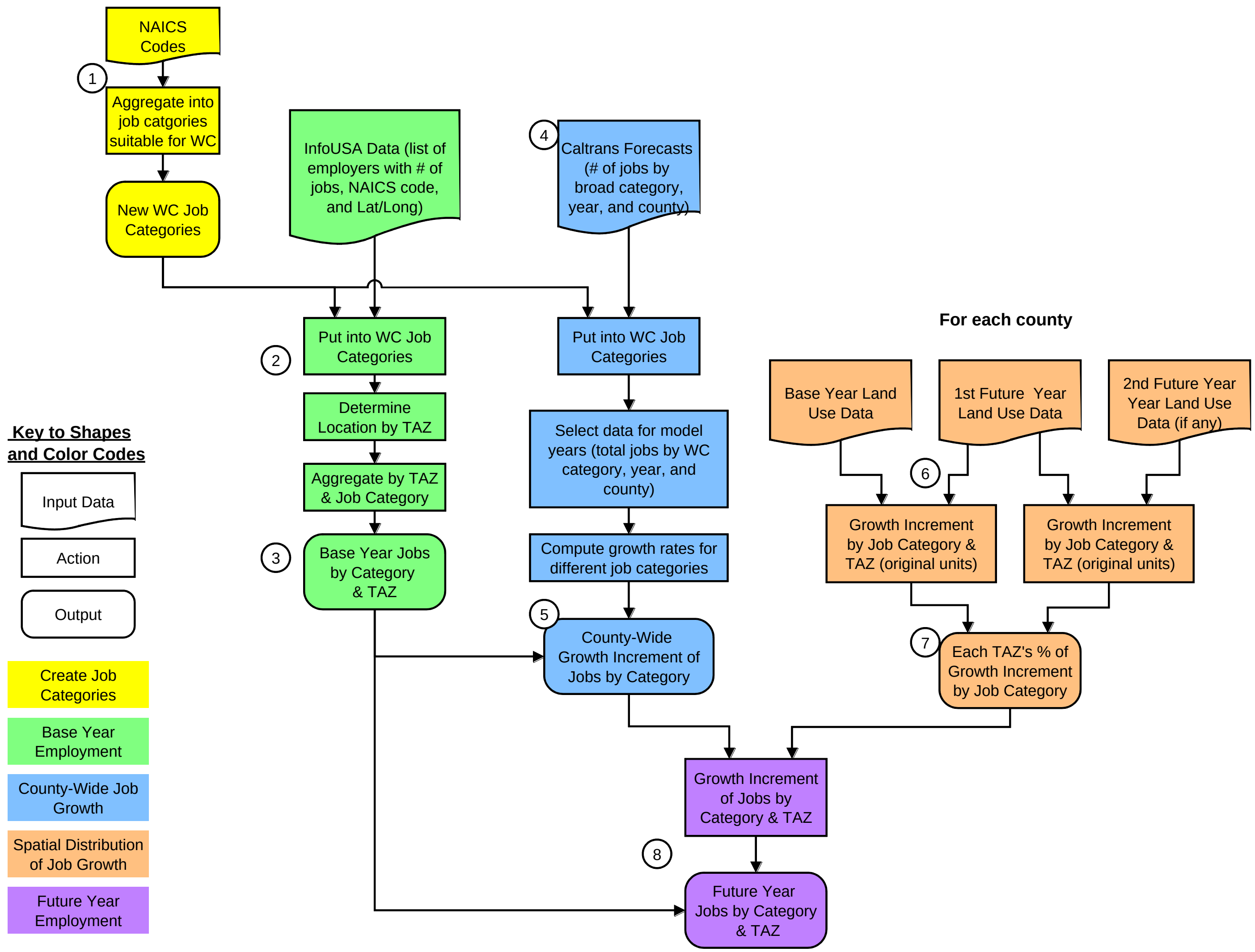

Figure 8: Development of Base and Future-Year Employment Figures

2) The InfoUSA data was then aggregated into the Wine Country job categories and TAZ system.
3) The result is the base year employment data in a format ready for use in the model. This data is summarized in Table 6.
4) We then downloaded the employment forecasts from the website of Caltrans' Office of Transportation Economics for the four counties in the Wine County region. This data is shown in Appendix E.
5) The Caltrans data was then used to compute growth rates by employment category, as shown in Appendix F.
6) The future year forecasts for each county-level traffic model were then checked to determine the total growth by land use category. This information was in a variety of different units such as acres, square feet of building space, and jobs. In some cases it was necessary to convert the land uses that fell within a single Wine Country employment category to common units so that they can be combined for mathematical purposes. If, for example, a local model measured hotels in units of beds and golf courses in units of acres then it would be necessary to convert them both to a common unit, such as trips/day or jobs, so that they can be meaningfully added together.
7) The percent of total growth in each employment category that occurred in each TAZ was then computed.
8) The growth in employment by category was then distributed to each TAZ based on its percentage share of total growth to produce the future year forecast of jobs by category for each TAZ.

<table>
<tr><th colspan="4">Table 5: Correspondence between Category Systems</th></tr>
<tr><th></th><th>NAICS Major Categories</th><th>Wine Country Category</th><th>Caltrans Employment Categories</th></tr>
<tr><td>11</td><td>Agriculture, Forestry, Fishing and Hunting</td><td>Agriculture</td><td>Farm</td></tr>
<tr><td>44-45</td><td>Retail Trade</td><td>Retail Trade</td><td>Wholesale & Retail Trade</td></tr>
<tr><td>71</td><td>Arts, Entertainment, and Recreation</td><td rowspan="3">Leisure & Recreation</td><td rowspan="3">Leisure</td></tr>
<tr><td>72</td><td>Accommodation and Food Services</td></tr>
<tr><td>312130</td><td>Wineries</td></tr>
<tr><td>62</td><td>Health Care and Social Assistance</td><td>Health</td><td>Health & Education</td></tr>
<tr><td>21</td><td>Mining</td><td rowspan="6">Industry</td><td rowspan="2">Mining & Construction</td></tr>
<tr><td>23</td><td>Construction</td></tr>
<tr><td>31-33</td><td>Manufacturing (except Wineries)</td><td>Manufacturing</td></tr>
<tr><td>22</td><td>Utilities</td><td rowspan="2">Transportation & Utilities</td></tr>
<tr><td>48-49</td><td>Transportation and Warehousing</td></tr>
<tr><td>42</td><td>Wholesale Trade</td><td></td></tr>
<tr><td>52</td><td>Finance and Insurance</td><td rowspan="9">Other</td><td rowspan="2">Financial Activities</td></tr>
<tr><td>53</td><td>Real Estate and Rental and Leasing</td></tr>
<tr><td>54</td><td>Professional, Scientific, and Technical Services</td><td rowspan="2">Professional Services</td></tr>
<tr><td>81</td><td>Other Services (except Public Administration)</td></tr>
<tr><td>51</td><td>Information</td><td>Information</td></tr>
<tr><td>92</td><td>Public Administration</td><td>Government</td></tr>
<tr><td>55</td><td>Management of Companies and Enterprises</td><td rowspan="3">Other</td></tr>
<tr><td>56</td><td>Administrative and Support and Waste Management and Remediation Services</td></tr>
<tr><td>99</td><td>Unclassified Establishment</td></tr>
</table>

Table 6: Base Year Employment by County and Category								
Sector	**NAICS Code**	**Description**	**Lake**	**Mendocino**	**Napa**	**Sonoma**	**Total**	**Percent of Total**
Agriculture								
	11	Agriculture, Forestry, Fishing and Hunting	1,266	2,261	3,724	4,106	**11,357**	**3.5%**
Industry								
	21	Mining	13	19	57	206	295	0.1%
	22	Utilities	570	98	196	300	1,164	0.4%
	23	Construction	1,090	1,928	4,384	16,367	23,769	7.4%
	31-33	Manufacturing (except Wineries)	353	1,942	4,436	15,552	22,283	6.9%
	42	Wholesale Trade	824	1,587	2,047	10,228	14,686	4.6%
	48-49	Transportation and Warehousing	242	525	1,477	4,497	6,741	2.1%
		Subtotal	**3,092**	**6,099**	**12,597**	**47,150**	**68,938**	**21.4%**
Retail								
	44-45	Retail Trade	**2,121**	**5,073**	**6,583**	**25,743**	**39,520**	**12.3%**
Leisure & Recreation								
	71	Arts, Entertainment, and Recreation	760	1,104	2,171	3,113	7,148	2.2%
	72	Accommodation and Food Services	1,200	3,847	8,697	18,275	32,019	9.9%
	312130	Wineries	125	334	6,685	3,751	10,895	3.4%
		Subtotal	**2,085**	**5,285**	**17,553**	**25,139**	**50,062**	**15.5%**
Education								
	61	Educational Services	**1,429**	**3,535**	**7,038**	**13,202**	**25,204**	**7.8%**
Health Care and Social Assistance								
	62	Health Care and Social Assistance	**2,099**	**4,244**	**7,137**	**21,517**	**34,997**	**10.9%**
Other Services								
	51	Information	146	508	784	3,651	5,089	1.6%
	52	Finance and Insurance	404	844	1,713	7,892	10,853	3.4%
	53	Real Estate and Rental and Leasing	624	1,023	1,447	5,524	8,618	2.7%
	54	Professional, Scientific, and Technical Services	547	1,270	2,881	12,817	17,515	5.4%
	55	Management of Companies and Enterprises	0	0	0	26	26	0.0%
	56	Administrative and Support and Waste Management	431	825	1,955	6,013	9,224	2.9%
	81	Other Services (except Public Administration)	1,639	1,767	2,725	12,696	18,827	5.8%
	92	Public Administration	1,478	3,082	3,695	11,794	20,049	6.2%
	99	Unclassified Establishment	62	765	237	1,117	2,181	0.7%
		Subtotal	**5,331**	**10,084**	**15,437**	**61,530**	**92,382**	**28.6%**
		Total	**17,423**	**36,581**	**70,069**	**198,387**	**322,460**	**100.0%**

This approach worked fairly well but we encountered a few problems. For example, the Sonoma County model does not include agricultural employment and the Lake County model does not cover employment in the health sector, and so these models provided no guidance on the spatial distribution of the employment growth predicted by Caltrans would occur within the county. Under such circumstances we fell back on the standard modeling approach which is, "if no data exists to support assumptions about a change, then assume that no change will occur". In this case we assumed that there would be no change in the spatial distribution of employment for these sectors (agriculture and health) and simply factored the employment in each TAZ up or down by the county-level growth factor for that sector. The growth in employment is discussed further in Chapter 7 of this report.

Schools

School-related trips make up a substantial percentage of total trips in the study area and therefore it is essential that the locations and size of schools be properly identified within the model. School location and enrollment data was obtained from three primary sources: School Accountability Report Cards, the National Center for Education Statistics, and public databases.

The Wine Country Model makes direct use of three types information related to individual schools: school type (i.e. K-9 or high school), enrollment, and physical location. School type is important because different school types have different trip generation rates. Enrollment is the primary measure of school size used in the trip generation step, and location informs the model of which TAZ will be the locus of the trips.

The best source for school enrollment information was the schools themselves through their websites. The first step in gathering this information was to compile a list of all public schools in each county from school district websites. For those schools that did not list their enrollment statistics on their websites, the second source of information was their School Accountability Report Card (SARC)[2], which is available at http://www.cde.ca.gov/ta/ac/sa/. The most recent SARC currently available is for most schools was for the 2007-2008 school year, but in some case the data was for the 2008-2009 school year.

A third source of school related information is the National Center for Education Statistics (NCES) database. The NCES is a federal organization that compiles education statistics on public schools nationwide. We used this data, all of which came from the 2006-2007 school year, whenever a school did not provide a SARC or if the SARC available contained data older than 2006-2007.

For the private schools and three of the public schools SARCs were not available and the schools were not listed by NCES. In those cases we utilized publicly available online databases such as www.greatschools.net, www.publicschoolreview.com, and www.privateschoolreview.com. While we consider these sources to be less reliable than SARC, the enrollment sizes of the schools in question were small and so any error is unlikely to have a significant impact on the overall accuracy of the model.

Once we had compiled data concerning school names, addresses, and enrollment we sorted the data by school district, in the case of public schools, and by city, in the case of private schools. TransCAD has a built-in database that displays public school locations. We used this database, in conjunction with Google Earth and the physical addresses already obtained, to locate each of the schools and

[2] Proposition 98, which was passed in 1988, requires that each school annually publish a SARC and make it available to the public

identify which local model TAZ they are in. Data for each school, including district/city, name, enrollment, and TAZ are presented in Appendix H. By identifying the TAZ location of each school we will be able to accurately assign trip generation and trip attraction rates based on school type.

As our final task we performed a reasonableness check by summing the total number of enrolled students for each county and then compare that value with the total number of students enrolled in kindergarten to high school according to the U.S. Census Bureau's American Community Survey for 2007 (the most recent year for which data is available). The results of this comparison are summarized in Table 7.

Table 7: Reasonableness Check of K-12 Enrollment Data

County	Enrollment from District, SARC, & Other Sources	ACS 2007 Enrollment (For Comparison)	% Difference
Lake	10,361	11,086	+7%
Mendocino	14,390	13,682	-5%
Napa	23,592	21,532	-9%
Sonoma	78,763	77,777	-1%

Table 7 shows that the differences between the numbers of students enrolled in schools and the number of students in the American Community Survey are relatively small; less than 10% in every case. This indicates that the school enrollment data probably does not contain any major omissions or cases of double-counting.

Colleges

As was the case for schools, trip generation for colleges is typically based on the number of students enrolled at each campus. Our main sources of data on college enrollment were https://misweb.cccco.edu/mis/onlinestat/studdemo_annual_college.cfm, http://nces.ed.gov/collegenavigator/, and http://www.californiacollegesearch.com/. In cases where enrollment information was not available from these sources we relied on individual college websites and in many cases, phone calls to the colleges in order to obtain enrollment statistics.

Table 8 displays the enrollment data and TAZ for each college in the region.

Table 8: Colleges in the Wine Country			
County	**Name**	**Enrollment**	**WC-TDM TAZ**
Lake	Mendocino College: Lake Campus	816[A]	1981
	Yuba College: Clear Lake Campus	1,000	1940
Mendocino	College of the Redwoods	350	4448
	Dharma Realm Buddhist University	[C]	4225
	Dominican University of California	2,125	4224
	Mendocino College: Ukiah Campus	4,031[A]	4202
	Mendocino College: Willits Center	1,030[A]	4322
Napa	Culinary Institute of America at Greystone	200	2175
	Napa Valley College	15,142[A]	2116
	Napa Valley College: Upper Valley Campus		2200
	Pacific Union College	1,363	2191
Sonoma	Bauman College	40	3248
	Empire College School of Business	900	3676
	Lytle's Redwood Empire Beauty College Inc	95	3110
	Santa Rosa Junior College: Main Campus	21,000	3689
	Santa Rosa Junior College: Windsor	1,000	3858
	Santa Rosa Junior College: Petaluma	7,000	3328
	Sky Hill Institute of Wholistic Healing Arts	20	3313
	Sonoma State University	8,770	3403
	University of Integrated Science, California	[C]	3542
	Total	64,917	

Notes:

[A] Some students attend classes at more than one campus, so the sum of the enrollment total for all campuses will be higher than the total enrollment for the college as a whole.

[B] The TAZ cannot be identified until we receive the awaiting TAZ boundaries from Mendocino County

[C] We were unable to obtain data on enrollment

5. TRAVEL BEHAVIOR DATA

Traffic models must distinguish between different types of trips in order to match trips to appropriate starting and ending land uses and to reflect a realistic distribution of trip lengths. This chapter describes our work in obtaining data related to trip distribution by purpose and length from both the U.S. Census Bureau and the 2000-2001 California Statewide Household Travel Survey. This data was used to help calibrate and validate the Wine Country Travel Demand Model.

Trip Purposes

The Wine Country Model uses the three trip categories traditionally found in traffic models, plus four additional categories that were added because their locations and temporal distributions were considerably different from the traditional categories. The trip purposes used in the model are:

Home-Based Work (HBW) Trips: These are trips between the traveler's residence and his/her workplace

Home-Based School (HBSch) Trips: These are trips between the traveler's residence and an elementary, junior high, or high school

Home-Based College (HBColl) Trips: These are trips between the traveler's residence and a college

Recreational (Recr) Trips: These are trips to recreational attractions that draw a high percentage of users from outside the county. For example, wineries and state parks get a much higher percentage of visitors from outside the county than most retail establishments and so need to be classified separately

Home-Based Other (HBO) Trips: These are all other trips with one end at the traveler's home that do not fall into any of the preceding categories. Shopping trips at neighborhood-serving retail, for example, are HBO trips.

Non-Home-Based (NHB) Trips: All trips where neither end is the traveler's home are non-home-based trips. This includes such things as trip chaining between stores or from an office to a meeting.

Data on the distribution of trips among these purposes was obtained from the *2000-2001 California Statewide Household Travel Survey*. This survey was undertaken by Caltrans specifically to support this aspect of model development. Tables 9 and 10, which are based on data from the *Statewide Household Travel Survey*, record the distribution of trips by these purposes. Several things can be learned from these tables:

- Table 9 shows that the overall trip generation rates are a bit higher in Napa and Sonoma Counties than in Lake and Mendocino Counties. This is expected given the more suburban character of the former compared to the latter (suburban areas typically have higher trip generation rates than rural areas).

Table 9: Statewide Household Travel Survey - Number of Trips by Purpose									
County	**Total # of HH**	**HBW**	**HBO**		**NHB**		**Total # of Trips**		**Ave. Trip /HH**
		Total Trips	**Total Trips**	**HB School**	**Total Trips**	**Non-HB School**	**Total Trips**	**School-related**	
Lake	192	134	616	90	475	59	1,225	149	6.38
Mendocino	171	148	593	90	451	52	1,192	142	6.97
Napa	79	66	304	43	222	33	592	76	7.49
Sonoma	122	123	450	79	377	70	950	149	7.79
Total	564	471	1,963	302	1,525	214	3,959	516	7.02

41% of school-related trips are non-home-based

Table 10: Statewide Household Travel Survey - Percent of Trips by Purpose							
County	**HBW**	**HBO**		**NHB**		**Total % of Trips**	
	% of Trips	**% of Trips**	**HB School**	**% of Trips**	**Non-HB School**	**% of Trips**	**School Related**
Lake	11%	50%	7%	39%	5%	100%	12%
Mendocino	12%	50%	8%	38%	4%	100%	12%
Napa	11%	51%	7%	38%	6%	100%	13%
Sonoma	13%	47%	8%	40%	7%	100%	16%
Average	12%	50%	8%	39%	5%	100%	13%

- Table 10 indicates that there is little variation in the distribution of trips by purpose between the counties. This means that a single set of trip purpose distribution figures will suffice for the study area.
- We also looked at school trips as a sub-component of HBO and NHB trips. We found that 13% of all trips had a school as either the original or the destination. This is a significant portion of trip-making in the region and shows the need for good information on school enrollments from the local school districts.
- Note also that 41% of school trips were NHB, meaning that the traveler's home was not the other end of the trip. This shows the importance of drop-off trips (trip chaining) for this particular component of travel.

Table 11 shows a reasonableness check done by comparing the data for the Wine Country with other parts of California that are analogous in some way. The distribution of trip-making among various purposes in the study area is consistent with that of comparable areas and was therefore deemed to be a reasonable basis for planning.

Table 11: Reasonableness Check of Trip Purposes				
Comparison Areas	**HBW**	**HBO**	**NHB**	**Total**
San Luis Obispo County[A]	11%	58%	32%	100%
Tuolumne County[B]	18%	46%	36%	100%
Santa Barbara County[C]	15%	56%	29%	100%
SACOG Region[D]	17%	51%	31%	100%
Average	12%	50%	39%	100%
Wine Country Model	12%	50%	39%	100%

[A] *SLOCOG Model Development Report*

[B] *Tuolumne County Model Development Report*

[C] *SBCAG TDM Update Report*

[D] *SACMET01 Model Update Report*

Trip Generation by Household Income

It has long been observed that the number of vehicle-trips per household rises with income. For the Wine Country Model we used trip records from the 2000 Statewide Household Travel Survey and the Bay Area Transportation Study 2000 survey to develop trip generation rates by income group. These are shown in Table 12:

Table 12: Trip Generation Rates by Income						
	Income $0-30k		**Income $30-100k**		**Income $100k+**	
Purpose	**Single-Family**	**Multi-Family**	**Single-Family**	**Multi-Family**	**Single-Family**	**Multi-Family**
HBW Low Income	0.664	0.664				
HBW Medium Income			1.343	1.343		
HBW High Income					1.343	1.343
HB School	0.406	0.218	0.406	0.218	0.406	0.218
HB College	0.108	0.039	0.108	0.039	0.108	0.039
HB Other	2.296	1.779	2.296	1.779	2.296	1.779
Non Home-Based	1.536	1.121	1.818	1.200	2.612	1.200
IX	0.425	0.405	0.976	0.694	1.038	0.694
Total Home-Based	3.899	3.106	5.129	4.073	5.190	4.073
Total	5.435	4.227	6.946	5.273	7.802	5.273

Note that work trips have been separated into by income group in order to facilitate a fine-grained analysis of commuting patterns. Trip attraction rates are also disaggregated by income group, as shown in Table 13 below. The rates shown in Table 13 were also developed through regression analysis of trip records from the 2000 Statewide Household Travel Survey and the Bay Area Transportation Study 2000 survey.

Table 13: Trip Attraction Rates										
Attractor	**Home-Based Work trips, Low Income**	**Home-Based Work trips, Medium Income**	**Home-Based Work trips, High Income**	**Home-Based School Trips**	**Home-Based College Trips**	**Home-Based Other trips**	**Non-Home-Based trips**	**External-to-Internal**	**Total**	**Total double-counting NHB***
single-family dwelling units	-	-	-	-	-	0.500	0.338	0.248	1.086	1.42
multi-family dwelling units	-	-	-	-	-	0.500	0.337	0.248	1.086	1.42
K-8th grade students	-	-	-	0.716	-	-	0.500	-	1.216	1.72
high school students	-	-	-	0.716	-	-	0.500	-	1.216	1.72
college students	-	-	-	-	0.152	-	0.165	-	0.317	0.48
retail employees	0.161	0.557	0.281	-	-	4.210	3.301	0.340	8.851	12.15
leisure/ recreational employees	0.197	0.576	0.227	-	-	1.858	1.798	0.340	4.996	6.79
health sector employees	0.128	0.502	0.369	-	-	3.168	1.862	0.340	6.370	8.23
industrial employees	0.100	0.562	0.338	-	-	-	-	0.340	1.340	1.34
other employees	0.136	0.485	0.379	-	-	0.851	1.244	0.340	3.435	4.68
agricultural employees	0.183	0.483	0.334	-	-	-	-	0.340	1.340	1.34

* When considering the total trip generation and attraction rates for any given type of land use it is important to remember that the rate for Non-home-based trips counts both for productions and for attractions.

Journey-To-Work Data from U.S. Census

The Inter-Regional Partnership agencies emphasized that the jobs/housing balance within the study area is an issue of central concern to them, and that they would like the model to help them to analyze this issue. We therefore analyzed the journey-to-work data from the U.S. Census Bureau. The county-level data for the study area is summarized in Tables 14 and 15 which report, respectively, the workplace of employed persons residing in each county and the place of residence of persons whose workplace is in each county. There are also some columns aggregating external counties into logical groupings.

Several things can be learned from these tables:

- Intra-county flows, shown in blue font in Table 14, indicate that 83% of study area residents work in their home county.
- Similarly, the intra-county flows shown in Table 15 indicate that 89% of the people working in the study area live in the same county as their workplace.
- Approximately 14% of employed residents of the four study counties work outside the study area (Table 14) and approximately 7% of the study area workforce comes from outside the area.
- As of the last census, there were relatively few people making an inter-county commute within the study area. That said, it doesn't take much commuting traffic to create congestion on a relatively sparse network of 2-lane rural roads.

Table 14: Workplaces of Employed Persons Residing in Study Area

		Workplace								
		Inside Study Area				External Areas				
	County	**Lake**	**Mendo-cino**	**Napa**	**Sonoma**	**East**	**East Bay**	**Marin & South**	**North**	**TOTAL**
Residence	**Lake**	**15,566**	1,013	762	1,415	165	268	599	39	19,827
Residence	**Mendocino**	254	**35,427**	19	1,023	79	202	358	138	37,500
Residence	**Napa**	58	23	**44,341**	2,146	390	3,222	6,944	37	57,161
Residence	**Sonoma**	323	545	3,030	**184,423**	379	5,501	29,978	43	224,222
	TOTAL	16,201	37,008	48,152	189,004	1,013	9,193	37,879	257	338,710
	% of TOTAL	4.8%	10.9%	14.2%	55.8%	0.3%	2.7%	11.2%	0.1%	100.0%

14%

Table 15: Place of Residence of Persons Employed in Study Area

			Workplace						
		County	**Lake**	**Mendocino**	**Napa**	**Sonoma**	**TOTAL**	**% of TOTAL**	
Place of Residence	**Inside Study Area**	**Lake**	**15,566**	1,013	762	1,415	18,756	6.0%	
		Mendocino	254	**35,427**	19	1,023	36,723	11.7%	
		Napa	58	23	**44,341**	2,146	46,568	14.8%	
		Sonoma	323	545	3,030	**184,423**	188,321	60.0%	
	External Areas	**East**	125	80	620	584	1,409	0.4%	7%
		East Bay	94	84	9,866	4,465	14,509	4.6%	
		Marin & South	79	230	1,089	5,747	7,145	2.3%	
		North	31	144	66	110	351	0.1%	
		TOTAL:	16,530	37,546	59,793	199,913	313,782	100.0%	

Trip Length Distribution for HBW Trips

Trip length distribution is an important part of any traffic model, but is particularly important for the Wine Country Model whose main purpose is to forecast relatively long trips between counties. Information on trip length distribution was used to calibrate the model; specifically, it was used to adjust the friction factors used in the trip distribution step.

The two best sources of trip length information are the U.S. Census 2000, which has an extensive database for home-based work trips, and the *Statewide Household Travel Survey*, which is a much smaller survey but includes several trip purposes. The two sources are not in exact agreement (see Figure 9) because both surveys rely on people's imperfect recollection of travel times. Moreover, there is a general tendency to under-report short trips when filling out the survey forms. Despite these imperfections the survey data can nevertheless be considered reasonably indicative of the distribution that should occur in the model.

Figure 10 shows the trip length distribution for HBW trips for each county based on the data from the *Statewide Household Travel Survey*. Several things can be learned from Figure 10:

- Mendocino County has a high proportion of short work trips (38% are less than 10 minutes long). This is because of the high percentage of the people who live and work in the same town.
- Napa County has a relatively high proportion of long work trips (10% are more than an hour long). It is likely due to the fact that Napa it is functionally connected to workplaces in the Bay Area.

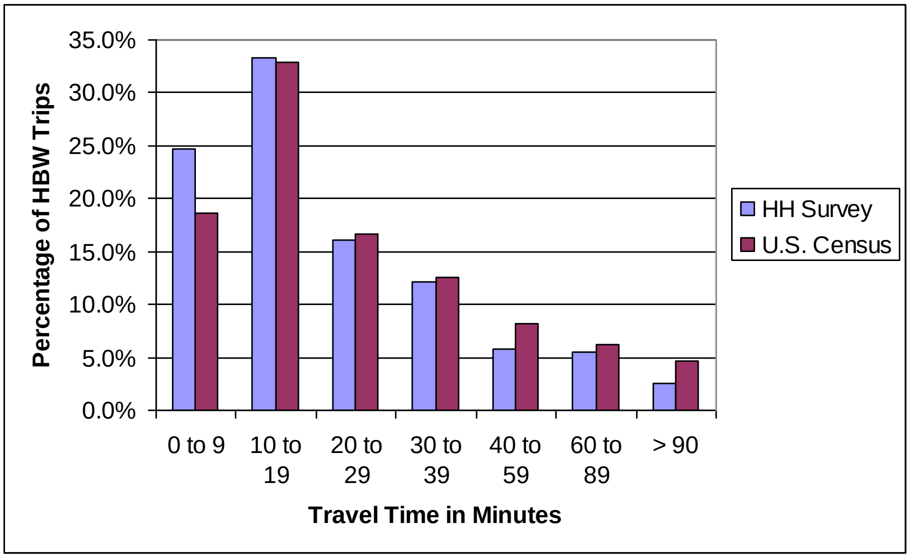

Figure 9: Trip Length Distribution for HBW Trips in Statewide HH Survey and U.S. Census

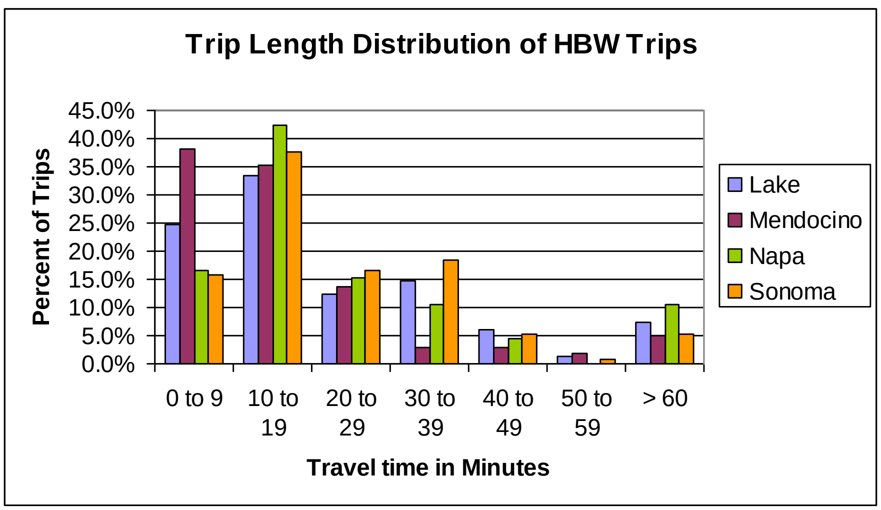

Figure 10: Trip Length Distribution by County for HBW Trips (Statewide HH Survey)

Comparison of Trip Length Distribution by Purpose

Figure 11 compares the trip length distribution for the three major trip purposes for the households in our study area. It shows the expected pattern of NHB trips being the shortest, HBW trips being the longest, and HBO trips in between.

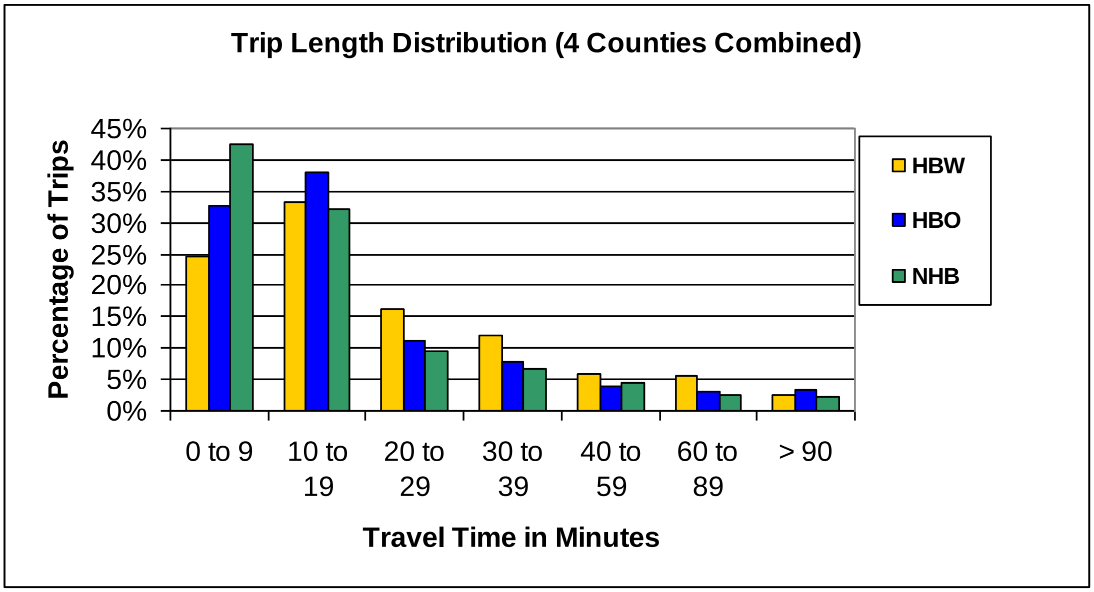

Figure 11: Comparison of Trip Length Distribution by Trip Purpose

Origin-Destination Surveys

One of the chief concerns that prompted the formation of the Wine Country Inter-Regional Partnership (IRP) was the issue of jobs/housing balance and inter-county commuting. To get a better understanding of this issue the IRP commissioned an origin-destination survey in 2005, which was carried out the following year. A second survey was performed in 2009 as part of the data collection for the Wine Country Model.

Survey Methodology

The same methodology was used for the 2005 and 2009 origin-destination surveys. The methodology consisted of the following steps:

Traffic Counts **-** 24-hour traffic counts were collected at the survey locations in both directions on the same day that license plate data was collected.

License Plate Data - The survey team recorded the license plate numbers for vehicles during the AM and PM peak periods, from 6-9 AM and 3-6 PM at each location, in both directions. At most sites the license plate numbers were recorded manually. However, this was not practicable for US-101 at the Marin/Sonoma boundary because of the high speed, close spacing, and heavy volume of traffic. We therefore used video cameras to record the license plates at this location.

Address Matching - We then worked with the Department of Motor Vehicles to obtain registration address information corresponding to those license plates.

Survey Implementation - A letter was then sent to each registered owner asking them to respond to six questions and then mail the response in an enclosed stamped pre-addressed envelope. To maintain as much consistency as possible, the survey instrument that was used in the original O-D survey was repeated except for updates to the location, date, and "if you have questions" section of the sheet. A minor modification was also made to note that the trip being asked about is the trip that occurred on the specific date that their license plate was recorded. This change enabled us to make a clear distinction between Friday trips and normal weekday trips. A copy of the survey instrument in attached as Appendix B.

The returned surveys were later entered into a spreadsheet for analysis.

One important difference between the 2005 survey and the 2009 survey is that the newer survey covers trips in the peak periods (only) while the old survey included trips throughout the day. This allowed for analysis of both peak hour and daily traffic patterns.

Results of the 2005 Survey

The 2005 survey covered five locations near the boundaries between IRP counties (see Figure 12) and collected information from approximately 1,600 vehicle trips.

The trips purposes reported in the survey were as shown in Table 16.

Table 16: Trip Purpose in 2005 Survey

Count Site	Work	Shopping & Errands	Recreation & Touring	School	Other	Total
SR-20 (Lake/Mendocino)	22%	45%	21%	2%	10%	100%
US-101 (Sonoma/Mendocino)	31%	32%	20%	4%	13%	100%
SR-29 (between Napa and Lake)	39%	30%	14%	4%	13%	100%
Petrified Forest Rd (Napa/Sonoma)	37%	42%	10%	3%	8%	100%
SR-121 (Napa/Sonoma)	53%	21%	16%	1%	9%	100%

The table shows that all of these routes are used both as commuter routes and discretionary trips such as shopping, errands, and recreation. There are degrees of difference; SR-121 is primarily a commuter route, while discretionary trips predominate on the surveyed sections of SR-20, US-101, and Petrified Forest Road. There are two plausible explanations for the high percentage of discretionary trips on all of the routes except SR-121. One is that Santa Rosa is a regional attraction for shopping and other urban services but not for people from the City of Napa, who have other options. The other is that traffic conditions on SR-121 are bad enough to discourage discretionary trips which would otherwise occur in similar proportions to the other survey sites. Both factors may be at work to some extent.

The main results of the 2005 survey in terms of origin-destination patterns were:

<u>SR-20 (between Lake and Mendocino Counties):</u> Of the trips made on SR 20 at the survey location, 70%, originate in Lake County and of these trips, 71% end in Mendocino County. Given that shopping and personal errands constitute the bulk of trips at this site it appears that Ukiah is providing urban services that may be unavailable locally in northern Lake County.

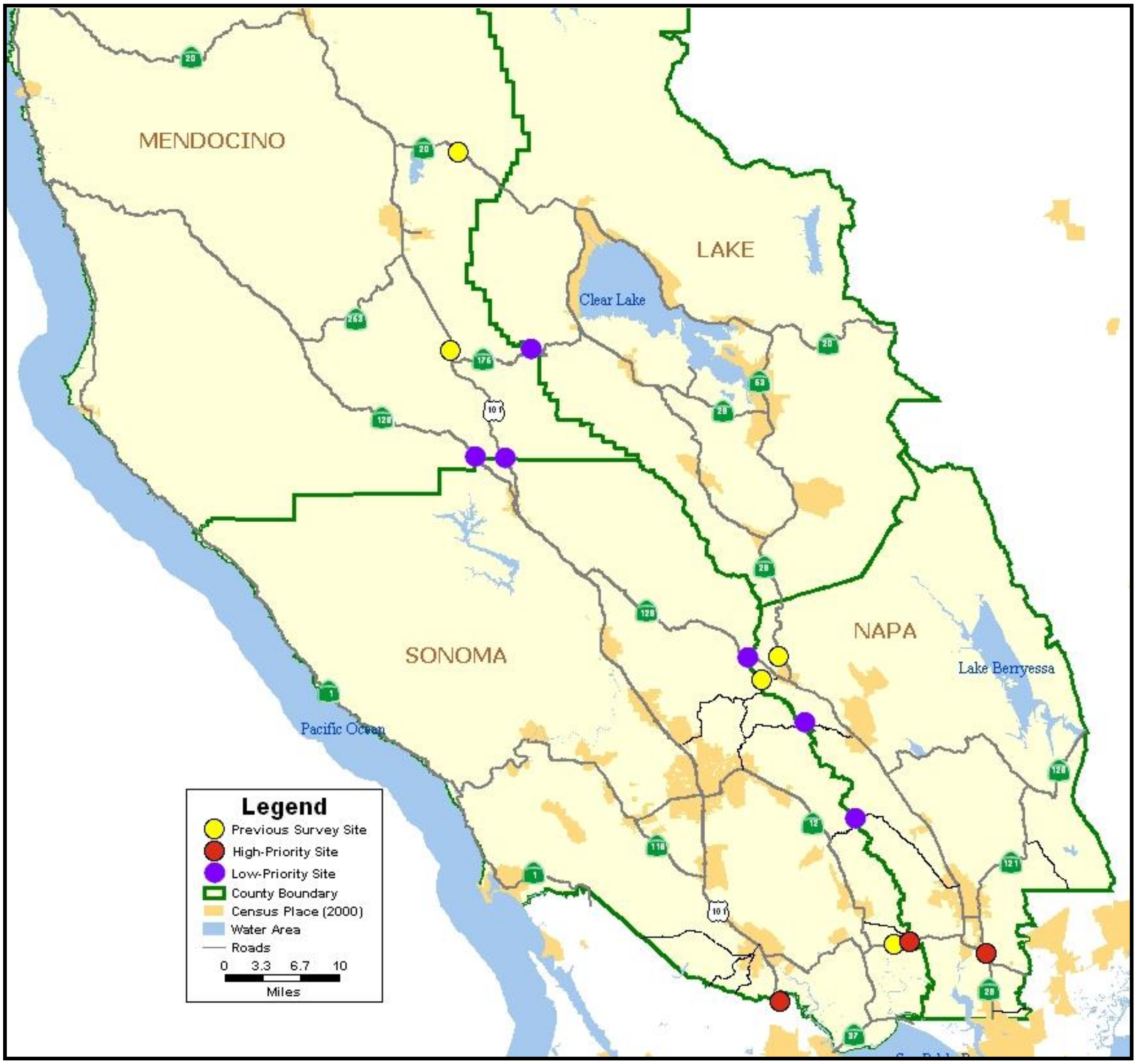

Figure 12: O-D Count Locations

<u>US-101 (between Sonoma and Mendocino Counties):</u> 56% of the trips on US 101 in the survey area originate in Mendocino County and 22% originate in Sonoma County. The site location seems to have been further north from the county boundary than is desirable, since one third off of the trips beginning in Mendocino County also ended in Mendocino County. A small percentage (about 3%) of the trips were through trips to or from Humboldt County.

<u>SR-29 (between Napa and Lake):</u> A majority (55%) of trips made on SR 29 in the survey area originate in Lake County and 28% originate in Napa County. Of the trips beginning in Lake County, 53% end in Napa and 18% end in Sonoma. Of trips originating in Napa, 42% end in Napa County and 37% end in Lake. As with the SR-20 site, it appears that Lake County residents are using this road to access jobs and services in neighboring counties. The 18% of Lake County trips going through to Sonoma County also affect the next site.

Petrified Forest Road (between Napa and Sonoma Counties): A majority of the trips (72%) were between Napa and Sonoma Counties. However, a substantial minority, 26%, were from Lake County, with more than three-quarters of these being between Lake and Sonoma Counties (some went to San Francisco or other counties). These results are consistent with the notion that Santa Rosa is a regional attraction not just as a workplace but also for the urban services it offers.

SR-121 (Napa/Sonoma): Of the trips surveyed at this location, 43% originate in Sonoma County, 36% in Napa County and 10% in Marin County. Of trips originating in Sonoma, 72% end in Napa County, while 28% pass through Napa to some other county, the two largest recipients being Sacramento (5%) and Solano County (4%). Unfortunately, this survey was conducted at a location west of the intersection with Napa Road and so missed the large volume of traffic that enters or leaves SR-121 there.

The 2005 survey yielded valuable information on travel behavior that had not previously been available to the IRP members. However, there were other locations that are important for inter-county movements that were not covered by the 2005 survey including two of the most important sites, US-101 between Marin and Sonoma Counties and SR-121 between Napa and Sonoma Counties. In addition, the most important[3] (in terms of traffic volume) of the five original sites was inadvertently surveyed at the wrong location which threw off the results. The IRP therefore made a second round of origin-destination surveying to supplement the 2005 survey as part of the scope of work on the current model development contract.

2009 Survey Sites

PB identified three high priority locations for supplemental O-D surveys, namely: State Route (SR) 121 between Napa and Sonoma Counties, SR-12/29 between Napa and Solano Counties, and US-101 between Sonoma and Marin Counties (see Figure 12). The first location was intended to replace the data collected in the 2006 survey by another consulting company but in the wrong location. The other two locations were intended to allow for a more robust mechanism to create internal-external trip tables directly from the data, rather than inferring them from more indirect sources. Detailed maps of the high-priority survey locations are attached as Appendix I.

In addition, there are a number of secondary inter-county routes that were not covered in the previous O-D survey that were worthwhile pursuing. These six sites were:

- SR- 128 at Napa / Sonoma County Line;
- US 101 at Sonoma / Mendocino County Line;
- US 128 at Sonoma / Mendocino County Line;
- SR- 175 at Lake / Mendocino County Line;
- St Helena Road at Napa / Sonoma County Line; and
- Dry Creek Road at Napa / Sonoma County Line.

The survey was performed on Thursday, September 10, 2009 at both the high- and low-priority sites. The survey was repeated on Friday September 11, 2009 for the high priority sites (only). It was important to conduct the Friday survey at both major external stations because it is expected that

[3] SR-121 between Napa and Sonoma Counties

those locations will prove particularly important to Friday travel. In contrast, a Friday O-D survey at just one of the internal inter-county locations was sufficient because the relationship between weekend and weekday travel at that location can be applied to the other internal inter-county survey locations.

Results of the 2009 Survey

A total of 12,782 survey forms were sent out to drivers. A total of 1,174 forms were returned, for an overall response rate of about 9%, which translates to a 95% confidence interval of 10% for the results. In other words, we can be 95% confident that the sampled results are within 10% of the actual item being estimated. However, this is the figure for the entire survey; some of the low priority sites had such small volumes of traffic that even a good response rate resulted in less than a dozen responses. Only limited use can be made of such data, typically by aggregating it with data from other sites in a screenline analysis.

Table 17 summarizes the results of the survey for trip purposes for weekday peak periods[4]. The overwhelming majority of trips are commutes to work, with personal errands running a distant second most common trip purpose. The percentage of work trips is almost twice as high in this survey as in the previous survey (73% versus 38%) presumably because the latter included trips taken in off-peak periods[5].

Table 18 shows the trip purposes for the Friday evening peak period. As expected, the percentage of work trips is lower and the percentage of trips for discretionary trips such as personal errands, shopping and recreation are much higher than on typical work days. This reinforces the idea that Friday traffic needs to be handled through a separate version of the model from weekday traffic.

Figures 13 through 17 show the origin-destination pattern for US-101 near the Marin/Sonoma county boundary. On typical weekdays the vast majority of traffic is either to or from the communities in south Sonoma County. However, northbound on Friday evening the percentage of trips north of Rohnert Park is twice as high as on other weekdays. So Friday traffic differs not only in amount and purpose but also in destinations.

Figures 18 through 23 show the origin-destination pattern for SR-12/29 near the Napa/Solano county boundary. During peak periods on weekdays more than 80% of the traffic on this highway is either to or from the City of Napa. A smaller but still significant portion of traffic is to or from Sonoma County. On Friday evenings the percentage of traffic to Sonoma is much higher (16% compared to 3%) than on other weekday evenings.

Figures 24 through 29 show the origin-destination pattern for SR-121 near the Napa/Sonoma county boundary. It appears from the survey that the vast majority of weekday peak period traffic on this highway is local traffic between the City of Napa and the Boyes Hot Springs/Sonoma/Petaluma area. On Fridays this section of highway carries a significant amount of traffic from outside the region that penetrates much further north in Napa and Sonoma Counties than typical weekday traffic.

[4] In cases where the driver listed two purposes both appear in Table 17. This was done to maintain consistency with the 2006 survey, which handled multiple purpose listings this way.

[5] It is likely that off-peak trips were over-sampled in the previous survey because teams taking manual notes on plate numbers find it easier to capture numbers when traffic is spread out a bit.

Table 17: Summary of Weekday Peak Period Trip Purposes

Results of the Current Survey	Traffic Volume (Daily)	Work/ Commute	School	Personal Errands	Shop-ping	Recreation /Touring	Total
US-101 at Sonoma/Marin County Line (San Antonio Road)	90,770	79%	5%	8%	3%	5%	100%
US 101 at Sonoma / Mendocino County Line (N. of Cloverdale)	12,150	62%	1%	15%	6%	15%	100%
US 128 at Sonoma / Mendocino County Line	1,500	44%	6%	13%	6%	31%	100%
SR-12/29 N. of Jameson Canyon Rd. (Napa/Solano)	64,900	71%	4%	9%	7%	10%	100%
SR-128 at Napa / Sonoma County Line	1,860	47%	6%	18%	6%	24%	100%
SR-121 W. of Napa Road (Napa/Sonoma)	25,780	67%	2%	9%	7%	14%	100%
St Helena Road at Napa / Sonoma County Line	610	100%	0%	0%	0%	0%	100%
Dry Creek Road at Napa / Sonoma County Line	580	57%	0%	14%	0%	29%	100%
SR- 175 at Lake / Mendocino County Line	3,200	75%	0%	17%	0%	8%	100%
Weighted Average		**73%**	**4%**	**9%**	**5%**	**9%**	**100%**

As expected, the percentage of discretionary trips is much higher on Friday evening than on other weekday evenings

Table 18: Summary of Friday Evening Trip Purposes

Results of the Current Survey	Traffic Volume (Daily)	Work/ Commute	School	Personal Errands	Shop ping	Recreation /Touring	Total
US-101 at Sonoma/Marin County Line (San Antonio Road)	90,770	52%	4%	20%	13%	12%	100%
SR12/29 N. of Jameson Canyon Rd. (Napa/Solano)	64,900	55%	5%	17%	9%	13%	100%
SR-121 W. of Napa Road (Napa/Sonoma)	25,780	41%	2%	20%	6%	31%	100%
Weighted Average		**51%**	**4%**	**19%**	**10%**	**15%**	**100%**

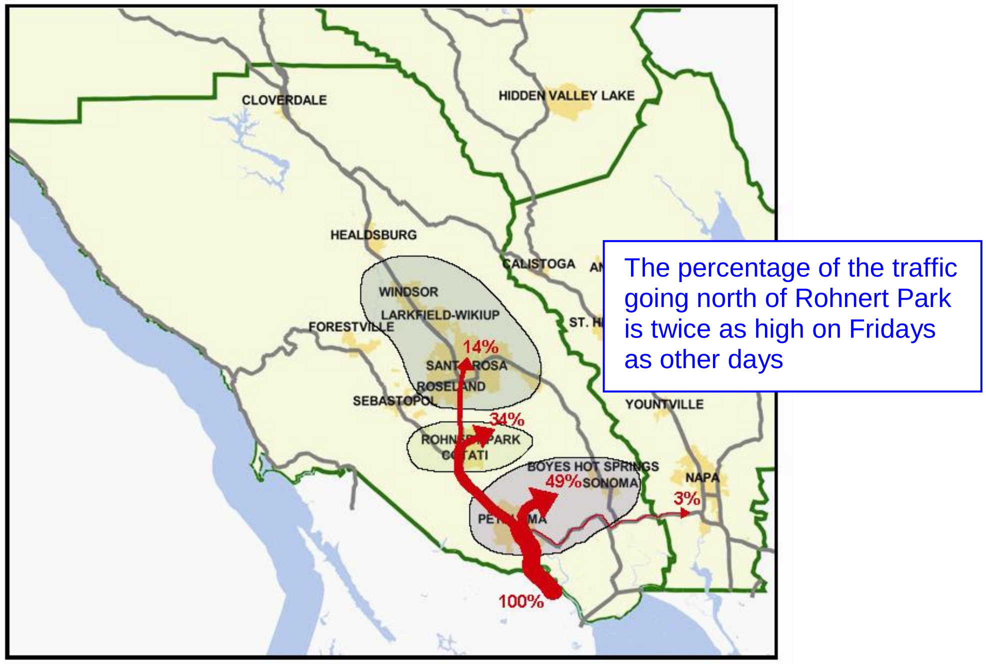

Figure 13: US-101 Northbound Weekday PM Peak

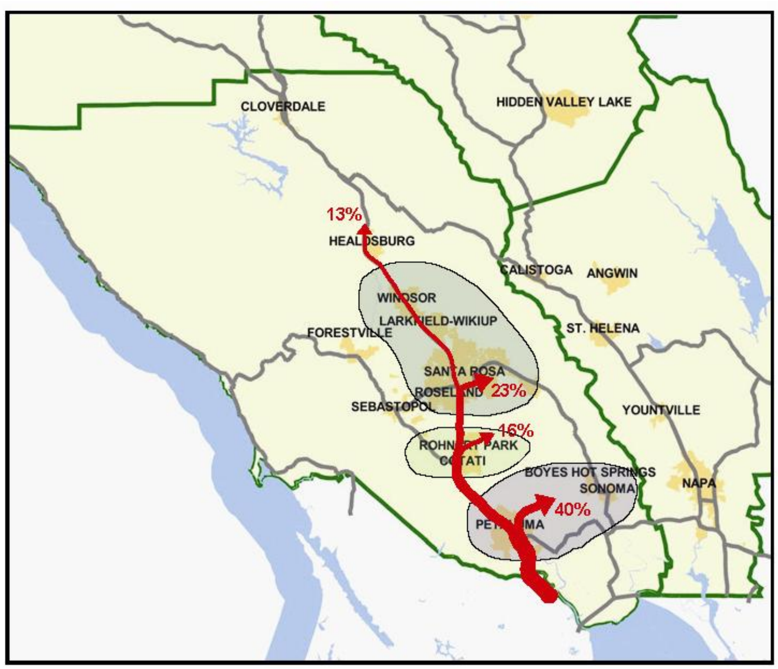

Figure 14: US-101 Northbound Friday PM Peak

The vast majority of traffic in this section of US-101 (Novato Narrows) is to or from south Sonoma County

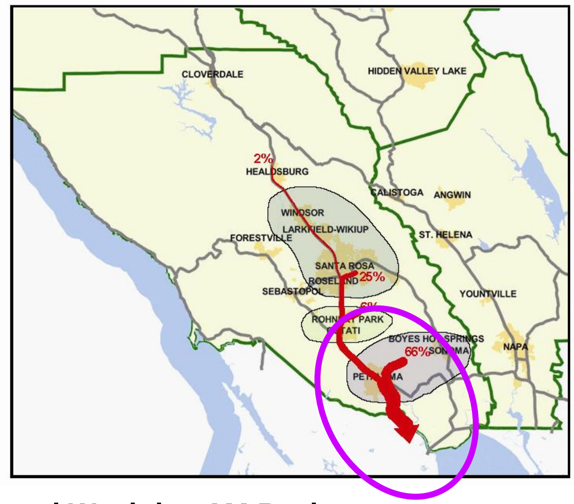

Figure 15: US-101 Southbound Weekday AM Peak

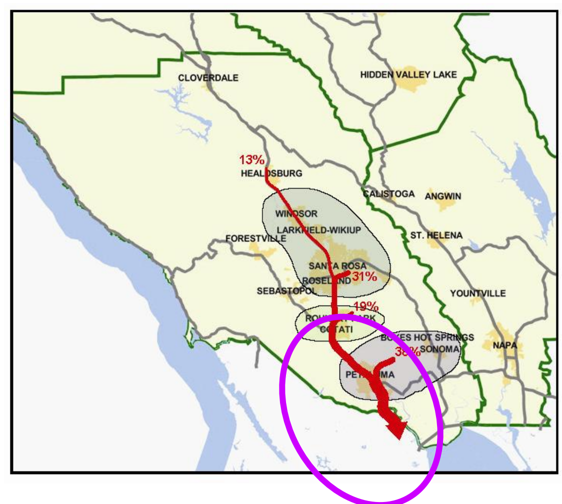

Figure 16: US-101 Southbound Weekday PM Peak

Southbound, the O-D pattern on Friday evening is much like that of other weekday evenings

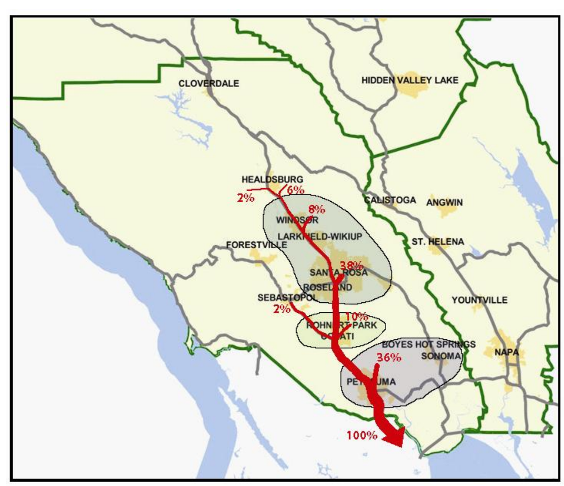

Figure 17: US-101 Southbound Friday PM Peak

80-some percent of the traffic on this section of SR-12/29 is associated with the City of Napa itself

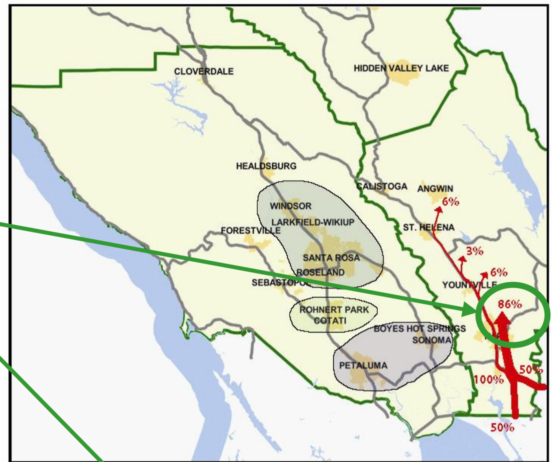

Figure 18: SR-12/29 Northbound Weekday AM Peak

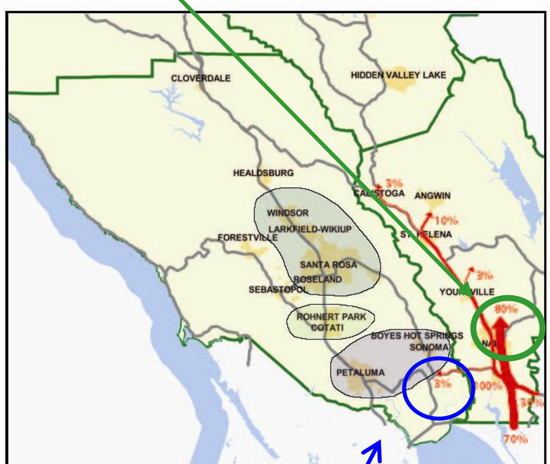

Figure 19: SR-12/29 Northbound Weekday PM Peak

SR-12/29 gets much more through traffic to Sonoma County on Fridays than on normal weekday evenings

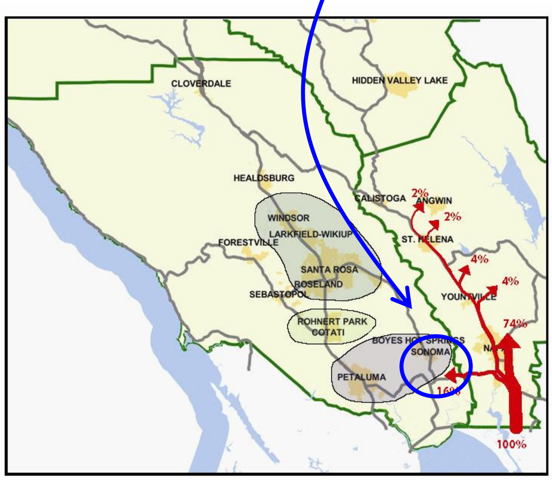

Figure 20: SR-12/29 Northbound Friday PM Peak

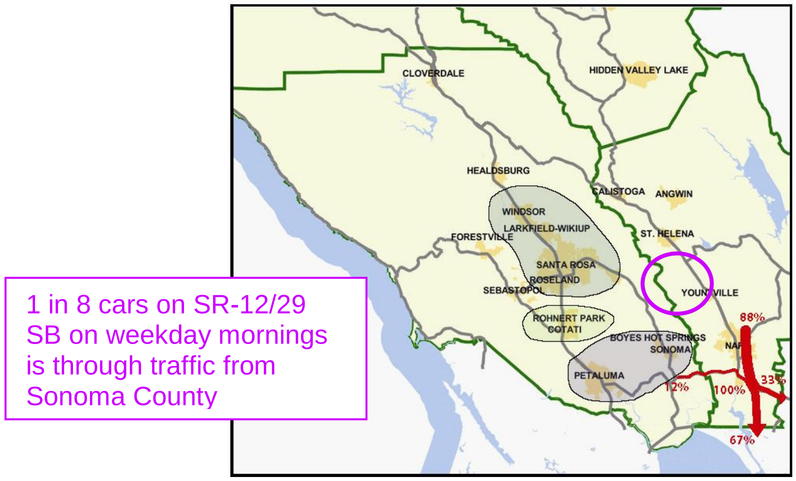

Figure 21: SR-12/29 Southbound Weekday AM Peak

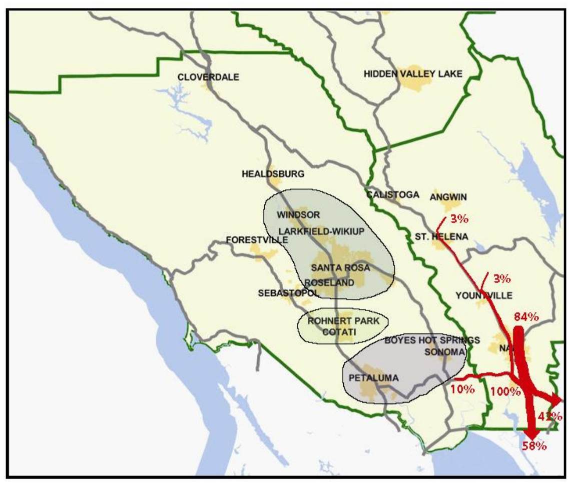

Figure 22: SR-12/29 Southbound Weekday PM Peak

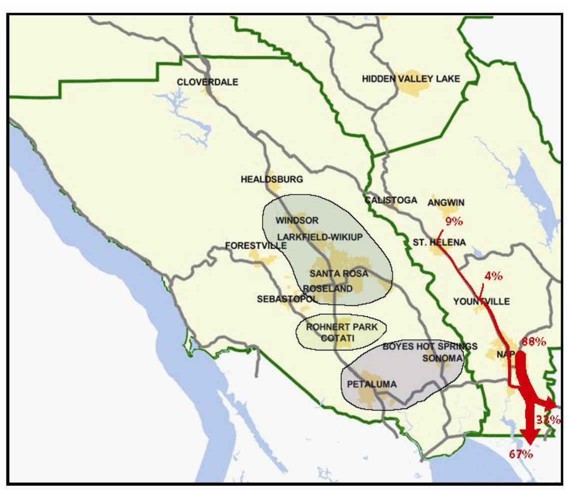

Figure 23: SR-12/29 Southbound Friday PM Peak

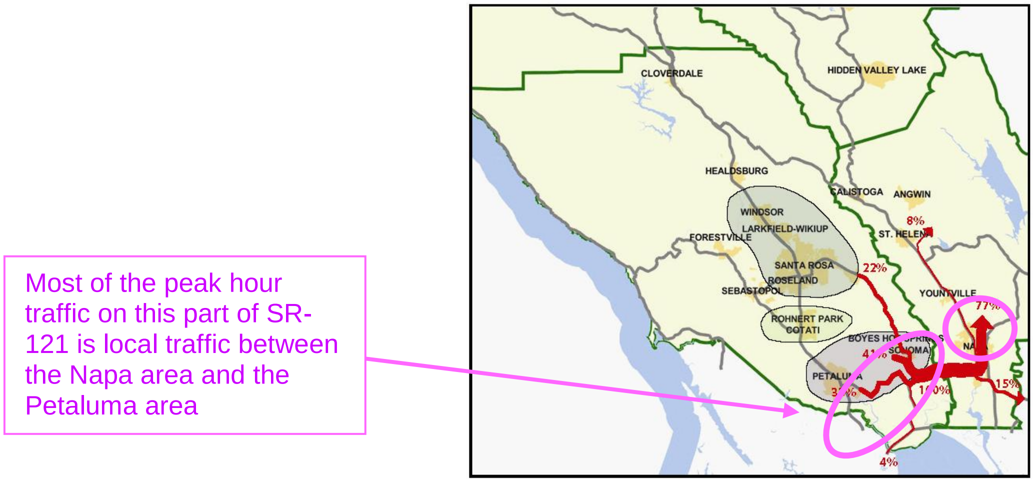

Figure 24: SR-121 Eastbound Weekday AM Peak

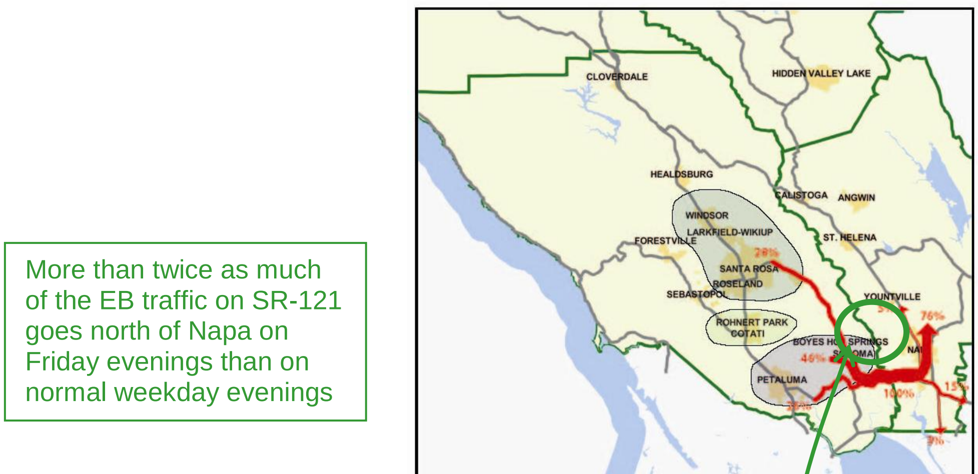

Figure 25: SR-121 Eastbound Weekday PM Peak

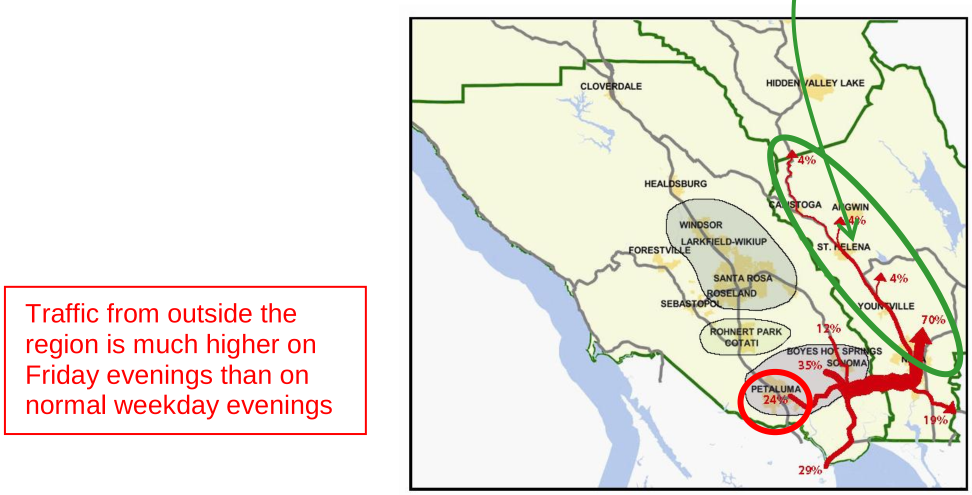

Figure 26: SR-121 Eastbound Friday PM Peak

Most of the peak hour traffic on this part of SR-121 is local traffic between the Napa area and the Petaluma area

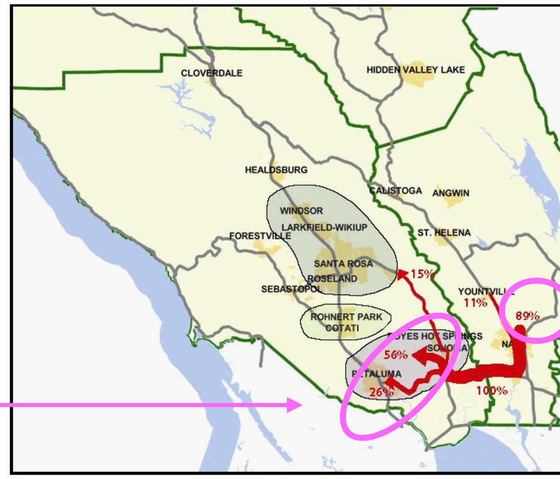

Figure 27: SR-121 Westbound Weekday AM Peak

About twice as much of the WB traffic on SR-121 goes to Santa Rosa on Friday evenings than on normal weekday evenings

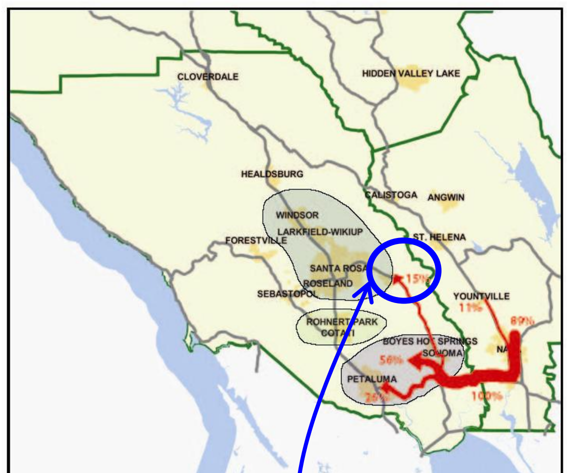

Figure 28: SR-121 Westbound Weekday PM Peak

Traffic from outside the region is much higher on Friday evenings than on normal weekday evenings

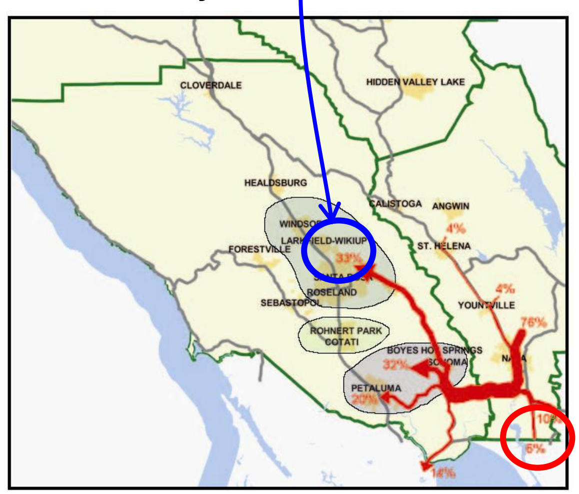

Figure 29: SR-121 Westbound Friday PM Peak

6. VALIDATION RESULTS

The data for the road network, land uses, and travel behavior were input into the draft model and some preliminary test runs were performed. The model was adjusted until it performed satisfactorily on every test. This chapter describes the various checks that were performed and the results of these tests.

Checks of Trip Generation

The first step in checking the model was to determine if the model assigns the correct quantity and type of trips, given the available data on trip-making in the study area. Table 19 shows that the total amount of trips per household in the model is within 2% of the trips found in the *Statewide Household Travel Survey*. This is quite good for an initial test.

Table 19: Overall Trip Generation Rates

Total Trip Generated per Households	Total Trips
Statewide Household Travel Survey	6.22
Wine Country Travel Demand Model	6.59
Ratio Model/Survey	1.06

After establishing that the gross number of trips is reasonably accurate, the next step was to determine if the trips are correctly distributed by trip purpose. Table 20 shows a comparison of the percentage of trips of each type in the model compared with those found in the *Statewide Household Survey*. Note that the Home-Based Other category in this table includes regional and recreational trips. Table 20 demonstrates that the model closely matches the trip purposes found in the household survey.

Table 20: Trip Type as a Percentage of Total Trips		
Trip Type	**Statewide Survey**	**WC-TDM Model**
Home-Based Work (HBW)	22.1%	20.5%
Home-Based School (HBSch)	4.1%	5.7%
Home-Based College (HBColl)	1.5%	1.6%
Home-Based Other (HBO)	38.6%	37.3%
Non-Home-Based (NHB)	33.8%	34.9%
Total	100.0%	100.0%

The next test was to determine how well the number of trips produced matched the number of trips attracted, based on the land uses and the trip generation rates. A traffic model will automatically adjust the number of productions and attractions to ensure a match for each trip purpose, since each trip must have exactly one starting and one ending point. Nevertheless, it is good practice to check if the P's and A's correspond reasonably well to each other; a poor match would indicate that something is wrong with either the land use data, the trip generation rates, or both.

This comparison is shown in Table 21. At the bottom of Table 21 is the ratio of productions to attractions. If this ratio were equal to 1.00 for a given purpose, say school trips, it would imply that the school trips being produced by applying the trip generation rates to the county's residences exactly equaled the number of trips generated by schools using the trip attraction rates. Table 21 shows that the model matches fairly well by trip purpose.

Table 21: Internal Trip Balance										
Area		**HBW_LO**	**HBW_MD**	**HBW_HI**	**HBSch**	**HBColl**	**NHB**	**HBO**	**Recr**	**TOTAL**
1	Napa	4,397	21,536	7,164	11,659	3,291	79,025	63,036	17,060	207,168
2	Petaluma	2,933	15,938	5,258	14,803	3,999	61,794	74,168	20,073	198,967
3	Rohnert Park	2,377	12,757	3,425	7,015	1,844	25,639	36,872	9,979	99,908
4	Santa Rosa & Central Sonoma Co.	17,943	87,294	28,300	40,223	10,782	297,794	207,767	56,232	746,335
5	Lake & North Napa Co.	6,128	14,227	3,127	8,086	2,234	52,198	40,498	10,961	137,458
6	Mendocino & North Sonoma Co.	8,883	23,885	5,303	11,848	3,216	64,330	60,254	16,308	194,027
7	American Canyon	112	430	0	870	59	721	909	246	3,346
Total Productions		**42,773**	**176,066**	**52,577**	**94,503**	**25,426**	**581,502**	**483,503**	**130,859**	**1,587,209**
1	Napa	4,538	13,676	3,996	13,864	4,045	79,025	65,561	21,127	205,832
2	Petaluma	4,124	15,937	4,893	14,189	2,843	61,794	51,258	11,661	166,698
3	Rohnert Park	1,986	8,332	2,635	5,677	3,848	25,639	20,875	6,122	75,113
4	Santa Rosa & Central Sonoma Co.	21,881	87,450	27,565	42,165	10,088	297,794	308,855	56,975	852,773
5	Lake & North Napa Co.	4,680	17,922	5,693	6,710	2,262	52,198	42,513	19,771	151,749
6	Mendocino & North Sonoma Co.	5,507	22,081	7,141	10,282	2,290	64,330	63,909	14,960	190,500
7	American Canyon	208	667	188	1,944	0	721	3,851	593	8,172
Total Attractions		**42,923**	**166,064**	**52,110**	**94,832**	**25,376**	**581,502**	**556,822**	**131,208**	**1,650,838**
Ratio of Prod's/Attr's		**1.00**	**1.06**	**1.01**	**1.00**	**1.00**	**1.00**	**0.87**	**1.00**	**0.96**

From the information provided in Tables 19, 20, and 21 we concluded that the Wine Country Model performs reasonably well in the steps associated with trip generation.

Checks of Trip Distribution

Our checks of trip distribution were performed using data from the 2000 Statewide Household Travel Survey. Table 22 shows the extent of in-commuting and out-commuting for work between the four study counties and other counties outside the model area in the model compared with the survey. The check shows that the in- and out-commuting pattern for closely matches the census data.

Table 22: In- and Out-Commuting

	In-commuting		**Out-commuting**	
	Survey	**Model**	**Survey**	**Model**
HBW Low Income	16.9%	18.5%	10.8%	10.3%
HBW Medium Income	19.9%	21.8%	15.7%	14.9%
HBW High Income	25.7%	27.5%	16.6%	15.9%

After external trip-making was checked, the next step was to check the overall pattern of internal trip-making. Table 23 shows an origin-destination table for home-based work trips between the four counties in the study area, and Table 24 presents the same information in the form of percentage of total internal trips. The figures shown in black font are from the U.S. Census 2000 while the figures in italicized blue font are from the base year model. As can be seen from the table, the overall match is quite good; well within the margin of error of the data sources. The model appears to be over-estimating trips between Sonoma County and Mendocino County, while under-estimating trips internal to Mendocino, but this involves only about 2% of the trips in the model.

Table 23: Origin-Destination Table for County Commuting Pairs
Black = U.S. Census 2000 *Blue = WC-TDM Model*

	Lake	Napa	Sonoma	Mendocino	Total
Lake	15,566 12,966	762 1,967	1,415 1,380	1,013 1,245	18,756 17,558
Napa	58 565	44,341 35,644	2,146 3,157	23 185	46,568 39,552
Sonoma	323 744	3,030 1,106	184,423 178,632	545 3,113	188,321 183,595
Mendocino	254 220	19 406	1,023 3,737	35,427 26,364	36,723 30,727
Total	16,201 14,496	48,152 39,124	189,007 186,906	37,008 30,907	290,368 271,432

Table 24: Origin-Destination Table for County Commuting Pairs
(cell values are the % of trips internal to the region)
Black = U.S. Census 2000 *Blue = WC-TDM Model*

	Lake	Napa	Sonoma	Mendocino	Total
Lake	5.4% 4.8%	0.3% 0.7%	0.5% 0.5%	0.3% 0.5%	6.5% 6.5%
Napa	0.0% 0.2%	15.3% 13.1%	0.7% 1.2%	0.0% 0.1%	16.0% 14.6%
Sonoma	0.1% 0.3%	1.0% 0.4%	63.5% 65.8%	0.2% 1.1%	64.9% 67.6%
Mendocino	0.1% 0.1%	0.0% 0.1%	0.4% 1.4%	12.2% 9.7%	12.6% 11.3%
Total	5.6% 5.3%	16.6% 14.4%	65.1% 68.9%	12.7% 11.4%	100.0% 100.0%

Check of Traffic Assignment

Once we determined that the correct number of trips was contained in the model and that the trips were of the correct length, the final test of the model's accuracy was to compare model's assigned traffic volumes to traffic counts. Models are not expected to duplicate traffic counts exactly, especially since traffic volumes change from day to day. Figure 30 shows the daily link volumes as bandwidths and volume-to-capacity ratios as a color code for the Base Year Model for the region as a whole, while Figures 31 and 32 show close-ups of the Santa Rosa and Napa City areas. The assigned volumes appear reasonable in a gross sense in that the largest traffic volumes are concentrated on the highways and arterials with less traffic on minor roads.

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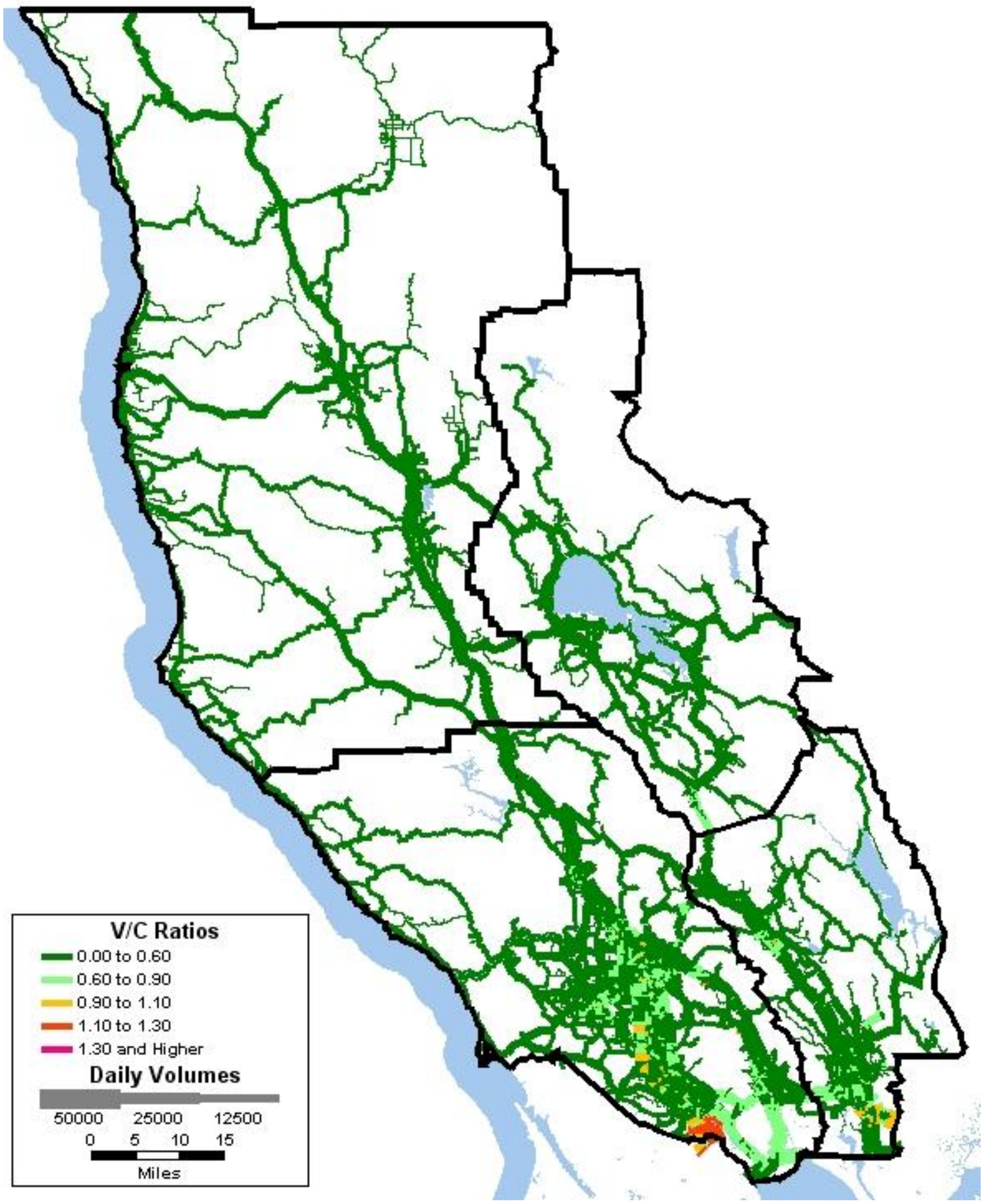

Figure 30: Base Year Daily Model Volumes and Volume/Capacity Ratios

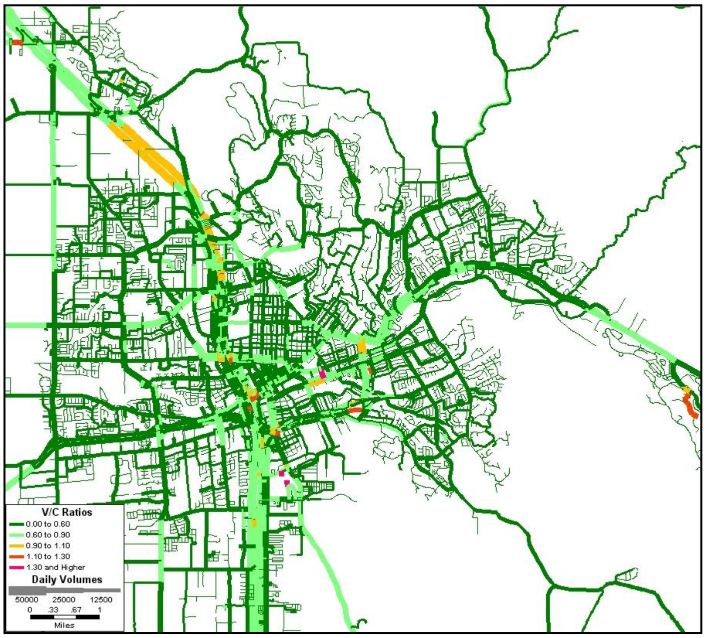

Figure 31: Base Year Daily Model Volumes and Volume/Capacity Ratios in Santa Rosa

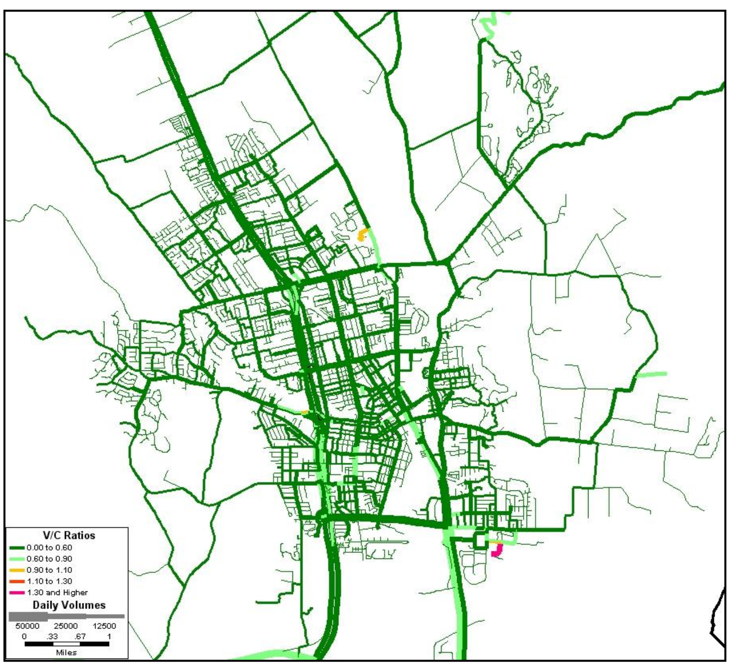

Figure 32: Base Year Daily Model Volumes and Volume/Capacity Ratios in Napa

Caltrans has published guidelines[6] for use in determining whether a model is sufficiently accurate for use. These guidelines include allowable deviations from traffic counts, which require that the higher-volume routes be more accurate (in percentage terms) than less important routes. Key validation standards based on the Caltrans guidelines for the Wine Country Model are summarized below.

- All screenlines between major catchment areas are within Caltrans' maximum desirable deviation, which ranges from approximately 15 to 60 percent depending on total volume (the larger the volume, the less deviation is permitted). See Table 25 and Figure 33.
- At least 75 percent of the roadway links should be within the maximum desirable deviation, which ranges from approximately 15 to 60 percent depending on total volume (the larger the volume, the less deviation is permitted).
- The two-way sum of the volumes on all roadway links for which counts are available should be within 10 percent of the counts.
- The correlation coefficient between the actual ground counts and the estimated traffic volumes should be greater than 88 percent.

Caltrans validation guidelines are explicitly applicable only to daily model results. However, we also checked the peak hour models against the same guidelines for informational purposes.

Thirty-nine traffic counts sites (seventy-eight directional counts) were used to validation the Wine Country Model. The results for daily and peak hour conditions are summarized in Table 26, while the detailed spreadsheets are presented in Appendix F.

Table 25 Validation Screenlines

Screenlines	Model Volumes	Traffic Counts	Model / Count	Maximum Deviation	Within Deviation
1) Sonoma / Marin County Line	131,044	132,670	0.99	0.22	Yes ✓
2) Napa / Solano County Line	84,394	86,010	0.98	0.26	Yes ✓
3) East External	4,984	5,050	0.99	0.61	Yes ✓
4) Napa / Sonoma County Line	76,224	74,200	1.03	0.28	Yes ✓
5) Lake / Napa County Line	11,663	8,520	1.37	0.58	Yes ✓
6) Sonoma/Mendocino County Line	21,887	16,560	1.32	0.49	Yes ✓
7) Lake / Mendocino County Line	10,879	9,460	1.15	0.57	Yes ✓

[6] *Travel Forecasting Guidelines*, Caltrans, November 1992

Figure 33: Screenlines Used to Check Trip Distribution

Table 26: Summary of Assignment Validation Results					
Validation Item	**Criterion for Acceptance**	**Daily Model**	**AM Peak Model**	**PM Peak Model**	**Friday PM Peak Model**
% of Links within Caltrans' Deviation Standard	**At Least 75%**	85% ✓	85% ✓	82% ✓	79% ✓
Sum of 2-Way Volumes of All Counted Links	**Within 10% of Actual**	+3% ✓	+2% ✓	-1% ✓	-2% ✓
Correlation between Counts and Model Forecast	**At least 88%**	99% ✓	99% ✓	99% ✓	98% ✓

As can be seen from Tables 25 and 26, the Wine Country Model exceeds all of Caltrans' calibration criteria for all time periods. Figures 34 through 37 show plots of the traffic count and modeled volume at the validation sites for various time periods. Caltrans' allowable standard deviation is shaded in the figures. These figures show a good match of forecasts to counts with no systematic bias towards either over-predicting or under-predicting traffic.

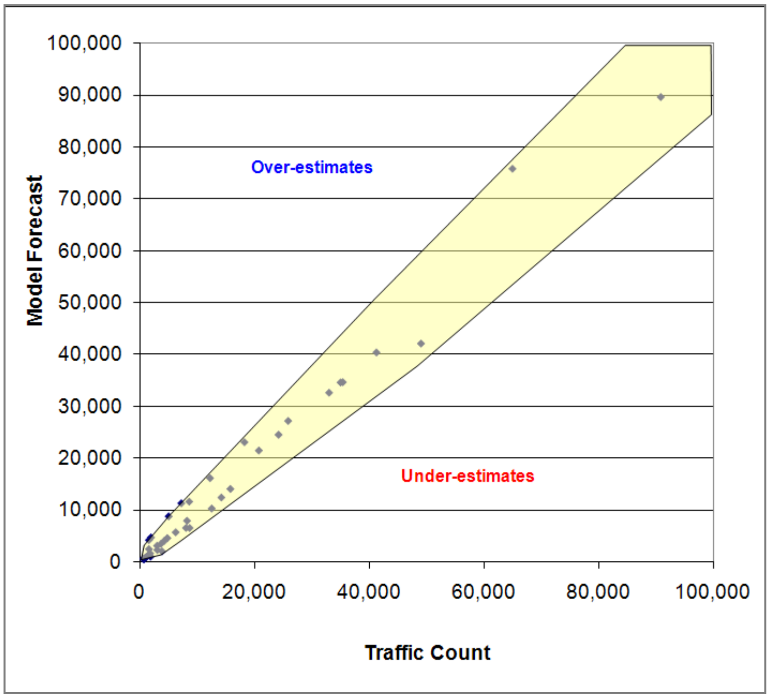

Figure 34: Modeled Volumes versus Traffic Counts (Daily)

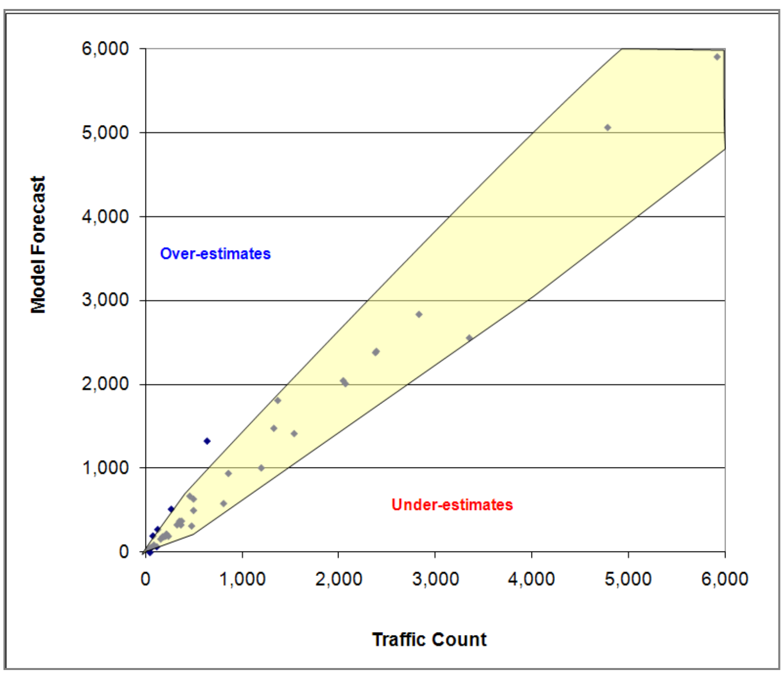

Figure 35: Modeled Volumes versus Traffic Counts (AM Peak Hour)

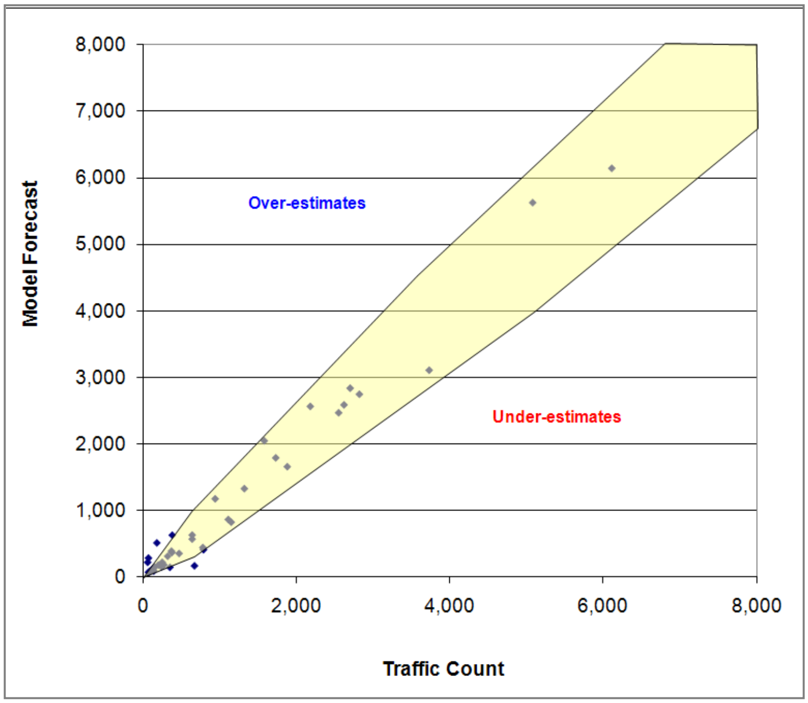

Figure 36: Modeled Volumes versus Traffic Counts (PM Peak Hour)

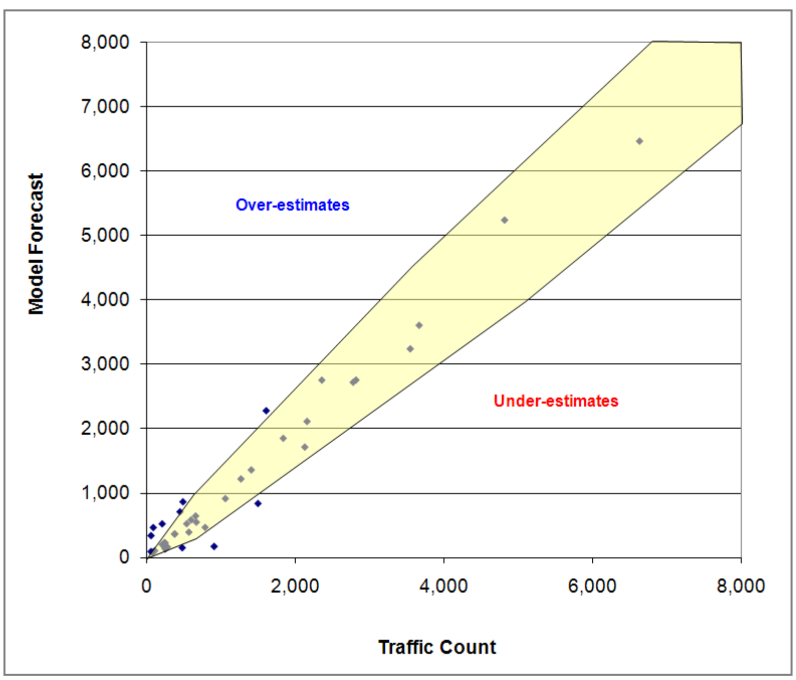

Figure 37: Modeled Volumes versus Traffic Counts (Friday PM Peak Hour)

Dynamic Validation

Dynamic validation[7] is a technique for evaluating how well models respond to changes in inputs. This differs from conventional model evaluation, which compares model outputs to traffic counts, because it tests how well models perform their basic function of predicting changes in traffic in response to changes in land use or roadways.

Three dynamic validation tests were run. The first added or subtracted households from a TAZ, the second added two sizes of mixed-used development to the Masonite Site in Ukiah, and the third added two configurations of the Willits Bypass project to the road network. These tests are described below.

Changing the Number of Residential Units

A common use of traffic models is to forecast the increase in traffic when a new residential development is built. For this test we added 1, 10, 100, and 1000 middle-income single-family dwellings to a single TAZ, and also subtracted 100 and 1000 households of the same type from the same TAZ. The test was done for TAZ 3330 in Petaluma, which was one of the few TAZs in the model with enough households of the appropriate type to allow for the subtraction of a thousand dwelling units. For this test the trip balancing component of the model was set to balance trips to productions which is the recommended practice for when using a model to forecast impacts from residential developments.

The results are shown in Table 27 and are summarized below:

- The number of additional vehicle trips (VT) per additional dwelling unit was stable for all magnitudes of change and corresponds with the trip generation rate for middle-income households in the Petaluma sub-region.
- The change in vehicle-miles of travel (VMT) per additional dwelling unit for very small numbers of DU's is a test of "noise" in the model. "Noise" comes from minor imperfections in the thousands of calculations done in each model run such as rounding of number and instability in selecting between very similar paths. Noise can sometimes be reduced by increasing the number of assignment iterations that the model goes through in a model run, though of course this increases the run time of the model. Noise can be a problem for things like Blueprint analyses where regional VMT is a key indicator of how well a scenario performs.

  In this case when land use was changed very slightly the VMT changed only 2 one-thousandths of one percent after ten iterations, indicating an unusually stable regional model.
- The change in vehicle-miles of travel (VMT) per additional dwelling unit was reasonably stable and the correct order of magnitude for the types of changes that the model might be used to test.

[7] First introduced in the paper *Dynamic Validation of Travel Demand Models,* Don Hubbard, Ron Milam, and Billy Park, published and presented at the ITE District 6 Annual Conference, Sacramento, California, April 2004

Finding 1: Changes in VT are stable and consistant with trip generation rate for Petaluma Area.

Finding 2: Change in VMT for very small changes in input is a test of "noise" in the model. VMT changed only 2 one-thousandths of a percent (i.e. very little noise).

Scenario	Change in DUs	Vehicle Trips (VT)	Change in VT	(Change in VT)/ (Change in DUs)	Vehicle Miles Traveled (VMT)	Change in VMT	(Change in VMT)/ (Change in DUs)
	(A)	(B)	(C)	(D) = (C)/(A)	(E)	(F)	(G) = (F)/(A)
Residential Base Case	-	1,827,225	-	-	14,331,555	-	-
Add 1 DU	1	1,827,230	5	4.8	14,331,898	343	343.0
Add 10 DUs	10	1,827,274	49	4.9	14,334,133	2,578	257.8
Add 100 DUs	100	1,827,713	488	4.9	14,339,178	7,623	76.2
Add 1,000 DUs	1,000	1,832,108	4,883	4.9	14,385,419	53,864	53.9
Subtract 100 DUs	-100	1,826,737	-488	4.9	14,328,218	-3,337	33.4
Subtract 1,000 DUs	-1,000	1,822,342	-4,883	4.9	14,285,008	-46,547	46.5

Centroid connectors are not included in VMT

Finding 4: Adding and subtracting DUs results in changes in outputs of similar magnitude but opposite direction.

Finding 3: For changes of 100 DU or more, VMT changes are reasonably stable and the correct order of magnitude.

Table 27: Results of the Dynamic Validation Test for Changes in Residential Land Uses

- Adding and subtracting the same number of households resulted in changes in VT and VMT that were similar in magnitude but opposite in direction, as should be the case.

Our conclusion from this set of model runs is that the model responds in a reasonable way to variations in residential land use assumptions.

Mixed-Used Development on the Masonite Site

Another common applicant for a traffic model is to determine the traffic impact of commercial developments. For this test we examined the traffic that would be generated by a mixed-used development on the Masonite site just north of Ukiah (TAZ 4172) at two scales of development. For the full development test we added 750,000 square feet of retail space, a 50-room hotel, and 120 middle-income housing units to the existing land uses, while for the half development test we added half that amount of each land use type. These combinations of land uses do not correspond to any actual proposals for development of this site but is are consistent with the scale of development being considered for the site.

For this test the trip balancing component of the model was set to balance trips to attractions which is the recommended practice for when using a model to forecast impacts from predominantly commercial developments. However, we did not perform a local calibration which would be the recommended practice if this were an actual evaluation of a real proposal.

The results are shown in Figure 38 and Tables 28, 29, and 30 and are summarized below:

- The change in vehicle trips was twice as much for the full development scenario as for the half development scenario, as it should be (Table 28).
- VMT increases for the full scenario more than VT. This is the expected outcome as trips divert to longer routes when the direct routes become congested.
- VHT increases for the full scenario more than VMT. This is the expected outcome because speeds will go down as congestion builds.
- The model shows a reasonable pattern of traffic increases on the two main routes to and from Ukiah (Figure 24 and Table 29).
- Table 30 indicates the number of shopping trips (home-based other trips and non-home-based trips) to and from the Masonite site. A small development on this site would likely serve a local market while the full-scale development would be more of a regional attraction. The model forecasts that a higher percentage of the trips would come from someplace other than Ukiah, which is consistent with a regional retail center.

Our conclusion from this set of model runs is that the model responds in a reasonable way to variations in commercial land use assumptions.

Scenario	Vehicle Trips (VT)	Change in VT	Vehicle Miles Traveled (VMT)	Change in VMT	Vehicle Hours Traveled (VHT)	Change in VHT
Non-Residential Base Case	1,889,606	-	14,673,361	-	460,059	-
Half-Scale Masonite Development	1,902,560	12,954	14,765,189	91,828	465,841	5,782
Full-Scale Masonite Development	1,915,514	25,908	14,904,346	230,985	477,010	16,951
Ratio of Full to Half Development		2.0		2.5		2.9

Centroid connectors are not included in VMT & VHT calculation

Finding 1: VT doubles, as it should.

Finding 2: VMT increases more than VT. This is due to trips diverting to longer routes as the direct routes become congested.

Finding 3: VHT increases more than VMT. This is due to lower speeds as the routes become congested.

Table 28: Regional VT and VMT for Masonite Development Test

Figure 38: Main Routes to/from Ukiah

Scenario	N. State Street (A)	Masonite Road (B)	Total for Both Routes (C)=(A)+(B)	Change from Base Case
Non-Residential Base Case	5,018	4	5,022	-
Half-Scale Masonite Development	10,671	5,948	16,619	11,597
Full-Scale Masonite Development	13,634	11,530	25,164	20,142
Ratio of Full to Half Development				1.7

Table 29: Traffic on Main Routes to/from Ukiah

The percentage of trips from Ukiah decreases as project size increases (more regional in nature).

	Trips		% of Trips	
Scenario	From Ukiah	From Other	From Ukiah	From Other
Base Case	58	26	69%	31%
Half Crossing	4,392	2,733	62%	38%
Full Crossing	6,825	5,332	56%	44%

Table 30: Shopping Trips from Ukiah and Elsewhere

Willits Bypass

The other common application for this type of traffic model is to forecast changes in traffic as a result of roadway improvements. For this test we added two configurations of the Willits Bypass project. The first test was for a four-lane freeway that can be accessed only from the Haehl Creek Interchange south of Willits and the Quail Meadows Interchange north of Willits (See Figure 39). This configuration would serve through traffic on US-101 only. The second test added local access at East Hill Road, East Valley Street, and East Commercial Street, which would allow the bypass to be used for local circulation and for long-distance trips to and from Willits.

For this test the trip balancing component of the model was left at its default configuration of balancing to productions for home-based work and other trips and balancing to attractions for other trip purposes. We did not perform a local calibration which would be the recommended practice if this were an actual evaluation of a real proposal.

The results are shown in Table 31 and are summarized below:

- The number of vehicle trips did not change, which is what should happen when land use assumptions are not changed.
- The configuration that serves through traffic only would reduce both VMT and VHT.
- The configuration that also serves local traffic would produce greater VHT reduction benefits than the more limited configuration. In this scenario the number of VMT increases, presumably due to some traffic electing to use the bypass route because it saves time even if it is somewhat longer than other routes.

Our conclusion from this set of model runs is that the model responds in a reasonable way to changes in the road network.

Our overall conclusion from the dynamic validation tests is that the model works quite well for the three most common types of model applications.

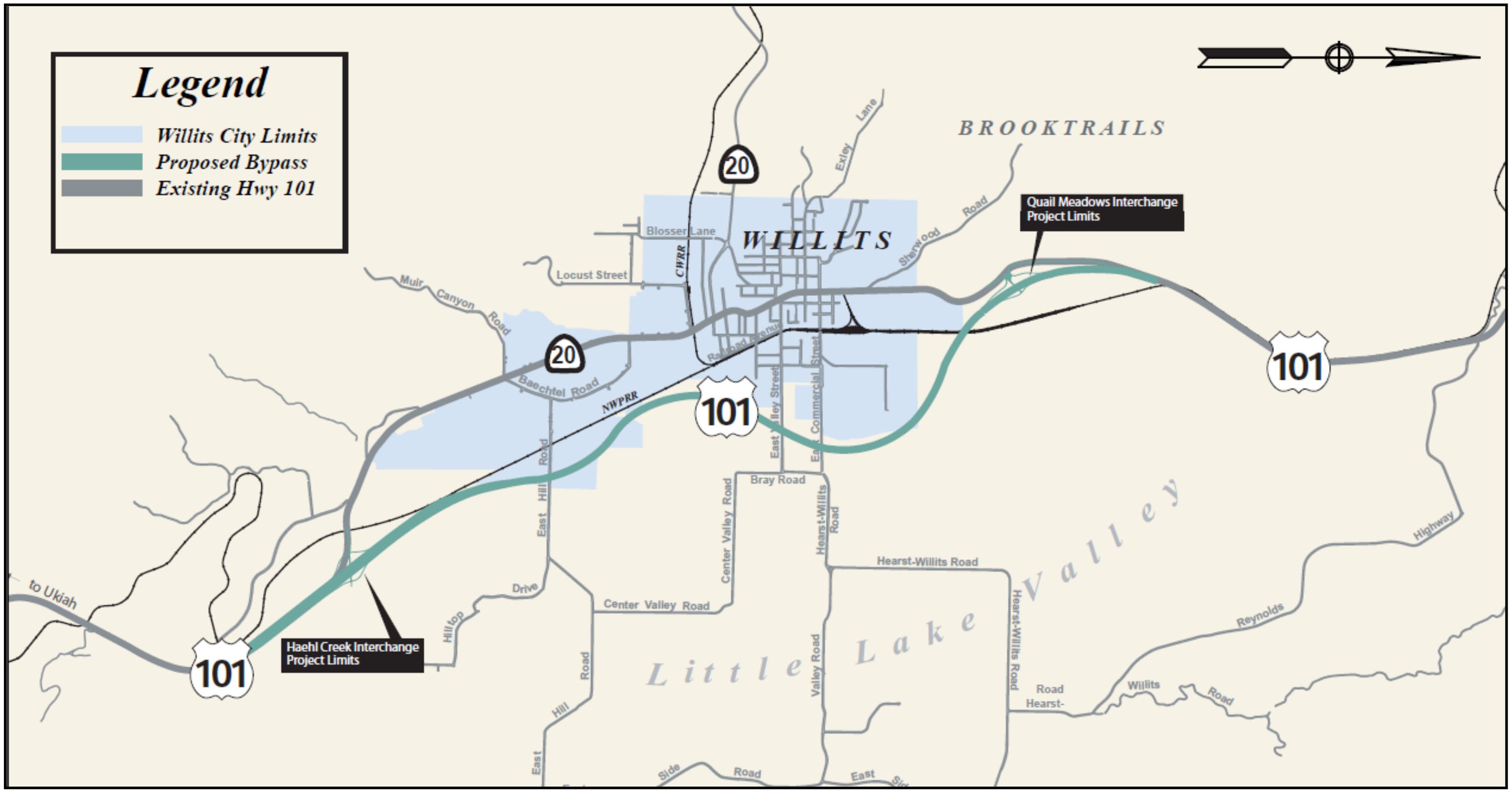

Figure 39: The Willits Bypass Project (from the Willits Bypass Open House brochure)

Finding 1: No changes were made in land uses and so VT should not change.

Finding 2: Both VMT and VHT would be reduced if through trips use a shorter

Scenario	Vehicle Trips (VT)	Change in VT	Vehicle Miles Traveled (VMT)	Change in VMT	Vehicle Hours Traveled (VHT)	Change in VHT
Default Base Case	1,899,790	-	14,768,452	-	464,924	-
Willits Bypass (through traffic only)	1,899,790	0	14,767,631	-821	464,239	-685
Willits Bypass with Local Access	1,899,790	0	14,771,602	3,150	464,209	-715

Centroid connectors are NOT included in VMT & VHT calculation

Finding 3: Some traffic would elect to use the bypass even if it is a longer route, because it is faster and saves time.

Table 31: Results of Willits Bypass Test

7. FUTURE YEAR MODELS

A key function of the traffic model is to predict traffic flows in future years, a task which requires that the model contain land use data that is a reasonable prediction of land use patterns in the future year. This chapter describes our work in obtaining data regarding predictions of future residential land use within the study area.

Residential Growth

We identified three possible sources of information regarding future residential land use:

> *County General Plans:* County general plans cover the policy side of future development and outline development plans at the county or city level. However, they are not forecasts *per se* because they describe what is allowed to occur rather than what is expected to occur. For example, a general plan may allow industrial development to occur on 500 acres of potentially developable land when only 200 acres is expected, with market forces being allowed to determine which 200 acres of the 500 actually gets developed.
>
> *Metropolitan Planning Organizations:* A second source of information is the forecasts of regional bodies of government such as the Association of Bay Area Governments (ABAG) and the Bay Area Metropolitan Transportation Commission (MTC). These are usually preferable to general plans because they include a regional control for employment and population.
>
> *Existing Traffic Models:* These are not independent data sources because it appears that the existing traffic models for each county were based on data from the other two sources. For example, the Sonoma model utilized data from ABAG Projections 2005 and the Napa-Solano model relied on both ABAG data and the MTC regional traffic model. However, the models contained the most spatially detailed information (at the TAZ level) and the model documentation for each county model indicated that the future land use information used by each model was both provided by and checked by local and county planning boards.

Based on this comparison we used the existing traffic models as the starting point for the future land uses in the Wine Country Model.

The local traffic model differs from each other in terms of the years which the base year and future year data represent. The Lake and Napa County models had forecasts for both 2020 and 2030, but the Sonoma County model only had one future year, 2035. We therefore used straight-line interpolation to develop forecasts for the Wine County forecast years (2020 and 2030).

Overall Growth Rates

As a first test of reasonableness, we checked the long-term growth rates for total dwelling units in the models with past trends. These are displayed in Tables 32 and 33 and in Figure 26.

Table 32: Number of Dwelling Units					
County	**1980**	**1990**	**2000**	**2005**	**2030**
Lake	15,192	20,805	23,974	25,760	42,963
Mendocino	25,072	30,419	33,266	34,297	39,913
Napa	36,624	41,312	45,402	48,202	58,902
Sonoma	114,474	149,011	172,403	177,212	214,103
Source:	Census	Census	Census	ACS	Model

Table 33: Average Annual Growth Rates					
County	**1980-1990**	**1990-2000**	**2000-2005**	**1980-2005**	**2005-2030**
Lake	3.7%	1.5%	1.5%	2.8%	2.7%
Mendocino	2.1%	0.9%	0.6%	1.5%	0.7%
Napa	1.3%	1.0%	1.2%	1.3%	0.9%
Sonoma	3.0%	1.6%	0.6%	2.2%	0.8%

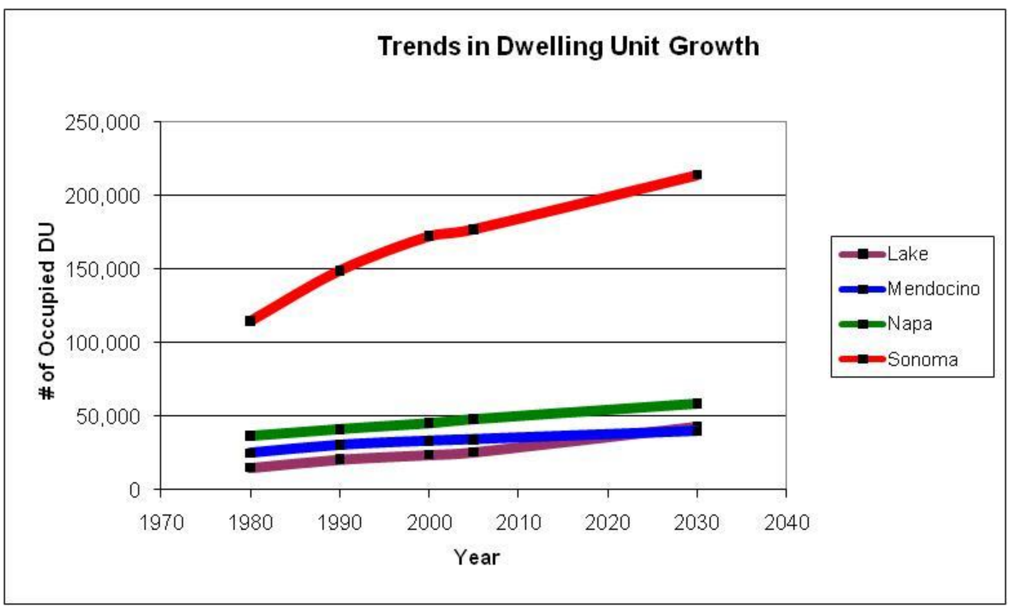

Figure 26: Overall Residential Growth by County

Based on Figure 26 the gross long-term growth rates seem reasonable in light of past trends. The one possible exception is Lake County, whose forecast seems odd because its long-term growth rate is considerably higher than the growth rates recorded over the last fifteen year period (2.7% versus 1.5%). This is because the Lake County 2030 model represents a build-out scenario while the other models do not[8]. The Wine Country Model has faithfully maintained the Lake County projections, but users of the model should be aware of this in case they would like to use other assumptions for their own scenarios.

Employment Growth

The methodology used to develop forecasts of future year employment was described in Chapter 4. The results of this process by county can be summarized as follows (see figures in Appendix G):

> Sonoma County – Most TAZs are forecast to have at least some job growth; in most cases this will consist of a small number of new jobs in the agricultural sector. The largest concentration of job growth is in the Santa Rosa area. These are mainly jobs in the retail and "other employment" category which includes services and government. There is some loss of jobs forecast for the Petaluma area. However, in most cases the number of jobs lost is small (less than ten).
>
> Lake County - Most TAZs are forecast to have no net change in the number of jobs. In general these TAZs have few jobs at present and no change is expected. There is a scattering of TAZs in the central part of the county that are expected to have a small amount of job growth. There is one TAZ in the south part of the county (in the vicinity of Pine Grove and Whispering Pines) that is forecast to add 410 leisure sector jobs between 2020 and 2030.
>
> Napa County – Napa County is forecast to have positive growth in all six of the Wine Country employment categories over the next twenty years. The highest concentrations of job growth are forecast to be in the SR-29 corridor between American Canyon and the City of Napa, and in and around St. Helena.
>
> Mendocino County – The rural TAZs, which represent the overwhelming majority of land in Mendocino County, are forecast to have little or no growth in employment. Moderate growth is expected in the urbanized areas.

Reasonableness Checks

The base year model was validated by comparison with traffic counts and recent survey data. This is clearly not an option for future year models. Instead, they are checked by comparison with base year results to determine if the future year inputs and outputs seem reasonable in light of trends in the region.

[8] One indication that the build-out scenario may be over-predicting actual growth is the fact that Caltrans' Office of Transportation Economics predicts a 26% growth in households 2008-2030 while the Lake County model has a 48% growth over the same period.

Land Use Growth

The residential and employment growth forecasts were done independently, so there was a possibility that the two would diverge significantly over the long term. Table 34 examines this possibility and shows that the growth rates are in reasonable alignment. The employment grows slightly faster than households, but that is in accordance with long-term trends in the American economy.

Table 34: Region-Wide Growth

Land Use Type	Unit	Land Use			% Growth	
		2008	2020	2030	By 2020	By 2030
Single Family Low Income	DU	56,991	66,284	74,132	16.3%	30.1%
Single Family Medium Income	DU	118,196	136,161	146,225	15.2%	23.7%
Single Family High Income	DU	38,498	43,330	45,677	12.6%	18.6%
Multi-Family Low Income	DU	20,478	20,770	22,700	1.4%	10.9%
Multi-Family Medium Income	DU	33,600	34,154	38,184	1.6%	13.6%
Multi-Family High Income	DU	7,144	7,517	8,613	5.2%	20.6%
Seasonal Dwelling Units	DU	15,953	17,771	20,308	11.4%	27.3%
All Housing					**12.1%**	**22.1%**
K through 8th Grade Students	Students	86,134	87,896	89,486	2.0%	3.9%
Jr. High and High School	Students	40,173	44,043	47,141	9.6%	17.3%
College	Students	64,013	80,978	93,789	26.5%	46.5%
Retail Employment	Employees	39,261	44,159	46,047	12.5%	17.3%
Leisure Employment	Employees	49,890	55,739	61,097	11.7%	22.5%
Health Services Employment	Employees	34,791	43,569	47,214	25.2%	35.7%
Industrial Employment	Employees	68,603	70,309	73,528	2.5%	7.2%
Other Employment	Employees	90,694	111,469	128,489	22.9%	41.7%
Agricultural Employment	Employees	10,618	11,376	12,132	7.1%	14.3%
Educational Employment	Employees	25,104	25,104	25,104	0.0%	0.0%
All Employment					**13.4%**	**23.4%**

Note also that certain employment sectors, especially health services and other employment (mostly office work) are forecast to grow much faster than educational and industrial employment. Again, this is in accordance with long-term trends in the American economy.

Traffic Growth

Once the trip generation and network portions of the future year models were completed the model was run and the results (see Figures 41 and 42) were compared to the Base Year model to determine whether the changes in traffic volumes were reasonable. Figures 43 and 44 show that the modeled volumes increased over time, as they should.

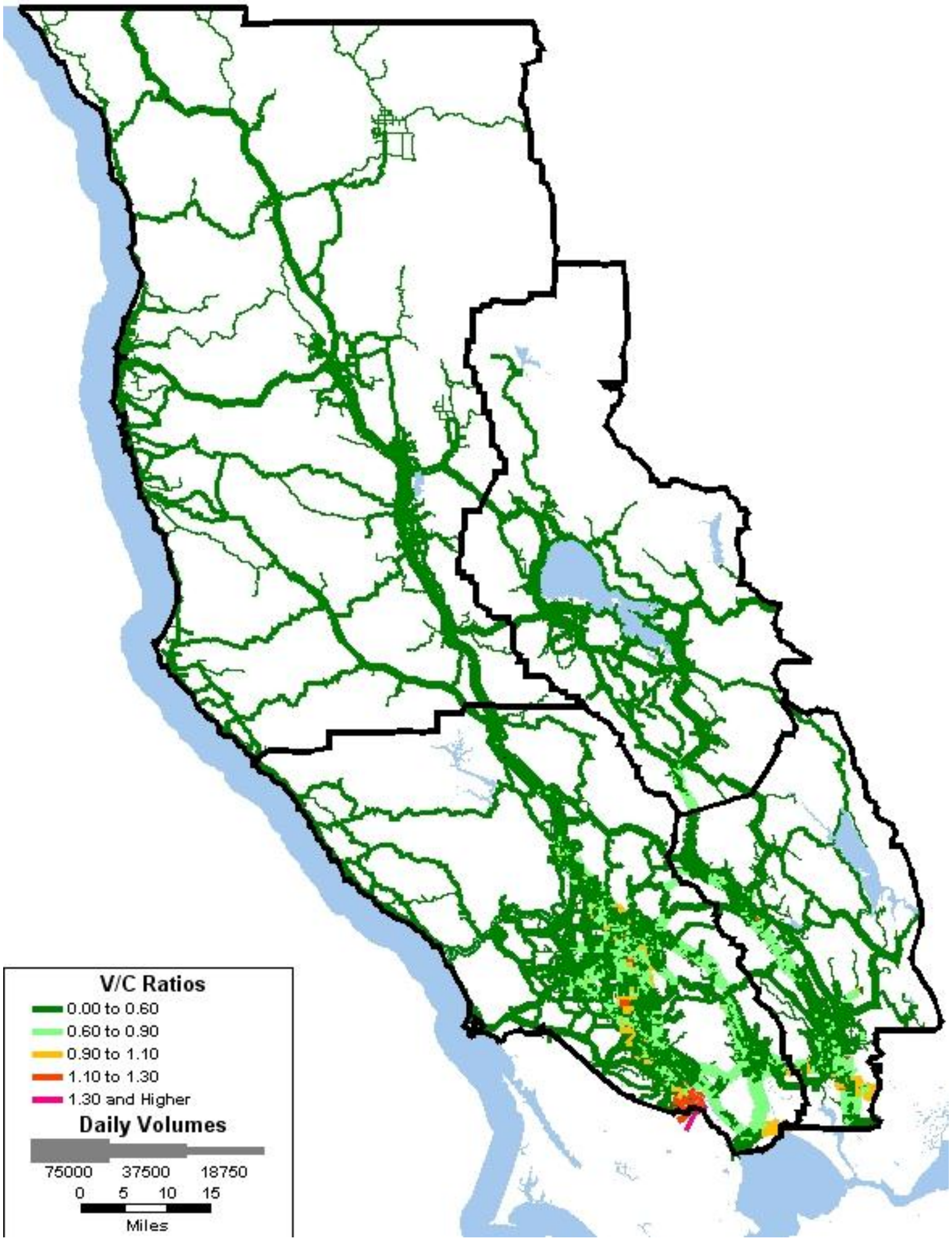

Figure 41: 2020 Model Daily Volumes and Volume/Capacity Ratios

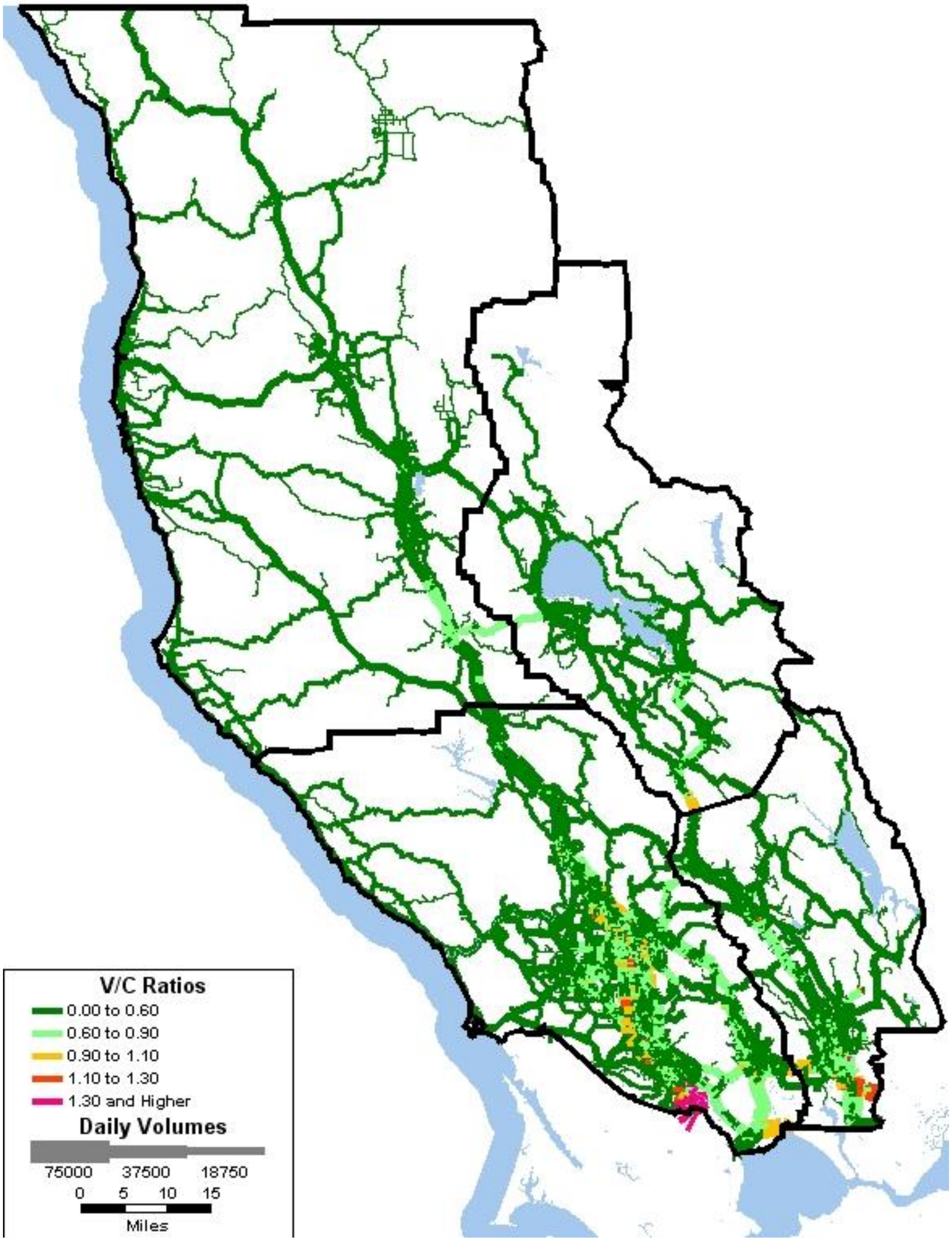

Figure 42: 2030 Model Daily Volumes and Volume/Capacity Ratios

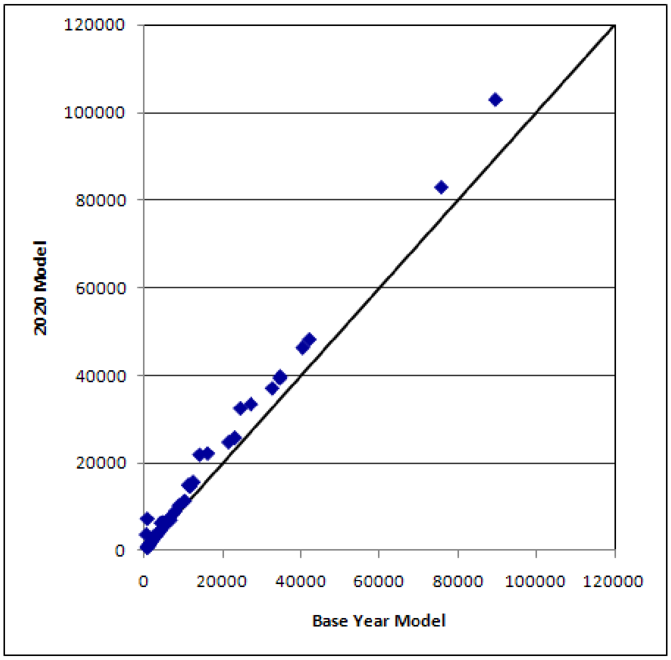

Figure 43: Daily Volumes at Validation Sites in 2020 Compared to Base Year

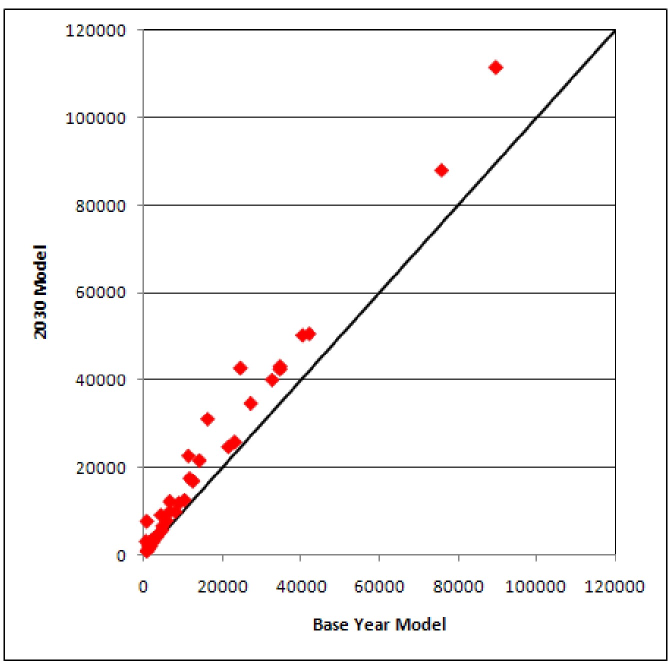

Figure 44: Daily Volumes at Validation Sites in 2030 Compared to Base Year

Having concluded that the future year model was producing reasonable forecasts, we then compared the forecast daily volumes across the screenlines for the three modeled years (see Table 35).

Table 35: Daily Traffic Growth Rates Across Screenlines					
Screenlines	**Base Year (2008)**	**2020**	**Increase over Existing**	**2030**	**Increase over Existing**
1. Sonoma / Marin County Line	131,044	150,318	15%	162,514	24%
2. Napa / Solano County Line	84,394	96,948	15%	104,934	24%
3. East External	4,984	5,718	15%	6,186	24%
4. Napa / Sonoma County Line	76,224	99,892	31%	104,778	37%
5. Lake / Napa County Line	11,663	14,785	27%	17,551	50%
6. Sonoma / Mendocino County Line	21,887	28,726	31%	39,195	79%
7. Lake / Mendocino County Line	10,879	13,464	24%	21,399	97%

The differences in growth rates across the screenlines are mainly a function of the differences in the pace of development in different parts of the region. The high growth in the Lake County screenlines in 2030 reflect the assumption of buildout (high growth) conditions in that county.

These reasonableness tests lead us to conclude that the future year versions of the model are functioning properly and reasonably reflect the future year assumptions.

8. FUTURE IMPROVEMENTS OF THE MODEL

We would like to close by suggesting future work that could serve to improve the usefulness of the model:

- It would be good to develop a second set of land use projections for Lake County for 2030 that correspond to a reasonable control total (perhaps derived from state population forecasts). The current projections, which are for a full build-out scenario, tend to distort the 2030 forecasts by over-predicting traffic to and from Lake County (the 2020 forecasts are not affected).
- Many users would find it useful to have a post-processor that performs EMFAC calculations automatically at the conclusion of model runs.
- Some users might also find a pre-processor to convert data from UPLAN into the format used by the Wine Country model would be useful in their development of integrated transportation/land-use scenarios.
- It would probably be worth exploring a link to the new statewide travel model for inter-regional trips when that comes online.
- If there is interest in transit, the statewide model is using an interesting approach where they have a simplified representation of local bus routes (because it is labor intensive to code and maintain lots of bus routes), but a full representation of fixed guideway and intercity transit. The IRP could employ something similar where you would not invest too much effort in the local routes, because the local models handle those, but do a transit mode split for the inter-county routes.
- There is also a whole direction of advancement in dynamic traffic assignment to better capture the realities of traffic operations, as was done in the recent Eureka demonstration model. The a post-processor could be added to the Wine Country model to generate the data needed for traffic operations software.

In addition to these new components, we expect that as the model gets used the users will detect and correct minor errors in the tens of thousands of data values in the model (land use data, link attributes, etc.). This accumulation of small corrections will improve the model's performance over time.