Appendix J

Kings Canyon National Park, California

Sustainable Communities Strategy: Reference Materials

CONTENTS

Appendix J Item 1:
San Joaquin Valley Demographic Forecasts (Planning Center Study)

San Joaquin Valley Demographic Forecasts 2010 to 2050

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- Fresno Council of Governments
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- Kings County Association of Governments
- Madera County Transportation Commission
- Merced County Association of Governments
- San Joaquin Council of Governments
- Stanislaus Council of Governments
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Contents

List of Figures

List of Tables

Introduction

Purpose

This report presents demographic forecasts for the San Joaquin Valley and the eight county-wide Metropolitan Planning Organizations (MPOs) in the Valley. The MPOs may use these forecasts to assist in determining the impact of various development densities on the fiscal health of cities and counties in the San Joaquin Valley and identifying market demand for higher density residential housing projects associated with the preferred growth scenario of the San Joaquin Valley Regional Blueprint. Equally important, these forecasts can be incorporated into the common traffic model being developed for the MPOs. The forecasts may also be used to formulate items such as Sustainable Community Strategies required under SB 375 and the Regional Housing Needs Allocation, also required under state law.

Forecast Models

The MPOs selected The Planning Center|DC&E and Arthur C. Nelson, PhD, FAICP, Presidential Professor of City & Metropolitan Planning at the University of Utah, to prepare the forecasts. The forecast models consist of a separate spreadsheet model for each county and one for the entire San Joaquin Valley. This report summarizes and presents the results of these forecast models.

The forecast models have been developed to allow each MPO to update the underlying data each year as new data are published by state and federal agencies. The ability to update is an important component of the forecast model. The deep recession of 2008/09, the slow pace of the recovery, and the lingering effects of the collapse of the housing and financial markets have caused many demographic measures to deviate from long-term trends in the last few years. As American businesses and households pay down their debt and the economy returns to a more normal rate of unemployment, some of these measures will return to trend. At the same time, other demographic characteristics may represent a new normal. For example, many economists expect the non-accelerating inflation rate of unemployment will be about a percentage point higher than it was in the '90s. Proposed federal housing finance regulations adopted in response to the housing and financial market collapse (discussed in more detail in a subsequent section in this report) will likely reduce homeownership rates. Updating the models over the next few years will allow the forecasts to better capture those demographic characteristics that return to trend and those that are at a new normal.

Organization

Introduction

The remaining sections of the Introduction discuss some demographic and economic factors that will influence the demographic trends covered by this report.

Methodology

The Methodology chapter provides a technical description of the methodology and data sources used in the forecast models.

Primary Forecasts

Three demographic characteristics provide the foundation for the forecasts:

+ Households
+ Population
+ Housing

Several different trends and measures have been analyzed and evaluated to develop the forecasts for these three characteristics. The Primary Forecasts chapter discusses the development of these models and summarizes the resulting forecasts.

Other Demographic Forecasts

The other demographic characteristics are all derived from the primary forecasts. These characteristics include:

+ Age Distribution
+ Average Household Size
+ Household Income
+ Household Type
+ Race/Ethnicity

The Other Demographic Forecasts chapter discusses issues surrounding these characteristics and summarizes the results of the forecasts.

Regional Differences

The regional differences chapter provides additional analysis of the differences among the four largest metropolitan areas in the Valley and the differences between the urban and rural areas.

Appendix

The appendix provides a brief explanation of some of the terminology used in the report and provides detailed results of all of the forecast models.

Home Ownership Trend

One key demographic measure that is heading to a new normal, or perhaps returning to an old normal, is the home ownership rate.

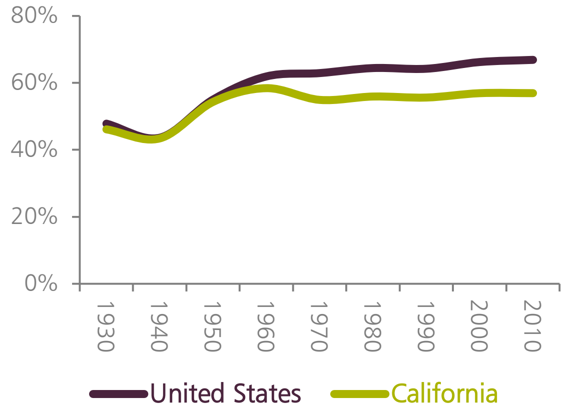
The Long-Term Trend

As shown in Figure 1, the portion of households owning their homes in the United States increased from the 1940 Census through the 2010 Census. In contrast, the home ownership rate in California peaked in 1960, declined from there, and only started increasing again after the 1990 Census.

Numerous public policies and social trends fueled the increase in home ownership. Most notable among these, however, were federal intervention in the mortgage market and rising incomes. Beginning in 1938, federally created agencies, such as the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac) created a secondary market for mortgages. These agencies bought mortgages from banks, thus allowing these banks to go out and issue new mortgages. This secondary market for mortgages transformed how housing was built and bought and sold in the United States. These agencies funneled vast new sums of money into the housing market, allowing the nation to go from primarily renter households to primarily owner households.

At the same time, economic expansion beginning in the post–World War II era resulted in decades of rising real wages for American workers. In the 1950s, household investment in housing accounted for 5.03 percent of national gross domestic product, the highest of any ten-year period in the post-war period.

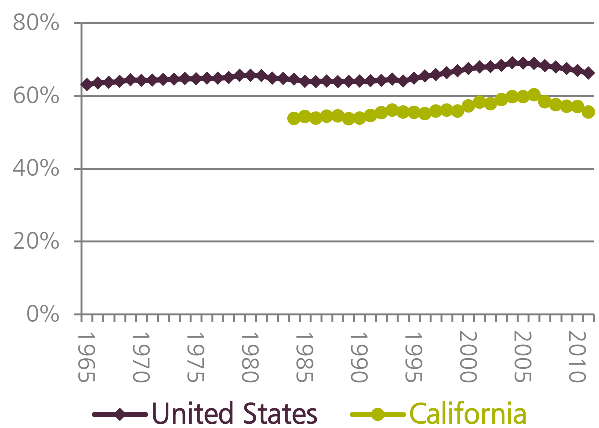
Figure 1: Home Ownership Rate from the Decennial Censuses, US and California, 1930 to 2010



The More Recent Trend

Figure 2 shows the rate of home ownership on an annual basis. Nationally, the generally increasing rate of ownership stagnated in the 1980s, then picked back up again in the 1990s, reaching a peak of 69.0 percent in 2004, and has since declined. As will be discussed in following sections, there are strong reasons to expect the national rate of home ownership to continue declining.

Figure 2: Home Ownership Rate by Year, US and California, 1965 to 2011



California's rate of ownership peaked slightly later, at 60.2 percent in 2006, but it has also since declined. Over the 28-year period from 1984 to 2011, California's home ownership rate averaged about 9.8 percentage points lower than that for the nation, 56 and 66 percent.

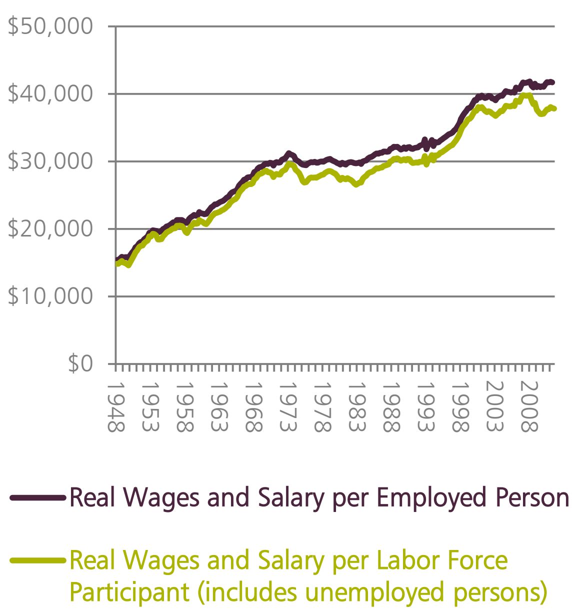
The Trend Going Forward

As discussed in the following sections of this paper, significant factors will likely continue to push the rate of home ownership downwards, and hence, increase the rentership rate. The factors include wages and incomes, housing finance, and demographics.

Wage and Income Trends

Real (inflation-adjusted) wages and salaries in the US steadily increased from the beginning of the post-war period through the early 1970s, stagnated through most of the 1970s and early 1980s, grew rapidly at the end of the 1990s, and has grown slowly since then. The total real wages and salaries per employed person in the third quarter of 2011, $41,600, was only 4.7 percent higher than that at end of the last major growth spurt, $39,739 in the first quarter of 2001. Considering the effects of high unemployment resulting from the last recession, the picture is even less rosy. Total real wages and salaries per labor force participant in the third quarter of 2011, $37,800, was 0.6 percent less than that in the first quarter of 2001, $38,100. Figure 3 shows the wage and salary data from the first quarter of 1948 through the third quarter of 2011.

Figure 3: Real Wages and Salaries, United States, 1948 to 2011



The data suggest that the typical household, including employed and unemployed persons, has no more money for housing payments than they had in 2000. Until unemployment returns to a more normal level, perhaps around 7 percent, real wages and salaries are unlikely to experience any significant growth. The Federal Reserve currently forecasts the economy will not return to full employment until the end of 2014, at the earliest. Thus, wages and salary income offer no prospect for supporting expansion in housing purchases in the short term, and the question of future wage and salary growth suggests a continuing constraint on affording home ownership. Interest rates and down payments affect the monthly payment that household income has to be able to afford for ownership. The next section explores down payment issues.

Housing Finance

In addition to income constraints, two factors of housing finance are likely to put downward pressure on the rate of home ownership, thus increasing the rentership rate.

Minimum Down Payment

In response to the housing market crash and the near collapse of the financial markets, most lenders increased their lending standards, requiring higher credit scores, lower debt to income ratios, and higher down payments. Of those making a down payment when financing a home purchase in 2009, 26.3 percent provided less than 5 percent down, 47.4 percent provided less than 10 percent down, and only 26.6 percent provided more than 20 percent down.

As part of the overhaul of the housing finance regulatory structure, a group of federal agencies are considering proposed rules that would effectively raise the minimum down payment required to obtain a residential mortgage from five percent to 10 or 20 percent. These rules would institutionalize some of the tighter lending standards that would otherwise likely ease over time.

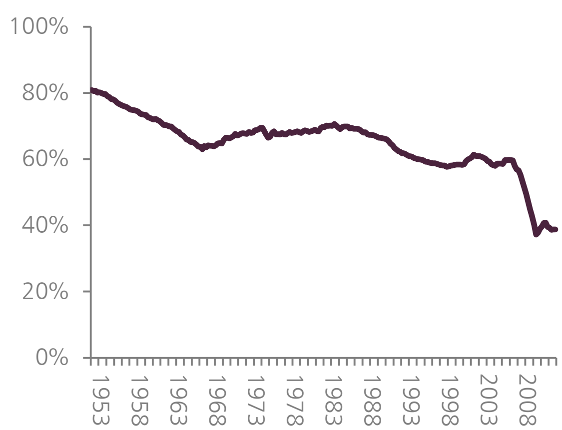
The National Association of Home Builders estimates that an increase to 20 percent would disqualify five million potential home buyers, reducing national housing sales by 250,000 per year. The Coalition for Sensible Housing Policy (CSHP) estimates that the increase from 5 percent to 10 percent would exclude 4 to 7 percent of potential home buyers.

CSHP further estimates that a shift from 5 to 10 percent down payment would extend the time it takes the average family to save the down payment from 6 to 9 years; a 20 percent down payment would require 14 years. What is not known is the degree to which the required years of savings would discourage potential home buyers from ever entering the market, perhaps deciding to rent and devote the 14 years of savings to education for their children.

Decreasing Home Equity

Many of those purchasing housing, however, are not saving for a down payment for a first house; rather, they are using the equity in the current house as the down payment on their next house. The American Housing Survey reports that more than half the number of home buyers who were not buying their first home used money from the sale of their previous house as the major source of their down payment in 2009. While the equity the average household has in its existing house has been declining across the postwar period, it declined dramatically with the fall in housing values following the housing market crash. The average equity dropped from 56.5 percent in 2005 to 39.2 percent in 2009. Figure 4 shows home owner equity from 1952 through 2011.

Figure 4: Homeowner Equity as a Portion of Housing Value, United States, 1952 through 2011



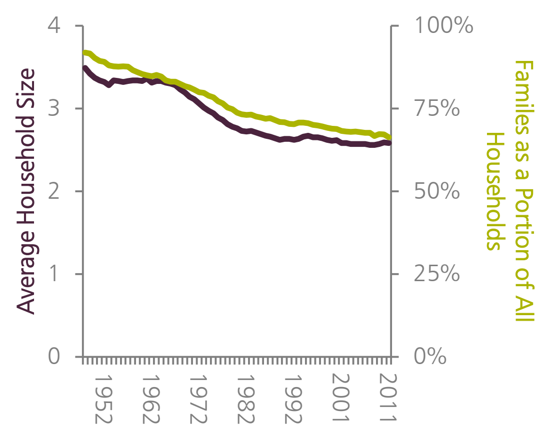
Source: The Planning Center|DC&E, 2011, using data from the Federal Reserve.

The decrease in home owner equity means that fewer households will be able to fund the down payment to purchase another house using their current equity. Over time, as households pay down their current mortgages and as housing values stabilize and begin to increase again, the steep drop in equity may reverse. Nevertheless, the long–term trend is that home owners have less and less equity, and at some point, the patterns of house purchasing and finance will have to adjust: less home equity financing or less frequent house purchasing.

Demographics

In the 20 years following World War II (1945 through 1964) the fertility rate increased substantially, creating the baby boom generation. Starting in 1965, a few years after the introduction of the birth control pill, the fertility rate declined dramatically, and has remained about the same level ever since. As the oldest of the baby boom generation began moving out of their parents' houses, the average household size began a long steady decline, from 3.36 persons per household in 1961 to 2.62 in 1989. Since 1989, the number of persons per household has averaged 2.61. During this same time frame, families as a portion of total households has steadily declined, from 91.9 percent in 1948 to 66.2 percent in 2011. Figure 5 shows these national household characteristics.

Figure 5: Household Characteristics, United States, 1949 to 2011



Source: The Planning Center|DC&E, 2011, using data from the US Census Bureau.

As the baby boom generation continues to transition from families with children to empty nesters and to move from employment to retirement, some portion will desire to sell their current family-sized houses and relocate to smaller housing units. There are substantially fewer households in the baby bust generation (those born from 1965 through 1973).

As previous generations retired and relocated, there were larger generations following them, ready to move into family-sized housing. With the coming generation change, however, there are fewer households that will be looking to buy housing from the baby boomers wanting to move.

The key to the housing market then becomes the echo boom generation, the children primarily of the baby boomers, born after 1973. Current survey research suggests that this generation, however, will have a higher preference for more urban housing and less of a preference for the traditional large-lot single-family detached houses. More importantly, though, lingering unemployment and lack of job growth coupled with changes in housing finance may force the echo boom generation to put off purchasing their first houses.

If there is insufficient demand to purchase housing that baby boomers desire to sell, the market result would be some combination of downward pressure on housing values, reduced selling, renting out existing housing that cannot be sold, and decreased housing production.

The long-term impact is uncertain. The survey research suggests that the housing preferences of the echo boom generation will drive changes to housing and development patterns. However, a precept of economics is to look at what people do, not what they say. No one can say with certainty that the echo boom generation, once they form families and have children of their own, will not emulate their parents and adopt a preference for traditional large-lot single-family detached houses.

Multigenerational Family Housing

Multigenerational family housing is a demographic and housing trend that will influence future housing demand. Multigenerational family housing is defined as a family household that contained at least two adult generations or a grandparent and at least one other generation.

Research by the Pew Research Center[1] found that this extended family living arrangement, which was common throughout our nation's history, began to fall out of favor after World War II. In 1940, about a quarter of the population, 39 million Americans, lived in an extended family household. By 1980, only 12 percent lived in such households. Since 1980, the portion of the population living in multigenerational family households has steadily increased, reaching 49 million people, or 16.1 percent of the population in 2008.

This increase includes all major demographic groups; however immigration from Latin American and Asia has driven a large portion of the increase. These immigrants, like those in earlier immigration waves, are more likely to live in extended family households than are native-born Americans.

While all age groups are more likely now than they were in 1980 to live in multigenerational family housing, it is young adults among whom the percentage increase has been the greatest. In 1980, 11 percent of those aged 25 to 34 lived in extended families; by 2008 the number had risen to 20 percent. The increase in median age at first marriage has been a primary driver of this long-term trend among young adults. However, in recent years the recession has added to the movement of young adults back home. In 2009 37 percent of 19- to 29-year olds were unemployed. A Pew survey that year found that one in eight of those aged 22 to 29 indicated that they had moved back in with their parents as a result of the recession.

Among those aged 65 and older, the portion living in extended family households increased from 17 percent in 1980 to 20 percent in 2008. Among this older generation, women are much more likely than men to live in an extended family, due in large part to women being more likely to outlive their spouse than men are. Among the 25 to 35 year olds, though, men are much more likely to be the ones living in multigenerational family households.

Because younger adults are more likely to rent than to own their residence, the trend of an increasing portion of young adults living in multigenerational family housing should lessen, although not reverse, the trend of increasing rentership and decreasing ownership. At the same time, the increasing movement of older Americans into extended family housing should decrease the total number of homeowners and put more housing on the market. Whether there are sufficient numbers of households in the baby bust and echo boom generations to absorb that housing will determine the degree to which it increases or decreases the ownership rate.

[1] See Taylor, Paul, et. al., "The Return of the Multi-generational Family Household." Washington DC: Pew Research Center (March 2010).

Migration

The demographic analysis conducted for the forecasts finds that migration is the primary factor driving differences in the development patterns among the eight counties. From 2000 to 2010, the population in each county grew faster than the natural rate of increase (number of births minus the number of deaths), and migration is the key difference. Who migrated to and from each county, their household characteristics, race and ethnicity, and the income their skills and education can command explain differences in the past and will drive the differences in the future.

Demographers often discuss migration push and pull factors, the factors that attract people to a region and those that push them out. Two in particular warrant additional discussion: economic growth and retirement.

Economic Growth

In the conventional model of regional development, economic growth leading to job growth attracts migration and helps retain younger people entering the labor force. In contrast, regions with stagnant or declining economies fail to attract many migrants and fail to retain their own residents, who often migrate away in search of better economic opportunities.

Each of the eight counties attracted migrants in the previous decade. Some of these may have come to fill low-wage farm laborer jobs while others may have come to work in higher-skilled higher-paying occupations, such as teaching, medical care, or accounting.

The total increase in employment is one key factor pulling migrants to a region. Kern, Kings, and Madera counties had the highest rates of job growth from 1990 to 2010, and they had the highest rates of population growth. Tulare County had a higher jobs growth rate than the Valley as a whole but a slightly lower population growth rate. Job growth in Tulare, however, might have more often been filled by those previously out-commuting to jobs in Fresno and Kern counties. Relative to the Valley, the other five counties had lower rates of job growth and population growth.

While the total number of jobs correlates to population growth, the types of jobs correlate to a variety of other demographic characteristics. For example, farm employment in the San Joaquin Valley increased by 20,800 jobs from 1990 to 2010, at about half the rate of overall job growth. Fresno, Merced, San Joaquin, and Stanislaus counties had a decrease in farm jobs over this time. However, Kern and Tulare counties had faster growth in farm jobs than in total jobs. Indeed, Kern County accounted for three quarters of the Valley's farm job growth, and farm jobs made up nearly a quarter of the county's total job growth.

During this same period, jobs in the professional, scientific, and technical services sector in the Valley increased by 33,500, at a rate a little less than double that for overall job growth. In all of the counties, employment in this sector increased faster than overall job growth. In Madera County, however, this relatively high-paying sector accounted for 18.2 percent of all of the county's job growth, and Madera County provided 19.1 percent of the Valley's job growth in this sector.

While many factors influence median household income, changes in the types of jobs are a key driver of changes in income. From 1990 to 2010, Kern County's real (inflation-adjusted) median household income decreased at a 0.1 percent per year rate, while Madera County's increased at 0.5 percent per year rate. Clearly more is at play in these income differences than just farm and professional jobs, but the magnitude of these employment and income differences in the two counties underscores the importance of economic growth and development in the future of the San Joaquin Valley.

Retirement

Retirement is the second major factor than can noticeably alter population growth. With the looming retirement of the baby boom generation over the next 20 years, this factor may influence future demographics more so than in the past.

There are three general avenues taken after retirement, at least in the past. The largest group, perhaps a majority, remain in their existing home. The other retirees split about equally between moving to another region and moving to another home, perhaps smaller, in the same region.

How big of an issue is this in the San Joaquin Valley? Data from the 2010 American Community Survey indicates that 92 percent of the population age 65 and older lived in the same house that they did a year earlier, and 5 percent moved from a different house in the same county as their current residence.

So only 3 percent had moved from another county or state or from abroad, fewer than the 5.3 percent of the total population that had moved into a San Joaquin Valley county in the past year.

Across the San Joaquin Valley, the population age 65 and older accounted for 5.5 percent of the in-migration in the past year. In three counties, however, this age group accounted for a larger share of in-migration: Fresno at 7.6 percent, San Joaquin at 7.7 percent, and Stanislaus at 6.8 percent. At the other end of the spectrum, this age group comprised only 3.1 percent of in-migration in Kern County, 2.7 percent in Kings, and 4.3 percent in Madera.

Because retirees can generally obtain the same benefits regardless of where they live, they are able to more easily choose a home unrestrained by employment opportunities than the working age population. It is likely that proximity to the Bay Area explains part of this age group's share of migration into San Joaquin and Stanislaus County. More than half of this age group's in-migration to these counties comes from within California. In Fresno County, however, more than half of this age group's in-migration comes from other states and abroad. Indeed, it is the only one of the eight counties in which more older migrants come from out of state than come from elsewhere in California.

With the I-5 through the Grapevine and no rail access connecting Kern County and Los Angeles County, Southern Californian retirees probably do not perceive Kern County as a close-by place to retire (a place where they can find a less expensive and perhaps smaller home that is still within an easy drive to family and friends). The Inland Empire probably handles much of the Southern Californian retiree relocation that San Joaquin and Stanislaus counties provide for the Bay Area.

A big unknown for the San Joaquin Valley is what will happen with future retirees, not only the aging baby boomers in the Valley but also those in Northern and Southern California. If past trends are an indication, retiree relocation will affect each of the counties differently. And these differences will have impacts for public services, housing, medical care, and a variety of other public policy concerns.

Three demographic measures form the primary forecasts:

1. Number of Households
2. Total Population
3. Total Number of Housing Units

The primary forecasts are based on several different projections and the authors' professional judgment. The remaining demographic forecasts are derived from the primary forecasts. This chapter describes the methodology and data sources for individual projections.

Generally, for each demographic trend, the least-squares method determines a line that best fits the trend data. That line is projected to the year 2050, and the projection is the straight line that connects the last datum to the 2050 trend datum. The descriptions for each projection explain if the projection employs a different methodology.

The preparation of the forecasts explored different curve-fitting techniques (e.g., parabolic curve, logistics curve). In some cases, alternative curve-fitting models provided acceptable projections for a few years, but none provided reasonable long-term projections. The forecasts incorporate no alternative curve-fitting models, and the least-squares linear curve forms the basis for all projections because the metropolitan planning organizations will use the forecasts for long-term planning efforts with 10-, 20-, and 40-year horizons.

Three measures evaluate the adequacy of each projection: mean absolute percentage error (MAPE), F-test, and t-test. The Appendix provides the detailed results, and the following sections of this chapter summarize the relevant statistics.

Household Trend

The household trend projection uses the DOF estimates for the total number of households in each county for each year from 1990 through 2011. The data for the San Joaquin Valley are sum of the data for the eight counties.

The least-squares line for the San Joaquin Valley household trend produces a MAPE of 1.4% and a relative standard error of 1.7%. The relative standard errors in the individual county models range from a low of 1.1% in Kings County to a high of 3.2% in Merced County.

Vacancy Rate

The vacancy rate analysis uses the DOF estimates of the vacancy rate from 1990 through 2011. The vacancy rate data for the San Joaquin Valley for each year were derived by dividing the total number of occupied housing units across the eight counties by the total number of housing units across the eight counties.

For all eight counties and the entire Valley, the least-squares line indicates an increasing vacancy rate, and in all nine models, the projected vacancy rate through 2050 would exceed the highest observed vacancy rate. Nevertheless, all nine models produced F-statistics and t-values that exceeded the critical values.

Instead of using the best-fit line to project increasing vacancy rates over the next 38 years, the projection models assume that the long-term vacancy rates will return to the average rate for the period from 1990 through 2011. The models assume that the vacancy rate will decrease in a straight line from the 2011 data to the average in 2016.

For the San Joaquin Valley, the average vacancy rate, and hence the long-term projection, is 6.77%. For the eight counties, the average vacancy rates range from a low of 4.44% in San Joaquin County to a high of 9.94% in Madera County.

Total Housing Units Trend

The total housing units trend projection uses the DOF estimates of the total number of housing units in each county from 1990 through 2011. The data for the Valley are the sum of the data for the eight counties.

The least-squares line for the Valley total housing unit trend produces a MAPE of 1.4% and a relative standard error of 1.63%. The relative standard errors in the individual county models range from a low of 1.11% in Kings County to a high of 2.73% in Merced County.

The projected vacancy rates are applied to the projected total number of housing units to derive a projection of the total number of households. This projection of the total number of households produces a MAPE of 1.53% for the San Joaquin Valley. For the eight counties, the MAPE ranges from a low of 0.94% in Kings County to a high of 2.86% in Merced County.

Housing Units Constructed Trend

The projection model based on the number of housing units constructed uses DOF-provided data on the total number of housing units permitted each year. For 1991 through 1999, the data reflect the difference in the total number of housing units from the previous year. For 2000 through 2011, the data are the number of housing units constructed and were provided by DOF for this project.

Because the number of housing units constructed each year is small compared to the total number of units, the housing construction data exhibit a higher degree of variability than do the total housing units data.

The least-squares line for the total number of housing units constructed in the San Joaquin Valley produces a MAPE of 71.4% and a relative standard error of 11.49%. More importantly, the least-squares line fails both the F-statistic and t-value check. Thus, one cannot accurately say that the number of housing units constructed each year represents a consistent trend that can be projected forward. Therefore, the forecast for the total number of housing units combines the projection based on housing units constructed and the total number of housing units..

Across the eight counties, the relative standard error ranges from a low of 9.51% in Kings County to a high of 16.41% in Merced County. The data for five of the counties fail both the F-statistic and t-value test. However, in three counties, Madera, San Joaquin, and Tulare, the data fail the t-value test but not the F-statistic test.

Housing Units by Type Trend

As with the housing units constructed, data on the number of housing units by type exhibits a great degree of variability, even more so than the total housing units constructed data. This is particularly true for multifamily housing because there are even fewer such units constructed in each county and because they are often constructed in larger projects, resulting in large changes in the number of units from year to year.

The least-squares line for the number of housing units constructed by type in the San Joaquin Valley produces a MAPE of 27.4% for single family, 123,7% for multifamily, and 54.5% for other housing types and a relative standard error of 33.9% for single family, 81.0% for multifamily, and 97.1% for other housing types. The least-squares lines fail only the t-test and then only for single family and for other housing types. The data across the counties produce similar results.

Because the actual data exhibit such variability, the forecast model uses the results of the construction by housing type to project each housing type's relative share of housing and then applies those proportions to the projected number of total housing units.

Employment Trend

The projection model based on the employment trend uses at-place employment by sector data from the CA Employment Development Department. The data for the San Joaquin Valley are a sum of the data for the eight counties. The model constructs a least-squares line for each economic sector, projects that forward, and sums the results to generate a projection for total employment in each county.

The least-squares line for total employment in the entire Valley produces a MAPE of 1.97% and a relative standard error of 2.99%. The relative standard error among the counties ranges from a low of 2.12% in Tulare to a high of 5.23% in Madera.

The model calculates a jobs-to-household ratio by dividing the actual employment in each year by the DOF-estimated number of households. Dividing the projected total employment by the projected jobs-to-household ratio provides a projection of the number of households.

The least-squares line for the jobs-to-households ratio in the San Joaquin Valley generates a MAPE of 2.71% and a relative standard error of 3.36%. Among the counties, the relative standard area varies from a low of 2.75% in Tulare to a high of 5.54% in Madera.

Cohort-Component Model

A standard cohort-component model was developed for each county and for the Valley-wide forecasts. The model uses data from the 2000 and 2010 census for age by gender in five-year age cohorts for each county, summing the county data to generate totals for the Valley. The model uses fertility data from the CA Department of Public Health's births statistical data tables for each county from 2005 through 2009. For Valley-wide fertility rates, the model calculates the number of births in each year, sums the births by age cohort of the mother, and divides those by the number of women DOF estimates for each age cohort in each year. The model calculates five-year survival rates for each age cohort using data from the California Abridged Life Tables, 2004. The survival rate data are not broken down by county. Finally, the model applies the survival and number-of-births data to the 2000 and 2010 Census data to estimate the migrations rate by gender and age cohort. The model also adjusts the migration rate data for the 5 to 9 and 10 to 14 age cohorts based on school enrollment data for each county.

With the exception of Stanislaus County, the cohort-component model projects a substantially larger population in 2050 than do the population trend and the household trend models. Therefore the population forecasts weigh cohort-component model for only 10% of the forecast, compared to 45% for the two other projections. It is not clear why the cohort-component model produces a smaller projection than the other two models for Stanislaus County.

The results of the cohort-component model are fitted to the final population forecast in order to generate the forecast for the age distribution. For each forecast year, the unadjusted cohort-component model projections are converted to percentage and the percentage for each age group is then multiplied by the population forecast.

Total Population Trend

Three different population trend projection models are used. In three of the counties and Valley-wide, the population in correctional facilities makes up a large percentage of the total group quarters population: Kern County, 85.3%; Kings County, 87.5%; Madera County, 90.3%; and the San Joaquin Valley, 68.1%. For these four, the model generates a projection for the household population and the group quarters population using estimates from DOF for 1990 through 2011. The model then assumes that the portion of the group quarters population in correctional facilities in 2010 will increase at the projected population growth for California. The model projects the state's population growth using a least-squares line generated from the DOF estimated population for 1990 through 2010. It assumes that the non–correctional facilities group quarters population will increase at the rate determined by the least-squares line for the total group population estimates from 1990 to 2011. The projected household population and the projected group quarters population are summed to generate the population trend projection for future population.

For four of the counties, Fresno, San Joaquin, Stanislaus, and Tulare, the model generates a least-squares line for the total population and uses this line to project future population. The model uses a least-squares line for the household population and group quarters population, projects these forward, and converts each population type's share of the sum total into a percentage. These percentages are applied to the final population forecast to generate the final projection for household and group quarters populations.

The third population trend model is used for Merced County because UC Merced will generate a significant increase in student population, in households, and in group quarters. But because UC Merced did not open in 2005, the population trend data would not adequately capture that potential growth. The model uses a least-squares line to project the total population, household population, and group quarters population without the students at the university since 2005. The model assumes that the university will reach its target student enrollment of 11,000 in 2020 and applies the growth rate needed to reach that target in the years after 2020 until the student population reaches 25,000. While the university anticipates housing half of these students on campus, in 2011 only about a third of the students lived in on-campus housing. The model assumes that the on-campus population will reach the 50% target in 2050, ten years after the model projects it will reach its buildout goal of 25,000 total students.

Average Household Size Trend

The average household size trend projection model uses data from the 1990, 2000, and 2010 Censuses. The model also adjusts the average household size based on race and ethnicity, using Census data from 2000 and 2010. The projections use the following race classifications: White alone; Black or African American alone; American Indian and Alaska Native alone; Asian alone; Native Hawaiian and Other Pacific Islander alone; Some other race alone; and Two or more races. The model provides a separate adjustment with the following ethnic categories: Hispanic; and White alone, non-Hispanic.

For the basic average household size projection for the San Joaquin Valley, the least-squares line produces a MAPE of 0.3% and a relative standard error of 0.62%. Because there are only three data points, though, one should expect a lower standard error than found with some of the previously described projections. The same process is used to project the average household size by housing type: single family, multifamily, and other.

Because the Census Bureau has changed how it collects and reports race and ethnicity data, the race/ethnicity adjustment to average household size uses only data from the 2000 and 2010 Censuses. The model uses the two data points for each race and ethnic classification to project the population and number of households for each forecast year. These projections are then adjusted on a percentage basis to reflect the population and households forecasts. The total population and total households are summed across race and ethnic categories and divided to provide the race/ethnic adjusted average households size in each forecast year. To calculate the average household size by housing type, the model applies the percentage change between the basic average household size projection and the race/ethnic adjusted average household size to the basic average household size by housing type.

The issue of future household sizes is complex yet very important to regional planning. Later sections in this report discuss this issue in great detail.

Age of Head of Household

The age of head of household trend projection model uses Census data from 1990, 2000, and 2010 for the number of household heads in 10-year age cohorts from age 15 through 75 and above. The data are converted to a percentage representing each age cohort's share of the total number of household heads. The model then uses a least-squares line to project the proportionate shares forward. The resulting projections are then adjusted such that each cohort's five-year change in share of households represents the average of the change from the initial projection and the change in the total population in that age cohort resulting from the cohort-component model. This adjustment is made so that the final projections reflect the changing age structure expected in the Valley through 2050 and not just the past trend in age of head of household. However, the full weight of the cohort-component model is not warranted because that model represents total population and not just household heads.

The final percentage projections are then applied to the household forecast to determine the projected number of household heads by age group. While the initial data and all of the projections are in 10-year age cohorts, the summary tables include only those age categories needed for the traffic model.

For the San Joaquin Valley, the least-squares lines for all age cohorts fail the t-test but satisfy the F-statistic test. The relative standard errors range from a low of 2.07% for the 15 to 24 age cohort to a high of 11.38% for the 55 to 64 age cohort.

Household Income Trends

There are two projections models for household income, one for the distribution of households among income categories and the other for the median household income, adjusted for inflation. The two models use data from 1990 and 2000 Censuses and data from the 2010 1-Year American Community Survey. For the Valley-wide model, average income is used instead of median household income because the median for the region cannot be derived from the median for each county.

For the distribution of households among income categories, the initial Census data are in the following classifications: Less than $10,000; $10,000 to $14,999; $15,000 to $24,999; $25,000 to $34,999; $35,000 to $49,999; $50,000 to $74,999; $75,000 to $99,999; $100,000 to $149,999; and $150,000 or more. However, for the traffic model, the data reflect classifications that were available in the 2000 Census but which the Census Bureau no longer uses. The projection model uses the classifications identified above to maintain the integrity of the original data. The final projections are converted into those needed for the traffic model based on the latter classifications' share of the households in the 2000 Census.

The distribution of households among income categories are adjusted for race and ethnicity, using Census data from 2000 and 2010. The final projections are an average of the number of households projected by the unadjusted model and the number of households projected by the race- and ethnicity-adjusted model.

Household Type Trend

The household type trend projection model uses Census data from 1990, 2000, and 2010. The model projects the number of households in four categories: Family households with children under age 18; Family households without children under age 18; Single person households; and All other non-family households. The original Census data represents the total number of households in each type. The model converts the number of households into each category's share of the total number of households.

For each category, the model uses a least-squares line to project the percentage of households for each forecast year. These projections are then multiplied by the household forecast to yield the number of households in each category.

Race and Ethnicity Trend

The race and ethnicity trend projection model uses Census data from 2000, and American Community Survey data from 2010 for the population in the following race and ethnicity categories: White alone, non-hispanic; Hispanic, all races; Black or African American alone, non-hispanic; American Indian and Alaska Native alone, non-hispanic; Asian alone, non-hispanic; Native Hawaiian and Other Pacific Islander alone, non-hispanic; and Some other race alone or in combination, non-hispanic.

The projection model uses a least-squares line for each category to project the future population. For each forecast year, the projected population is converted into each category's share of the population. Those percentage shares are then multiplied by the population forecast to yield the final forecast of population by race and ethnicity.

The three primary forecasts are number of households, population, and housing units. The other forecasts are derived from the primary forecasts. This chapter summarizes and discusses the primary forecasts, and the next chapter covers forecasts for the other remaining demographic characteristics.

Household Forecast

A household is one or more people who occupy a housing unit. And a house, apartment or other group of rooms, or a single room is regarded as a housing unit when it is occupied or intended for occupancy as separate living quarters; that is, when the occupants do not live and eat with any other persons in the structure.

Because housing tends to be the single largest expenditure for most households, the household often is the basic unit of analysis in economic research. The household is also an important unit of analysis in planning research because households make choices on where to live and housing often has the longest lifetime of real estate development products.

The household forecast is based on an assessment of five separate projection models:

1. Household Trend. This projection is based on the total number of households from 1990 through 2011.
2. Total Housing Units Trend. This projection is based on the total number of housing units and the projected vacancy rate.
3. Housing Construction Trend. This projection is based on the total number of housing units constructed and the projected vacancy rate.
4. Employment Trend. This projection is based on the total number of jobs and the projected jobs-housing ratio.
5. Cohort-Component Projection. This projection is based on the total population projected by a cohort-component model and the projected average household size.

Valley-wide Forecast

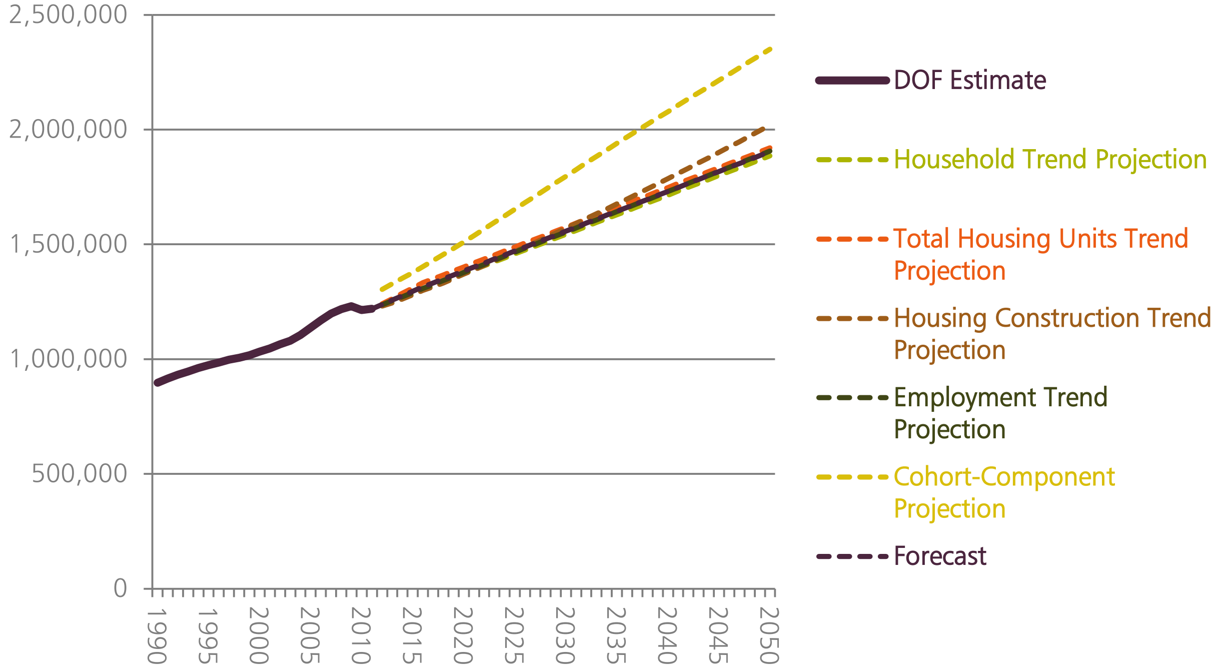
Table 1 shows the household projection generated by each of these five models for the San Joaquin Valley and Figure 6 compares them graphically.

Table 1: Comparison of Five Household Projection Models, San Joaquin Valley, 2010 to 2050

Year	Household Trend Projection	Total Housing Units Trend Projection	Housing Construction Trend Projection	Employment Trend Projection	Cohort-Component Projection
2010	1,214,000	1,214,000	1,214,000	1,214,000	1,214,000
2015	1,288,000	1,310,000	1,280,000	1,290,000	1,376,000
2020	1,373,000	1,402,000	1,370,000	1,378,000	1,510,000
2025	1,458,000	1,488,000	1,468,000	1,466,000	1,652,000
2030	1,544,000	1,575,000	1,570,000	1,554,000	1,797,000
2035	1,629,000	1,661,000	1,676,000	1,642,000	1,940,000
2040	1,715,000	1,748,000	1,786,000	1,730,000	2,080,000
2045	1,800,000	1,834,000	1,901,000	1,819,000	2,210,000
2050	1,885,000	1,921,000	2,020,000	1,907,000	2,350,000
Increase 2010 to 2050:	671,000	706,000	805,000	692,000	1,136,000
Annual Growth Rate:	1.11%	1.15%	1.28%	1.13%	1.67%

Source: The Planning Center|DC&E, 2012

Figure 6: Comparison of Household Projections, San Joaquin Valley, 1990 to 2050



Source: The Planning Center|DC&E, 2012.

The forecast for total households is based on the household trend projection, the total housing units trend projection, and the employment trend projection, with each weighted equally. The forecast does not use the housing construction trend projection because the data have a higher degree of variability than do the data in the three projection trends that are used. The forecast also does not use the cohort-component model because its projections are significantly higher than those produced by the other trend projections. Also, because the cohort component model represents the sum of many small projections—one for each five-year age increment—plus assumptions that fertility, survival, and migration rates remain constant over time, the household projections derived from the cohort-component model are inherently less reliable than those produced by the other projection models.

Eight Counties Forecasts

The models for seven of the eight individual counties use the same methodology to generate the forecast for total number of household: equal weighting of the household trend projection, the total housing units projection, and the employment trend projection. For Tulare County, the household forecast using this same model generates a projected household growth rate that is substantially lower than the population and housing unit forecasts. Therefore, the Tulare County forecast for total households uses the household trend projection, the total housing units projection, and the employment trend projection, each weighted at 0.3, and the housing construction trend projection, weighted at 0.1.

Table 2 summarizes the forecasts for total number of households for each county in the San Joaquin Valley. Figure 7 graphically compares the DOF estimates for total number of households from 1990 to 2011 and the forecasts from 2011 to 2050 for each of the eight counties.

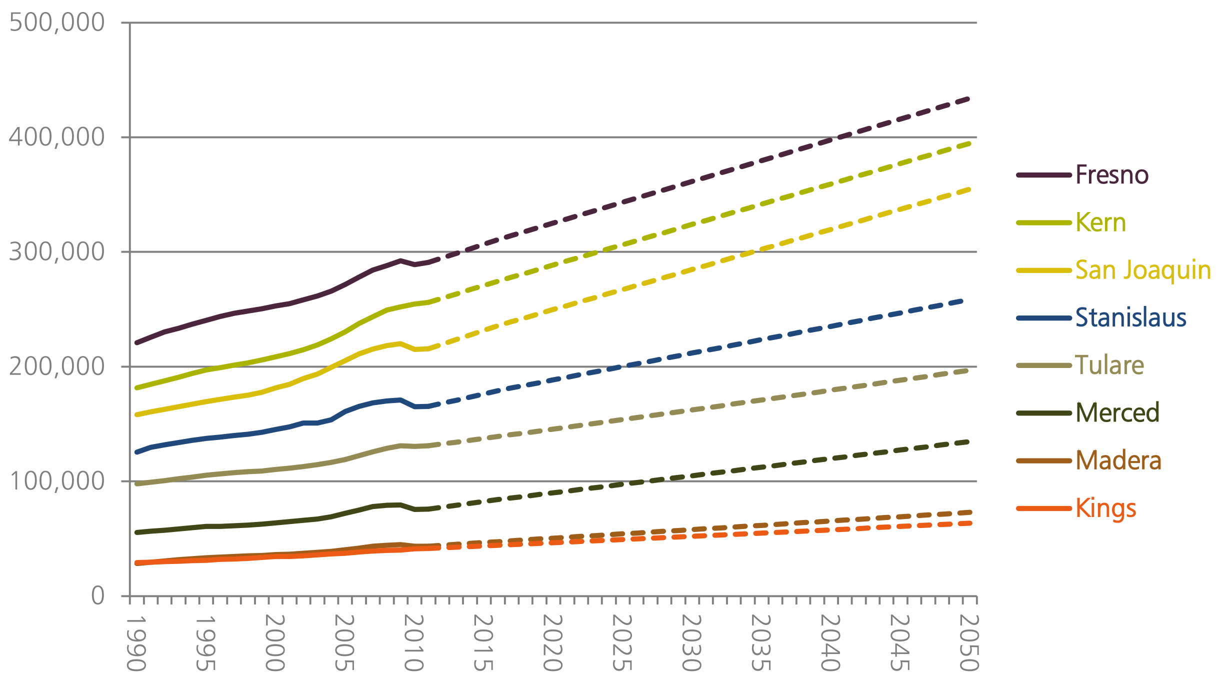
If present trends continue, all eight counties would continue growing in the number of households. The 40-year growth would range from 22,200 household in Kings County to 145,000 in Fresno County. The annual household growth rate would range from a low of 1.0% per year in Fresno and Tulare counties to a high of 1.3% per year in Madera and San Joaquin counties. Tulare and Fresno counties would increase in households at less than the Valley-wide rate; Kern, King, and Stanislaus counties at about the Valley-wide rate; and Madera, Merced, and San Joaquin counties at a faster rate.

Table 2: Forecast for Total Number of Households, Eight San Joaquin Valley Counties, 2010 to 2050

Year	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
2010	289,000	255,000	41,200	43,300	75,600	215,000	165,200	130,400
2015	307,000	271,000	43,700	46,600	82,400	232,000	176,300	137,400
2020	325,000	289,000	46,500	50,500	90,000	250,000	188,500	145,600
2025	343,000	306,000	49,300	54,200	97,500	267,000	200,000	153,900
2030	362,000	324,000	52,200	57,900	104,900	285,000	212,000	162,400
2035	380,000	342,000	55,000	61,700	112,400	302,000	224,000	170,900
2040	398,000	359,000	57,800	65,400	119,800	320,000	235,000	179,500
2045	416,000	377,000	60,600	69,200	127,300	337,000	247,000	188,200
2050	434,000	395,000	63,400	72,900	134,700	355,000	259,000	197,000
Increase 2010 to 2050:	145,000	140,000	22,200	29,600	59,100	140,000	93,800	66,600
Annual Growth Rate:	1.0%	1.1%	1.1%	1.3%	1.5%	1.3%	1.1%	1.0%

Source: The Planning Center|DC&E, 2012.

Figure 7: Comparison of Estimates and Forecasts for Total Number of Households, Eight San Joaquin Valley Counties, 1990 to 2050



Source: The Planning Center|DC&E, 2012, using DOF estimates for total number of households from 1990 to 2011.

Note: In this and subsequent charts, solid lines represent actual or estimated data and dashed lines indicate projections or forecasts.

County Total and Valley-wide Comparison

The question naturally arises as to what the difference is between the projection results for the eight individual county models and the projection results of the Valley-wide model. Table 3 presents the data for this comparison.

The difference between the summed total of the eight counties and the Valley-wide forecasts is a mere 6,000 households, less than 1%.

Table 3: Comparison of Eight County and Valley-wide Forecasts for Total Number of Households, 2010 to 2050

Year	Summed Total of the Eight Counties	Valley-wide Forecast
2010	1,214,000	1,214,000
2015	1,296,000	1,296,000
2020	1,385,000	1,384,000
2025	1,472,000	1,471,000
2030	1,560,000	1,558,000
2035	1,647,000	1,644,000
2040	1,735,000	1,731,000
2045	1,822,000	1,818,000
2050	1,910,000	1,904,000
Increase 2010 to 2050:	696,000	690,000
Annual Growth Rate:	1.1%	1.1%

Source: The Planning Center|DC&E, 2012.

Population Forecast

Population refers to the total number of people living in a geographic area. For demographic purposes, population is often divided into two categories: household population and group quarters population. Household population includes all people living in housing units and those that are homeless. Group quarters population includes people living in institutional facilities—including correctional institutions, college dormitories, and assisted living facilities.

The population forecasts cover the total population. As discussed in the Methodology chapter, however, in some cases the forecasts for the individual counties have been adjusted to reflect particular circumstances with group quarters. Nevertheless, the forecasts for population reflect the total population, both household and group quarters. As discussed in the methodology chapter, the trend in household population and group quarters population are projected forward in order to divide the population forecast into the two categories.

The population forecast is derived from three projection models:

1. Population Trend. This projection is based on the total population from 1990 through 2011.
2. Household Forecast. This projection is based on the household forecast and the projected average household size.
3. Cohort-Component Model. This projection is based on the total population projected by a cohort-component model.

Valley-wide Forecast

The population forecast uses the results of all three projection models. Because the data for the population trend and household forecast models have less variability, the forecast gives these two models a larger weight, 0.45. The cohort-component model produces a projection that is higher than that produced by the other two projection models, but it does not have to be combined with a separate projection as in the household forecast. Therefore, the population forecast incorporates the projection from the cohort-component model, but gives it a weight of 0.1.

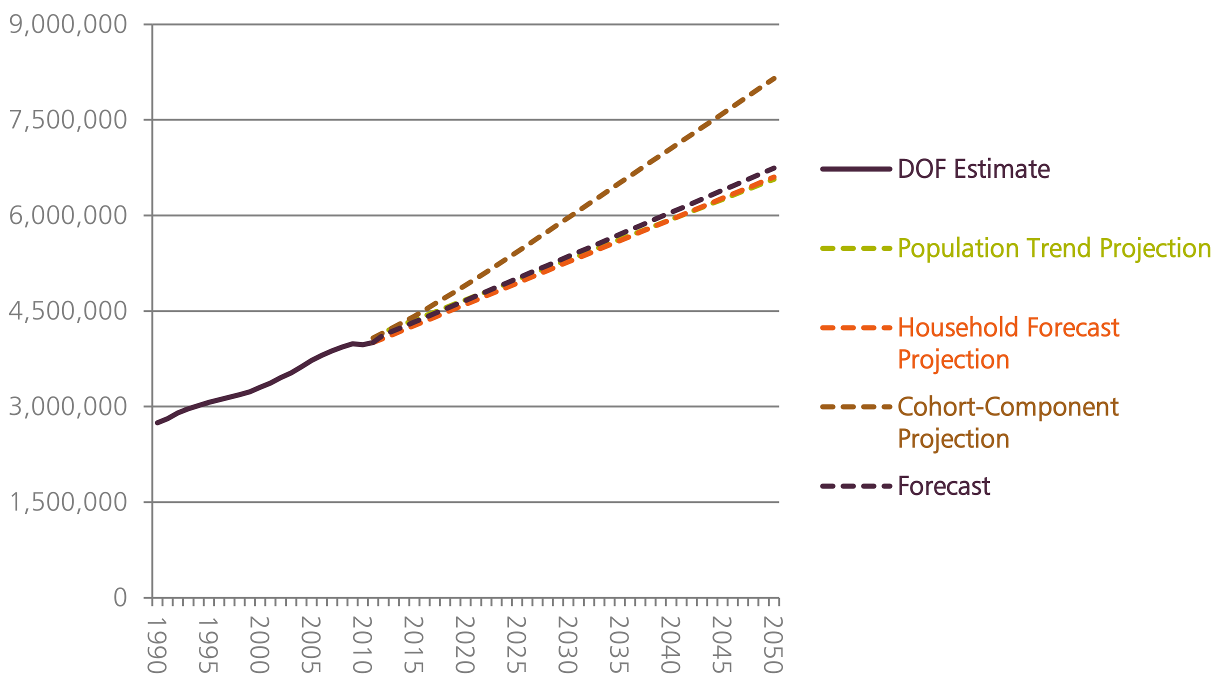
The Methodology chapter describes the process used to adjust the population trend projection to better account for the large portion of the group quarters population in correctional institutions.

Table 4: Comparison of Three Population Projection Models and the Population Forecast, San Joaquin Valley, 2010 to 2050

Year	Population Trend Projection	Household Forecast Projection	Cohort-Component Projection	Population Forecast
Weight:	0.45	0.45	0.10	
2010	3,970,000	3,970,000	3,970,000	**3,970,000**
2015	4,360,000	4,270,000	4,420,000	**4,330,000**
2020	4,680,000	4,600,000	4,900,000	**4,670,000**
2025	4,990,000	4,940,000	5,430,000	**5,010,000**
2030	5,310,000	5,270,000	5,970,000	**5,360,000**
2035	5,620,000	5,600,000	6,510,000	**5,700,000**
2040	5,940,000	5,940,000	7,050,000	**6,050,000**
2045	6,250,000	6,270,000	7,600,000	**6,390,000**
2050	6,570,000	6,600,000	8,150,000	**6,740,000**
Increase 2010 to 2050:	2,600,000	2,630,000	4,180,000	**2,770,000**
Annual Growth Rate:	1.27%	1.28%	1.81%	**1.33%**

Source: The Planning Center|DC&E, 2012.

Figure 8: Comparison of Population Projections and Forecast, San Joaquin Valley, 1990 to 2050



Source: The Planning Center|DC&E, 2012.

Eight Counties Forecasts

The population forecasts for each of the eight counties use the same methodology as the Valley-wide forecast, with the exception of Stanislaus County. For Stanislaus County, the cohort-component model project much lower total population than the other two models project. Therefore, the forecast model increases the weights for the population trend projection and the household forecast projection from 0.45 to 0.475 and reduces the weight of the cohort-component projection from 0.1 to 0.05. Also, as described in the Methodology chapter, the population trend projections for Kern, Kings, and Madera counties have been adjusted to reflect the high portion of the group quarters population in correctional facilities, and the population trend projection for Merced County has been adjusted to better account for the planned growth of the on- and off-campus student population at UC Merced.

Table 5 summarizes the forecasts for total population for each county in the San Joaquin Valley. Figure 9 graphically compares the DOF estimates for total population from 1990 to 2011 and the forecasts from 2011 to 2050 for each of the eight counties.

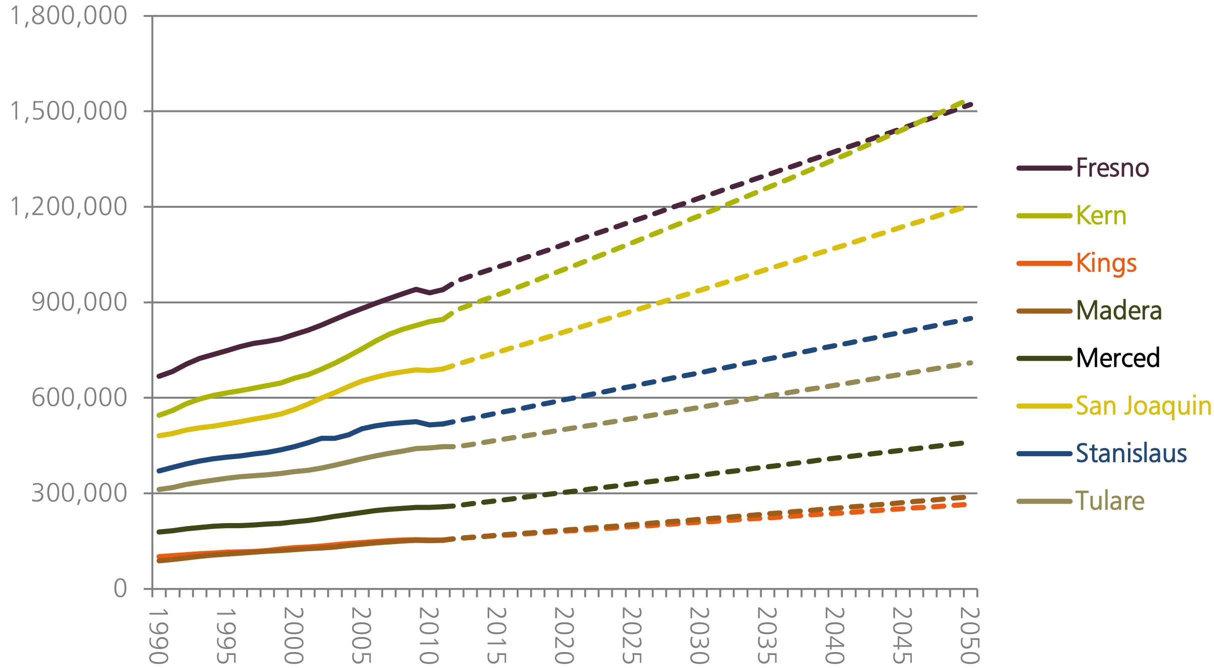
If present trends continue, all eight counties would continue to grow in population, with 40-year growth ranging from 113,000 in Kings County to 700,000 in Kern County. Stanislaus and Kings counties' populations would grow at about the same rate as the Valley as a whole; Fresno and Tulare counties would grow more slowly; and Kern, Madera, Merced, and San Joaquin would grow at a faster rate. The forecasts indicate that Madera County should grow to a larger population than Kings County in the near term, and Kern County would grow past Fresno County to become the largest population in the Valley over the long term.

Table 5: Forecast for Total Population, Eight San Joaquin Valley Counties, 2010 to 2050

Year	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
2010	930,000	840,000	153,000	150,900	256,000	685,000	514,000	442,000
2015	1,010,000	923,000	167,000	168,000	277,000	743,000	552,000	466,000
2020	1,082,000	1,004,000	181,000	184,500	303,000	807,000	594,000	501,000
2025	1,155,000	1,087,000	195,000	201,000	330,000	872,000	637,000	535,000
2030	1,228,000	1,173,000	209,000	218,000	356,000	938,000	679,000	570,000
2035	1,301,000	1,260,000	223,000	235,000	383,000	1,004,000	722,000	605,000
2040	1,374,000	1,349,000	237,000	253,000	410,000	1,070,000	764,000	640,000
2045	1,447,000	1,442,000	251,000	271,000	436,000	1,137,000	807,000	675,000
2050	1,521,000	1,540,000	266,000	289,000	461,000	1,204,000	849,000	710,000
Increase 2010 to 2050:	591,000	700,000	113,000	138,100	205,000	519,000	335,000	268,000
Annual Growth Rate:	1.2%	1.5%	1.4%	1.6%	1.5%	1.4%	1.3%	1.2%

Source: The Planning Center|DC&E, 2012.

Figure 9: Comparison of Estimates and Forecasts for Total Population, Eight San Joaquin Valley Counties, 1990 to 2050



Source: The Planning Center|DC&E, 2012.

County Total and Valley-wide Comparison

The Valley-wide model projects the Valley's population will reach 2,770,000 in 2050. This result is about 100,000 lower than the summed result of the eight individual county projections, or 3.6%. The cohort-component model projects a higher population than the other projection models, and summing the results simply magnifies the effect.

Table 6: Comparison of Eight Counties and Valley-wide Forecasts for Total Population, 2010 to 2050

Year	Summed Total of Eight Counties	Valley-wide Forecast
2010	3,970,000	3,970,000
2015	4,310,000	4,330,000
2020	4,660,000	4,670,000
2025	5,010,000	5,010,000
2030	5,370,000	5,360,000
2035	5,730,000	5,700,000
2040	6,100,000	6,050,000
2045	6,470,000	6,390,000
2050	6,840,000	6,740,000
Increase 2025 to 2050:	2,870,000	2,770,000
Annual Growth Rate:	1.37%	1.33%

Source: The Planning Center|DC&E, 2012.

Household and Group Quarters Population

As described in the Methodology chapter, the forecast for household and group quarters population is derived from the total population forecast. Table 7 summarizes the forecasts for household population in each of the eight counties and Valley-wide. The annual growth rate in household population varies from a low of 1.2% in Fresno County to a high of 1.7% in Madera County.

Table 8 summarizes the forecasts for group quarters population in each of the eight counties and Valley-wide. The annual growth rate ranges from a low of –0.1% in Tulare County to a high of 3.4% in Merced County.

Household population would account for the largest share of total population growth in Tulare County, where the group quarters population is projected to continue to decline. Household population would account for the smallest share of total population growth in Kings County. In Kings County, the large prison population, 12.6% of the total population in 2010, skews the demographics. The forecast model for Kings County separates out the group quarters population in correctional institutions, and group quarters constitutes a smaller share of total population in 2050 than in 2010.

Table 7: Household Population Forecasts, Eight Counties and the San Joaquin Valley, 2010 to 2050

	2010 Household Population	Share of Total Population	2050 Household Population	Share of Total Population	Increase 2010 to 2050	Annual Growth Rate	Share of Total Population Growth
Fresno	921,000	97.9%	1,488,000	97.8%	541,000	1.2%	97.6%
Kern	802,000	95.5%	1,473,000	95.6%	635,000	1.5%	95.7%
Kings	131,300	85.8%	229,000	86.2%	92,800	1.4%	86.6%
Madera	141,900	94.1%	274,000	94.8%	125,100	1.7%	95.5%
Merced	251,000	98.0%	441,000	95.7%	186,100	1.4%	93.1%
San Joaquin	669,000	97.6%	1,186,000	98.5%	497,000	1.4%	99.6%
Stanislaus	507,000	98.5%	838,000	98.6%	319,000	1.3%	98.8%
Tulare	436,000	98.7%	704,000	99.2%	263,000	1.2%	100.1%
San Joaquin Valley	3,850,000	96.9%	6,530,000	96.9%	2,540,000	1.3%	96.9%

Source: The Planning Center|DC&E, 2012.

Table 8: Group Quarters Population Forecasts, Eight Counties and the San Joaquin Valley, 2010 to 2050

	2010 Group Quarters Population	Share of Total Population	2050 Group Quarters Population	Share of Total Population	Increase 2010 to 2050	Annual Growth Rate	Share of Total Population Growth
Fresno	19,460	2.1%	33,600	2.2%	13,510	1.4%	2.4%
Kern	37,500	4.5%	67,200	4.4%	28,300	1.5%	4.3%
Kings	21,700	14.2%	36,700	13.8%	14,340	1.3%	13.4%
Madera	8,930	5.9%	15,160	5.2%	5,920	1.3%	4.5%
Merced	5,220	2.0%	19,840	4.3%	13,760	3.4%	6.9%
San Joaquin	16,170	2.4%	18,270	1.5%	2,120	0.3%	0.4%
Stanislaus	7,610	1.5%	11,470	1.4%	3,730	1.0%	1.2%
Tulare	5,760	1.3%	5,440	0.8%	-190	-0.1%	-0.1%
San Joaquin Valley	121,500	3.1%	207,000	3.1%	81,100	1.3%	3.1%

Source: The Planning Center|DC&E, 2012.

Total Housing Units Forecast

The total housing units forecast includes occupied and vacant housing units. It is perhaps the most challenging dataset to analyze because the number of housing units constructed varies considerably from one year to the next and because the vacancy rate also rises and falls as market conditions change.

Over the long term, the number of housing units is also a challenge to forecast. Changing family structures, changes in housing product types, housing preferences changing with age, and planning initiatives to promote more sustainable development patterns will all influence the rates and types of housing construction.

Nevertheless, good planning requires a good educated forecast of where current trends are heading. It also requires monitoring those trends over time to understand how trends are changing.

As used in this report, single-family housing includes single-family detached housing and attached housing, such as townhouses and row houses, as well as duplexes, triplexes, and quadplexes. Multifamily housing includes apartments and condominiums. The key difference between single-family attached and multifamily is where the units are attached. A unit is single-family attached if it has no other units above or below, regardless of how many units are attached at the side or rear. An attached unit is multifamily if it has one or more units above or below in the same building, regardless if there are units attached to the side or rear. Other units are primarily mobile homes, but this category also includes boats and recreational vehicles when they are used as a primary residence.

Valley-wide Forecast

As described in the Methodology chapter, the forecast for housing units uses a single projection based on the total housing units as estimated by DOF to forecast the total number of housing units. Separate projections based on number of units constructed are used to allocate the projected total number of housing units by type of housing.

Table 9 summarizes the forecast for the total number of housing units and the number of units by type. The forecast model indicates that the region's housing stock would increase by about 1.2% per year, but multifamily housing would grow faster, 1.4% per year, than single-family housing will grow, 1.1% per year.

Table 9: Housing Units Forecast, by Type of Housing, San Joaquin Valley, 2010 to 2050

	Total Housing Units	Total Single Family Units	Total Multifamily Units	Total Other Units
2010	1,331,127	996,763	246,219	83,375
2015	1,382,357	1,038,096	258,751	85,510
2020	1,450,676	1,088,224	274,227	88,225
2025	1,531,314	1,147,146	292,647	91,521
2030	1,624,270	1,214,862	314,010	95,397
2035	1,729,544	1,291,373	338,317	99,854
2040	1,847,138	1,376,678	365,568	104,891
2045	1,977,049	1,470,778	395,763	110,509
2050	2,119,279	1,573,672	428,901	116,707
Increase 2010 to 2050:	788,152	576,909	182,682	33,332
Annual Growth Rate:	1.2%	1.1%	1.4%	0.8%

Source: The Planning Center|DC&E, 2012.

Eight Counties Forecasts

The housing units forecast models are the same as the Valley-wide model. Table 10 summarizes the forecast increase in the total number of housing units and the increase in the number of units by housing type. The forecasts indicate that in Fresno, Kern, Kings, and Tulare counties, multifamily housing will increase at a faster rate than single-family housing. In Madera County, the trend in multifamily housing slopes downward very steeply. However, this is more of a statistical anomaly than it is a statement on market sentiment. Indeed, if Madera County were to add multifamily housing at the Valley-wide rate, it would add a total of 4,200 units through 2050, not just 1,894. Merced County is also something of an outlier. No adjustments were made to the housing unit forecast to account for student growth at UC Merced. If the university adds 12,500 students living off-campus, then the county could grow well beyond the 5,300 multifamily units that the trend suggests.

Table 10: 40-Year Increase in Housing Units, by Type of Unit, Eight Counties, 2010 to 2050

	Total Housing Increase	Annual Growth Rate	Single Family Housing Increase	Annual Growth Rate	Multifamily Housing Increase	Annual Growth Rate	Other Housing Increase	Annual Growth Rate
Fresno	171,785	1.1%	119,168	1.1%	48,492	1.2%	4,132	0.6%
Kern	200,599	1.3%	124,289	1.2%	61,880	2.0%	17,274	1.3%
Kings	21,852	1.0%	15,559	1.0%	6,611	1.6%	808	0.8%
Madera	31,320	1.2%	27,212	1.3%	1,894	0.7%	1,207	0.7%
Merced	59,423	1.4%	51,765	1.5%	5,362	0.8%	476	0.2%
San Joaquin	175,259	1.4%	146,908	1.5%	27,144	1.3%	4,807	1.0%
Stanislaus	123,359	1.3%	103,537	1.4%	14,861	1.1%	5,895	1.2%
Tulare	71,036	1.0%	48,716	0.9%	21,716	1.9%	603	0.1%

Source: The Planning Center|DC&E, 2012.

The remaining demographic forecasts are all derived from the primary forecasts. The demographics summarized in this chapter include:

+ Age Distribution
+ Average Household Size
+ Household Income
+ Household Type
+ Race/Ethnicity

Because these forecasts do not employ multiple projections, the summaries in this chapter are shorter and more concise.

AGE DISTRIBUTION

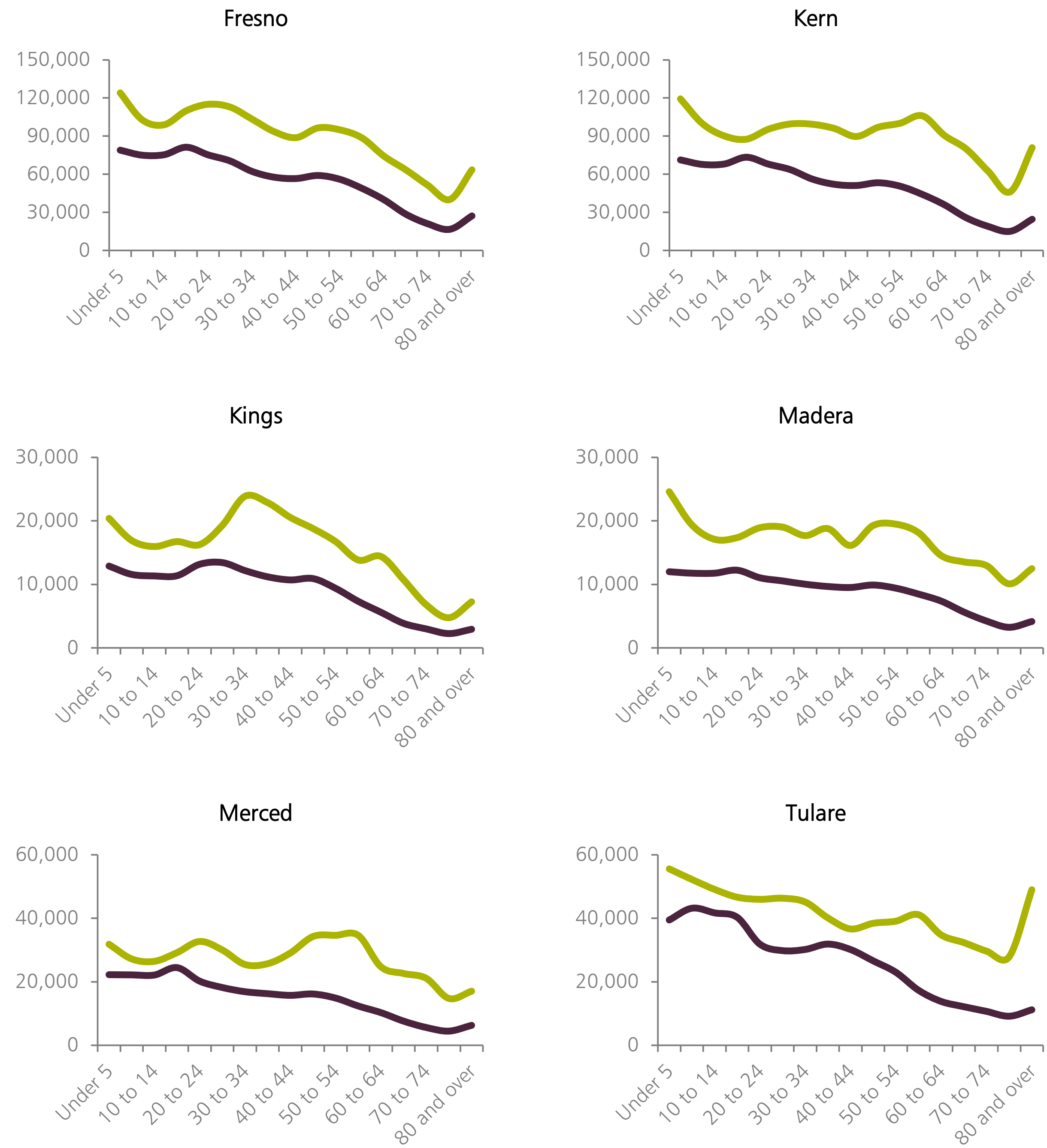
The forecast for age distribution uses the cohort component model to project the population in five-year age cohorts by gender, for every five-year period to 2050. The model uses standard five-year age cohorts (e.g., under 5, 5 to 9, 10 to 14, etc.). However, the traffic model requires age categories that more closely reflect the ages for attending the different levels of school. The forecast uses 1-year age increment data from the Census Bureau to divide the five-year age cohorts into the age categories needed for the traffic model.

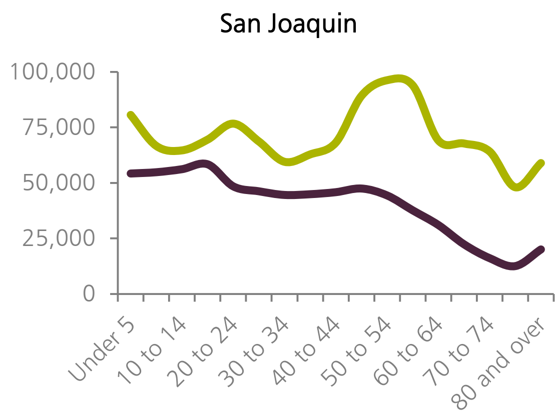
Figure 10 shows the age distribution across the Valley as of the 2010 Census and the age distribution forecast for 2050. The age bump in the 15 to 19 cohort in 2010 would become, with migration, the very large bulge in the 50 to 54 cohort in 2050. As this and the adjacent cohorts age over time, they would have profound impacts on housing, public services, and the economy, similar to the effects nationally of the baby boom generation. Figure 11 shows the age distribution for the eight counties in 2010 and 2050.

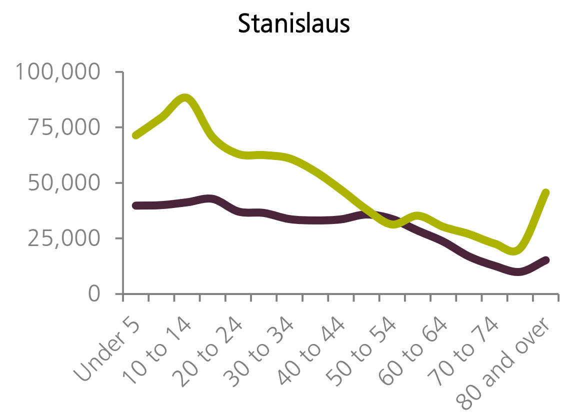
Figure 10: Age Distribution, San Joaquin Valley, 2010 and 2050

Source: The Planning Center|DC&E, 2012; data for 2010 are from the US Census Bureau.

Figure 11: Age Distribution, Eight San Joaquin Valley Counties, 2010 and 2050







The charts for the individual counties show that three of the counties have the pronounced bump in the 50 to 54 age cohort in 2050: Kern, Merced, and San Joaquin. Fresno, Madera and Tulare counties have a slight bump, but it does not overshadow the rest of the age distribution. Finally, Kings and Stanislaus counties have age distributions that show no signs of the population bump in the 50 to 54 age cohort.

The cohort component models for the individual counties use the same statewide data for survival rates to calculate mortality. The fertility rates and the number of women in child-bearing age cohorts are unique to each county, but they are not too dissimilar. The primary difference among the individual models is the assumed migration rate by age cohort. Thus most of the differences in the long-range forecasts is driven by migration. These forecasts implicitly assume that migration rates will continue. To the degree that migration patterns change, the age distributions could change, perhaps significantly.

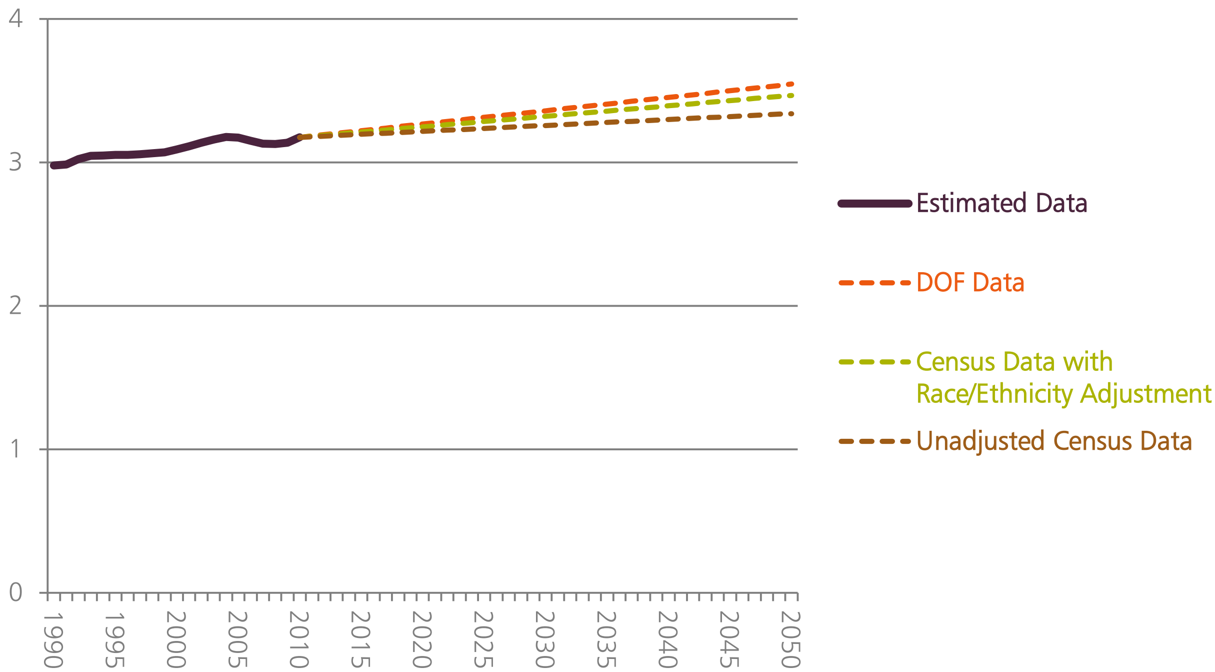
Average Household Size

The forecast model for average household size evaluated three different projections. The first used a least squares line fitted to the DOF-estimated average household size from 1990 to 2010. The second used the average household size from the 1990, 2000, and 2010 Censuses, and the average household size by units in structure from the 1990 and 2000 Censuses and the 2010 American Community Survey. The third model used average household size by race and ethnicity data from the 2000 and 2010 Censuses. Figure 12 shows the three projections for average household size.

All three projections showed an increasing average household size. This result seems suspect in light of the long-term national decline in average household size, as described in the Introduction. On the other hand, international migration, especially from Central and South America and from Asia tends to increase household size. And the increasing rate of multigenerational family households will also lead to larger households. Because these larger trends are likely to continue in the San Joaquin Valley, no adjustment has been made to adjust the average household size downward to approach the national trend of decreasing household size.

The model based on DOF data projects the largest household sizes (3.55 Valley-wide in 2050) and the model based on Census data unadjusted for race and ethnicity projects the smallest increase in household size (3.34 Valley-wide in 2050). The forecast uses the middle projection produced using Census data with the adjustment for race and ethnicity.

Figure 12: Comparison of Three Projections for Average Household Size, San Joaquin Valley, 1990 to 2050



Source: The Planning Center|DC&E, 2012; estimated data are COF estimates for average household size.

Table 11 summarizes the forecast change in average household size from 2010 to 2050 for each of the eight counties. The current average household size ranges from a low of 3.08 in Stanislaus to a high of 3.36 in Tulare. By 2050, Stanislaus would still have the lowest average household size, but Kings County would have the highest, at 3.77. The average household size Valley-wide would increase from 3.17 to 3.47.

Table 11: Forecast for Average Household Size, Eight San Joaquin Valley Counties, 2010 and 2050

	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare	San Joaquin Valley
2010	3.15	3.15	3.19	3.28	3.32	3.12	3.08	3.36	3.17
2050	3.27	3.34	3.77	3.54	3.43	3.22	3.15	3.44	3.47
Increase:	0.31	0.40	0.92	0.45	0.17	0.19	0.20	0.24	0.30

Source: The Planning Center|DC&E, 2012.

Household Income

The household income forecast covers two distinct demographic characteristics, the distribution of households among nine income groups and the median household income. The model converts the nine income categories under which data is currently reported by the Census Bureau into the five categories required for the traffic model, and adjusts the forecasts to account for differing income distributions and differing population growth rates among race and ethnic classifications.

For the distribution of households across income categories, the data are not adjusted for inflation. The categories remain the same, and over time, one should expect inflationary effects to gradually move households into higher income categories.

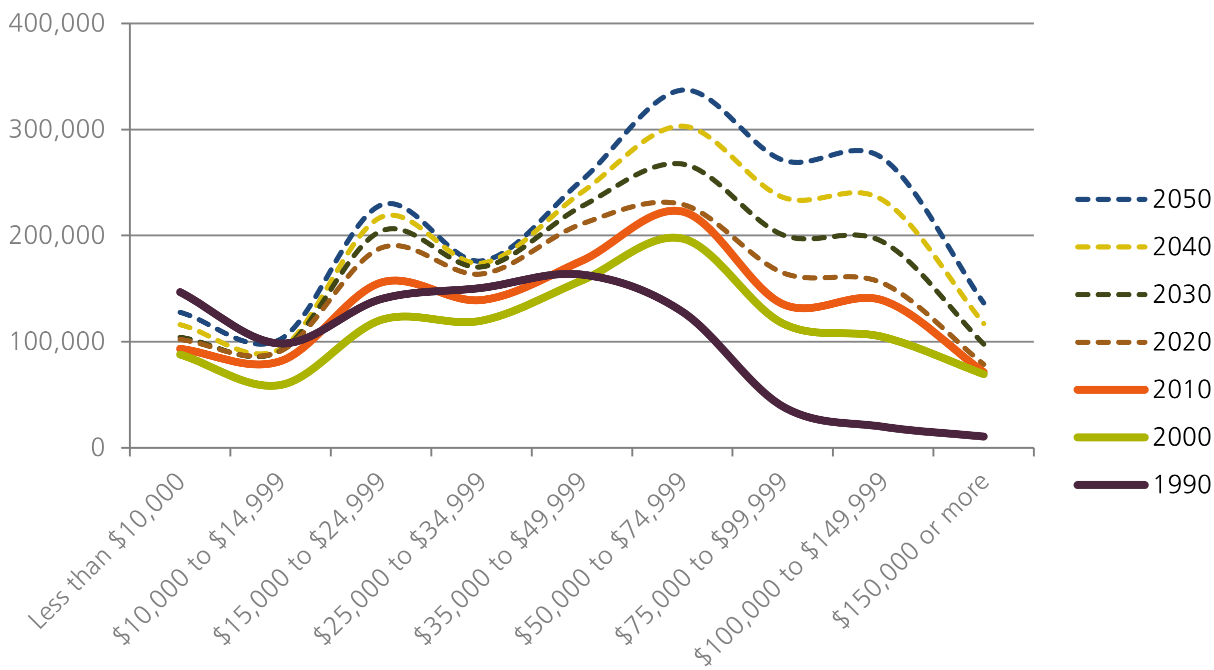
The model does not account for differing income distributions among age categories. Nevertheless, each county's past migration patterns—that is the relative ages of those moving into and out of each county—will have influenced the trend. Projecting the trend forward implicitly assumes that those migration patterns will continue.

Valley-wide Income Distribution Forecast

Figure 13 graphically shows the distribution of households by income categories. In 1990, 78% of households had annual income of $50,000 or less. Ten years later, the total number of households in every income category below $50,000 per year had decreased, and the number in every category from $50,000 and above had increased. By 2010, there more households in every category, but the distribution changed very little. If present trends continue, the number of households would increase in each income category, with the highest rates of growth in the categories from $75,000 and above. Table 12 summarizes the Valley-wide income distribution forecast.

Because income distribution data is not adjusted for inflation, Figure 13 conveys an image that is far rosier than reality. As a point of reference, a $100,000 per year household income in 2005 had the same purchasing power as a $20,000 household income in 1965. Thus, the large increases in the upper income categories do not necessarily imply an increase in purchasing power or living standard.

Figure 13: Distribution of Households by Income Category, San Joaquin Valley, 1990 to 2050



Source: The Planning Center|DC&E, 2012, with data from the 1990 Census, 2000 Census, and 2010 ACS.

Table 12: Summary of Household Distribution by Income by Category Forecast, San Joaquin Valley, 2010 to 2050

	Less than $10,000	$10,000–$14,999	$15,000–$24,999	$25,000–$34,999	$35,000–$49,999	$50,000–$74,999	$75,000–$99,999	$100,000–$149,999	$150,000 or more
2010	93,278	81,722	155,691	139,227	176,290	222,632	135,440	138,804	71,249
2050	127,660	102,374	228,752	176,034	252,222	337,116	271,106	272,488	136,492
Increase:	34,382	20,652	73,061	36,807	75,932	114,484	135,666	133,684	65,243
Annual Rate of Change:	0.8%	0.6%	1.0%	0.6%	0.9%	1.0%	1.8%	1.7%	1.6%

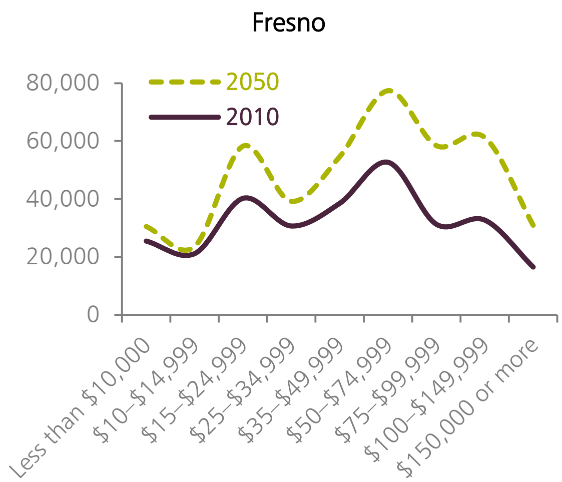
Source: The Planning Center|DC&E, 2012.

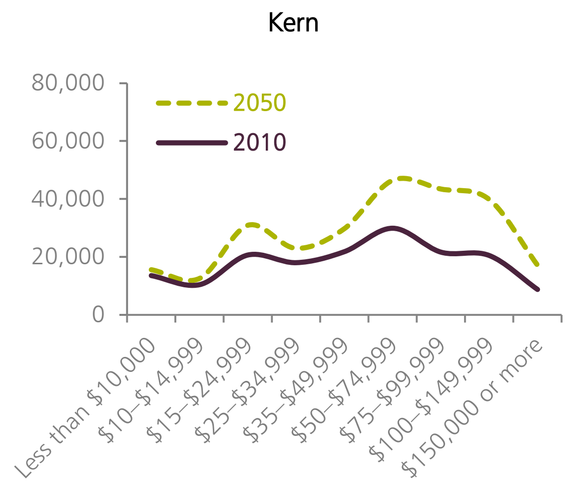
Eight Counties Income Distribution Forecast

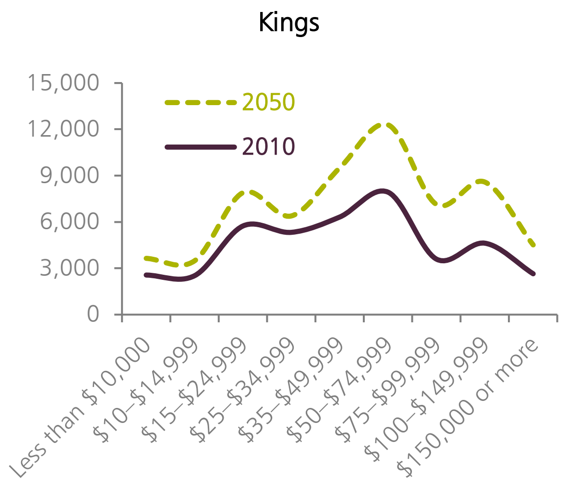
Figure 14 graphically shows the household distribution by income category for each of the eight counties in 2010 and 2050. Table 13 summarizes the forecasts.

As discussed in the Valley-wide forecast, these charts appear to suggest large increases in household income because the data are not adjusted for inflation. The median household income forecast provides a much better understanding of the real increase in household income and purchasing power because the median household income data can be adjusted for inflation.

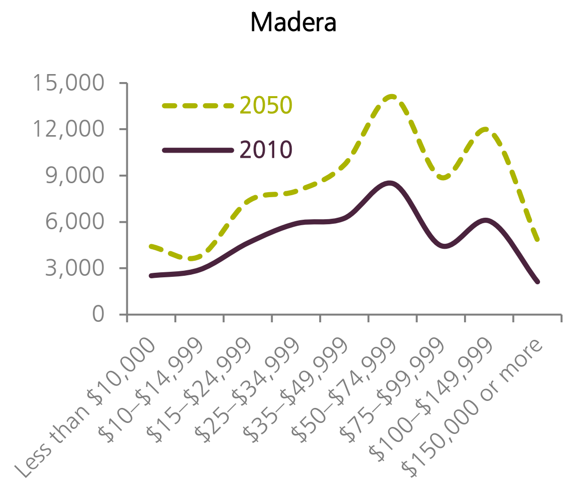
Figure 14: Household Distribution by Income Category, Eight San Joaquin Counties, 2010 and 2050



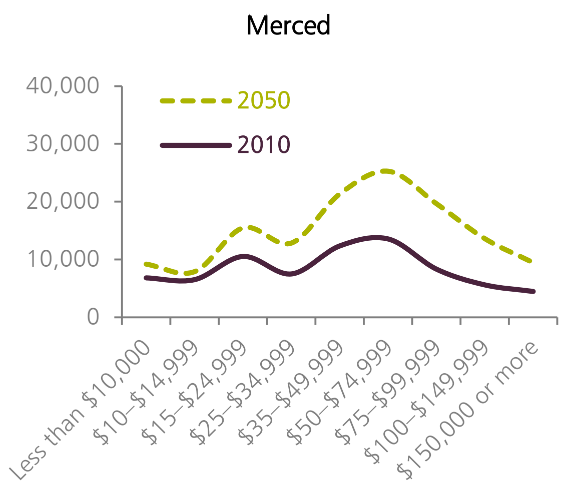




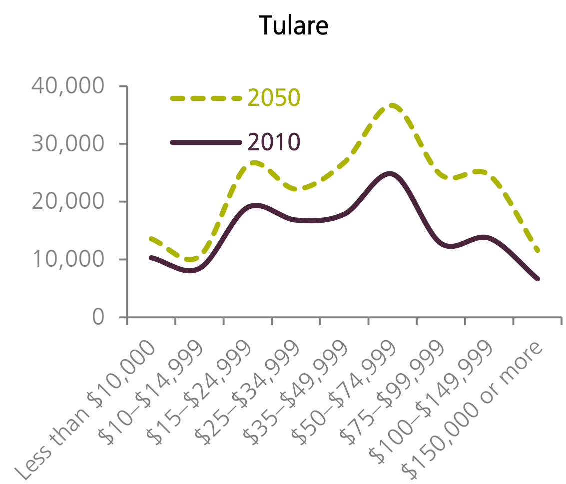
Kings
15,000
12,000
9,000
6,000
3,000
0
2050
2010
Less than $10,000
$10–$14,999
$15–$24,999
$25–$34,999
$35–$49,999
$50–$74,999
$75–$99,999
$100–$149,999
$150,000 or more



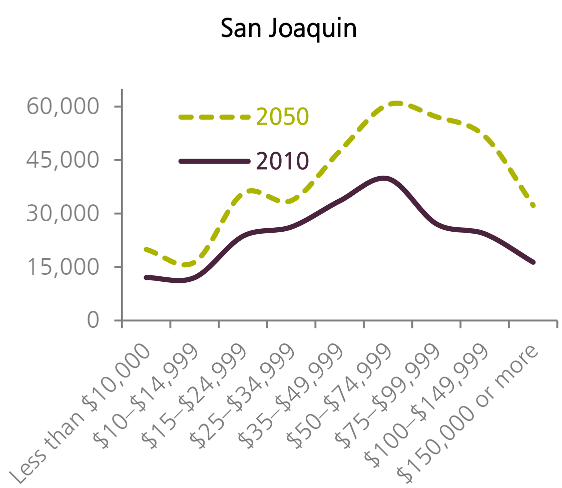
Madera
15,000
12,000
9,000
6,000
3,000
0
2050
2010
Less than $10,000
$10–$14,999
$15–$24,999
$25–$34,999
$35–$49,999
$50–$74,999
$75–$99,999
$100–$149,999
$150,000 or more



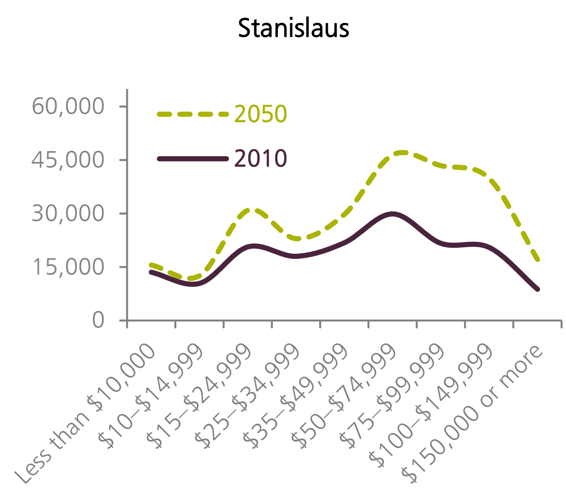
Merced
40,000
30,000
20,000
10,000
0
2050
2010
Less than $10,000
$10–$14,999
$15–$24,999
$25–$34,999
$35–$49,999
$50–$74,999
$75–$99,999
$100–$149,999
$150,000 or more



Tulare
40,000
30,000
20,000
10,000
0
2050
2010
Less than $10,000
$10–$14,999
$15–$24,999
$25–$34,999
$35–$49,999
$50–$74,999
$75–$99,999
$100–$149,999
$150,000 or more



San Joaquin
60,000
45,000
30,000
15,000
0
2050
2010
Less than $10,000
$10–$14,999
$15–$24,999
$25–$34,999
$35–$49,999
$50–$74,999
$75–$99,999
$100–$149,999
$150,000 or more



Stanislaus
60,000
45,000
30,000
15,000
0
2050
2010
Less than $10,000
$10–$14,999
$15–$24,999
$25–$34,999
$35–$49,999
$50–$74,999
$75–$99,999
$100–$149,999
$150,000 or more

Table 13: Household Distribution by Income Category Forecast, Eight San Joaquin Valley Counties, 2010 to 2050

	Less than $10,000	$10,000–$14,999	$15,000–$24,999	$25,000–$34,999	$35,000–$49,999	$50,000–$74,999	$75,000–$99,999	$100,000–$149,999	$150,000 or more
Fresno County									
2010	25,466	21,126	40,225	30,675	38,489	52,669	31,254	32,701	16,495
2050	30,480	23,587	58,236	39,207	54,605	77,394	58,410	61,225	30,938
Increase	5,014	2,461	18,011	8,532	16,116	24,725	27,156	28,524	14,443
Annual Rate	0.5%	0.3%	0.9%	0.6%	0.9%	1.0%	1.6%	1.6%	1.6%
Kern County									
2010	20,114	17,823	31,317	28,771	39,719	45,575	26,225	31,317	13,749
2050	26,309	22,025	47,291	36,789	54,504	65,638	54,021	61,647	26,559
Increase	6,195	4,202	15,974	8,018	14,785	20,063	27,796	30,330	12,810
Annual Rate	0.7%	0.5%	1.0%	0.6%	0.8%	0.9%	1.8%	1.7%	1.7%
Kings County									
2010	2,559	2,518	5,737	5,324	6,315	7,925	3,591	4,623	2,642
2050	3,640	3,483	7,896	6,387	9,497	12,285	7,133	8,582	4,512
Increase	1,081	965	2,159	1,063	3,182	4,360	3,542	3,959	1,870
Annual Rate	0.9%	0.8%	0.8%	0.5%	1.0%	1.1%	1.7%	1.6%	1.3%
Madera County									
2010	2,512	2,902	4,635	5,891	6,238	8,490	4,462	6,064	2,123
2050	4,410	3,761	7,330	7,991	9,700	14,117	8,876	11,921	4,817
Increase	1,898	859	2,695	2,100	3,462	5,627	4,414	5,857	2,694
Annual Rate	1.4%	0.7%	1.2%	0.8%	1.1%	1.3%	1.7%	1.7%	2.1%
Merced County									
2010	6,815	6,512	10,525	7,496	12,342	13,553	8,329	5,603	4,467
2050	9,191	7,903	15,474	12,839	21,330	25,272	19,656	13,608	9,456
Increase	2,376	1,391	4,949	5,343	8,988	11,719	11,327	8,005	4,989
Annual Rate	0.8%	0.5%	1.0%	1.4%	1.4%	1.6%	2.2%	2.2%	1.9%
San Joaquin County									
2010	12,040	12,040	23,651	26,231	33,541	39,776	27,091	24,296	16,341
2050	19,915	16,358	35,681	33,637	47,498	60,540	57,153	51,683	32,287
Increase	7,875	4,318	12,030	7,406	13,957	20,764	30,062	27,387	15,946
Annual Rate	1.3%	0.8%	1.0%	0.6%	0.9%	1.1%	1.9%	1.9%	1.7%
Stanislaus County									
2010	13,545	10,406	20,648	18,005	21,804	29,898	21,639	20,482	8,755
2050	15,566	12,565	30,912	22,962	29,761	46,460	43,437	39,823	17,129
Increase	2,021	2,159	10,265	4,957	7,957	16,562	21,798	19,341	8,374
Annual Rate	0.3%	0.5%	1.0%	0.6%	0.8%	1.1%	1.8%	1.7%	1.7%
Tulare County									
2010	10,298	8,473	19,031	16,815	17,858	24,767	12,774	13,687	6,648
2050	13,579	10,579	26,361	22,189	26,814	36,646	24,642	24,607	11,588
Increase	3,281	2,106	7,330	5,374	8,956	11,879	11,868	10,920	4,940
Annual Rate	0.7%	0.6%	0.8%	0.7%	1.0%	1.0%	1.7%	1.5%	1.4%

Source: The Planning Center|DC&E, 2012.

Eight Counties Median Household Income Forecast

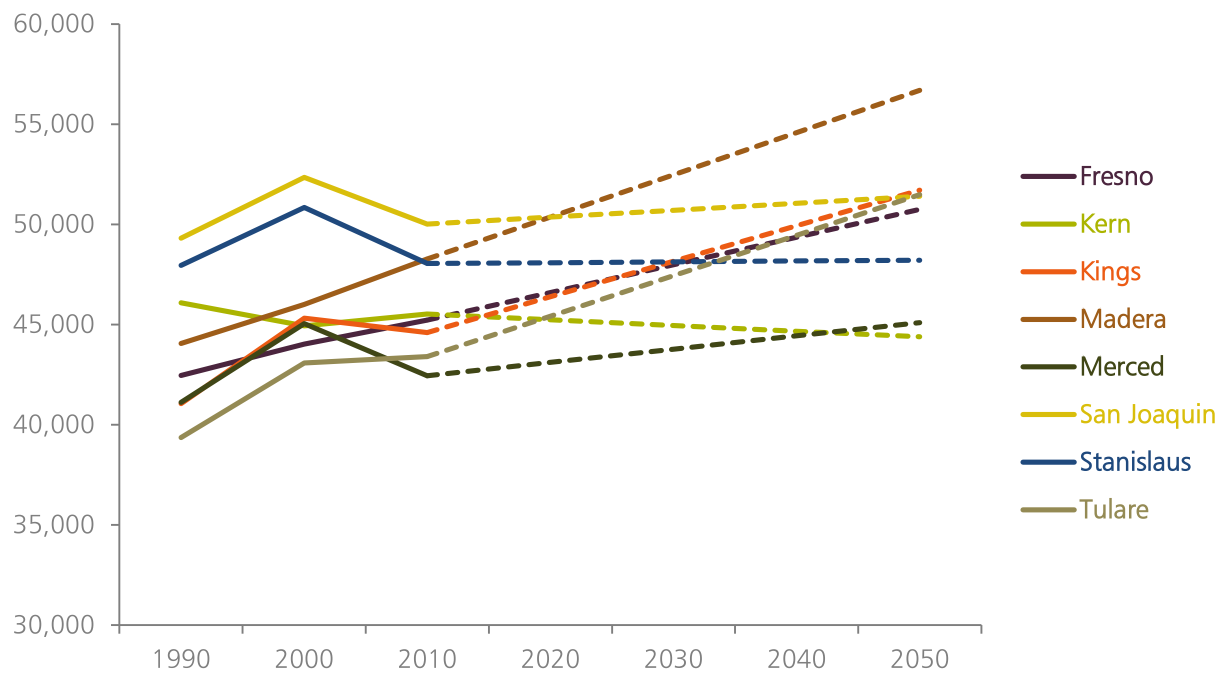
The forecast model adjusts the median household income data from 1990, 2000, and 2010 for inflation and then fits the least-squares line to the adjusted data. Projecting that line forward provides the forecast for real median household income. Increases in the real income signify increases in purchasing power and the potential for an improved standard of living.

Figure 15 graphically shows the real median household forecasts for the eight counties. Table 14 summarizes the forecast for each of the counties.

If present trends continue, Kings, Madera, and Tulare counties would experience the largest increase in real household income. Even in these counties, however, the increase would only be 0.4% per year, and the median household would see only a $7,000 to $8,000 increase in real terms over 40 years. Fresno, Merced, and San Joaquin counties would have slightly less growth in household income; Stanislaus would have almost no change; and Kern County would see a decline in real household income.

These forecasts have implications for a full spectrum of public policies. In regard to land use planning, however, the lack of substantial growth in real household income suggests that the region will not be able to support increases in housing costs above the rate of inflation. Furthermore, it suggests that households will be unable to increase retail spending beyond the rate of inflation. With little increase in retail spending and property values beyond the rate of inflation, local government revenues are unlikely to increase on a per capita and inflation-adjusted basis.

Figure 15: Real Median Household Income Forecast, Eight San Joaquin Valley Counties 1990 to 2050



Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Table 14: Summary of Real Median Household Income Forecast, Eight San Joaquin Valley Counties, 2010 to 2050

	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
2010	45,221	45,524	44,609	48,268	42,449	50,011	48,044	43,397
2050	50,744	44,387	51,709	56,688	45,097	51,406	48,216	51,476
Increase	5,523	-1,137	7,100	8,420	2,648	1,395	172	8,079
Annual Rate of Change	0.3%	-0.1%	0.4%	0.4%	0.2%	0.1%	0.0%	0.4%

Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Household Type

The household type model uses data from the 1990, 2000, and 2010 Censuses to forecast the number of household in four categories: Family households with children under age 18; Family households without children under age 18; Single person households; All other non-family households.

Valley-wide Forecast

Figure 16 shows the trend and forecast for household by type of for the Valley, and Table 15 summarizes the forecast.

If present trends continue, family households with children under the age of 18 would increase at the slowest rate among the four household types. By 2045, the number of family households without children under age 18 would exceed the number with children. Non-family households would account for over 25% of the total household growth. Even still, families with and without children would grow faster than non-family households.

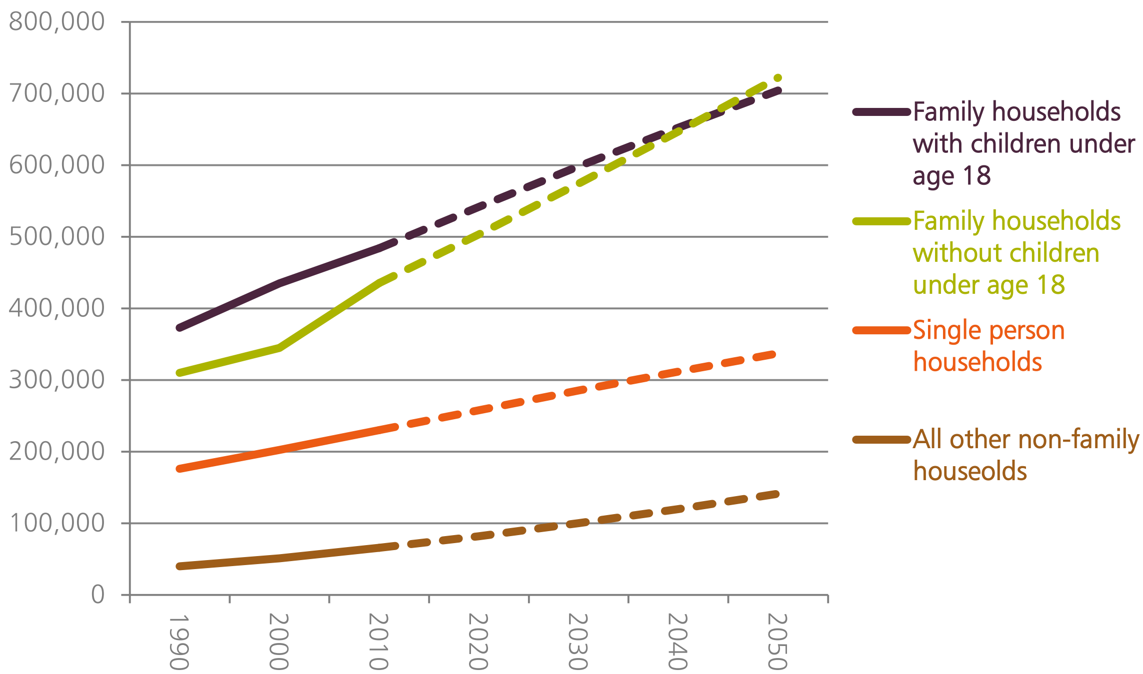
This forecast is consistent with the age distribution forecast, which shows a population bulge in the 50 to 59 age cohort in 2050 and is consistent with the forecast for increasing household size.

Table 15: Summary of Household Type Forecast, San Joaquin Valley, 2010 to 2050

	Family households with children under age 18	Family households without children under age 18	Single person households	All other non-family households
2010	483,811	435,117	230,026	65,778
2050	704,141	721,847	336,949	141,306
Change	220,330	286,730	106,923	75,528
Annual Rate of Change	0.9%	1.3%	1.0%	1.9%
Share of Total Change	32.0%	41.6%	15.5%	11.0%

Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Figure 16: Household Type Forecast, San Joaquin Valley, 1990 to 2050



Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Eight Counties Forecast

Table 16 summarizes the forecast for household type for each of the eight counties. As with the Valley-wide forecast, families without children under the age of 18 would add more households and grow at a faster rate than families with children. By 2050, families without children would outnumber families with children in Fresno, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties. In all eight counties, non-family households would grow a faster rate than the other three household types. However, families with and without children would still account for the majority of all households.

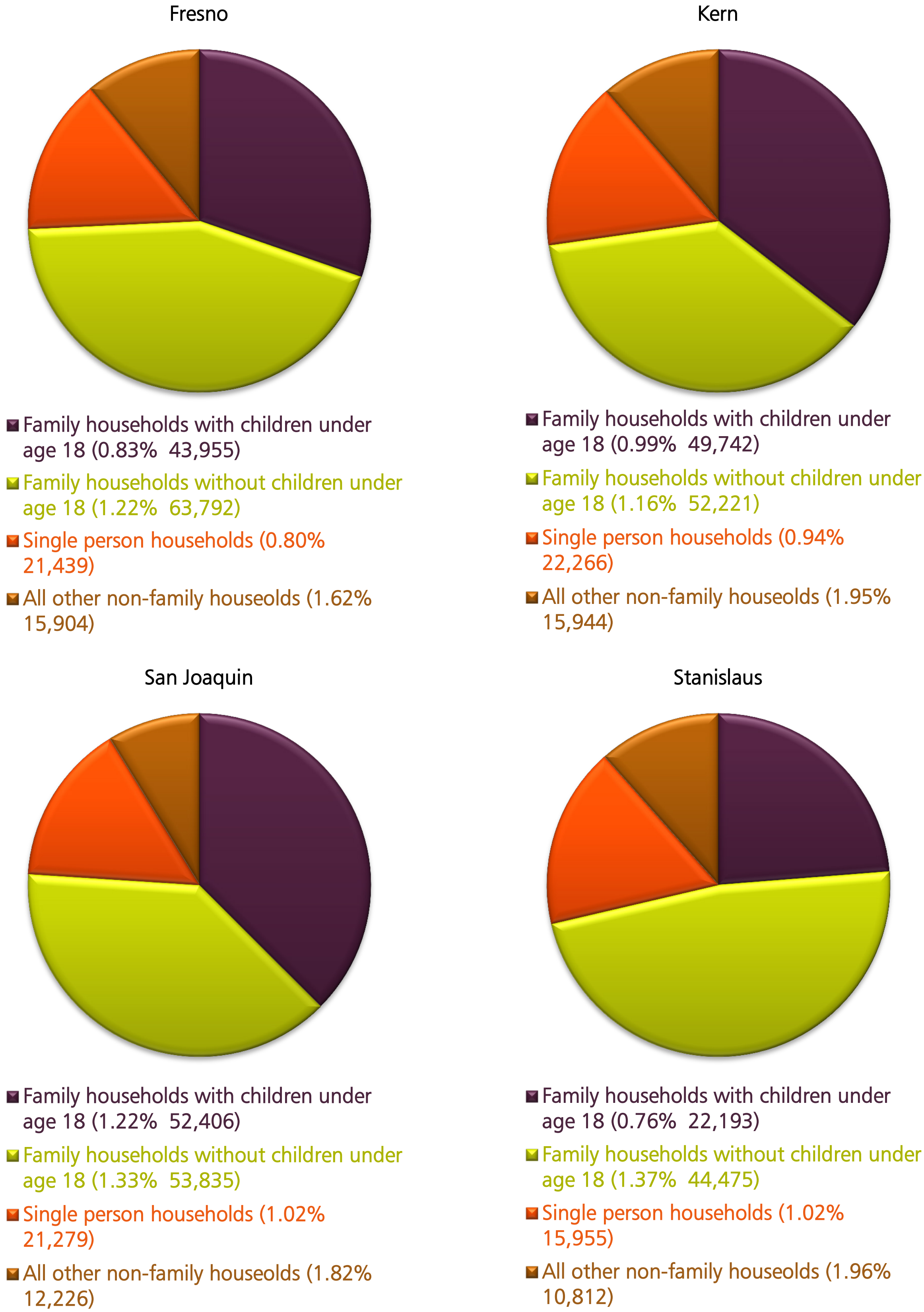
Table 16: Summary of Household Type Forecast, Eight San Joaquin Valley Counties, 2010 to 2050

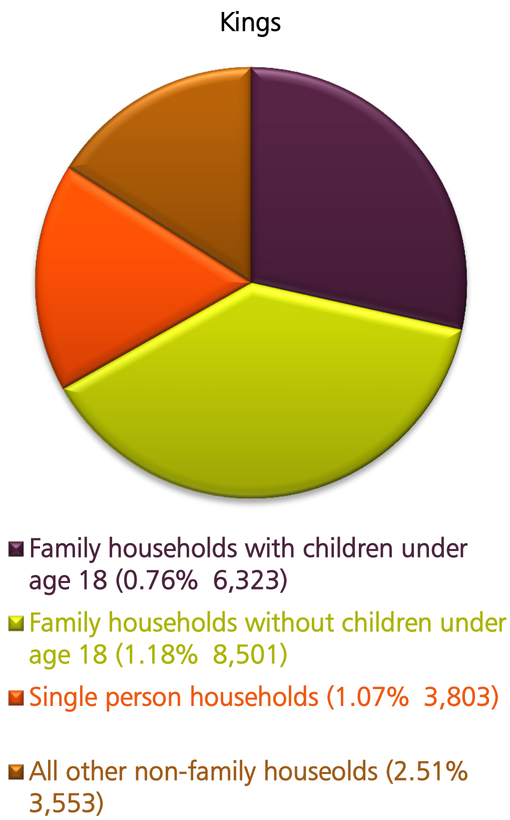
	Family households with children under age 18	Family households without children under age 18	Single person households	All other non-family households
Fresno County				
2010	111,984	102,165	57,233	17,610
2050	155,939	165,957	78,672	33,514
Increase	43,955	63,792	21,439	15,904
Annual Rate of Change	0.8%	1.2%	0.8%	1.6%
Share of Total Increase	30.3%	44.0%	14.8%	11.0%
Kern County				
2010	102,961	88,778	49,209	13,662
2050	152,703	140,999	71,475	29,606
Increase	49,742	52,221	22,266	15,944
Annual Rate of Change	1.0%	1.2%	0.9%	2.0%
Share of Total Increase	35.5%	37.3%	15.9%	11.4%

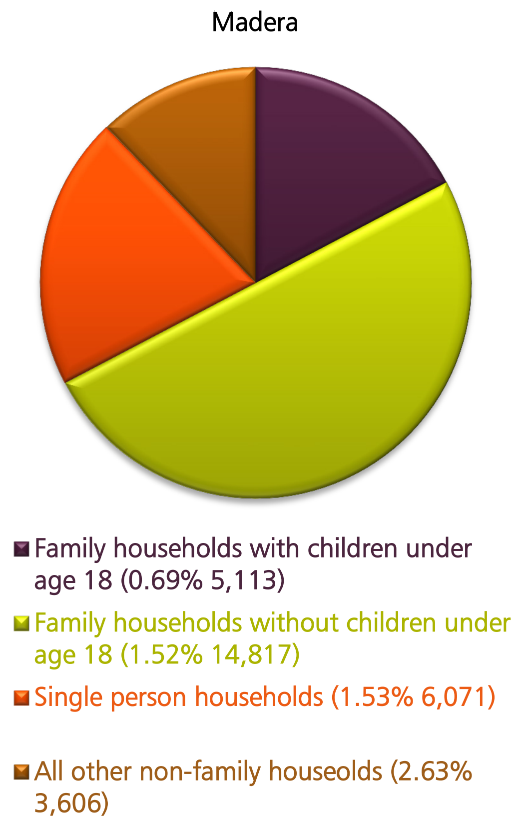
	Family households with children under age 18	Family households without children under age 18	Single person house-holds	All other non-family households
Kings County				
2010	17,793	14,146	7,197	2,097
2050	24,116	22,647	11,000	5,650
Increase	6,323	8,501	3,803	3,553
Annual Rate of Change	0.8%	1.2%	1.1%	2.5%
Share of Total Increase	28.5%	38.3%	17.1%	16.0%
Madera County				
2010	16,220	17,873	7,251	1,973
2050	21,333	32,690	13,322	5,579
Increase	5,113	14,817	6,071	3,606
Annual Rate of Change	0.7%	1.5%	1.5%	2.6%
Share of Total Increase	17.3%	50.0%	20.5%	12.2%
Merced County				
2010	32,134	26,633	13,157	3,718
2050	48,848	52,410	23,698	9,775
Increase	16,714	25,777	10,541	6,057
Annual Rate of Change	1.1%	1.7%	1.5%	2.4%
Share of Total Increase	28.3%	43.6%	17.8%	10.3%
San Joaquin County				
2010	83,711	77,346	42,389	11,561
2050	136,117	131,181	63,668	23,787
Increase	52,406	53,835	21,279	12,226
Annual Rate of Change	1.2%	1.3%	1.0%	1.8%
Share of Total Increase	37.5%	38.5%	15.2%	8.7%
Stanislas County				
2010	62,458	61,574	31,923	9,225
2050	84,651	106,049	47,878	20,037
Increase	22,193	44,475	15,955	10,812
Annual Rate of Change	0.8%	1.4%	1.0%	2.0%
Share of Total Increase	23.8%	47.6%	17.1%	11.6%
Tulare County				
2010	56,395	46,461	21,588	5,908
2050	81,634	71,914	29,337	14,121
Increase	25,239	25,453	7,749	8,213
Annual Rate of Change	0.9%	1.1%	0.8%	2.2%
Share of Total Increase	37.9%	38.2%	11.6%	12.3%

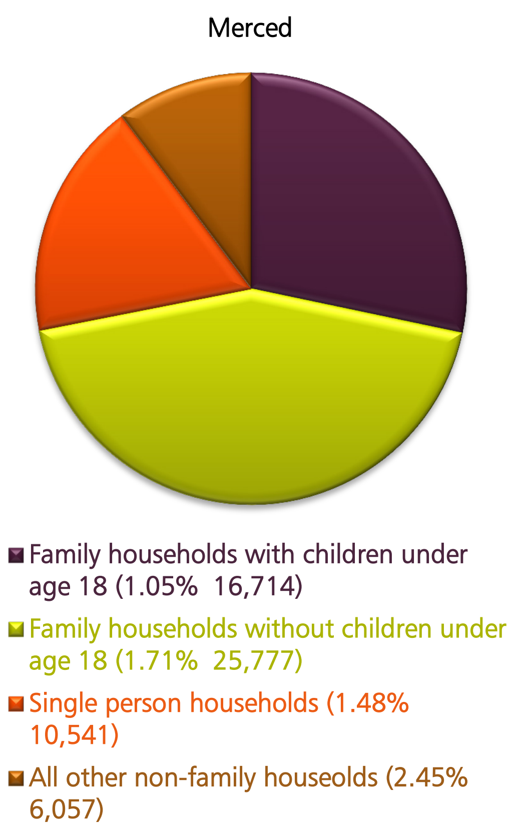
Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

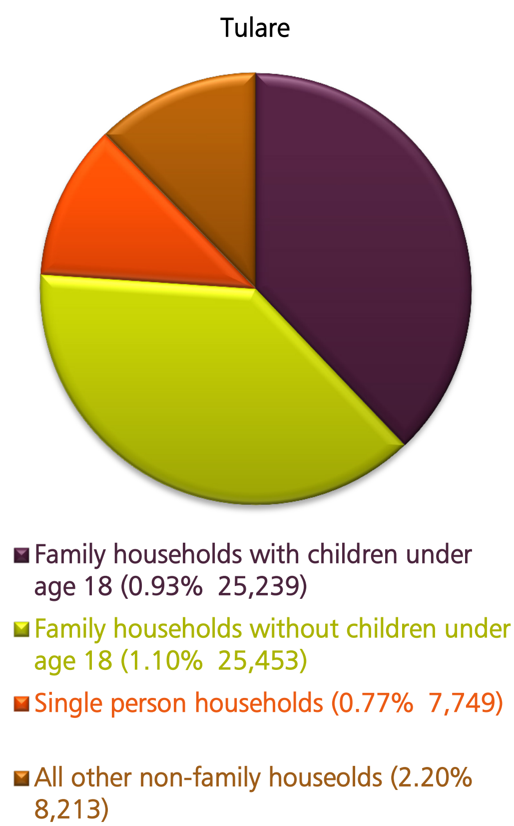
Figure 17: Household Growth by Household Type (annual growth rate and total increase), Eight San Joaquin Valley Counties, 2010 to 2050




Kings
Family households with children under age 18 (0.76% 6,323)
Family households without children under age 18 (1.18% 8,501)
Single person households (1.07% 3,803)
All other non-family houseolds (2.51% 3,553)


Madera
Family households with children under age 18 (0.69% 5,113)
Family households without children under age 18 (1.52% 14,817)
Single person households (1.53% 6,071)
All other non-family houseolds (2.63% 3,606)


Merced
Family households with children under age 18 (1.05% 16,714)
Family households without children under age 18 (1.71% 25,777)
Single person households (1.48% 10,541)
All other non-family houseolds (2.45% 6,057)


Tulare
Family households with children under age 18 (0.93% 25,239)
Family households without children under age 18 (1.10% 25,453)
Single person households (0.77% 7,749)
All other non-family houseolds (2.20% 8,213)

Race and Ethnicity

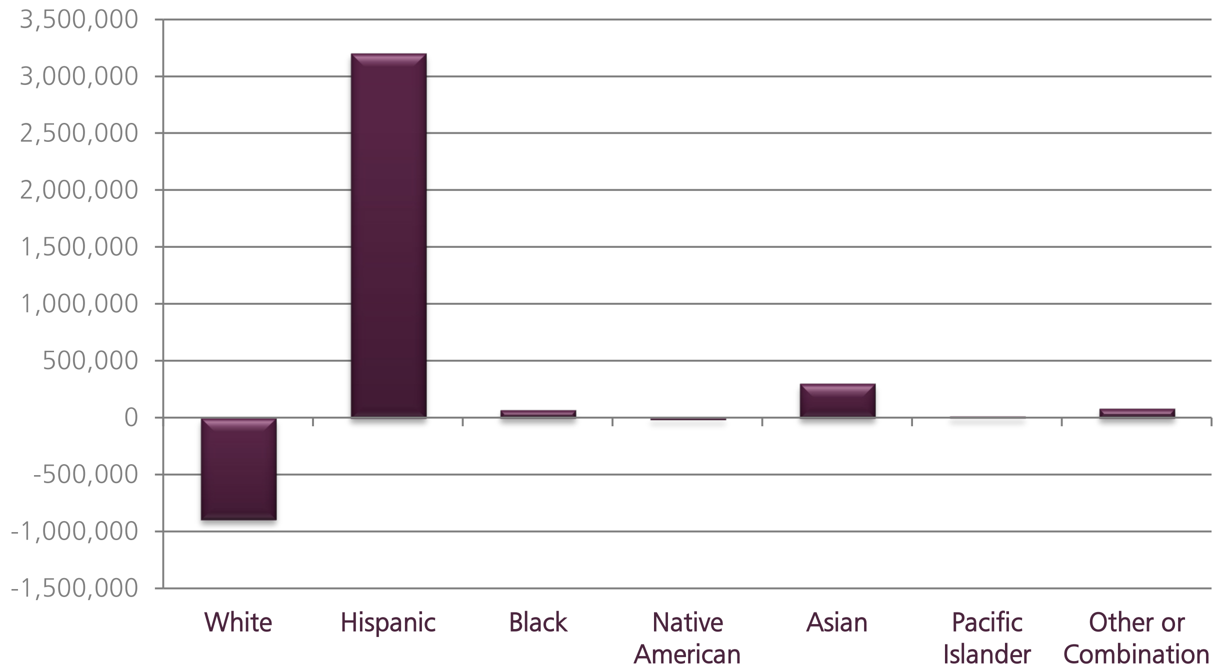
The San Joaquin Valley, like many parts of California, has experienced substantial immigration, especially Hispanics, and Asians to a lesser degree. Other forecasts have made adjustments to reflect differences in demographics characteristics among race and ethnic groups. The final model forecasts changes in the racial and ethnic composition of the population.

Valley-wide Forecast

Figure 18 graphically shows the change in the population by race and ethnicity, and Table 17 summarizes the forecast.

If present trends continue, the white non-Hispanic population in the Central Valley will continue to decline in total number. The magnitude of the decline, 2.4% per year, is too large to represent just natural change (births and deaths). This indicates an out-migration of this population. Similarly, the total number of Hispanics would continue to increase, and the magnitude of this change, 2.6% per year, is too large to represent natural increase. This suggests that the Central Valley would continue to attract Hispanic in-migration, whether domestic or international. Asians would constitute a large source of population growth, although the rate of growth in this group, 1.8% per year, would be lower than that of Native Hawaiian and Pacific Islander.

Figure 18: Change in Population by Race and Ethnic Group, San Joaquin Valley, 2010 to 2050



Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Table 17: Summary of Forecast of Population by Race and Ethnicity, San Joaquin Valley, 2010 to 2050

	White alone, non-Hispanic	Hispanic, all races	Black or African American alone, non-Hispanic	American Indian and Alaska Native alone, non-Hispanic	Asian alone, non-Hispanic	Native Hawaiian and Other Pacific Islander alone, non-Hispanic	Some other race alone or in combination, non-Hispanic
2010	1,451,451	1,820,337	181,592	25,457	279,474	9,506	203,842
2050	559,461	5,024,454	251,976	11,697	581,563	26,474	284,374
Increase	-891,990	3,204,117	70,384	-13,760	302,089	16,968	80,532
Annual Rate of Change	-2.4%	2.6%	0.8%	-1.9%	1.8%	2.6%	0.8%

Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Eight County Forecasts

The forecasts for the eight counties indicate that all would follow a similar pattern as the Valley as a whole: a sizeable out-migration of the white non-Hispanic population and an even large increase in the Hispanic population. The four largest counties, Fresno, Kern, San Joaquin, and Stanislaus would also have a significant increase in the Asian population. Table 18 summarizes the forecast for each county.

Table 18: Summary of Race and Ethnicity Forecast, Eight San Joaquin Valley Counties, 2010 to 2050

	White alone, non-Hispanic	Hispanic, all races	Black or African American alone, non-Hispanic	American Indian and Alaska Native alone, non-Hispanic	Asian alone, non-Hispanic	Native Hawaiian and Other Pacific Islander alone, non-Hispanic	Some other race alone or in combination, non-Hispanic
Fresno County							
2010	304,522	442,992	45,005	5,979	86,856	1,066	44,030
2050	159,100	1,004,444	65,630	3,195	220,155	3,283	65,193
Increase	-145,422	561,452	20,625	-2,784	133,299	2,217	21,163
Annual Rate	-1.6%	2.1%	0.9%	-1.6%	2.4%	2.9%	1.0%
Kern County							
2010	323,794	391,144	45,377	5,893	33,100	995	39,328
2050	227,959	1,027,764	81,180	4,578	98,741	2,406	97,373
Increase	-95,835	636,620	35,803	-1,315	65,641	1,411	58,045
Annual Rate	-0.9%	2.4%	1.5%	-0.6%	2.8%	2.2%	2.3%
Kings County							
2010	53,879	73,630	10,314	1,297	5,339	228	8,295
2050	43,109	182,126	7,517	984	13,461	409	18,393
Increase	-10,770	108,496	-2,797	-313	8,122	181	10,098
Annual Rate	-0.6%	2.3%	-0.8%	-0.7%	2.3%	1.5%	2.0%
Madera County							
2010	57,380	77,097	5,009	1,790	2,533	107	6,949
2050	47,386	217,480	6,121	2,116	9,062	0	7,097
Increase	-9,994	140,383	1,112	326	6,529	-107	148
Annual Rate	-0.5%	2.6%	0.5%	0.4%	3.2%	-100.0%	0.1%
Merced County							
2010	81,599	133,256	8,785	1,126	18,183	476	12,368
2050	40,399	350,943	14,883	987	41,706	1,655	10,428
Increase	-41,200	217,687	6,098	-139	23,523	1,179	-1,940
Annual Rate	-1.7%	2.5%	1.3%	-0.3%	2.1%	3.2%	-0.4%
San Joaquin County							
2010	245,919	244,695	48,540	3,179	94,547	3,248	45,178
2050	62,612	620,688	119,744	294	286,834	13,162	100,667
Increase	-183,307	375,993	71,204	-2,885	192,287	9,914	55,489
Annual Rate	-3.4%	2.4%	2.3%	-5.8%	2.8%	3.6%	2.0%
Stanislaus County							
2010	240,423	201,738	13,065	2,870	24,712	3,016	28,629
2050	100,686	592,986	28,360	0	66,547	14,183	48,007
Increase	-139,737	391,248	15,295	-2,870	41,835	11,167	19,378
Annual Rate	-2.2%	2.7%	2.0%	-100.0%	2.5%	3.9%	1.3%
Tulare County							
2010	143,935	255,785	5,497	3,323	14,204	370	19,065
2050	48,410	597,911	6,419	4,396	27,330	962	24,572
Increase	-95,525	342,126	922	1,073	13,126	592	5,507
Annual Rate	-2.7%	2.1%	0.4%	0.7%	1.6%	2.4%	0.6%

Source: The Planning Center|DC&E, 2012, using data from the US Census Bureau.

Appendix

The appendix provides definitions of terminology used in the report, followed by tables providing the data and analysis referenced in the report.

Terminology

Household

The Census Bureau defines a household as all the people who occupy a single housing unit. A household includes the related family members and all the unrelated people, if any, such as lodgers, foster children, wards, or employees who share the housing unit. A person living alone in a housing unit, or a group of unrelated people sharing a housing unit such as partners or roomers, is also counted as a household. The count of households excludes group quarters. There are two major categories of households, "family" and "nonfamily".

Family Household

The Census Bureau defines a family as a group of two people or more (one of whom is the householder) related by birth, marriage, or adoption and residing together; all such people (including related subfamily members) are considered as members of one family. A family household is defined as a household maintained by a householder who is in a family (as defined above), and includes any unrelated people (unrelated subfamily members and/or secondary individuals) who may be residing there. The number of family households is equal to the number of families. The count of family household members differs from the count of family members, however, in that the family household members include all people living in the household, whereas family members include only the householder and his/her relatives.

Nonfamily Household

The Census Bureau defines a nonfamily household as householder living alone (a one-person household) or where the householder shares the home exclusively with people to whom he/she is not related.

Housing Unit

The Census Bureau defines a housing unit as a house, an apartment or other group of rooms, or a single room, when it is occupied or intended for occupancy as separate living quarters; that is, when the occupants do not live and eat with any other persons in the structure and there is direct access from the outside or through a common hall.

Projection and Forecast

Although these two terms are often used interchangeably, there is a difference between the two. A projection most often refers to the extension of a particular trend into the future. For a particular demographic characteristic, there might be several datasets and several trends that describe or influence the characteristic. Thus there could be several projections for the characteristic, and these projections may vary greatly. On the other hand, there is usually a single forecast. The forecast represents an analysis of different projections, application of assumptions, and the professional judgment of the demographer or statistician preparing the forecast.

Appendix J Item 2:
MIP Model Documentation

Model Description & Validation Report

Fresno Council of Governments

Travel Demand Model

2008 Base

Prepared for:
Fresno Council of Governments

January 2014

20140205

WC12-2974

FEHR PEERS

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

This report describes the Fresno Council of Governments Travel Demand Model (Fresno COG Model), as updated in 2013 to reflect 2008 conditions. The year 2008 is the base year and the model was also used to backcast year 2005 as a benchmark for California Senate Bill Number 375. There is also a separate user guide for application of the model using the Cube software, and a description of how the model meets the requirements of California Senate Bill Number 375.

This chapter includes a summary of the Fresno COG Model. The following chapters describe the individual components of the model.

MODEL PURPOSE

The purpose of the Fresno COG Model is to provide a defensible tool to:

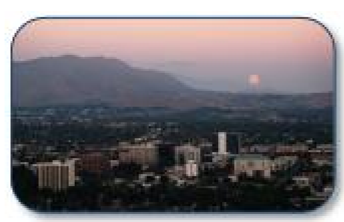
- provide input into the air quality analysis required by the Clean Air Act Amendments for transportation improvement plans and projects;
- evaluate the traffic circulation systems of the cities and county;
- provide basic traffic information for environmental analysis and preliminary design work on proposed highway projects; and
- evaluate the traffic impacts of large-scale development proposals.

SUMMARY OF MODEL

The Fresno COG model is a conventional travel demand forecasting model that is similar in structure to most other current area-wide models used for traffic forecasting. It uses land use, socioeconomic, and road network data to estimate travel patterns, roadway traffic volumes and transit volumes.

The Fresno COG model differs from a basic trip model through the integration of the components.

MODEL COVERAGE AND TRANSPORTATION ANALYSIS ZONES (TAZS)



The study area for the Fresno COG Model covers all of Fresno County. The county is divided into approximately 2,900 transportation analysis zones (TAZs). Other travel to and from Fresno County is represented by 30 gateway zones at major road crossings of the county line.

LAND USE INPUTS

The travel demand model land use inputs (socioeconomic data) are aggregated by TAZ. Population-related inputs include total population and numbers of households stratified by structure type, household income, age of population in households, and housing density. Employment-related inputs are employee by detailed sector and employment density. In addition to employees, schools are represented by student enrolment. “Special Generators," primarily for unique uses not covered specifically by a standard land use category, are represented as total person trips by purpose. Similarly, interaction with land uses outside the model area are represented by total person productions and attractions by purpose based on the California Statewide Travel Demand Model.

NETWORK CHARACTERISTICS

The model roadway network includes nodes and links. Link types include freeway, highway, expressway, arterial, collector, local, and freeway ramps. The model distinguishes roadways by adjacent development (central business district, fringe, urban, suburban, or rural) and terrain (flat, rolling or mountainous). Transit network have been coded to represent walk/bike access, drive access, park-and-ride lots, highway based (i.e. local bus) and non-highway based (i.e. rail) transit in the model area.

The North American Datum (NAD) 83 State Plane California (feet) coordinate projection is used so that the model network can be viewed together with other GIS data such as street centerlines, TAZ boundaries and Census information.

FORECASTING PROCESS

Four primary sub-models are involved in the travel demand forecasting process:

1. Trip Generation. This initial step calculates person or truck trip ends using trip generation rates established during model calibration, cross-classified residential data, employment, and student enrollment. This step also uses the demographics to determine the household passenger vehicle availability. The land use forecast is implemented prior to trip generation in a pre-processer outside of the model.

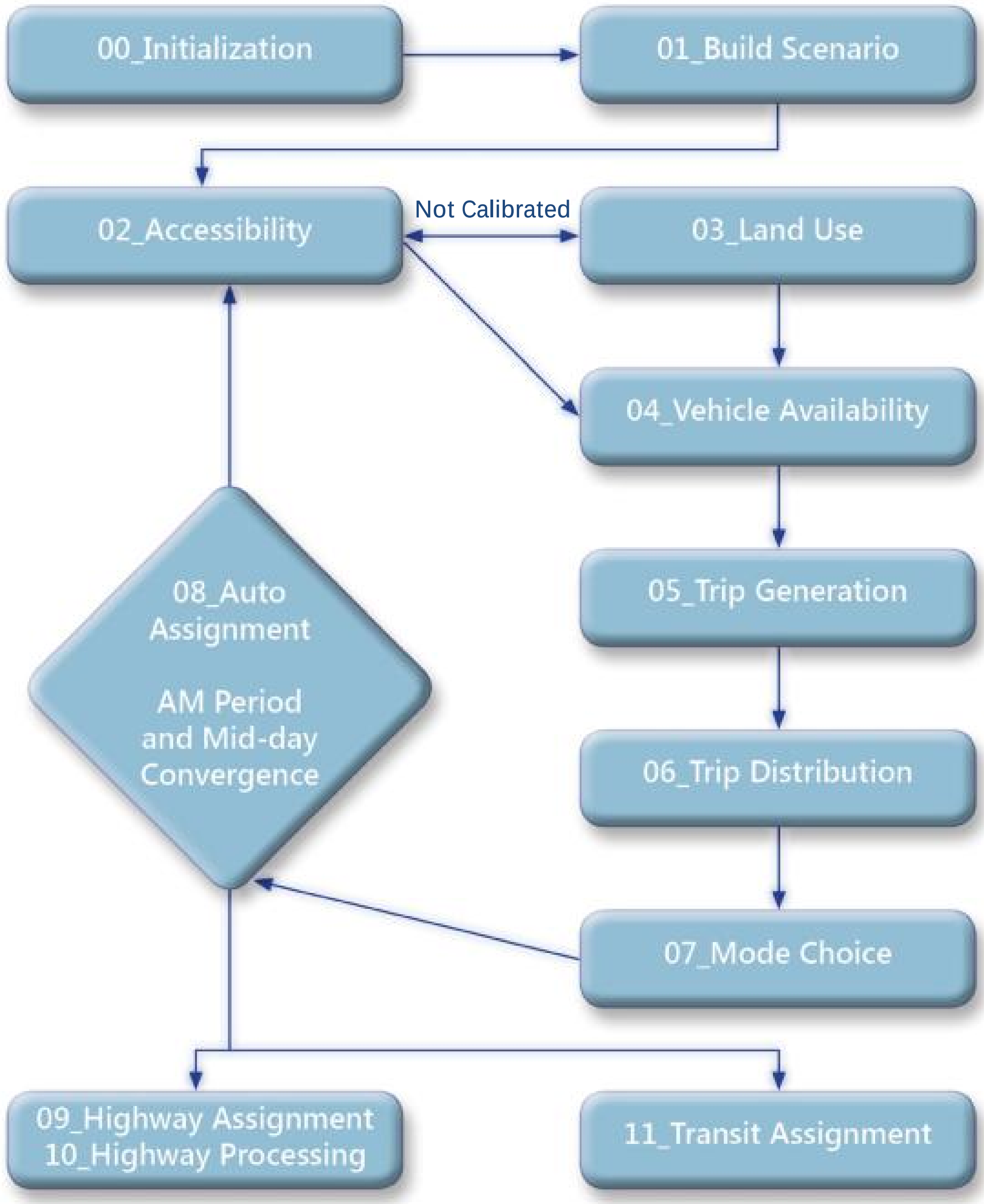
2. Trip Distribution. The second general step estimates how many trips travel from one zone to any other zone. The distribution is based on the number of trip ends generated in each of the two zones, and on factors that relate the likelihood of travel between any two zones to the travel time between the two zones such as distance, cost, time, and varies by accessibility to passenger vehicles, transit, and walking or biking.

3. Mode Choice. This step uses demographics and the comparison of distance, time, cost, and access between modes to estimate the proportions of the total person trips using drive-alone or shared-ride passenger auto, transit, walk or bike modes for travel between each pair of zones.

4. Trip Assignment. In this final step, vehicle trips or transit trips from one zone to another are assigned to specific travel routes between the zones. Congested travel information is used to influence each of the steps described above starting with vehicle availability.

A flow chart of the travel model process is shown in Figure 1.

Figure 1 Travel Model Process



FORECAST TIME PERIODS

The SJV MIP travel models estimate travel demand and traffic and transit volumes for the average weekday (Monday through Friday). The daily roadway volumes are aggregated from AM and PM peak period, and Mid-day and Evening off-peak periods. The daily transit volumes are aggregated from a peak period and an off-peak period. In addition, AM and PM peak one-hour traffic volume estimates are available for roadways.

FEEDBACK LOOPS

The Fresno COG Model includes a feedback loop that uses the congested speeds estimated from traffic assignment to recalculate the travel time and cost. The feedback loop repeats the process iteratively until the congested speeds and traffic volumes do not vary significantly between iterations. This ensures that the congested travel speeds used as input to the air quality analysis are consistent with the travel speeds used throughout the model process, as required by the Transportation Conformity Rule (40CFR Part 93).

MODEL VALIDATION

The Fresno COG Model was validated by comparing its estimates of 2008 traffic volumes with 2008 traffic counts. The 2008 validation meets standard criteria for replicating total daily traffic volumes on various road types. The 2008 validation also meets standard criteria for percent error relative to daily traffic counts on eight out of 10 tested groups of roads ("screenlines") throughout Fresno County.

TRAVEL MODEL SOFTWARE

The Fresno COG Model uses the Citilabs Cube software (Version 6) implemented with Scenario Manager and Application Manager for all model components. Model networks may be viewed using the Cube Base component. Most input data files were prepared using ArcGIS or Microsoft Excel.

2. MODEL STUDY AREA AND ZONE SYSTEM

The study area for the Fresno COG Model covers all of Fresno County, including the cities of Clovis, Coalinga, Firebaugh, Fowler, Fresno, Huron, Kerman, Kingsburg, Mendota, Orange Cove, Parlier, Reedley, Sanger, San Joaquin, and Selma. The county has been divided into Transportation Analysis Zones (TAZs) that are used to represent origins and destinations of travel. Travel to, from and through Fresno County is represented by external gateway zones.

MODEL COVERAGE AND TRANSPORTATION ANALYSIS ZONES (TAZS)

The model area is divided into transportation analysis zones (TAZs) representing land use within the model area, and by gateway zones at major road crossings of the model boundary. To allow for maximum flexibility in the future and through coordination of each San Joaquin Valley (SJV) model and parallel projects such as the Air Resources Board Eight-County SJV Model, the following gateway, TAZ, and screenline numbering process was developed:

- Gateways external to SJV: Gateways 1-60
- Gateways within the SJV: Gateways 61-100
- TAZs within a model: 101-3,000
    - TAZs allocated alphabetically within each model by sphere of influence
    - Gaps in numbering sequence allow for additional zone detail in the future
- Screenline numbering identical for models that share a boundary and unique number range
    - Hundreds place designates screenline
    - Tens place designates location
        - Odd number: North or East
        - Even number: South or West

Not all zone numbers in this range have been used, allowing for future detailing or expansion of the model. The TAZs are generally smaller in size where land use density is higher, such as in downtown Fresno, while larger zones are used for the more rural portions of the county. The TAZs are consistent with United States Census tract boundaries, but are generally smaller than census tracts to provide for better allocations of traffic to the street system.

The TAZ map is maintained as a Geographic Information System (GIS) file. The GIS file can be displayed with the travel model road network.

Figure 2 shows the overall TAZ system in the County.

Figure 3 shows a closer view of the Fresno/Clovis urban area. Detailed TAZ maps are available at Fresno COG. The Fresno COG Model currently has 30 external gateways for representing travel into, out of, and through the region (Figure 4 and Table 1). Zone numbers 1 to 100 are reserved for external cordons.

Figure 2 Transportation Analysis Zones (Outlined in Blue), Fresno County

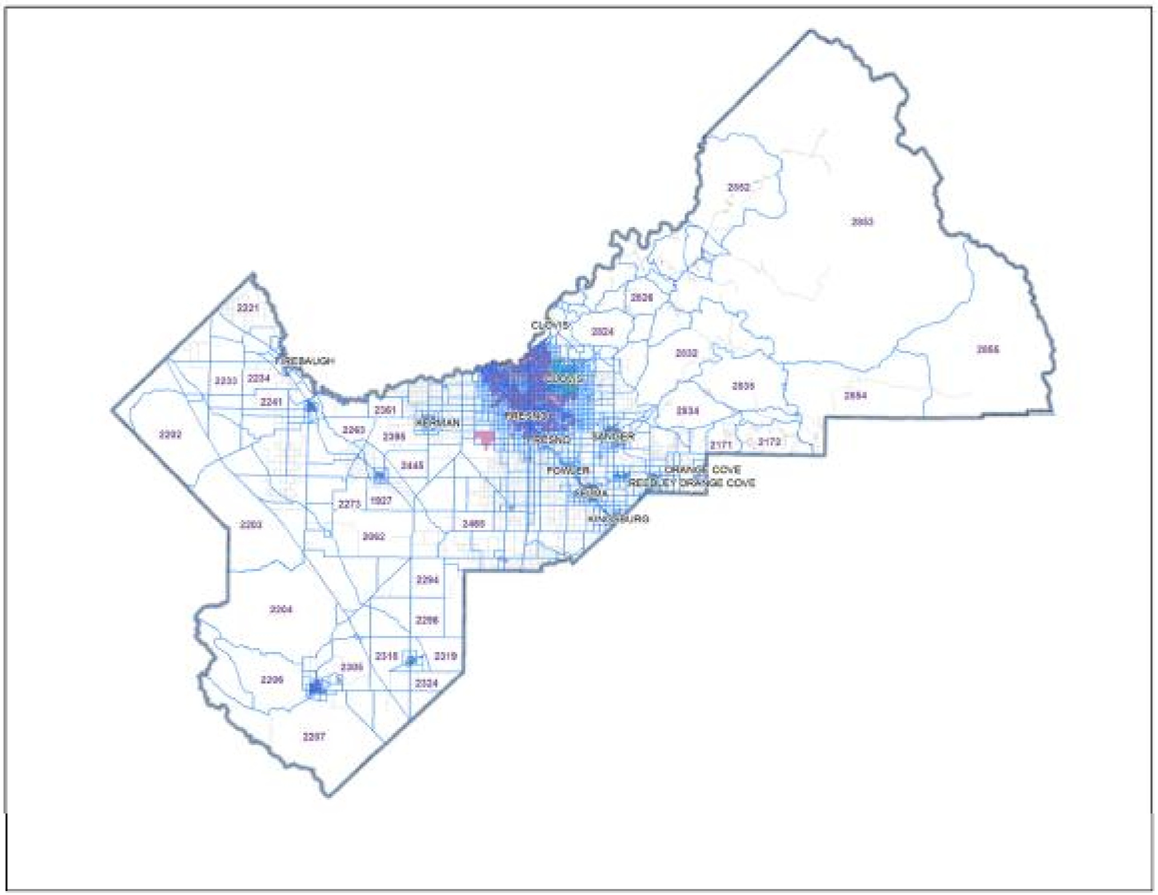


Figure 3 Transportation Analysis Zones (Outlined in Blue), Fresno and Clovis Urban Areas

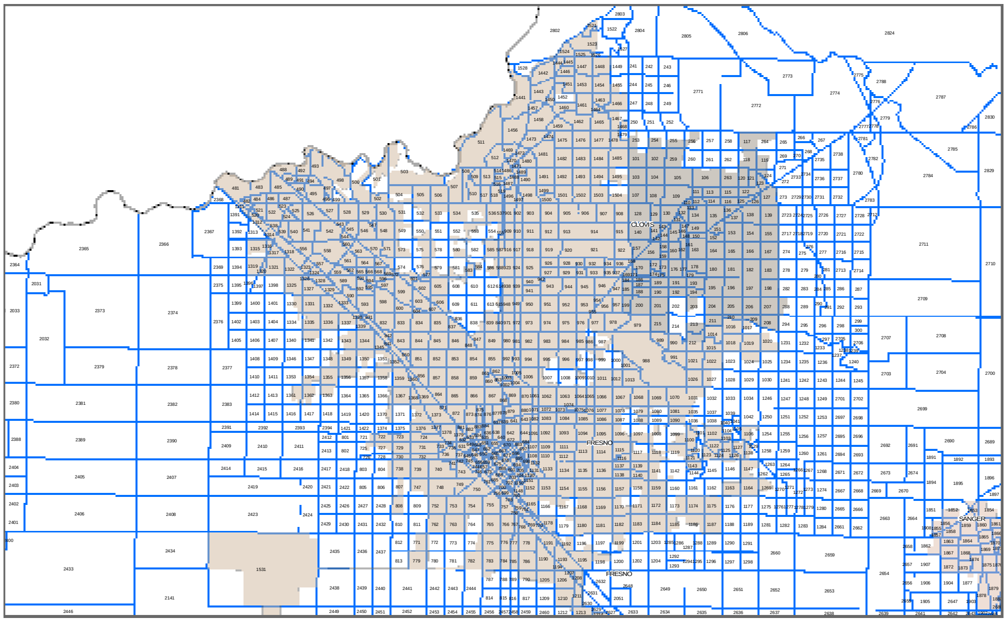


Figure 4 Fresno Model External Gateways

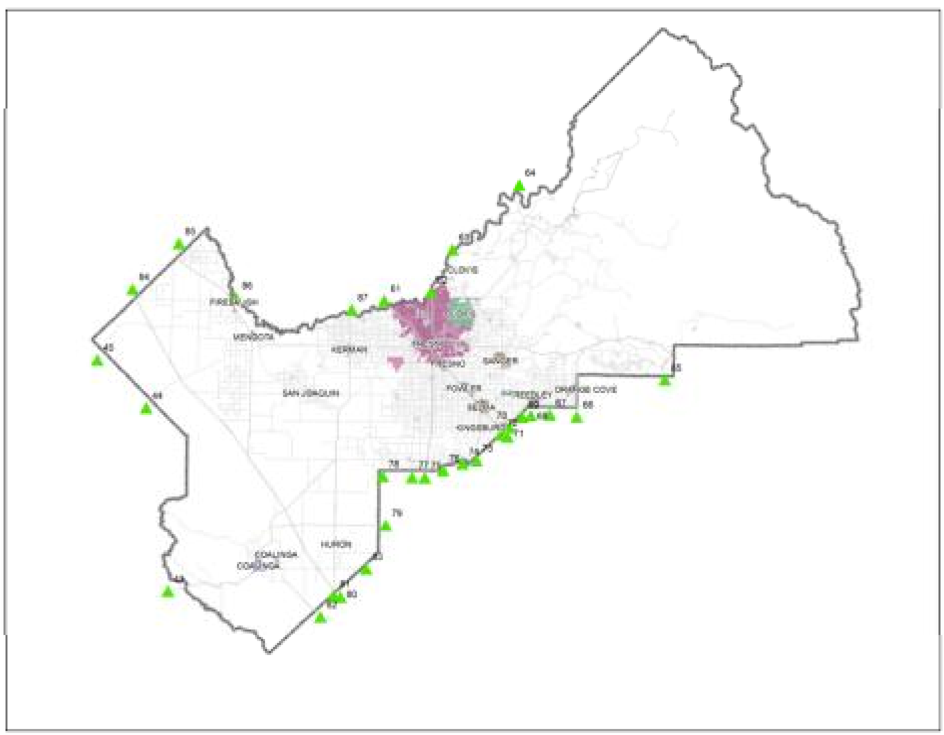


TABLE 1
FRESNO MODEL GATEWAY PRODUCTIONS AND ATTRACTIONS

Zone Number	External County	Gateway	2008	2035
43	Monterey	SR-198	161 (464)	87 (459)
44	San Benito	Panoche Road	13 (39)	4 (17)
45	San Benito	Ltl Panoche Road	121 (348)	148 (434)
61	Madera	SR-99	36,699 (20,113)	44,066 (25,141)
62	Madera	SR-41	30,820 (8,792)	38,525 (10,195)
63	Madera	County Road 206/ Millerton	28,093 (12,911)	29,225 (12,581)
64	Madera	Road 222/ Powerhouse Road	6,052 (1,189)	4,793 (966)
65	Tulare	SR-245	163 (92)	191 (110)
66	Tulare	Hill Valley/ Road 120	4,687 (12,663)	4,377 (10,884)
67	Tulare	Alta Avenue	5,107 (7,099)	3,631 (8,345)
68	Tulare	Reed/Road 52	1,877 (3,196)	2,014 (3,011)
69	Tulare	Mountain View/ Avenue 416	6,972 (4,902)	5,897 (3,989)
70	Tulare	SR 201/Sierra	4,217 (1,876)	4,186 (2,129)
71	Tulare	SR-99	22,365 (15,240)	27,243 (19,050)
72	Tulare	Road 8/10th Avenue	20 (11)	24 (14)
73	Kings	SR-43	8,034 (2,022)	9,825 (2,527)
74	Kings	Fowler Avenue	2,263 (960)	1,882 (1,191)
75	Kings	SR-41	11,704 (3,616)	11,170 (4,418)
76	Kings	Excelsior	99 (16)	85 (17)
77	Kings	Marks Avenue/22nd Avenue	1,743 (739)	1,359 (903)
78	Kings	Paige Avenue/Elder Avenue	790 (129)	986 (162)
79	Kings	SR-198	4,673 (2,142)	5,842 (2,676)
80	Kings	I-5	235 (147)	295 (183)
81	Kings	SR-269	1,478 (940)	1,725 (1,143)

TABLE 1
FRESNO MODEL GATEWAY PRODUCTIONS AND ATTRACTIONS

Zone Number	External County	Gateway	2008	2035
82	Kings	SR-33	7,828 (3,328)	8,988 (3,370)
83	Kings	Jayne Avenue	872 (369)	975 (319)
84	Merced	I-5	222 (207)	277 (257)
85	Merced	SR-33	2,246 (1,353)	0 (0)
86	Madera	13th Street	4,568 (3,000)	2,940 (2,874)
87	Madera	SR-145	15,712 (14,796)	14,830 (13,046)

Notes: Values shown as Production (Attraction)

3. TRANSPORTATION NETWORKS

The Fresno COG Model uses coded representations of the county's existing and future roadway and transit networks.

ROAD NETWORKS

The road network is a computerized representation of the major street and highway system. Only the more important streets (generally freeways, highways, expressways, arterials and collectors) are included in the network. The model does not explicitly include some collector streets or most local streets. Most local streets and driveways are instead represented by simplified network links ("zone centroid connectors") that represent local connections to the coded road network.

MASTER NETWORK

All road network information for all base year and forecast scenarios is contained in a single "master network" file. The master network contains information on the years that various road improvement projects are programmed for implementation. The master network can be used to generate the model road network for any study year between 2005 and 2040.

The purpose of creating a master network was to make the task of network maintenance more efficient. In the past, if a roadway network improvement was to be included in several alternatives (e.g., add a new widening to the near term network and all other future networks), the same network editing had to be performed individually for each of the scenarios. With a master network, the user need only input the improvement in one place with the appropriate scenarios designated and then all scenarios built from the master network will be consistent.

The network node and link variables shown in Table 2 are coded for each master network scenario.

TABLE 2
STANDARD MASTER HIGHWAY NETWORK VARIABLES

Attribute	Description
Nodes	
X	X-coordinate of node in Nad 83
Y	Y-coordinate of node in Nad 83

TABLE 2
STANDARD MASTER HIGHWAY NETWORK VARIABLES

Attribute	Description
N	Node number
TAZ	Traffic Analysis Zone Number
DISTRICT	Super district number used for aggregation
SOI	Sphere of influence used to number TAZs alphabetically
STYINT	Study location number used to record turning movements when non-zero
COUNTY	County where node is located
JURISDICTION	Political jurisdiction where node is located
COMMUNITY	Community/district name
Links	
A	A node
B	B node
DISTANCE	Distance in miles
NAME	Local street name
ROUTE	Numerical state route number
TERRAIN	Terrain (F=Flat , R=Rolling, M=Mountain)
JURISDICTION	Political jurisdiction where link is located location
SCREENLINE	Screenline by direction
XXXX_PRJID	RTP Project ID number
XXXX_PRJYR	RTP Project Opening Year
XXXX_FACTYP	Facility type by year
XXXX_AREATYP	Area type by year
XXXX_LANES	Number of directional through travel lanes by year
XXXX_AUX	Auxiliary lane (0=no, 1=yes)
XXXX_SPEED	Free-flow speed in miles-per hour by year
XXXX_CAPCLASS	Capacity class by year (derived from Terrain, Facility type, and Area Type)
XXXX_CAPACITY	Vehicle per hour (calculated based on Lanes and CapClass)

TABLE 2
STANDARD MASTER HIGHWAY NETWORK VARIABLES

Attribute	Description
XXXX_USE	Identifies vehicle prohibitions by year
XXXX_TOLL	Code used for cost on toll facilities by year
AREATYP	Character to store scenario variable
AIRBASIN	Air basin number for air quality
TSM	Transportation System Management
EJ	Environmental Justice designation (0 or 1)

At the beginning of the model process, the master network is processed to create the individual road network for the desired scenario. Maps and summary tables are created to be reviewed prior to running the full model.

ROAD NETWORK ELEMENTS

The coded road network is comprised of three basic types of data: nodes, links and turn penalties.

Nodes

Nodes are established at each and every intersection between two or more links. Nodes are assigned numbers, with node numbers 101-3000 in the Fresno COG Model reserved for centroids of the traffic analysis zones. The road network nodes are coded with geographical “X” and “Y” coordinates to permit plotting and graphic displays. The North American Datum (NAD) 83 State Plane California (feet) coordinate projection is used so that the model network can be viewed together with other GIS data such as street centerlines, TAZ boundaries and Census information.

Links

Links represent road segments, and are uniquely identified by the node numbers at each end of the segment (for example, a link may be identified as “1232-1234”). Information is coded for each road link including facility type, number of lanes in each direction, and speeds. In the Fresno COG Model, average uncongested speeds are coded individually for each road link. These average uncongested speeds represent the average speeds for all vehicle types (automobiles and trucks), including delays at traffic signals and stop signs, but excluding delays related to other vehicles on the same road segment.

Capacities and speed-versus-congestion characteristics are assigned to groups of links based on the capacity class (Table 3).

The basic information coded in the road network is used to derive additional link characteristics such as capacities and speed/congestion relationships. The capacity of each link is determined based on the terrain, facility type, and area type.

The capacities are based on the capacity formulas for each road type in the 2000 *Highway Capacity Manual* (HCM). Input assumptions are based on HCM defaults wherever possible. The speed characteristics of each link are also determined by terrain, facility type, and area type using Bureau of Public Roads formulas (Table 5 and Table 6).

The capacities in the Fresno COG Model are based on level of service “E/F” capacities representing the maximum flow which can pass through a given segment. However, the model may still estimate traffic demands which exceed these maximum capacities.

TABLE 3
CAPACITY CLASS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Flat					
1. Freeway	1	11	21	31	41
2. Highway	2	12	22	32	42
3. Expressway	3	13	23	33	43
4. Arterial	4	14	24	34	44
5. Collector	5	15	25	35	45
6. Local	6	16	26	36	46
7. Ramp: Freeway-Freeway	7	17	27	37	47
8. Ramp: Slip	8	18	28	38	48
9. Ramp: Loop	9	19	29	39	49
10. Connector: Dist. ≤ 0.25	10	N/A	N/A	N/A	N/A

TABLE 3
CAPACITY CLASS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
11. Connector: Dist. > 0.25	20	N/A	N/A	N/A	N/A
Rolling					
1. Freeway	51	61	71	81	91
2. Highway	52	62	72	82	92
3. Expressway	53	63	73	83	93
4. Arterial	54	64	74	84	94
5. Collector	55	65	75	85	95
6. Local	56	66	76	86	96
7. Ramp: Freeway-Freeway	57	67	77	87	97
8. Ramp: Slip	58	68	78	88	98
9. Ramp: Loop	59	69	79	89	99
10. Connector: Dist. ≤ 0.25	60	N/A	N/A	N/A	N/A
11. Connector: Dist. > 0.25	70	N/A	N/A	N/A	N/A
Mountain					
1. Freeway	101	111	121	131	141
2. Highway	102	112	122	132	142
3. Expressway	103	113	123	133	143
4. Arterial	104	114	124	134	144
5. Collector	105	115	125	135	145
6. Local	106	116	126	136	146
7. Ramp: Freeway-Freeway	107	117	127	137	147
8. Ramp: Slip	108	118	128	138	148

TABLE 3
CAPACITY CLASS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
9. Ramp: Loop	109	119	129	139	149
10. Connector: Dist. ≤ 0.25	110	N/A	N/A	N/A	N/A
11. Connector: Dist. > 0.25	120	N/A	N/A	N/A	N/A

TABLE 4
DEFAULT CAPACITY BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Flat					
1. Freeway	2100	2000	1900	1800	1750
2. Highway	1680	1600	1600	1500	1300
3. Expressway	1155	1100	1000	900	800
4. Arterial	945	900	800	800	750
5. Collector	735	700	700	700	700
6. Local	600	600	600	600	600
7. Ramp: Freeway-Freeway	1900	1800	1800	1800	1800
8. Ramp: Slip	1600	1500	1500	1500	1500
9. Ramp: Loop	1300	1250	1250	1250	1250
10. Connector: Dist. ≤ 0.25	N/A	N/A	N/A	N/A	N/A
11. Connector: Dist. > 0.25	N/A	N/A	N/A	N/A	N/A

TABLE 4
DEFAULT CAPACITY BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Rolling					
1. Freeway	1800	1800	1620	1580	1580
2. Highway	1300	1300	1300	1220	1060
3. Expressway	1300	890	810	730	650
4. Arterial	1300	730	730	650	610
5. Collector	1300	570	650	650	570
6. Local	1000	550	640	640	550
7. Ramp: Freeway-Freeway	1800	1800	1500	1500	1500
8. Ramp: Slip	1500	1500	1500	1500	1500
9. Ramp: Loop	1250	1250	1250	1250	1250
10. Connector: Dist. ≤ 0.25	N/A	N/A	N/A	N/A	N/A
11. Connector: Dist. > 0.25	N/A	N/A	N/A	N/A	N/A
Mountain					
1. Freeway	1500	1500	1350	1310	1310
2. Highway	700	700	700	660	570
3. Expressway	700	700	440	390	350
4. Arterial	700	390	390	350	330
5. Collector	700	310	350	350	310
6. Local	600	330	380	380	330
7. Ramp: Freeway-Freeway	1500	1500	1500	1500	1500
8. Ramp: Slip	1500	1500	1500	1500	1500
9. Ramp: Loop	1250	1250	1250	1250	1250

TABLE 4
DEFAULT CAPACITY BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
10. Connector: Dist. ≤ 0.25	N/A	N/A	N/A	N/A	N/A
11. Connector: Dist. > 0.25	N/A	N/A	N/A	N/A	N/A

Note: Capacity shown as vehicles per hour per lane (VPHPL)

TABLE 5
BUREAU OF PUBLIC ROADS ALPHA AND BETA COEFFICIENTS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Flat					
1. Freeway	0.25 (9)	0.25 (9)	0.25 (9)	0.18 (8.5)	0.1 (10)
2. Highway	0.08 (6)	0.08 (6)	0.34 (4)	0.07 (6)	0.07 (6)
3. Expressway	0.08 (6)	0.08 (6)	0.74 (5)	0.74 (5)	1.16 (6)
4. Arterial	0.07 (6)	0.38 (5)	0.7 (5)	0.7 (5)	1 (5)
5. Collector	0.07 (6)	0.96 (5)	1 (5)	1 (5)	1.4 (5)
6. Local	0.34 (4)	1.11 (5)	1.2 (5)	1.5 (5)	1.5 (5)
7. Ramp: Freeway-Freeway	0.08 (6)	0.08 (6)	0.08 (6)	0.08 (6)	0.08 (6)
8. Ramp: Slip	0.74 (5)	0.74 (5)	0.74 (5)	0.74 (5)	0.74 (5)
9. Ramp: Loop	0.7 (5)	0.7 (5)	0.7 (5)	0.7 (5)	0.7 (5)
10. Connector: Dist. ≤ 0.25	N/A	N/A	N/A	N/A	N/A
11. Connector: Dist. > 0.25	N/A	N/A	N/A	N/A	N/A

TABLE 5
BUREAU OF PUBLIC ROADS ALPHA AND BETA COEFFICIENTS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Rolling					
12. Freeway	0.25 (9)	0.25 (9)	0.18 (8.5)	0.18 (8.5)	0.1 (10)
13. Highway	0.08 (6)	0.08 (6)	0.34 (4)	0.07 (6)	0.07 (6)
14. Expressway	0.08 (6)	0.08 (6)	0.74 (5)	0.74 (5)	1.16 (6)
15. Arterial	0.07 (6)	0.38 (5)	0.7 (5)	0.7 (5)	1 (5)
16. Collector	0.07 (6)	0.96 (5)	1 (5)	1 (5)	1.4 (5)
17. Local	0.34 (4)	1.11 (5)	1.2 (5)	1.5 (5)	1.5 (5)
18. Ramp: Freeway-Freeway	0.08 (6)	0.08 (6)	0.08 (6)	0.08 (6)	0.08 (6)
19. Ramp: Slip	0.74 (5)	0.74 (5)	0.74 (5)	0.74 (5)	0.74 (5)
20. Ramp: Loop	0.7 (5)	0.7 (5)	0.7 (5)	0.7 (5)	0.7 (5)
21. Connector: Dist. ≤ 0.25	N/A	N/A	N/A	N/A	N/A
22. Connector: Dist. > 0.25	N/A	N/A	N/A	N/A	N/A
Mountain					
12. Freeway	0.18 (8.5)	0.18 (8.5)	0.1 (10)	0.1 (10)	0.1 (10)
13. Highway	0.08 (6)	0.08 (6)	0.34 (4)	0.07 (6)	0.07 (6)
14. Expressway	0.08 (6)	0.08 (6)	0.74 (5)	0.74 (5)	1.16 (6)
15. Arterial	0.07 (6)	0.38 (5)	0.7 (5)	0.7 (5)	1 (5)
16. Collector	0.07 (6)	0.96 (5)	1 (5)	1 (5)	1.4 (5)
17. Local	0.34 (4)	1.11 (5)	1.2 (5)	1.5 (5)	1.5 (5)
18. Ramp: Freeway-Freeway	0.08 (6)	0.08 (6)	0.08 (6)	0.08 (6)	0.08 (6)
19. Ramp: Slip	0.74 (5)	0.74 (5)	0.74 (5)	0.74 (5)	0.74 (5)
20. Ramp: Loop	0.7 (5)	0.7 (5)	0.7 (5)	0.7 (5)	0.7 (5)

TABLE 5
BUREAU OF PUBLIC ROADS ALPHA AND BETA COEFFICIENTS BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
21. Connector: Dist. ≤ 0.25	N/A	N/A	N/A	N/A	N/A
22. Connector: Dist. > 0.25	N/A	N/A	N/A	N/A	N/A

Note: Values shown as Alpha Coefficient (Beta Coefficient)

TABLE 6
TYPICAL SPEED RANGES BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Flat					
1. Freeway	70	65-70	55-65	55-65	55-65
2. Highway	40-45	40-45	40-45	40-45	40-45
3. Expressway	55	45-55	45-55	45-55	40-45
4. Arterial	40-45	30-45	25-45	30-45	25-45
5. Collector	50	50	35-40	35-40	35-40
6. Local	25-40	25-40	25-40	25-40	25-40
7. Ramp: Freeway-Freeway	50	50	50	50	50
8. Ramp: Slip	50	50	50	50	50
9. Ramp: Loop	45	45	45	45	45
10. Connector: Dist. ≤ 0.25	35	35	35	35	35
11. Connector: Dist. > 0.25	15	15	15	15	15

TABLE 6
TYPICAL SPEED RANGES BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
Rolling					
1. Freeway	65-70	65-70	65-70	65-70	65-70
2. Highway	40-45	40-45	40-45	40-45	40-45
3. Expressway	50-65	50-65	50-65	50-65	50-65
4. Arterial	30-45	30-45	30-45	30-45	30-45
5. Collector	50	50	50	50	50
6. Local	50	50	50	50	50
7. Ramp: Freeway-Freeway	50	50	50	50	50
8. Ramp: Slip	50	50	50	50	50
9. Ramp: Loop	45	45	45	45	45
10. Connector: Dist. ≤ 0.25	35	35	35	35	35
11. Connector: Dist. > 0.25	15	15	15	15	15
Mountain					
1. Freeway	65	65	65	65	65
2. Highway	40-45	40-45	40-45	40-45	40-45
3. Expressway	40-55	40-55	40-55	40-55	40-55
4. Arterial	30-45	30-45	30-45	30-45	30-45
5. Collector	25-40	25-40	25-40	25-40	25-40
6. Local	25-40	25-40	25-40	25-40	25-40
7. Ramp: Freeway-Freeway	50	50	50	50	50
8. Ramp: Slip	45	45	45	45	45
9. Ramp: Loop	35	35	35	35	35

TABLE 6
TYPICAL SPEED RANGES BY TERRAIN, FACILITY TYPE, AND AREA TYPE

Facility Type	Area Type				
	Rural (R)	Suburban (SU)	Urban (U)	Fringe (F)	Central Business District (CBD)
10. Connector: Dist. ≤ 0.25	15	15	15	15	15
11. Connector: Dist. > 0.25	25	25	25	25	25

Note: Speed shown as miles per hour (MPH)

Turn Penalties

Turn penalties can be used to identify node-to-node movements that are prohibited (such as certain left turns) or that have additional delays. Turn penalties are primarily used to represent prohibited left turns to and from ramps at freeway interchanges, in particular if an interchange has two on-ramps.

TRANSIT NETWORKS

The highway based transit routes are coded into the Cube LIN file format. The Public Transport module of Voyager combines the LIN files with the Transit System (PTS file defining the modes and wait curves), Transit Fare (FAR containing the far system for the modes), and Transit Factors (FAC combines the modes, far system, and time factors for transit). Access to and from each bus stop is generated automatically based on the road network and the "walk" speed of three miles per hour (can be modified in scenario key). The Walk and Drive access BLOCK files control which nodes are park-n-ride and the maximum distance for walk and drive to transit stops. Fresno County transit lines are shown on Figure 5.

BUS SPEEDS

Bus travel times are derived from the road network, with a delay factor to account for stops and slower operating speeds. A factor by facility class increases is used to modify bus speeds, and current factors were calibrated at 1.0.

TRANSFER POINTS

At timed transfer locations, the maximum wait time between buses is set to be 5 minutes rather than one-half the headway. No timed transfer points are designated for the 2008 base year. Timed transfer points can be designated for future year forecasts.

WALK ACCESS

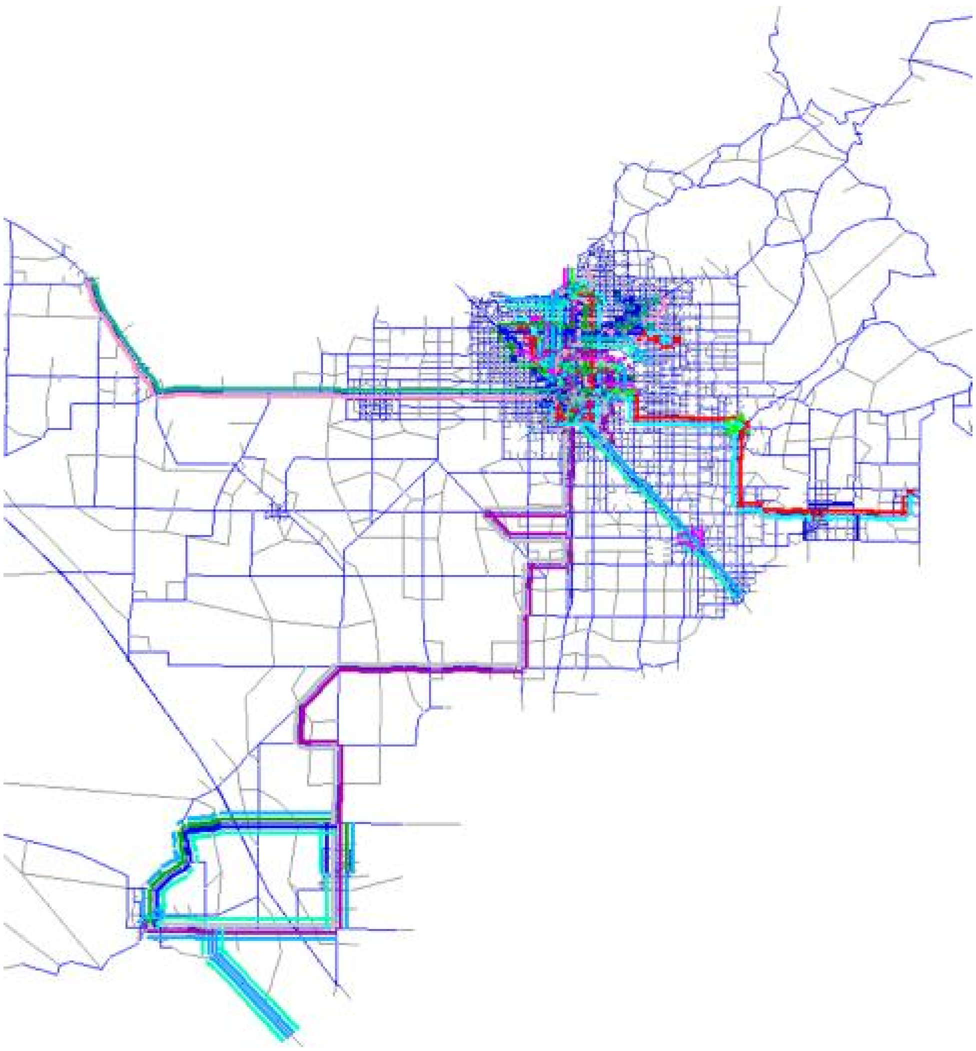
Walk access is allowed for any TAZ centroid within one mile of a transit stop. The walking route and distance is determined automatically along the model road network. An average walking speed of three miles per hour is used to calculate the average walk time to and from transit stops. A given TAZ is assumed to have access to any number of transit stops and lines within one mile.

DRIVE ACCESS

Separate "park and ride" (PNR) nodes are designated to indicate locations where people could use automobiles to access transit, including drop-off or pick-up as well as passengers who park.

Walk and Drive access should be further calibrated with the transit or household survey data.

Figure 5 Fresno County Transit Lines (2008)



4. DEMOGRAPHIC/LAND USE DATA

Land use and socioeconomic data at the zonal level are used for determining trip generation.

LAND USE CATEGORIES

The land use inputs to the model were divided into a number of residential and non- residential categories (Table 7 thru Table 12). The categories represent different levels and types of trip generation per housing unit, employee, or student.

TABLE 7
LAND USE CATEGORIES

Attribute	Description	Units
Residential		
RU [1]	Units in structure	Households
TOTHH	Total Households	Households
INC [2]	Households by Annual Income (2009 Dollars)	Households
RU_AGE [3]	Age of Householder	Households
POP [4]	Population by age range	People
HHPOP	Total Household Population	People
HHSIZE [5]	Average Household Size	People
Non-Residential		
TOTEMP	Total employees	Employees
EMPOTH	Agriculture, Forestry, Fishing and Hunting (11), Construction (23)	Employees
EMPIND	Mining, Quarrying, Oil and Gas Extraction (21), Utilities (22), Manufacturing (31-33), Wholesale Trade (42), Transportation and Warehousing (48-49)	Employees
EMPRET	Retail Trade (44-45)	Employees

TABLE 7
LAND USE CATEGORIES

Attribute	Description	Units
EMPOFC	Information (51), Finance and Insurance (52), Real Estate, Rental and Leasing (53), Professional, Scientific, and Technical Services (54), Management of Companies and Enterprises (55), Administrative/Support, Waste Management & Remediation (56)	Employees
EMPEDU	Educational Services (61)	Employees
EMPMED	Health Care and Social Assistance (62)	Employees
EMPSVC	Arts, Entertainment and Recreation (71), Other Services Except Public Administration (81)	Employees
EMPFOO	Accommodation (721), Food Services (722)	Employees
EMPGOV	Public Administration (92)	Employees
ELEM	Elementary and middle school enrollment	Student Enrollment
HS	High school enrollment	Student Enrollment
COLLEGE	College enrollment	Student Enrollment

1. See Table 8
2. See Table 9
3. See Table 10
4. See Table 11
5. See Table 12

TABLE 8
RESIDENTIAL UNIT TYPES

Category	Description
RU1	1, detached
RU2	1, attached
RU3	2
RU4	3 or 4
RU5	5 to 9
RU6	10 to 19
RU7	20 to 49

TABLE 8
RESIDENTIAL UNIT TYPES

Category	Description
RU8	50 or more
RU9	Mobile home
RU10	Boat, RV, van, etc.

TABLE 9
AVERAGE HOUSEHOLD INCOME

Category	Description
INC1	Less than $19,999
INC2	$20,000 to $39,999
INC3	$40,000 to $59,999
INC4	$60,000 to $99,999
INC5	$100,000 or more

TABLE 10
AGE OF HOUSEHOLDER

Category	Description
Age1524	Householder 15 to 24 years
Age2564	Householder 25 to 64 years
Age6574	Householder 65 to 74 years
Age75	Householder 75 years and over

TABLE 11
POPULATION BY AGE RANGE

Category	Description
POP0005	People under 5 years
POP0514	People 5 to 14 years
POP1517	People 15 to 17 years
POP1824	People 18 to 24 years
POP2554	People 25 to 54 years
POP5564	People 55 to 64 years
POP6574	People 65 to 74 years
POP75	People 75 years and over

TABLE 12
HOUSEHOLD SIZE

Category	Description
HHSIZE1	1 person household
HHSIZE2	2 person household
HHSIZE3	3 person household
HHSIZE4	4 person household
HHSIZE5	5 or more person household

2008 BASE YEAR LAND USE

The 2008 land use database was developed to provide inputs to the 2008 model validation. The land use inputs are used to set up model parameters such as trip generation rates and external gateway trip types and percentages. Once these model parameters are established, they are used in conjunction with future land use data alternatives for model application.

The 2008 population and household inputs were initially developed based on 2000 United States Census information by census block. The increment between the 2000 Census and the 2008 model base year was determined based on building permits. The Census data and building permits were coded to specific geographic locations. They were then summed into the corresponding TAZs. Households were first stratified by single and multiple housing types and vehicle ownership based on Census data. Later when the MIP (model improvement program) transportation model was used, housing types were expanded to ten categories and vehicle ownership data was used in the mode choice calculation portion of the model.

Employment numbers and locations were initially compiled from a commercial database from InfoUSA. The InfoUSA database included records for 27,113 employment sites in Fresno County. The InfoUSA database was expanded through a significant amount of additional research and phone calls to verify addresses and employment levels. The commercial database is particularly incomplete for public sector employment quantities and locations. Therefore, each local government and school district in Fresno County was contacted to get direct information on employee numbers and locations.

Fresno COG also obtained the rights to use specific employer information from the California Employment Development Department (EDD). The EDD database included records for 28,930 employment sites in Fresno County. The specific employment sites were matched with the InfoUSA database wherever possible. There were many employment sites which were only included in one of the two databases. The combined employment database contains nearly 30,000 employment sites. The totals from the expanded employment site database were compared to the 2008 annual averages from the California EDD as reported in the Current Employment Statistics (CES). The totals were also compared to an independent estimate of Fresno County employment compiled by the private firm Woods and Poole.

The 2008 population and housing unit data was controlled to data based on State of California Department of Finance (DOF) files. Since the DOF files are for January 1 of each year, the files for January 1, 2008 and January 1, 2009 were interpolated to produce a July 1, 2008 estimate by assuming constant rates of growth between the two January 1 dates.

The 2008 employment data was controlled to the employment calculated in the worksheets for Fresno County prepared by The Planning Center for their report *San Joaquin Valley Demographic Forecasts: 2010 to 2050.*

SPECIAL GENERATORS

The special generators in the Fresno COG Model are intended to account for primarily recreational sites that produce and attract trips unrelated to housing or employment. Most of the special generators included for Fresno County are local and regional parks, plus the Table Mountain Casino and the River Place movie theater. For these zones, estimated vehicle trips and trip purpose assumptions are input directly to the model. Daily vehicle trips were estimated based on typical values in the Institute of

Transportation Engineers Trip Generation reference. Daily vehicle trips by special generators are shown in Table 13.

TABLE 13
SPECIAL GENERATOR DAILY PRODUCTIONS AND ATTRACTIONS

Purpose	Productions and Attractions
Home-Work	0 (0)
Home-Shop	0 (0)
Home-K12	0 (0)
Home-College	0 (0)
Home-Other	0 (52,386)
Work-Other	0 (0)
Other-Other	744 (744)
Highway Commercial	0 (0)
Trucks-Small	0 (0)
Trucks-Medium	0 (0)
Trucks-Heavy	0 (0)

Notes: Values shown as Production (Attraction)

FUTURE LAND USE

The land use forecasts for the Fresno COG Model were developed using a combination of:

- Detailed information on available vacant land and individual planned development in each jurisdiction
- Overall growth forecasts for Fresno County

Forecasts were compiled for a 2040 horizon year and all interim years between 2005 and 2040.

Allocations are based on Spheres of Influence rather than current city limits. This allows comparison to General Plans.

Figure 6, Figure 7, and Figure 8 display the spheres of influence and current city limits in Fresno County.

Figure 6 City Limits, Fresno County

Figure 7 City Limits and Spheres of Influence, Fresno/Clovis

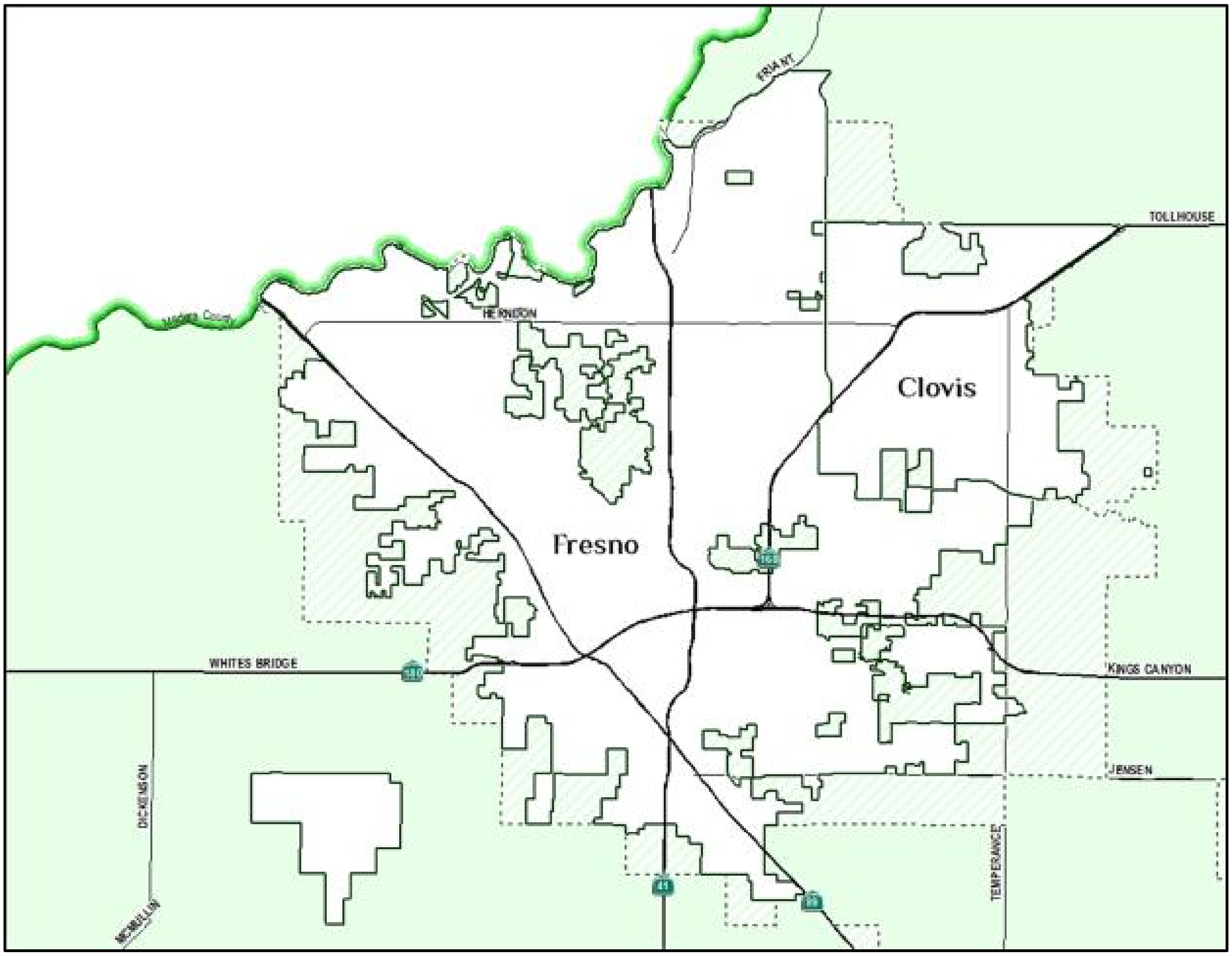


Figure 8 City Limits and Spheres of Influence, Southeast County

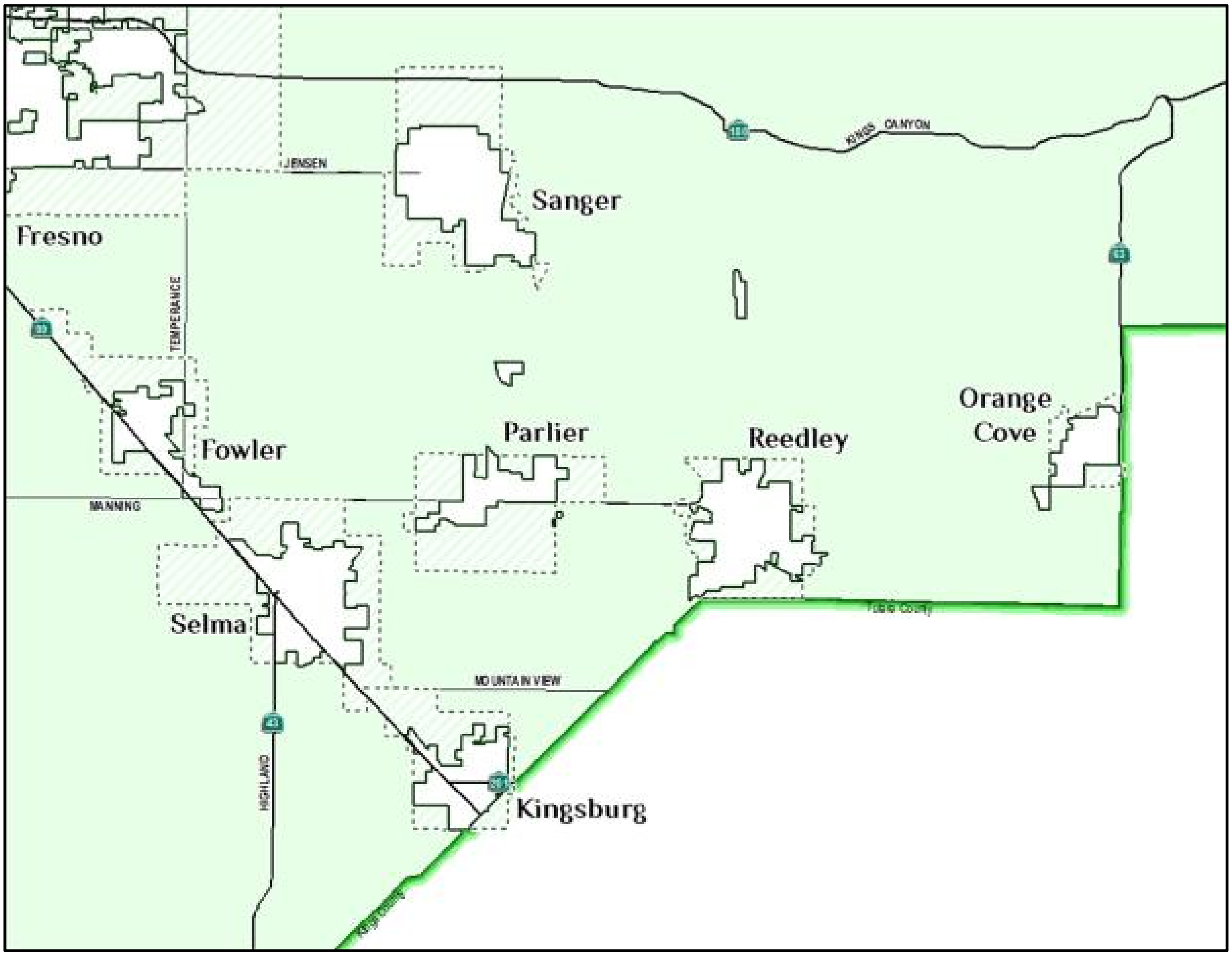


Figure 9 City Limits and Spheres of Influence, West County

Figure 10 City Limits and Spheres of Influence, Southwest County

POPULATION FORECAST

The forecasts used for the Fresno COG Regional Transportation Plan/Sustainable Communities Strategy were from the *San Joaquin Valley Demographic Forecasts: 2010 to 2050* prepared by The Planning Center, March 2012. This forecast was part of a San Joaquin Valley demographic study commissioned by the eight metropolitan planning organizations (MPOs) of the valley, in an effort to obtain recently-prepared projections. The latest State of California Department of Finance (DOF) projection at the time was released in July 2007 and did not take into account the 2007-2008 recession and the subsequent slow economic recovery, thus prompting the need for an updated forecast. In January 2013, the Department of Finance released their latest projection for Fresno County, which differed from The Planning Center forecasts by less than two percent for every year between now and the forecast horizon year of 2050, which helped confirm the validity of the Planning Center forecast for use in the RTP/SCS.

The Planning Center Study *San Joaquin Valley Demographic Forecasts: 2010 to 2050* is attached.

This study includes three primary forecasts of population, households and housing units. Other projections developed by The Planning Center, e.g., age distribution, average household size, household income, household type, race/ethnicity, are derived from the three primary forecasts. The Planning Center forecasts are based on several different projections including household trend, total housing unit trend, housing construction trend, employment trend, cohort-component model, population trend, average household size trend, and household income trend. The least-squares linear curve forms the basis for all projections because the forecasts are long-term and curve-fitting techniques (e.g., parabolic curve, logistic curve) do not provide reasonable long-term results. Three measures evaluate the adequacy of each projection: mean absolute percentage error (MAPE), F-test, and t-test. Population and Employment Forecasts for the SCS/RTP years are shown in Table 14.

TABLE 14
FRESNO COUNTY POPULATION AND EMPLOYMENT FORECASTS

Year	Population	Employment
2005	872,569	335,159
2008	912,521	345,816
2020	1,082,097	363,581
2035	1,300,597	427,727
2040	1,373,679	449,111

EMPLOYMENT FORECAST

Employment was forecast by The Planning Center using the at-place employment data by sector from the State of California Employment Development Department. The model constructs a least-squares line for each economic sector and sums the results to generate a projection for total employment in the County. The least-squares line for total employment in Fresno County produces a MAPE of 2.21% and a standard error of .85%.

The resulting employment forecast is included in the table above.

DEVELOPMENT PROJECTS

Fresno COG staff met with the staffs of each of the sixteen jurisdictions (15 incorporated cities and the County) concerning the types and locations of development expected to occur in the jurisdiction. The information was then recorded on maps and the staffs from each jurisdiction reviewed the information for accuracy.

JURISDICTION GROWTH FORECAST

Household Population Growth Distribution by Jurisdiction

An initial step in the distribution of housing population growth was the calculation of growth due to the expected increase in household size. According to the San Joaquin Valley Demographic Forecasts: 2010 to 2050 prepared by The Planning Center, household sizes in the San Joaquin Valley are projected to increase steadily—from approx. 3.1298 persons per household in 2008 to approx. 3.3515 in 2035. Thus, some of the expected total growth in household population for Fresno County will manifest not in new development but rather in existing housing units, as each household on average will contain more people.

To calculate the household population growth due to household size increase, Fresno COG used the following formula:

$$HH_{2008}(HHsize_N - HHsize_{2008})$$

Where

> HH_{2008} = number of total households in Fresno County in 2008 (the base year) = *308,047*
> $HHsize_N$ = projected average countywide household size for target year N
> $HHsize_{2008}$ = average countywide household size in 2008 (the base year) = *3.1298*

Therefore, by this formula, the projected household population growth from 2008 to 2035 due to household size increase is *308,047 (3.3515 – 3.1298) = 68,289 persons*. Subtracting this value from the total projected growth in household population for the County represents the household population growth due to new development: *309,851 persons* by 2035.

The housing population growth was distributed to incorporated cities and the unincorporated County using data from three independent sources and combined them in a weighted percentage distribution. The datasets used, their relative significance in the total distribution calculation, and how they were used are as follows:

> *Decennial Census (45% significance)*
>
> Fresno COG compared total household population numbers from the 2000 and 2010 decennial census datasets from the U. S. Census Bureau to determine the share of Fresno County's growth by percentage for each incorporated city and the unincorporated area.

California Department of Finance (45% significance)

The growth in housing units from 2007 to 2012 was used in a similar fashion to create a distribution methodology between the incorporated cities and the unincorporated area.

2008 Base Land Use Modeling Data (10% significance)

The growth results from the first two datasets were slightly weighted by each jurisdiction's share of the existing housing units for 2008, by percent. These numbers were taken from the base land use dataset used by Fresno COG's regional traffic model.

Household Population Growth Distribution to Unincorporated Communities

To further divide the unincorporated growth into communities, only the California Department of Finance methodology was used. The resulting population growth totals were further adjusted through collaboration with Fresno County planning staff to more accurately reflect expected growth for future development sites (such as the Friant Ranch and Millerton communities).

Employment Growth Distribution by Jurisdiction

In a similar manner to the methodology for household population growth distribution, Fresno COG used two methodologies and combined them in a weighted percentage distribution to determine employment growth distribution by jurisdiction. The methodologies used, their relative significance in the total distribution calculation, and how they were used are as follows:

Housing Unit to Employment Ratio (75% significance)

Fresno COG used the 2008 land use dataset from the regional traffic model to determine each incorporated city's ratio of housing units to jobs, and allocated the employment growth projection according to these percentages.

Commute Estimates to the City of Fresno (25% significance)

This method used data from analysis done by Dowling Associates Inc. on the number of employees from each city/community in Fresno County who work in their community of residence compared to the number who commute to the City of Fresno.

Employment Growth Distribution to Unincorporated Communities

To further divide the unincorporated employment growth into communities, two methods were used and weighted evenly:

Commute Estimates to the City of Fresno (50% significance)

See description above.

Direct Relationship to Housing Growth (50% significance)

Each community's respective share in the total unincorporated housing growth was applied to distribute the total unincorporated employment by the same proportion.

5. TRIP GENERATION

The trip generation step quantifies the total magnitude of travel (person trips) generated in each zone based upon land uses within the zone.

TRIP STRATIFICATION

Trips are stratified by 11 trip purposes. The trip ends generated within any area are further classified as either trip end productions or trip end attractions. The four trip purposes are estimated separately and then later combined prior to assignment to the networks.

TRIP PURPOSES

To derive more accurate projections of future travel behavior, the Fresno COG Model stratifies trip ends by 11 trip purposes:

1. Home-Work trips are commute trips between residences and places of employment, including both trips from home to work and from work to home.
2. Home-Shop trips are trips between residences and places of retail employment.
3. Home-K12 trips are trips between residences and schools from kindergarten to 12th grade.
4. Home-College trips are trips between residences and colleges.
5. Home-Other trips account for all other trips that begin or end at home, and include social trips, recreational trips and medical appointments.
6. Work-Other trips are trips between places of employment and places other than home, such as driving to a restaurant during a lunch break, driving a delivery truck away from the main office, or stopping at the gas station on the way home from work.
7. Other-Other trips account for other “non-home-based” trips, such as trips between two stores.
8. Highway Commercial trips account for interaction with the gateways (not currently used).
9. Trucks-Small trips account for delivery truck trips.
10. Trucks-Medium trips account for truck trips between intermodal locations and distribution centers.
11. Trucks-Large trips account for longer distance truck trip, such as between counties or across the country.

Splitting the trips into purposes allows for a better understanding of the relationship between jobs and housing, by separating commute trips. It also provides more control over the trip distribution, since different types of trips involve different trip lengths. For a peak period model, it is important to identify the differences in travel characteristics over the day.

PRODUCTIONS AND ATTRACTIONS

Consistent with conventional modeling practice, each one-way trip is defined as having two trip ends in the trip generation process:

- Trip Production. This is defined as the home end of any home-based trip, regardless of whether the trip is directed to or from home. If neither end of the trip is a home (i.e., non-home based), it is defined as the origin end.
- Trip Attraction. This is the non-home end (e.g., place of work, school or shopping) of a home-based trip. If neither end of the trip is a home (i.e., it is a non-home based trip), the trip attraction is defined as the destination end.

In other words, trip productions are generally home related while trip attractions are generally related to place of work. For example, a typical commute from home to work in the morning and then back home in the evening represents two separate one-way trips, and there are two trip ends produced in the home zone and two trip ends attracted in the work zone.

TRIP GENERATION RATES

Trip generation rates for the Fresno COG Model were originally derived from the Caltrans 2000/2001 Statewide Travel Survey wherever possible, supplemented by information from previously developed models and knowledge about the accuracy of travel surveys. Separate trip generation rates were derived for each land use category and for each trip purpose. Daily person trip generation rates are shown in Table 15. Daily truck trip generation rates, which need to be updated, are shown in Table 16.

TABLE 15
DAILY PERSON TRIP GENERATION RATES

Land Use	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other
Residential							
RU1_HHSIZE1_INC1	0.17 (0)	0.37 (0)	0 (0)	0 (0)	0.91 (0.33)	0 (0)	0.16 (0.18)
RU1_HHSIZE1_INC2	0.43 (0)	0.45 (0)	0 (0)	0 (0)	0.78 (0.37)	0 (0)	0.19 (0.21)
RU1_HHSIZE1_INC3	0.75 (0)	0.55 (0)	0 (0)	0 (0)	0.56 (0.42)	0 (0)	0.21 (0.23)
RU1_HHSIZE1_INC4	0.76 (0)	0.56 (0)	0 (0)	0 (0)	0.72 (0.46)	0 (0)	0.23 (0.25)
RU1_HHSIZE1_INC5	0.69 (0)	0.4 (0)	0 (0)	0 (0)	0.59 (0.38)	0 (0)	0.19 (0.21)
RU1_HHSIZE2_INC1	0.6 (0)	0.93 (0)	0 (0)	0 (0)	1.1 (0.59)	0 (0)	0.29 (0.33)
RU1_HHSIZE2_INC2	0.82 (0)	0.8 (0)	0 (0)	0 (0)	1.29 (0.65)	0 (0)	0.32 (0.36)
RU1_HHSIZE2_INC3	0.95 (0)	1.08 (0)	0 (0)	0 (0)	1.37 (0.76)	0 (0)	0.38 (0.42)
RU1_HHSIZE2_INC4	1.51 (0)	1.2 (0)	0 (0)	0 (0)	1.43 (0.92)	0 (0)	0.46 (0.51)
RU1_HHSIZE2_INC5	1.57 (0)	1.05 (0)	0 (0)	0 (0)	1.49 (0.92)	0 (0)	0.46 (0.51)
RU1_HHSIZE3_INC1	0.56 (0)	0.78 (0)	0 (0)	0 (0)	1.45 (0.62)	0 (0)	0.31 (0.35)
RU1_HHSIZE3_INC2	0.99 (0)	0.75 (0)	0 (0)	0 (0)	2.47 (0.94)	0 (0)	0.47 (0.52)
RU1_HHSIZE3_INC3	1.82 (0)	1.03 (0)	0 (0)	0 (0)	1.63 (1)	0 (0)	0.5 (0.56)
RU1_HHSIZE3_INC4	1.98 (0)	1.05 (0)	0 (0)	0 (0)	2.29 (1.19)	0 (0)	0.6 (0.66)
RU1_HHSIZE3_INC5	2.44 (0)	0.98 (0)	0 (0)	0 (0)	1.64 (1.13)	0 (0)	0.57 (0.63)

TABLE 15
DAILY PERSON TRIP GENERATION RATES

Land Use	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other
RU1_HHSIZE4_INC1	1.16 (0)	1.18 (0)	0 (0)	0 (0)	3.79 (1.37)	0 (0)	0.69 (0.76)
RU1_HHSIZE4_INC2	1.19 (0)	0.92 (0)	0 (0)	0 (0)	3.49 (1.25)	0 (0)	0.63 (0.7)
RU1_HHSIZE4_INC3	1.84 (0)	0.96 (0)	0 (0)	0 (0)	3.36 (1.38)	0 (0)	0.69 (0.77)
RU1_HHSIZE4_INC4	1.91 (0)	0.9 (0)	0 (0)	0 (0)	4 (1.52)	0 (0)	0.76 (0.85)
RU1_HHSIZE4_INC5	2.31 (0)	1.24 (0)	0 (0)	0 (0)	3.11 (1.49)	0 (0)	0.75 (0.83)
RU1_HHSIZE5_INC1	0.89 (0)	0.92 (0)	0 (0)	0 (0)	2.08 (0.87)	0 (0)	0.44 (0.48)
RU1_HHSIZE5_INC2	1.4 (0)	1.12 (0)	0 (0)	0 (0)	4.2 (1.5)	0 (0)	0.75 (0.84)
RU1_HHSIZE5_INC3	2.03 (0)	0.92 (0)	0 (0)	0 (0)	4.32 (1.63)	0 (0)	0.81 (0.9)
RU1_HHSIZE5_INC4	1.79 (0)	1.37 (0)	0 (0)	0 (0)	5.37 (1.91)	0 (0)	0.96 (1.06)
RU1_HHSIZE5_INC5	2.17 (0)	1.29 (0)	0 (0)	0 (0)	5.32 (1.97)	0 (0)	0.98 (1.09)
RU3_HHSIZE1_INC1	0.14 (0)	0.37 (0)	0 (0)	0 (0)	0.75 (0.28)	0 (0)	0.14 (0.16)
RU3_HHSIZE1_INC2	0.63 (0)	0.4 (0)	0 (0)	0 (0)	0.67 (0.38)	0 (0)	0.19 (0.21)
RU3_HHSIZE1_INC3	0.83 (0)	0.6 (0)	0 (0)	0 (0)	1.1 (0.56)	0 (0)	0.28 (0.31)
RU3_HHSIZE1_INC4	1.14 (0)	0.4 (0)	0 (0)	0 (0)	0.29 (0.41)	0 (0)	0.2 (0.23)
RU3_HHSIZE1_INC5	1.23 (0)	0.09 (0)	0 (0)	0 (0)	0.62 (0.43)	0 (0)	0.22 (0.24)
RU3_HHSIZE2_INC1	0.45 (0)	0.11 (0)	0 (0)	0 (0)	0.91 (0.33)	0 (0)	0.16 (0.18)

TABLE 15
DAILY PERSON TRIP GENERATION RATES

Land Use	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other
RU3_HHSIZE2_INC2	1.06 (0)	0.55 (0)	0 (0)	0 (0)	1.11 (0.61)	0 (0)	0.3 (0.34)
RU3_HHSIZE2_INC3	0.97 (0)	0.35 (0)	0 (0)	0 (0)	1.34 (0.6)	0 (0)	0.3 (0.33)
RU3_HHSIZE2_INC4	1.99 (0)	0.91 (0)	0 (0)	0 (0)	0.81 (0.83)	0 (0)	0.41 (0.46)
RU3_HHSIZE2_INC5	0.96 (0)	0.65 (0)	0 (0)	0 (0)	1.45 (0.69)	0 (0)	0.34 (0.38)
RU3_HHSIZE3_INC1	0.36 (0)	0.98 (0)	0 (0)	0 (0)	3.12 (1)	0 (0)	0.5 (0.56)
RU3_HHSIZE3_INC2	1.04 (0)	0.81 (0)	0 (0)	0 (0)	2.17 (0.9)	0 (0)	0.45 (0.5)
RU3_HHSIZE3_INC3	1.2 (0)	0.99 (0)	0 (0)	0 (0)	2.73 (1.1)	0 (0)	0.55 (0.61)
RU3_HHSIZE3_INC4	2.06 (0)	0.28 (0)	0 (0)	0 (0)	1.66 (0.9)	0 (0)	0.45 (0.5)
RU3_HHSIZE3_INC5	0.64 (0)	1.8 (0)	0 (0)	0 (0)	1.8 (0.95)	0 (0)	0.47 (0.53)
RU3_HHSIZE4_INC1	1.16 (0)	0.23 (0)	0 (0)	0 (0)	1.52 (0.65)	0 (0)	0.33 (0.36)
RU3_HHSIZE4_INC2	1.41 (0)	0.45 (0)	0 (0)	0 (0)	3 (1.09)	0 (0)	0.54 (0.6)
RU3_HHSIZE4_INC3	1.37 (0)	0.95 (0)	0 (0)	0 (0)	2.05 (0.98)	0 (0)	0.49 (0.54)
RU3_HHSIZE4_INC4	1.39 (0)	0.5 (0)	0 (0)	0 (0)	1.17 (0.68)	0 (0)	0.34 (0.38)
RU3_HHSIZE4_INC5	2.12 (0)	0.59 (0)	0 (0)	0 (0)	0.68 (0.76)	0 (0)	0.38 (0.42)
RU3_HHSIZE5_INC1	0.69 (0)	1.35 (0)	0 (0)	0 (0)	3.24 (1.18)	0 (0)	0.59 (0.66)
RU3_HHSIZE5_INC2	1.63 (0)	1.82 (0)	0 (0)	0 (0)	2.25 (1.28)	0 (0)	0.64 (0.71)

TABLE 15
DAILY PERSON TRIP GENERATION RATES

Land Use	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other
RU3_HHSIZE5_INC3	2.06 (0)	1.74 (0)	0 (0)	0 (0)	4.86 (1.94)	0 (0)	0.97 (1.08)
RU3_HHSIZE5_INC4	1.06 (0)	0.94 (0)	0 (0)	0 (0)	1.74 (0.84)	0 (0)	0.42 (0.46)
RU3_HHSIZE5_INC5	0.78 (0)	0.7 (0)	0 (0)	0 (0)	1.29 (0.62)	0 (0)	0.31 (0.34)
RU9_HHSIZE1_INC1	0.33 (0)	0.49 (0)	0 (0)	0 (0)	0.51 (0.3)	0 (0)	0.15 (0.17)
RU9_HHSIZE1_INC2	0.4 (0)	0.32 (0)	0 (0)	0 (0)	0.46 (0.26)	0 (0)	0.13 (0.15)
RU9_HHSIZE1_INC3	1.14 (0)	0.36 (0)	0 (0)	0 (0)	0.41 (0.43)	0 (0)	0.21 (0.24)
RU9_HHSIZE1_INC4	0.96 (0)	0.19 (0)	0 (0)	0 (0)	0.39 (0.35)	0 (0)	0.17 (0.19)
RU9_HHSIZE1_INC5	1.31 (0)	0.39 (0)	0 (0)	0 (0)	0.41 (0.47)	0 (0)	0.24 (0.26)
RU9_HHSIZE2_INC1	0.48 (0)	0.36 (0)	0 (0)	0 (0)	0.54 (0.31)	0 (0)	0.15 (0.17)
RU9_HHSIZE2_INC2	0.43 (0)	0.63 (0)	0 (0)	0 (0)	0.82 (0.42)	0 (0)	0.21 (0.23)
RU9_HHSIZE2_INC3	1.14 (0)	0.66 (0)	0 (0)	0 (0)	0.69 (0.56)	0 (0)	0.28 (0.31)
RU9_HHSIZE2_INC4	1.68 (0)	1.13 (0)	0 (0)	0 (0)	0.22 (0.68)	0 (0)	0.34 (0.38)
RU9_HHSIZE2_INC5	1.35 (0)	2.17 (0)	0 (0)	0 (0)	1.8 (1.19)	0 (0)	0.6 (0.66)
RU9_HHSIZE3_INC1	0.98 (0)	1.8 (0)	0 (0)	0 (0)	2.7 (1.23)	0 (0)	0.61 (0.68)
RU9_HHSIZE3_INC2	0.79 (0)	0.25 (0)	0 (0)	0 (0)	0.73 (0.39)	0 (0)	0.2 (0.22)
RU9_HHSIZE3_INC3	1.52 (0)	1.11 (0)	0 (0)	0 (0)	0.78 (0.76)	0 (0)	0.38 (0.42)

TABLE 15
DAILY PERSON TRIP GENERATION RATES

Land Use	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other
RU9_HHSIZE3_INC4	2.11 (0)	1.49 (0)	0 (0)	0 (0)	1.77 (1.2)	0 (0)	0.6 (0.67)
RU9_HHSIZE3_INC5	0.85 (0)	0.9 (0)	0 (0)	0 (0)	5.4 (1.6)	0 (0)	0.8 (0.89)
RU9_HHSIZE4_INC1	0.91 (0)	0.74 (0)	0 (0)	0 (0)	1.37 (0.68)	0 (0)	0.34 (0.38)
RU9_HHSIZE4_INC2	0.39 (0)	0.31 (0)	0 (0)	0 (0)	1.93 (0.59)	0 (0)	0.29 (0.33)
RU9_HHSIZE4_INC3	1.76 (0)	1.24 (0)	0 (0)	0 (0)	1.36 (0.97)	0 (0)	0.49 (0.54)
RU9_HHSIZE4_INC4	1.7 (0)	2.7 (0)	0 (0)	0 (0)	2.7 (1.59)	0 (0)	0.79 (0.88)
RU9_HHSIZE4_INC5	1.83 (0)	1.49 (0)	0 (0)	0 (0)	2.75 (1.36)	0 (0)	0.68 (0.75)
RU9_HHSIZE5_INC1	1.43 (0)	0.35 (0)	0 (0)	0 (0)	5.04 (1.53)	0 (0)	0.76 (0.85)
RU9_HHSIZE5_INC2	1.19 (0)	0.64 (0)	0 (0)	0 (0)	3.2 (1.13)	0 (0)	0.56 (0.63)
RU9_HHSIZE5_INC3	2.21 (0)	0.44 (0)	0 (0)	0 (0)	7.49 (2.27)	0 (0)	1.13 (1.26)
RU9_HHSIZE5_INC4	0.85 (0)	0.4 (0)	0 (0)	0 (0)	3.6 (1.09)	0 (0)	0.54 (0.6)
RU9_HHSIZE5_INC5	1.7 (0)	0.43 (0)	0 (0)	0 (0)	8.1 (2.29)	0 (0)	1.14 (1.27)
Non-Residential (DAYSIM Activity Group Aggregations)							
EMPOTH	0 (0.53)	0 (0.05)	0 (0)	0 (0)	0 (0.12)	0.35 (0.03)	0.24 (0.18)
EMPIND	0 (0.5)	0 (0.42)	0 (0)	0 (0)	0 (0.24)	0.31 (0.14)	0.78 (0.55)
EMPRET	0 (0.59)	0 (2.38)	0 (0)	0 (0)	0 (1.66)	0.3 (0.71)	2.26 (2.25)

TABLE 15
DAILY PERSON TRIP GENERATION RATES

Land Use	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other
EMPOFC	0 (1.01)	0 (0)	0 (0)	0 (0)	0 (0.4)	0.5 (0.17)	0.04 (0.13)
EMPEDU	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
EMPMED	0 (0.94)	0 (0.32)	0 (0)	0 (0)	0 (0.79)	0.32 (0.13)	1.09 (0.91)
EMPSVC	0 (1.41)	0 (0.49)	0 (0)	0 (0)	0 (1.2)	0.28 (0.63)	0.62 (0.75)
EMPFOO	0 (3.4)	0 (6.09)	0 (0)	0 (0)	0 (7.25)	0.21 (1.85)	1.36 (2.46)
EMPGOV	0 (0.79)	0 (0.18)	0 (0)	0 (0)	0 (0.11)	0.37 (0.07)	0.62 (0.5)
School							
ELEM	0 (0.38)	0 (0)	0 (1.22)	0 (0)	0 (0)	0 (0)	0 (0)
HS	0 (0.5)	0 (0)	0 (1.62)	0 (0)	0 (0)	0 (0)	0 (0)
COLLEGE	0 (1.09)	0 (0)	0 (0)	0 (0.98)	0 (0)	0 (0)	0 (0)

Notes: Values shown as Production (Attraction)

TABLE 16
DAILY TRUCK TRIP GENERATION

Land Use	People	Mail	Urban Freight	Construction	Service
Trucks Small					
TOTHH	0.0075	0.00167	0.03551	3.04E-02	0.35243
TOTEMP	0.0121	0.00167	0	3.04E-02	0.32839
RETAIL	0	0	0.12571	0	0
AG	0	0	0.15714	0	0
MINING	0	0	0.15714	0	0
CONSTR	0	0	0.15714	0.03041	0
MFGPROD	0	0	0.13278	0	0
MFGEQUIP	0	0	0.13278	0	0
TRANSP	0	0	0.13278	0	0
WHLSALE	0	0	0.13278	0	0
FINANCE	0	0	0.06186	0	0
EDUGOV	0	0	0.06186	0	0
Trucks Medium					
TOTHH	0.0051	0.00008	0.00719	1.07E-02	0.09483
TOTEMP	0.00158	0.00008	0	1.07E-02	0.0844

TABLE 16
DAILY TRUCK TRIP GENERATION

Land Use	People	Mail	Urban Freight	Construction	Service
RETAIL	0	0	0.01835	0	0
AG	0	0	0.02099	0	0
MINING	0	0	0.02099	0	0
CONSTR	0	0	0.02099	0.0107	0
MFGPROD	0	0	0.01758	0	0
MFGEQUIP	0	0	0.01758	0	0
TRANSP	0	0	0.01758	0	0
WHLSALE	0	0	0.01758	0	0
FINANCE	0	0	0.0049	0	0
EDUGOV	0	0	0.0049	0	0
Trucks Heavy					
TOTHH	0	0.00001	0.00345	0.00394	0.00161
TOTEMP	0	0.00001	0	0.00394	0.00161
RETAIL	0	0	0.00592	0	0
AG	0	0	0.01583	0	0
MINING	0	0	0.01583	0	0

TABLE 16
DAILY TRUCK TRIP GENERATION

Land Use	People	Mail	Urban Freight	Construction	Service
CONSTR	0	0	0.01583	0.00394	0
MFGPROD	0	0	0.00945	0	0
MFGEQUIP	0	0	0.00945	0	0
TRANSP	0	0	0.00945	0	0
WHLSALE	0	0	0.00945	0	0
FINANCE	0	0	0.00081	0	0
EDUGOV	0	0	0.00081	0	0

HOUSEHOLD TRIP PRODUCTIONS

The Caltrans 2000/2001 Statewide Travel Survey was based on households. Therefore, it is most useful for determining travel characteristics at households as opposed to employment. The households in the travel survey were divided into six categories according to housing type and auto ownership.

A standard procedure for “cross-classification” trip generation would be to determine the average trip rate for each of the six household categories. With a small survey sample size, this procedure can result in zero or inconsistent rates for certain household categories. To ensure larger sample sizes, the Fresno COG Model used survey results from four counties: Fresno, Kern, Kings and Tulare. The resulting survey sample sizes are shown in Table 8.

During model validation, the household production rates for the Home-Other trip purpose were increased by 1.8 compared to the household survey results. This increase was intended to bring the household vehicle trip generation rates closer to the averages reported in ITE Trip Generation. It is also probable that these trips are among the most likely to be left out when survey participants are filling out their travel diary forms.

WORK-OTHER TRIP PRODUCTIONS

The Caltrans Statewide Travel Survey can also provide some information on trips made by surveyed workers. For each surveyed person, the work trip characteristics can be correlated to their reported type of employment. These survey records were used to determine Work-Other productions for each of the five types of employment in the Fresno COG Model.

TRIP ATTRACTIONS

Home-Work attractions can be derived from the travel survey. Each person at the surveyed households was also asked about their type of employment. The average number of home-work commute trips for each type of employment can be calculated from these survey records. The Home-Work trip attraction rates from the survey results were factored by 0.92 to better balance with household trip production estimates. See Table 17 for the model trip productions/attractions balance.

TABLE 17
TRIP PRODUCTIONS/ATTRACTIONS BALANCE

Trip Purpose	Evaluation Criterion	Productions	Attractions	P/A Ratio	Difference	Percent Difference
HBW	+/- 10%	484,919	467,649	1.04	-17,269	-3.6%
HBS	+/- 10%	276,845	290,934	0.95	14,089	5.1%
HBO	+/- 10%	1,018,477	1,007,823	1.01	-10,654	-1.0%
NHB	+/- 10%	572,150	561,126	1.02	-11,023	-1.9%

Notes: HBW = home-based-work; HBS = home-based-shopping; HBO = home-based-other; NHB = non-home-based

OTHER-OTHER TRIP RATE ADJUSTMENTS

After adjusting the home-based and work-based trips based on available survey data, the total trip generation rates for several employment categories were still well below the total average vehicle trip generation rates reported in ITE Trip Generation. It is assumed that the most likely trips to be under-reported in the travel survey would be incidental trips, such as a trip between the grocery store and the laundry. These trips mostly fall into the Other-Other category.

The Other-Other production and attraction rates for each employment type were estimated by comparing the trip generation to standard vehicle trip generation rates in Trip Generation. The model person trip generation rates were converted to vehicle trips using average Fresno County auto occupancies for each trip purpose. The vehicle trip rates were compared for each employment type.

The Other-Other trip rates were increased so that the model trip generation rates would replicate the ITE vehicle trip generation rates. The average weekday person trips per household from survey data and the Fresno COG Model are shown in Table 21

TABLE 18
WEEKDAY PERSON TRIPS PER HOUSEHOLD

CHTS	Model
6.8	6.9

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, made by households within the county, weighted by weekday, household-level weights ("HHWDWGT").

EXTERNAL TRIPS

There are two types of external trips at the cordons or "gateways" of a model, through trips (external-external or X-X) and external trips (internal-external, external-internal, I-X/X-I or I-E/E-I). Through trips are trips that pass through the model area without stopping. Daily productions and attractions at gateways are shown in Table 19.

TABLE 19
DAILY PRODUCTIONS AND ATTRACTIONS AT GATEWAYS

Purpose	Productions and Attractions
Home-Work	92,109 (26,049)
Home-Shop	10,056 (10,560)
Home-K12	0 (0)
Home-College	306 (194)
Home-Other	41,353 (26,191)
Work-Other	11,508 (26,719)
Other-Other	39,336 (17,402)
Highway Commercial	4,117 (4,117)
Trucks-Small	1,531 (1,526)
Trucks-Medium	759 (747)
Trucks-Heavy	8,760 (9,192)

Notes: Values shown as Production (Attraction)

STATEWIDE MODEL

The basic source of information for external trips in the Fresno COG Model is the California Statewide Model maintained by Caltrans. The available version of the Statewide Model was initially developed in 2003 and was minimally updated during the MIP to include more current land uses throughout the state to reflect the most recently adopted RTPs.

HIGH SPEED RAIL MODEL

An updated version of the California Statewide Model was prepared for the California High Speed Rail Authority in 2007. The High Speed Rail version was not made available for use in the development of the Fresno COG Model. The High Speed Rail version significantly updated the estimates of long-distance trips and trips to and from the major metropolitan areas (Bay Area, Los Angeles area). However, the High Speed Rail version did not update land uses in the San Joaquin Valley and did not significantly revise the procedures for shorter distance interregional trips compared to the 2003 version of the Statewide Model. Therefore, it is expected that the prior 2003 version of the Statewide Model (with the land use and journey-to-work updates) would provide equal or better estimates of the majority of the external trips affecting Fresno County.

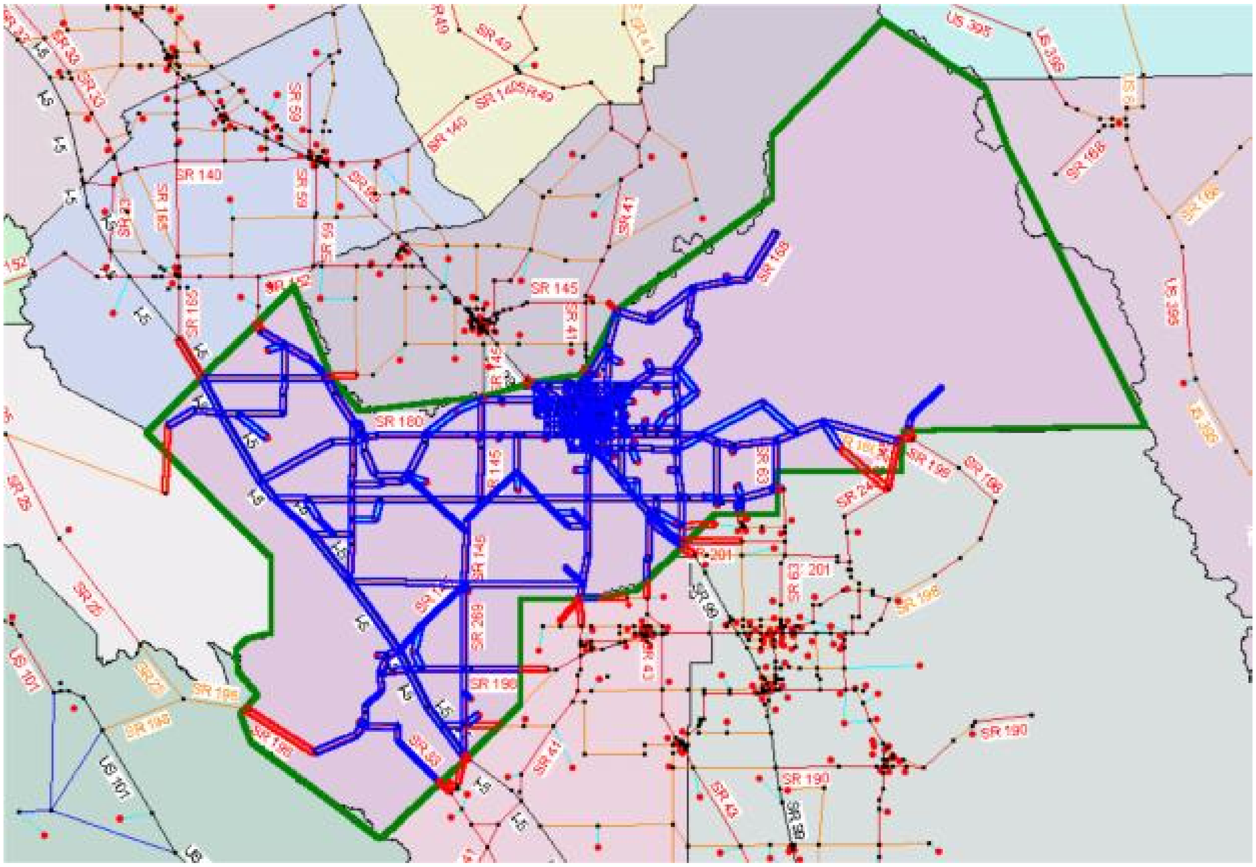
APPLICATION OF STATEWIDE MODEL

The California Statewide Model is not used to provide direct values of external trips for the Fresno COG Model. The following information is extracted from the Statewide model:

- The proportions of through trips versus internal-external trips at each Fresno County gateway.
- Proportions of internal-external trips by each of the five trip purposes and by productions versus attractions (representing in-commute versus out-commute for Fresno County)
- Base through trip patterns from the 2000 model calibration year.
- Annual growth rates for each gateway based on the 2000 and 2025 statewide model estimates.

A “subarea analysis” of Fresno County was used to isolate the statewide trips which pass into, out of or through Fresno County. See Figure 11 for the Fresno subarea used in the analysis.

Figure 11 California Statewide Model Fresno Subarea



The following steps are used in the process:

1. Total gateway traffic volumes for each Fresno COG Model year are estimated by multiplying the 2003 base year traffic count at each gateway by the annual traffic growth rates for each gateway derived from the 2000 and 2025 Statewide Model subarea results.

2. The 2000 and 2025 Statewide Model subarea vehicle trips by purpose at each gateway are interpolated or extrapolated for each Fresno COG Model year.

3. The proportions of through trips versus internal-external trips from the interpolation in Step 2 are used to split the total gateway traffic volumes from Step 1.

4. The estimated through trip totals at each gateway for each Fresno COG Model year from Step 3 are used as control totals to factor the 2000 base year through trip patterns for each Fresno COG Model year.

5. The proportions of trips by trip purpose and productions versus attractions from the interpolation in Step 2 are used to split the total internal-external traffic volumes from Step 3.

6. The internal-external vehicle trips for each trip purpose are multiplied by the appropriate average auto occupancy rate to convert them to person trips.

INTERNAL-EXTERNAL TRIP BALANCING

The initial estimates of productions and attractions at each gateway are added to the Fresno County trips. The model must have a balance between productions and attractions for each trip purpose, as every trip has two ends. Unlike the previous version of the Fresno COG Model where trips are held constant, the external gateway trips are automatically factored to provide an overall balance of person-trip productions and attractions for each trip purpose. The total trips at each gateway by purpose are dynamic and respond to the land use within the model area. These adjusted gateway trips are then distributed to the model zones along with the internal model area trips.

Since the initial estimate of productions and attractions are based on the previous RTPs, significant changes within Fresno or after significant updates to assumptions throughout the valley (land use development or infrastructure projects) should be implemented in the statewide or other multi-region model to obtain new estimates of gateways.

SPECIAL GENERATORS

As discussed above, special generators are used to include trips from land uses that are not well represented by the standard trip rates. In the Fresno COG Model, special generators are used primarily to define Home-Other trips attracted to recreational areas such as parks and golf course. Typical vehicle trip generation values were estimated for each of these recreational areas based on ITE Trip Generation. The vehicle trips are converted to person trips using average auto occupancy rates. The special generator trips are then added to the appropriate TAZs after trips are calculated using the standard household and employment trip generation rates.

6. TRIP DISTRIBUTION

The trip distribution process estimates how many trips travel from one zone to another. The model uses a method known as the gravity model to estimate trips between zones based on the trip productions and attractions in each zone and on factors that relate the likelihood of travel between zones to the separation between the zones.

DESCRIPTION OF GRAVITY MODEL

The gravity model follows the concept of Isaac Newton's Universal Law of Gravitation, which states that the attractive force between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them. Similarly, zone-to-zone trip interchanges in the gravity model are assumed to be proportional to the relative attraction or opportunity provided by each of the zones (productions and attractions) and inversely proportional to the separation between zones. Expressed mathematically, the gravity model formula of trip distribution is:

$$T_{ij} = P_I * \frac{A_j F(t_{ij}) K_{ij}}{\sum_{x=1}^{n} A_x F(t_{ij}) K_{ij}}$$

where: T_{ij} = number of trips produced in zone i and attracted to zone j

P_i = total number of trips produced in zone I

A_j = attractions of zone j

t_{ij} = travel cost between zone i and zone j

$F(t_{ij})$ = the friction factors between zone i and zone j

K_{ij} = zone-to-zone adjustment factor

n = number of zones

The inputs to the gravity model include the person trip productions and attractions for each zone (as defined earlier in the trip generation step), the zone-to-zone travel times and travel cost (converted to time using the value of time by purpose), and friction factors that define the effects of travel time. The zone-to-zone distributions are calculated separately for each trip purpose.

TRAVEL TIMES

The travel time between each pair of zones is calculated by determining the shortest time path along the coded network between the two zones, and accumulating the travel time along that path. The path building process produces a table (skim matrix) of travel times between each pair of zones in the model. The resulting table of zone-to-zone travel times is then used as an input to the trip distribution analysis.

INTRAZONAL TRAVEL TIMES

Intrazonal travel times represent the average travel time for trips that stay within a particular zone. For urban areas, intrazonal times are estimated as 100 percent of the average travel time to the nearest adjacent TAZ. For rural areas, the intrazonal times are estimated as one-third the average time to the nearest adjacent TAZ. For larger rural TAZs, the active land uses tend to be clustered together and the total size of the TAZ is not necessarily a good indicator of the trips distances for very local trips.

TERMINAL TIMES

Terminal times are added to represent the average time to access one's vehicle at each end of the trip. The terminal times for the Fresno model were estimated by comparing the model estimate of road network travel times with the reported travel times for trips in Fresno County from the Statewide travel survey. The surveyed trips were stratified by origins and destinations in the Central Business District (CBD) or universities.

The Fresno COG Model assumes one minute at the home (production) end of each trip and two minutes at the non-home (attraction) end for most TAZs. Terminal times of four minutes are assumed at each end of the trip in the Fresno CBD, and a three minute terminal time is assumed at each end of the trips for colleges and universities within the urban area.

TRAVEL COST

Node variables and link variables were added to the highway network to account for travel costs. The node variables can be used to represent point fees such as parking cost on centroids or toll booths. Link variables can be used to represent toll facilities in dollars per mile, supplement to auto ownership costs, or VMT tax.

FRICTION FACTORS

The effects of spatial separation in the gravity model are represented empirically by "friction factors" that express the effect that travel time exerts on the propensity for making a trip to a given zone. Typically, the probability for making a particular trip declines as the travel time increases. For the Fresno COG Model, 11 sets of friction factors are used, with each set corresponding to one of the 11 trip purposes. This accounts for the possibility that people may be willing to drive a long distance to go to work, but only short distances for most shopping or school trips.

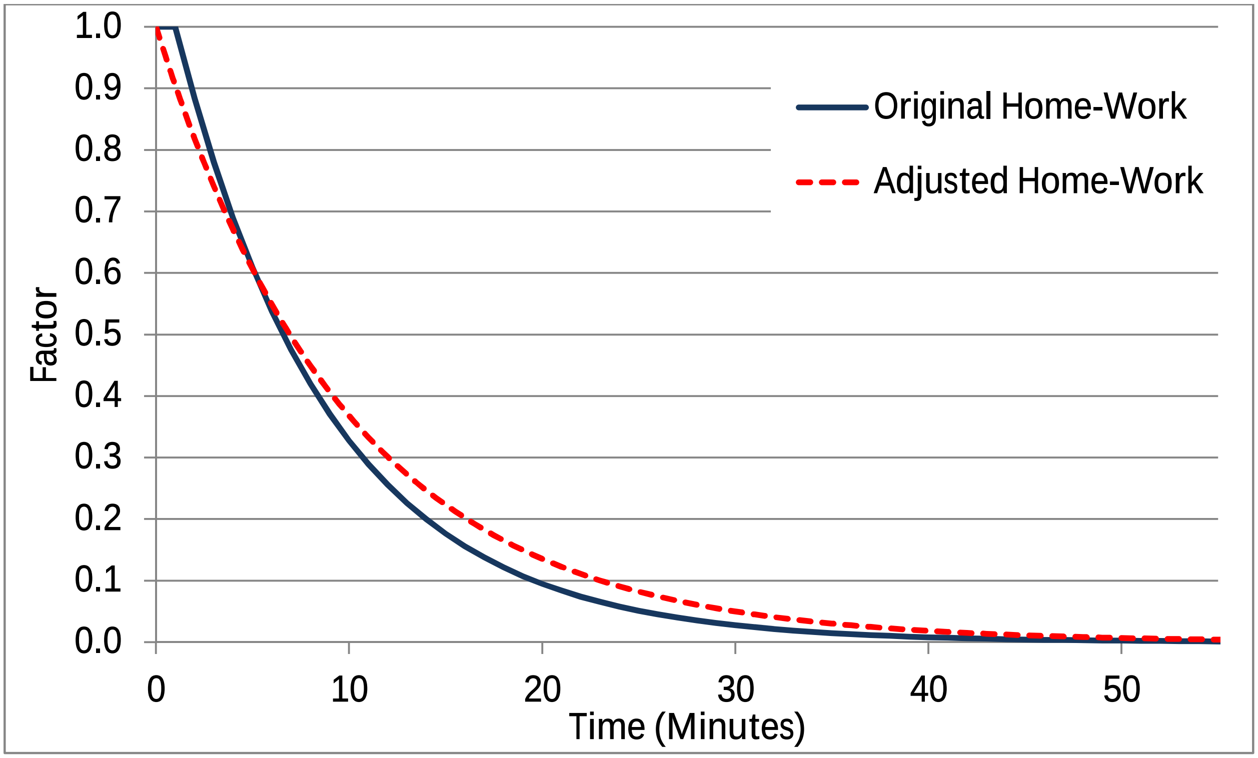
The friction factors for the Fresno COG Model were initially based on the gamma function friction factors reported in NCHRP 365. The trip lengths estimated by the model using these factors were compared to trip lengths reported in the 2001 California travel survey. The friction factors were then adjusted using an iterative process to better replicate the survey trip distribution in each five minute trip length category (Table 20. The original and adjusted friction factors are shown in Figure 12.

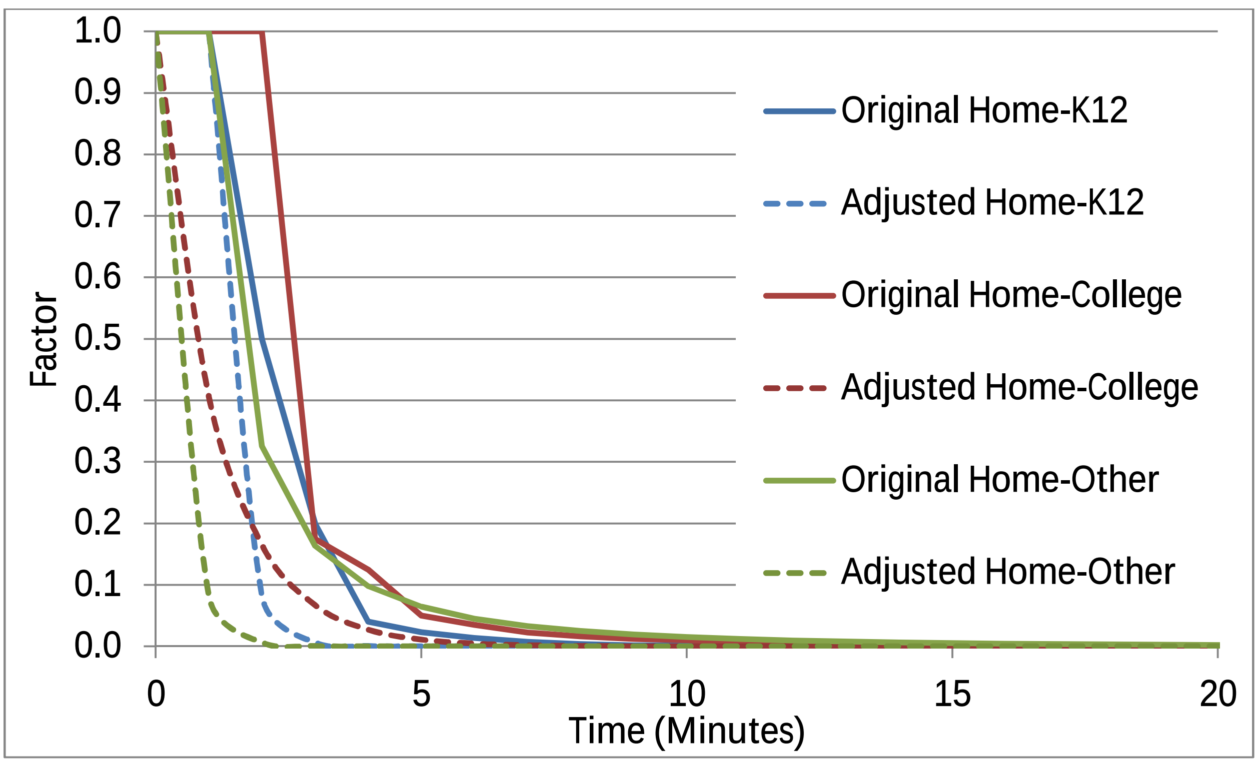
TABLE 20
FRESNO COUNTY FRICTION FACTOR COEFFICIENTS

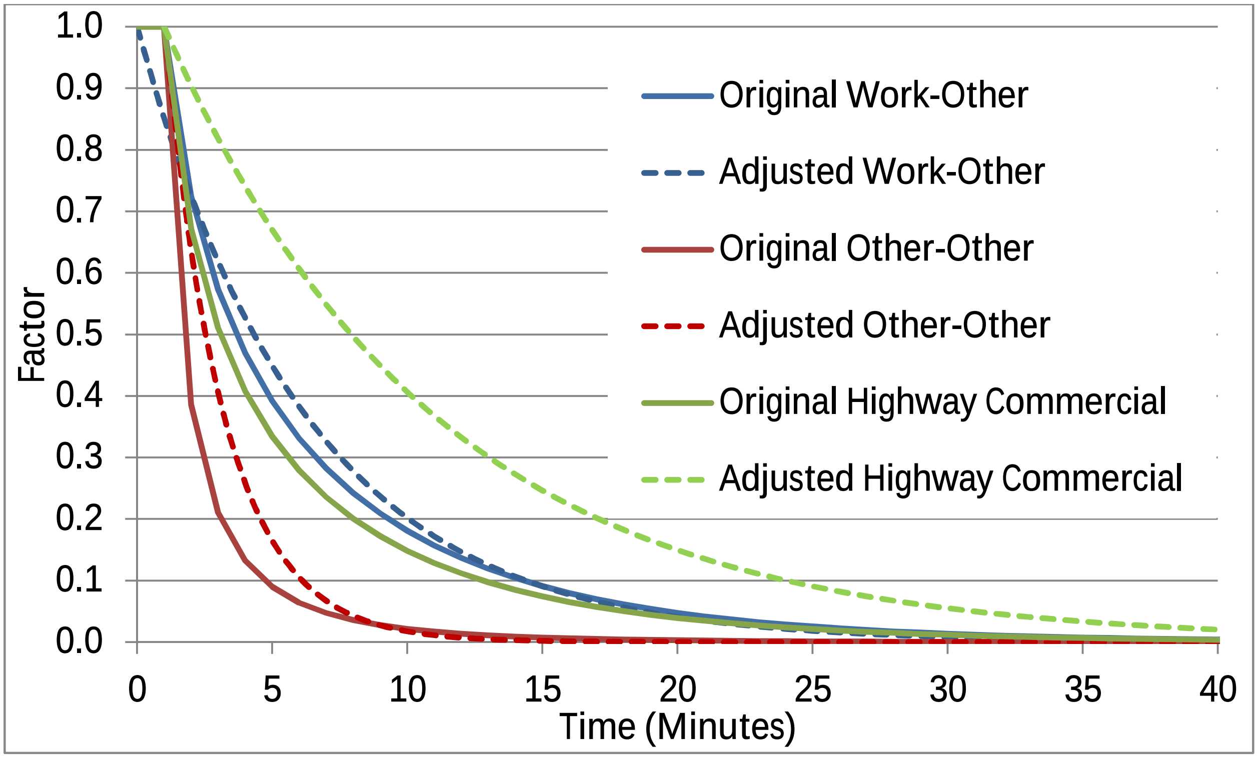
Purpose	Coefficient A	Coefficient B	Coefficient C
Home-Work	1	-0.100	0.000
Home-Shop	1	-2.500	0.000
Home-K12	1	-2.500	0.000
Home-College	1	-0.900	0.000
Home-Other	1	-2.500	0.000
Work-Other	1	-0.160	0.000
Other-Other	1	-0.450	0.000
Highway Commercial	1	-0.100	0.000
Trucks-Small	100000	-0.070	-0.500
Trucks-Medium	100000	-0.070	-0.500
Trucks-Heavy	100000	-0.070	-0.500

Notes: auto friction factor = $A \times e^{B \times x}$ truck friction factor= $A \times x^{C} \times e^{B \times x}$

Figure 12 Fresno County Friction Factors






1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Factor
0
5
10
15
20
25
30
35
40
Time (Minutes)
Original Work-Other
Adjusted Work-Other
Original Other-Other
Adjusted Other-Other
Original Highway Commercial
Adjusted Highway Commercial

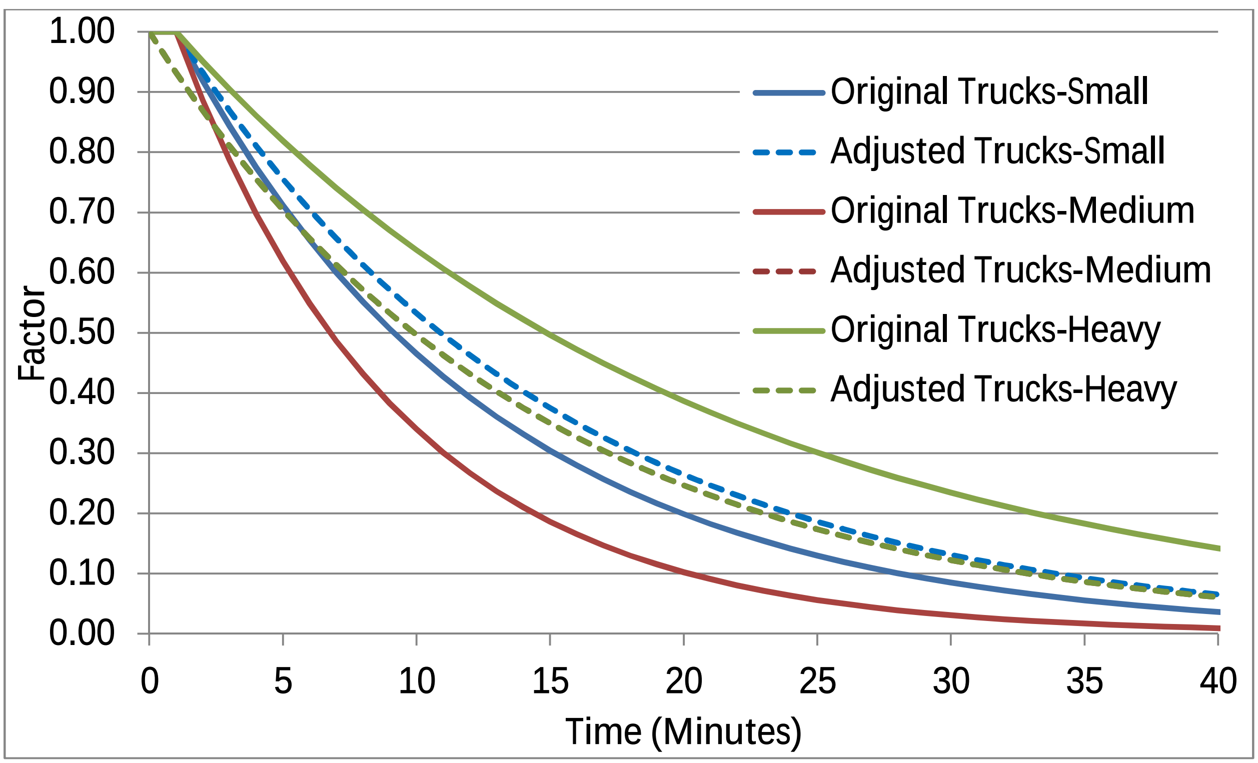

1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Factor
0
5
10
15
20
25
30
35
40
Time (Minutes)
Original Trucks-Small
Adjusted Trucks-Small
Original Trucks-Medium
Adjusted Trucks-Medium
Original Trucks-Heavy
Adjusted Trucks-Heavy

TABLE 21
TRIP DISTRIBUTION BY PURPOSE (ALL MODES)

Trip Type	Trip Purpose							
	Total		HBW		HBO		NHB	
	CHTS	Model	CHTS	Model	CHTS	Model	CHTS	Model
II	88.2%	95.7%	83.0%	83.1%	91.1%	99.4%	86.8%	98.0%
IX	5.8%	0.9%	9.0%	2.2%	4.5%	0.3%	5.7%	1.0%
XI	6.0%	3.4%	8.0%	14.6%	4.4%	0.3%	7.5%	1.0%

Notes: 2000-2001 California Statewide Household Travel Survey. All modes, weekday trips only. External-to-external (XX) trips are excluded; reported values are percentages of the total of all non- external-to-external weekday trips. Trips are weighted by weekday, trip-level weights ("WDWGT"). Driver trips are adjusted by a factor of 1.647 to correct for underreporting.

TABLE 22
AVERAGE TRAVEL TIME (IN MINUTES) BY TRIP PURPOSE

Trip Purpose					
HBW		HBO		NHB	
CHTS	Model	CHTS	Model	CHTS	Model
20.2	16.4	15.1	20.6	15.5	16.1

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT").

ADJUSTMENT FACTORS

Adjustment Factors (“K factors”) are used in gravity model trip distribution calculations where travel time does not fully explain the attractiveness or unattractiveness of certain trips. The adjustments are often used where bridges, other perceived travel barriers or special socioeconomic factors (such as housing prices or campus housing areas) may distort the distribution of trips between specific areas. The K factors are not adjustments to the number of trips, but rather adjustments to the friction factors that represent the attractiveness of a certain trip relative to other trips.

The model does not use K-factors other than the gateways as described below.

GATEWAY ADJUSTMENTS

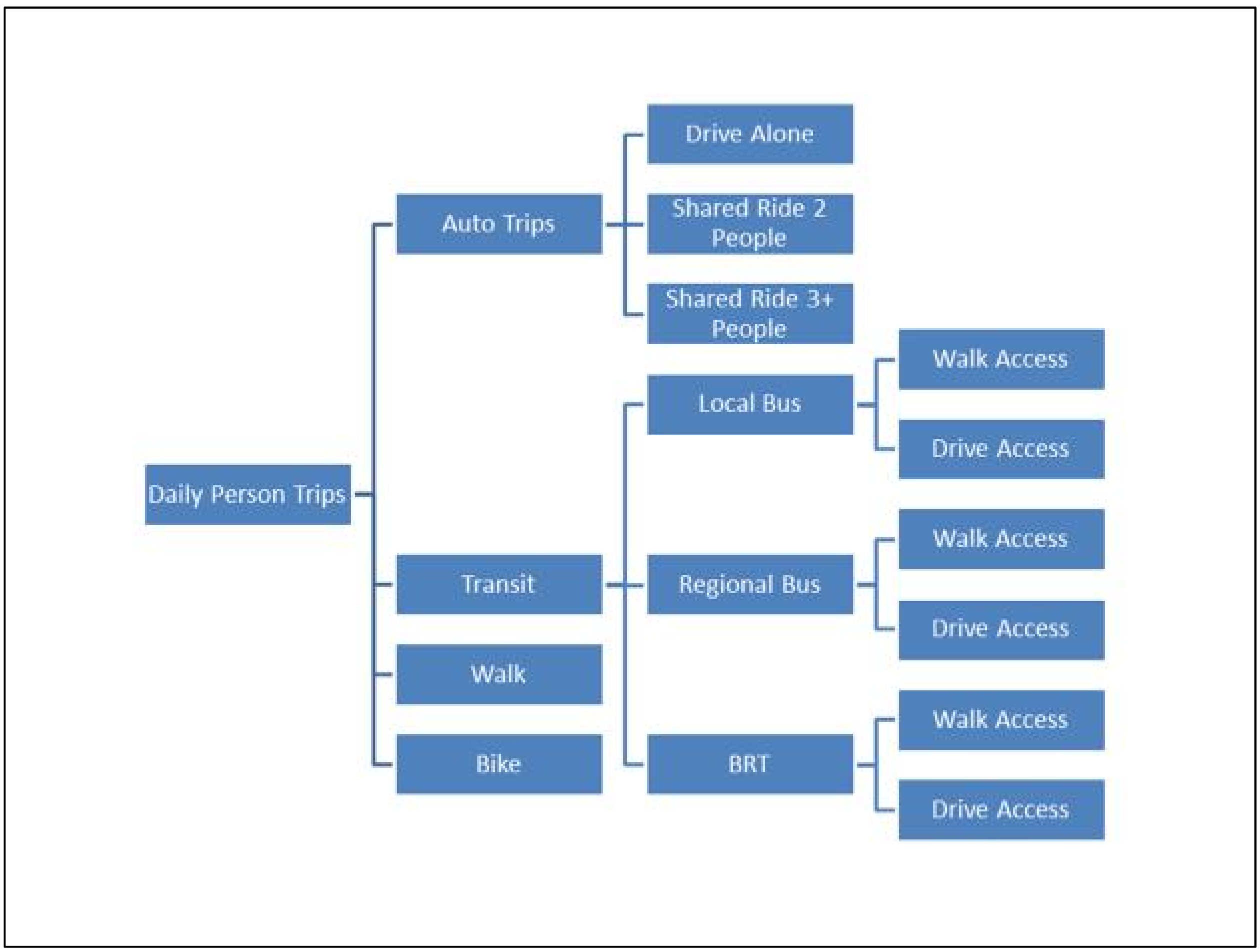
Many of the gateways to and from Fresno County only serve trips in certain parts of the county. For example, it is unlikely that trips to and from the Millerton Lake area would use Route 41 or Route 99 to cross the San Joaquin River, as Friant Road provides a more direct route to and from Madera County. Therefore, K factors are used to prohibit the trips at each gateway to travel to and from other gateways. Trips between gateways are contained in the through trip matrix.

7. MODE CHOICE

The mode choice step estimates how many of the trips between each pair of zones will use each travel mode. The Fresno COG Model includes a mode choice step which divides trips into drive alone, shared ride 2 people, shared ride 3+ people, local bus, regional bus, BRT, walk and bike (Figure 13). For the transit modes, the model further distinguishes between walk access and drive access. The mode choice analysis is accomplished in two steps:

1. The Initial Mode Choice estimates initial mode choice using average ratios of persons to vehicles from travel surveys, in order to estimate vehicle trips and congestion levels for use in the mode choice calculations.
2. The Full Mode Choice uses congested road times from the first step to assess the tradeoffs between autos and other modes.

Figure 13 Mode Choices



MODE CHOICE

The mode choice model in the prior Fresno COG Model was replaced and recalibrated as part of the 2008 base year update.

MODE CHOICE CALIBRATION DATA

The calibration of mode choice models requires data on transit ridership characteristics and automobile occupancy rates. Data sources included:

- 2000/2001 California Statewide Travel Survey
- Annual ridership by route on Fresno Area Express (FAX) transit and Clovis Transit

HOUSEHOLD TRAVEL SURVEY

The California Statewide Travel Survey was used to estimate average vehicle occupancy (Table 26) and trips by vehicle ownership and also to estimate shared ride characteristics by trip purpose.

The household survey provided information on the mode shares of trips made by households with 0 vehicles, 1 vehicle or 2+ vehicles.

TABLE 23
AVERAGE PERSON TO VEHICLE RATIOS

Trip Purpose	Average Ratio of Person Trips to Vehicle Trips
Home-Work	1.14
Home-Shop	1.45
Home-Other	2.321
Work-Other	1.10
Other-Other	1.70
TOTAL	1.74

1. Includes trips by school bus and auto passengers.
Source: 2000/2001 California Statewide Travel Survey results for Fresno County.

TABLE 23
AVERAGE PERSON TO VEHICLE RATIOS

Trip Purpose	Average Ratio of Person Trips to Vehicle Trips
Home-Work	1.14
Home-Shop	1.45
Home-Other	2.32[1]
Work-Other	1.10
Other-Other	1.70
TOTAL	1.74

1. Includes trips by school bus and auto passengers.
Source: 2000/2001 California Statewide Travel Survey results for Fresno County.

TABLE 24
TRIPS BY HOUSEHOLD VEHICLE OWNERSHIP

Travel Mode	Home-Work	Home-Shop	Home-Other	Work-Other	Other-Other	Total Trips
0 AUTO HOUSEHOLDS						
Total Trips	1,100	4,700	24,100	2,700	8,700	41,300
Auto Driver	-	-	4.7%	-	-	2.8%
Auto Passenger	42.7%	-	23.9%	10.7%	31.5%	22.5%
Transit	-	-	2.5%	17.3%	63.2%	15.9%
School Bus	-	-	6.8%	-	-	4.0%
Bicycle	-	26.5%	5.1%	-	-	6.0%
Walk	57.3%	73.5%	57.1%	71.9%	5.3%	48.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1 AUTO HOUSEHOLDS						
Total Trips	71,700	46,500	123,500	23,500	45,700	310,900
Auto Driver	72.8%	74.9%	43.7%	90.6%	51.1%	59.7%
Auto Passenger	16.3%	16.7%	33.9%	9.4%	28.9%	24.7%

TABLE 24
TRIPS BY HOUSEHOLD VEHICLE OWNERSHIP

Travel Mode	Home-Work	Home-Shop	Home-Other	Work-Other	Other-Other	Total Trips
Transit	0.8%	-	4.5%	-	6.7%	3.0%
School Bus	-	-	6.4%	-	-	2.6%
Bicycle	2.8%	1.3%	2.1%	-	-	1.7%
Walk	7.3%	7.1%	9.4%	-	13.3%	8.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
2+ AUTO HOUSEHOLDS						
Total Trips	323,300	169,800	706,300	137,100	242,500	1,579,000
Auto Driver	92.7%	70.8%	43.3%	97.6%	58.6%	63.4%
Auto Passenger	7.1%	28.0%	39.8%	0.7%	35.5%	27.8%
Transit	-	-	-	-	0.2%	-
School Bus	-	-	8.0%	-	3.4%	4.1%
Bicycle	-	-	0.2%	-	-	0.1%
Walk	0.2%	1.3%	8.8%	1.7%	2.2%	4.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
ALL HOUSEHOLDS						
Total Trips	396,100	221,000	854,000	163,300	297,000	1,931,200
Auto Driver	88.8%	70.1%	42.3%	95.0%	55.8%	61.5%
Auto Passenger	8.9%	25.0%	38.5%	2.1%	34.3%	27.2%
Transit	0.1%	-	0.7%	0.3%	3.1%	0.8%
School Bus	-	-	7.7%	-	2.8%	3.8%
Bicycle	0.5%	0.8%	0.6%	-	-	0.5%
Walk	1.6%	4.0%	10.2%	2.6%	4.0%	6.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: 2000/2001 California Statewide Travel Survey results for Fresno County.

The household survey also asked respondents to list the number of persons in their vehicle during each trip made during the survey period. This allowed an estimate of vehicle occupancy by trip purpose (Table 25). The percentages shown for school trips only account for vehicles where the driver's trip purpose was "school." There are many other trips where the driver's trip purpose was "non-work" (serving passengers was considered non-work) while their passengers' trip purpose was "school."

TABLE 25
TRIPS BY VEHICLE OCCUPANCY

Persons in Vehicle	Home-Work	Home-Shop	Home-Other	Work-Other	Other-Other	Total Trips
1	81.3%	17.6%	41.3%	56.3%		52%
2	13%	30.8%	32.3%	25.5%		26%
3+	5.7%	51.6%	26.4%	18.2%		22%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: 2000/2001 California Statewide Travel Survey results for Fresno County.

The survey data on household vehicle availability was used to calibrate the Fresno COG Model vehicle availability module (Table 26).

TABLE 26
VEHICLE AVAILABILITY

Vehicle Availability							
0		1		2		3+	
CHTS	Model	CHTS	Model	CHTS	Model	CHTS	Model
11.9%	12.0%	32.5%	29.5%	37.1%	37.7%	18.5%	20.8%

Notes: 2000-2001 California Statewide Household Travel Survey - Weekday Travel Report (June 2003).

BUS RIDERSHIP

Ridership information for the 2008 base year was estimated for each of the transit services. A total of 37,831 average weekday transit boardings are estimated for 2008 on fixed-route services (Table 27). Of those trips, 37,094 are estimated to occur on FAX and 737 are estimated to occur on Clovis Transit. The travel model does not include a choice for demand-responsive services; these trips are assumed as a fixed percentage for each trip purpose based on travel survey information.

Weekday ridership on FAX routes was available from the FAX July 2007- June 2008 fiscal year operating summary.

TABLE 27
DAILY BUS RIDERSHIP

Validation Statistic	Evaluation Criterion	Observed Ridership	Model Ridership	Percentage
Difference between actual ridership to model results for entire system	+/- 20%	37,831	41,617	10%

Notes: Observed Ridership includes Fresno Area Express (FAX) and Clovis Transit average weekday unlinked trips as reported by Fresno Area Express and the City of Clovis for the period of July 2007 - June 2008

Ridership on Clovis Transit fixed routes, which accounts for 2% of the total regional bus ridership, was available for July 2007 – June 2008.

MODE CHOICE MODEL DESCRIPTION

The Fresno County mode choice models use a multinomial logit formulation which is by far the most commonly used model form for operating mode choice models in the United States. The logit model assigns the probability of using a particular travel mode based upon an attractiveness measure ("utility") for that mode in relation to the sum of the attractiveness measures for all modes. The attractiveness measure is expressed as an exponential function of level of service (mostly travel time and cost) and other variables. The mathematical expression for the logit model is as follows:

$$\text{Probability of using Mode 1} = \frac{e^{\text{Utility (Mode 1)}}}{e^{\text{Utility (Mode 1)}} + e^{\text{Utility (Mode 2)}} + e^{\text{Utility (Mode 3)}} + \ldots}$$

Typically, the utility is calculated as a function of the attributes of each mode and each traveler group.

For example, the utility of a transit trip may be expressed as follows:

Utility(Transit) = C1 + [C2 * In-Vehicle Time] + [C3 * Wait+Walk Time]+ [C4 * Fare/Value of Time]

Where:

C1, C2, C3, C4 = Coefficients which are set during calibration

Value of Time = Dollars one would spend to save one minute of travel time (or the inverse of minutes to spend to save one dollar), generally based on the household income.

The coefficient "C1" is referred to as the constant and is used to represent factors other than travel time and cost, such as attitudes towards convenience, reliability and safety. The constant coefficient will be specific to each travel mode, while the coefficients for travel time and cost are generally held constant for all modes for a given trip purpose and population segment. In the Fresno County mode choice model calibration, most coefficients were set based on standard values, and the constants were the focus of the calibration.

MODES REPRESENTED IN THE MODEL

The mode choice model extends the definition of "mode" beyond the basic auto and transit options. In the Fresno COG Model, both 2-person and 3+-person autos are predicted separately so as to retain the capability of analyzing 2- person vs. 3-person minimum carpool occupancy policies for HOV lanes. The model also predicts "walk access" to transit separately from "drive access" to better represent the tradeoffs between access modes, and to provide a clearer analysis of passenger facility usage and requirements at transit stations for walk, feeder bus, park/ride and kiss/ride transit access options. In all, the mode choice model predicts the following seven modes:

1. Drive Alone (D1)
2. 2-Person vehicle (S2)
3. 3+-Person vehicle (S3)
4. Walk to transit (TW)
5. Drive to transit (TD)
6. Bicycle (BK)
7. Walk (WK)

This set of alternative modes permits analysis of the trade-offs that will occur with a wide range of transportation projects or policies.

SCHOOL BUS

School bus trips represent approximately 7.7 percent of Home-Other trips and 2.8 percent of Other-Other trips (some school bus trips are Other-Other if the students go to another location between school and home).

School bus trips are generally not estimated specifically in mode choice models, as they are not generally true “choice” trips and the routes cannot be easily represented in a travel model. Therefore, school bus trips are factored from total person trips prior to the mode choice step.

MODE CHOICE STRATIFICATIONS

The Fresno COG Model performs mode choice calculations separately for eight trip purposes, three household categories and two time periods:

TRIP PURPOSES

1. Home-Work
2. Home-Shop
3. Home-K12
4. Home-College
5. Home-Other
6. Work-Other
7. Other-Other
8. Highway Commercial

HOUSEHOLD CATEGORIES

1. Zero Auto Households
2. One Auto Households
3. Two-Plus Auto Households

During the mode choice, trips are segregated by auto availability and households with zero autos that do not have to drive (DA, SR2, SR3+) as an option.

TIME PERIODS

1. Peak Transit Service (3-hour A.M. and 3-hour P.M. periods)
2. Off-Peak Transit Service (All other 18 hours)

Each of the household categories has a different likelihood of using transit and therefore model constants are estimated separately for each category.

MODE CHOICE STANDARD COEFFICIENTS

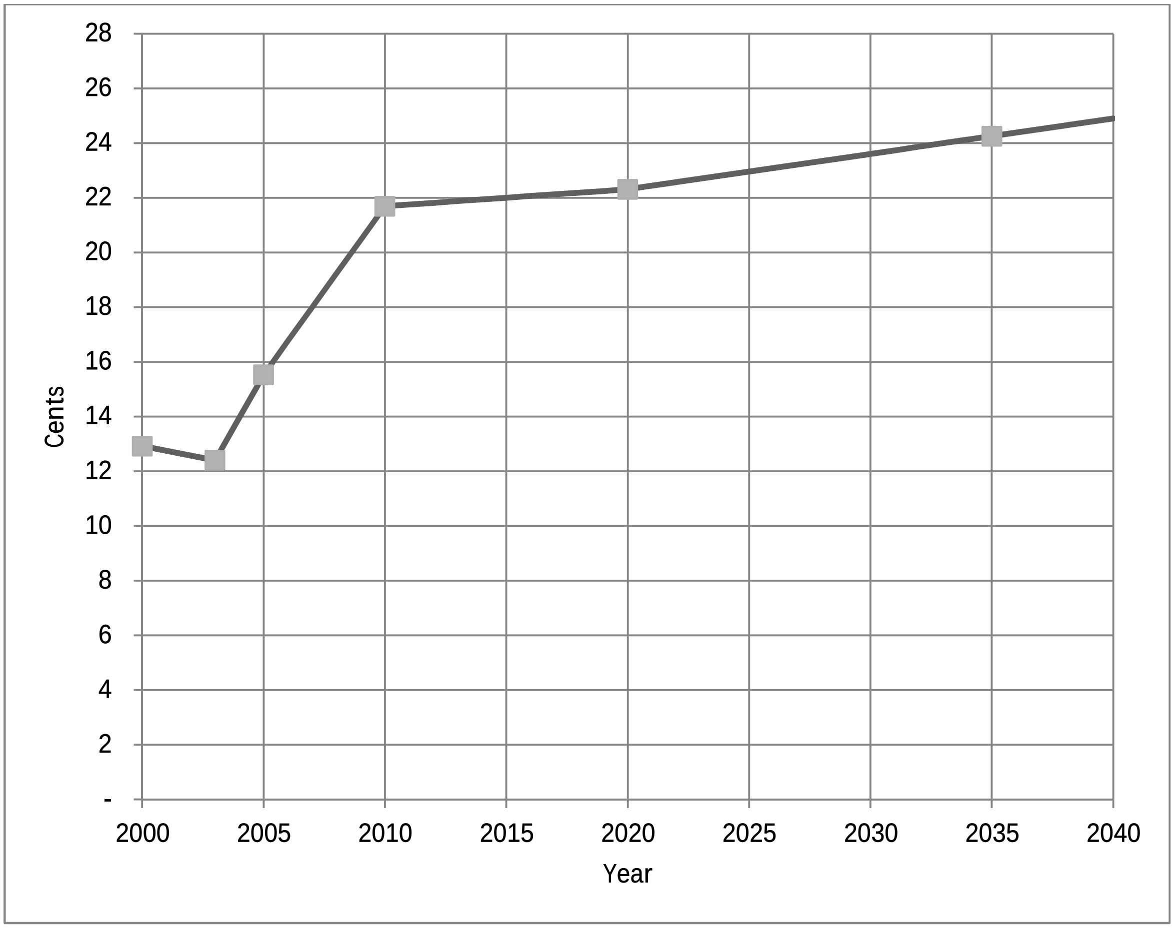
Several basic coefficients and parameters were set based on standard assumptions used in other models. The amount of data and resources required to fully estimate specific coefficients were not available for this model update. However, many of these standard coefficients have been found to not vary significantly between areas.

Coefficient on in-vehicle time (minutes)	-0.025
Coefficient on out-of-vehicle time (minutes)	-0.050 (2x in-vehicle)
Perceived auto operating cost (2000 cents)	15.52 cents per mile (2005) – 24.90 cents per mile (2040) (Figure 14)

Time penalty for shared ride pick-up/drop-off

Shared Ride 2	5 minutes
Shared Ride 3+	7 minutes

Figure 14 Auto Operating Cost by Year (2000 cents)



Source: Metropolitan Transportation Commission 2009 Regional Transportation Plan Analysis.

VALUE OF TIME

Travel costs are converted to time units using a value of time. The average perceived value of time is estimated to be six dollars per hour per person.

The time values are further adjusted from the median for vehicle ownership as follows:

0 Vehicle Household Income = 0.33 * Median for TAZ

1 Vehicle Household Income = 0.63 * Median for TAZ

2+ Vehicle Household Income = 1.17 * Median for TAZ

LOGIT MODEL CALIBRATION

The basic coefficients on time and cost were set to standard values. Therefore, calibration of the mode choice model for the 2008 Base Year update consisted of estimating the constants for each household category and mode. The goal of calibration is for the model-estimated number of trips for each mode to closely replicate "observed" trips from the ridership counts and surveys. The mode choice model was applied iteratively to adjust the various constants until the model-estimated number of trips in each stratification closely approximated the observed number of trips.

The necessary adjustment to each constant was estimated with the equation:

New Constant = Old Constant + ln(observed trips / estimated trips)

Where ln = natural log function

This equation provides an approximate value for the next iteration. Several iterations were necessary because it is only an approximation, and because all of the adjustable constants change simultaneously during the process.

The final mode choice constants are shown in Table 28. The summarized target and estimated mode choice is shown in Table 29.

TABLE 28
FINAL MODE CHOICE CONSTANTS

Purpose	Drive Alone	Shared Ride 2	Shared Ride 3+	Transit Walk	Transit Drive	Bike	Walk
0 VEHICLE HOUSEHOLDS							
Home-Work	0	-3.67	-4.91	-2.13	-3.06	-4.10	-1.56
Home-Shop	0	-0.88	-1.42	-1.80	-2.21	0.12	-0.75
Home-K12	0	-0.45	-1.95	0.51	0.43	-0.56	0.92
Home-College	0	-0.45	-1.95	0.51	0.43	-0.56	0.92
Home-Other	0	-1.69	-1.50	-3.22	0.54	-3.86	1.99
Work-Other	0	-1.48	-1.48	-4.90	-0.41	-3.01	0.24
Other-Other	0	-1.48	-1.48	-4.90	-0.41	-3.01	0.24

TABLE 28
FINAL MODE CHOICE CONSTANTS

Purpose	Drive Alone	Shared Ride 2	Shared Ride 3+	Transit Walk	Transit Drive	Bike	Walk
Highway Commercial	0	-1.48	-2.43	0.35	1.29	-1.01	2.24
1 VEHICLE HOUSEHOLDS							
Home-Work	0	-2.69	-3.26	-2.88	-3.39	-4.39	-1.61
Home-Shop	0	-0.18	-0.54	-2.30	-3.42	-1.44	-2.20
Home-K12	0	1.51	-0.03	-1.64	-2.18	-2.01	-0.06
Home-College	0	1.51	-0.03	-1.64	-2.18	-2.01	-0.06
Home-Other	0	-0.50	-0.03	-3.95	-2.54	-4.50	-0.14
Work-Other	0	-0.14	-0.71	-7.63	-4.76	-4.82	-0.94
Other-Other	0	-0.14	-0.71	-7.63	-4.76	-4.82	-0.94
Highway Commercial	0	-0.14	-1.71	-5.08	-4.76	-3.82	-0.94
2+ VEHICLE HOUSEHOLDS							
Home-Work	0	-2.39	-2.69	-5.25	-7.00	-6.85	-5.16
Home-Shop	0	0.02	-0.15	-4.45	-4.50	-1.50	-4.38
Home-K12	0	1.44	0.64	-1.32	-1.92	-2.82	0.13
Home-College	0	1.44	0.64	-1.32	-1.92	-2.82	0.13
Home-Other	0	0.01	0.45	-4.57	-3.39	-5.48	-0.40
Work-Other	0	-0.74	-0.18	-7.77	-4.82	-6.62	-1.26
Other-Other	0	-0.74	-0.18	-7.77	-4.82	-6.62	-1.26
Highway Commercial	0	0.26	-1.18	-4.80	-4.82	-5.62	-4.37

TABLE 29
MODE CHOICE

	CHTS	Model
Drive Alone	41.7%	38.3%
Shared Ride 2	26.5%	27.3%
Shared Ride 3+	24.3%	26.1%
Transit	1.1%	1.6%
Walk	5.8%	5.0%
Bike	0.6%	1.7%
Total	100.0%	100.0%

Notes: 2000-2001 California Statewide Household Travel Survey. Includes only internal-to-internal, weekday person trips for all modes, weighted by weekday, trip-level weights ("WDWGT"). Transit excludes school bus trips.

8. PEAKING FACTORS

The Fresno COG model has been set up to estimate travel demand during six periods:

- AM peak three-hour period
- PM peak three-hour period
- Off-peak eleven hours
- AM peak hour
- PM peak hour
- Mid-Day seven hours

The traffic volumes projected for the three-hour peak periods, mid-day seven hours, off-peak eleven hours, and remaining hours are added together to create daily traffic projections.

The traffic volumes operating under peak and off-peak speed conditions are identified separately, as route choices between certain origins and destinations may be different in peak and off-peak conditions. The three-hour peak periods were selected to ensure that the model will estimate separate traffic volumes for peak period congested speeds and for off-peak uncongested speeds for future conditions as well as for existing conditions. Currently, peak congested traffic conditions only last for one to two hours in Fresno County. With long-range land use growth, it is possible that congestion would last over two hours during each peak period, as in other urban areas in California. Therefore, three-hour peak periods are used to ensure that the model will identify all of the traffic volumes traveling under congested conditions for future forecasts.

The Fresno COG Model also projects A.M. and P.M. peak hour traffic volumes. Peak one-hour volumes are often required for capacity analysis and local traffic studies.

VEHICLE TIME OF DAY FACTORS

The trips for each time period are calculated by factoring the daily vehicle trips after the trip distribution step and conversion from person trips to vehicle trips. The daily vehicle trips are factored separately for each trip purpose and by departures/returns (Table 30). The percentages are set so that the total percentages for each hour add up to 100 percent between departures and returns.

The time-of-day factors are based on information from the 2000/2001 California Statewide Travel Survey. During model validation, the factors were adjusted from the survey results to better match observed traffic counts.

TABLE 30
VEHICLE TRIP TIME OF DAY FACTORS

Hour of Day	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other	Highway Commercial	Trucks -Small	Trucks -Medium	Trucks -Heavy
Departures											
12am-1am	7%	4%	0%	0%	4%	0%	0%	0%	1%	1%	1%
1am-2am	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
2am-3am	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
3am-4am	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
4am-5am	6%	0%	-2%	-2%	-1%	0%	0%	0%	0%	0%	1%
5am-6am	10%	0%	0%	0%	1%	0%	0%	0%	1%	1%	1%
6am-7am	8%	1%	0%	0%	1%	0%	0%	0%	3%	3%	3%
7am-8am	4%	5%	24%	24%	10%	1%	2%	2%	4%	5%	4%
8am-9am	1%	2%	4%	4%	3%	1%	1%	2%	3%	3%	3%
9am-10am	1%	6%	5%	5%	3%	6%	2%	5%	2%	3%	2%
10am-11am	4%	5%	5%	5%	5%	6%	3%	4%	4%	5%	5%
11am-12pm	2%	4%	2%	2%	3%	6%	5%	4%	2%	3%	2%
12pm-1pm	1%	3%	5%	5%	1%	9%	3%	3%	2%	3%	2%

TABLE 30
VEHICLE TRIP TIME OF DAY FACTORS

Hour of Day	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other	Highway Commercial	Trucks -Small	Trucks - Medium	Trucks - Heavy
1pm-2pm	2%	2%	4%	4%	3%	4%	6%	2%	2%	3%	2%
2pm-3pm	1%	3%	0%	0%	3%	5%	4%	3%	2%	3%	2%
3pm-4pm	1%	2%	0%	0%	3%	7%	4%	2%	2%	3%	2%
4pm-5pm	1%	3%	3%	3%	3%	6%	3%	5%	5%	4%	4%
5pm-6pm	1%	3%	3%	3%	3%	6%	3%	5%	5%	4%	4%
6pm-7pm	1%	3%	3%	3%	3%	6%	3%	5%	5%	4%	4%
7pm-8pm	0%	2%	0%	0%	1%	1%	1%	4%	1%	1%	1%
8pm-9pm	0%	1%	3%	3%	2%	0%	0%	1%	1%	1%	1%
9pm-10pm	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	1%
10pm-11pm	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	1%
11pm-12am	0%	0%	0%	0%	2%	0%	0%	0%	1%	1%	1%
Returns											
12am-1am	10%	3%	0%	0%	3%	0%	0%	0%	1%	1%	1%
1am-2am	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
2am-3am	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
3am-4am	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%

TABLE 30
VEHICLE TRIP TIME OF DAY FACTORS

Hour of Day	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other	Highway Commercial	Trucks -Small	Trucks - Medium	Trucks - Heavy
4am-5am	0%	0%	0%	0%	0%	-1%	-1%	0%	0%	0%	1%
5am-6am	0%	6%	0%	0%	0%	1%	0%	0%	1%	1%	1%
6am-7am	0%	0%	0%	0%	0%	0%	0%	0%	3%	3%	3%
7am-8am	0%	3%	0%	0%	4%	10%	8%	0%	4%	5%	4%
8am-9am	0%	1%	0%	0%	3%	3%	1%	1%	3%	3%	3%
9am-10am	0%	2%	0%	0%	1%	3%	1%	2%	2%	3%	2%
10am-11am	1%	2%	2%	2%	2%	5%	4%	2%	4%	5%	5%
11am-12pm	1%	2%	6%	6%	3%	2%	4%	2%	2%	3%	2%
12pm-1pm	1%	4%	4%	4%	3%	5%	7%	5%	2%	3%	2%
1pm-2pm	1%	3%	7%	7%	2%	3%	5%	3%	2%	3%	2%
2pm-3pm	3%	3%	6%	6%	4%	3%	8%	4%	2%	3%	2%
3pm-4pm	7%	5%	8%	8%	5%	2%	7%	5%	2%	3%	2%
4pm-5pm	7%	5%	2%	2%	3%	0%	5%	5%	5%	4%	4%
5pm-6pm	7%	4%	2%	2%	5%	1%	4%	8%	5%	4%	4%
6pm-7pm	3%	3%	2%	2%	3%	0%	3%	5%	5%	4%	4%
7pm-8pm	2%	3%	2%	2%	1%	0%	2%	5%	1%	1%	1%

TABLE 30
VEHICLE TRIP TIME OF DAY FACTORS

Hour of Day	Home-Work	Home-Shop	Home-K12	Home-College	Home-Other	Work-Other	Other-Other	Highway Commercial	Trucks -Small	Trucks - Medium	Trucks - Heavy
8pm-9pm	1%	1%	0%	0%	3%	1%	0%	2%	1%	1%	1%
9pm-10pm	1%	1%	1%	1%	2%	0%	1%	2%	1%	1%	1%
10pm-11pm	1%	0%	0%	0%	1%	0%	0%	0%	1%	1%	1%
11pm-12am	1%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%

Notes: The same time of day factors were assumed for all modes.

EXTERNAL PEAK FACTOR ADJUSTMENTS

In prior versions of the Fresno COG Model, additional adjustment factors were applied for peak period volumes at each of the model gateways. The 2008 base year model does not use additional adjustments to the peak factors for external trips.

TRANSIT TIME OF DAY FACTORS

Transit trips are split into peak period and off-peak trips so that peak trips can be assigned to peak period transit services. The time of day factors are similar to the vehicle factors (Table 20).

9. TRIP ASSIGNMENT

In this step, zone-to-zone trips from the trip distribution step are assigned to the network.

TRAFFIC ASSIGNMENT

The Fresno COG Model uses a process known as “equilibrium” assignment to assign vehicles. Vehicle trips are initially assigned to the road network using the all-or-nothing method, which assumes that all drivers will use the fastest route without regard to congestion caused by other vehicles. Travel times on the road network are recalculated based on the estimated level of congestion, and trips are reassigned to paths based on the congested speeds. The process is repeated for several iterations. After each iteration, some traffic is shifted to alternative routes with competitive travel times.

The equilibrium assignment method is intended to ultimately assign traffic so that no driver can shift to an alternative route with a faster travel time. The overall road system is considered to be at equilibrium at this point.

The Fresno COG Model is currently set for a maximum of 20 iterations for peak and off-peak period traffic assignments and 50 iterations for peak hour traffic assignments.

CONGESTED TRAVEL SPEEDS

The relationship of speed to congestion on a particular roadway is based on a set of speed-flow curves that are included in the traffic assignment model. For example, the curves may indicate that an arterial street with no congestion will operate at 35 miles per hour, while an arterial link with a traffic volume equal to 90 percent of the capacity of the link will operate at about 28 miles per hour.

The curves are based on the Bureau of Public Roads (BPR) formula. The Fresno COG Model uses the BPR formula for all roads, with the coefficients shown in Table 5. Zone connectors are not actual streets and are not assumed to slow down during the assignment process.

FACTORS

The Fresno COG Model assumes the following vehicle occupancy factors for shared-ride 3+ trips:

- Home-Work: 4.35
- Home-Shopping: 3.65
- Home-K12: 4.35
- Home-College: 4.35
- Home-Other: 3.42
- Work-Other: 3.16
- Other-Other: 3.37

The Fresno Cog Model assumes the following passenger car equivalency factors for trucks:

- Small truck: 1
- Medium truck: 1.5
- Heavy truck: 2

TRANSIT ASSIGNMENT

Daily transit trips are assigned to the transit network. Transit trips are assigned to the single best path based on in-vehicle time plus weighted out-of- vehicle times. The transit trips are assigned in four groups:

1. Peak period (A.M. plus P.M.), walk access
2. Peak period (A.M. plus P.M.), drive access
3. Off-peak, walk access
4. Off-peak, drive access

The peak period transit trips represent trips occurring during the A.M. three- hour peak period plus the P.M. three hour peak period. Peak period transit trips are assigned to the peak transit service (peak period headways) with travel times based on the congested speeds from the A.M. peak period traffic assignment. Off-peak transit trips represent trips during the remaining 18 hours and are assigned to the off-peak transit service (off-peak headways) with travel times based on the congested road speeds from the off-peak traffic assignment.

Transit trips are all assigned as production to attraction rather than origin to destination. For example, a person who uses transit for work will be assigned as two trips from the home TAZ to the work TAZ rather than one trip in each direction. This is done so that the model can keep track of which end of the trip can use drive access. In order to convert to actual directional boardings, the assigned transit trips in each direction must be added together and then divided by two.

The transit vehicle times and drive access times are affected by congestion on the road network.

10. FEEDBACK MECHANISMS

The Fresno COG Model includes a feedback loop that uses congested travel times as an input to the trip distribution step. The feedback loop is intended to ensure that the congested travel impedances (times) used for final traffic assignment and as input to the air quality analysis are consistent with the travel impedances used throughout the model process.

For the Fresno COG Model, the feedback loop is considered to converge when the travel times that result from the congested travel speeds after traffic assignment compare closely with the travel times used as input to the trip distribution process.

In an effort to meet all Transportation Conformity Rule modeling requirements, a full feedback loop process was implemented as of 2001 that iterates until it reaches a set of convergence criteria. The convergence criteria are consistent with Transportation Conformity Rule Section 93.12 (b)(1)(v).

CONGESTED SKIMS

The initial trip distributions for all trip purposes are calculated using uncongested (free-flow) travel times on the road network. After the initial trip distribution and assignment, the congested travel times calculated from the most recent A.M. peak three-hour period traffic assignment are used as input to the Home-Work trip distribution and the congested travel times from the most recent off-peak 18-hour traffic assignment are used for the other four trip purposes. These feedback loops undergo five iterations.

11. MODEL VALIDATION

Model calibration takes place at each step in the model process and involves initial specification and then refinement of the various parameters and coefficients by comparing model results to observed conditions. Where applicable, calibration of the individual model steps is described in the preceding chapters. The 2008 base Year Fresno COG Model is primarily calibrated to 2000 United States Census data and 2000/2001 Caltrans Statewide Travel Survey data.

Model validation refers to comparing the model outputs (traffic volumes) to observed conditions (traffic counts). During validation, adjustments are primarily made to model inputs, such as the road network and base year land uses, rather than calibrated parameters such as trip generation rates or peak factors. Once validated, the model can be used to predict future travel patterns with a high degree of confidence.

The Fresno COG Model was validated to 2008 traffic data to conform to the base year land use data. The majority of the traffic count database is from 2008. However, traffic counts from 2007 through 2010 were used, adjusted to 2008 levels based on annual growth rates.

TRAFFIC DATA

Traffic data for validation were obtained from the Fresno COG traffic count database and Caltrans.

LOCAL TRAFFIC COUNTS

The Council of Fresno County Governments maintains a database of local traffic counts for roads within the cities and Fresno County. Daily directional traffic counts from the database were coded to the appropriate road network links by Fresno COG staff.

CALTRANS TRAFFIC COUNTS

Caltrans makes traffic count information available through their internet web site, Traffic Data Branch page. The 2008 two-way total daily and one-way peak hour traffic volumes are posted for each segment of the state highway system. Daily traffic counts are also publicly available for each freeway ramp. More detailed daily and hourly traffic counts from permanent count station locations are available through the Caltrans Performance Measurement System (PeMS).

CALTRANS HPMS

Caltrans prepares estimates of vehicle miles of travel (VMT) for all roads in each California County for the Highway Performance Monitoring System (HPMS). The VMT estimates are based on a traffic counting program on a sample of roads throughout the state. Local jurisdictions provide Caltrans with updates on the number of lane-miles of road within each classification type. Caltrans statistically extrapolates the traffic counts to provide estimates of total traffic volume on all lane-miles of each functional classification, and VMT.

TRAFFIC VALIDATION

The Fresno COG Model traffic validation is based on several criteria, including vehicle-miles of travel, total volume by road type, screenlines, gateways and percent of links within acceptable limits.

VEHICLE MILES OF TRAVEL

Vehicle miles of travel (VMT) were estimated from the travel demand model by multiplying link volumes by link distances. The model estimates intrazonal trips (trips remaining within a TAZ) but does not assign these trips to the model road network. The intrazonal trips were multiplied by the estimated intrazonal distances to calculate intrazonal VMT.

The Caltrans HPMS 2008 estimate of VMT in Fresno County was 22,376,000. The 2008 model base year estimated 22,077,974 VMT on the roadway links and 71,001 in intrazonal VMT for a total of 22,148,975 VMT. The 2008 model estimate is 1% lower than the Caltrans 2008 HPMS VMT target.

OVERALL ROADWAY VALIDATION

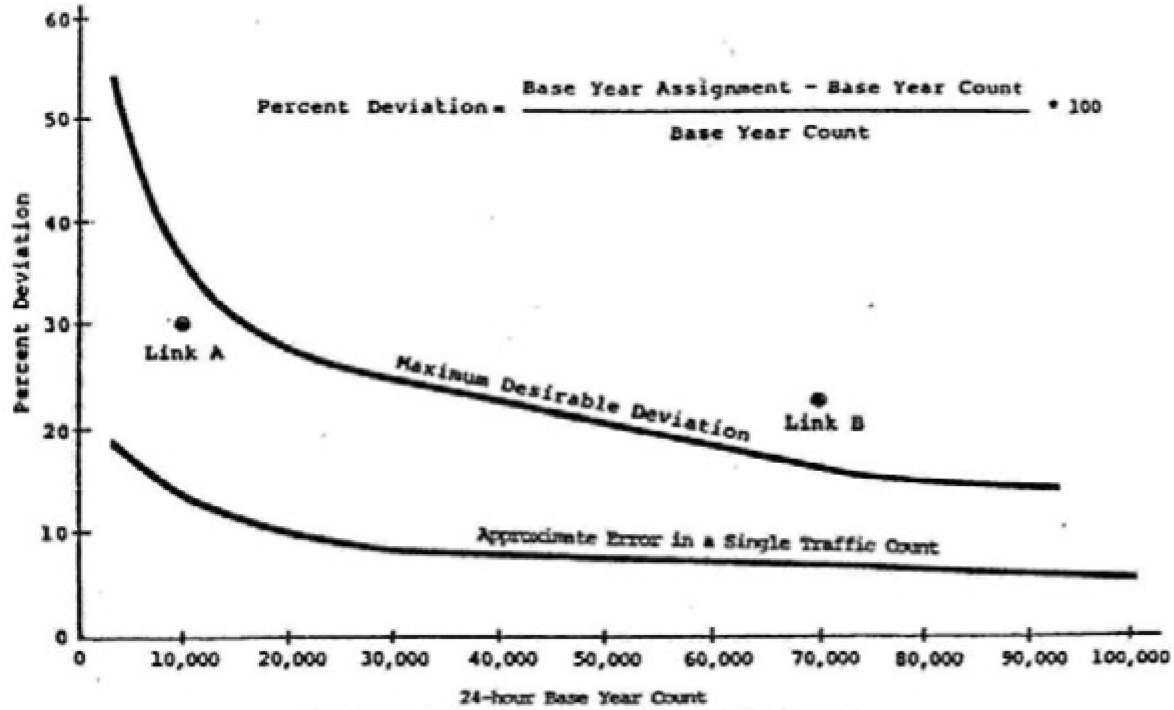
TABLE 31
TWO-WAY OVERALL ROADWAY VALIDATION

	Criteria	Daily	AM Peak Period	PM Peak Period	Midday Peak Period	Off Peak Period	AM Peak Hour	PM Peak Hour
Model/Count Ratio	1.00 ± 0.1	0.99	1.06	0.95	0.94	1.11	0.90	0.93
Percent of Links Within Caltrans Maximum Deviation	>75%	60%	63%	63%	54%	56%	58%	59%
Percent Root Mean Square Error	<40%	36%	42%	35%	38%	66%	44%	38%
Correlation Coefficient	>88%	91%	88%	89%	88%	81%	83%	88%
Percent of Screenlines Within Caltrans Maximum Deviation	100%	80%	70%	70%	70%	60%	90%	70%

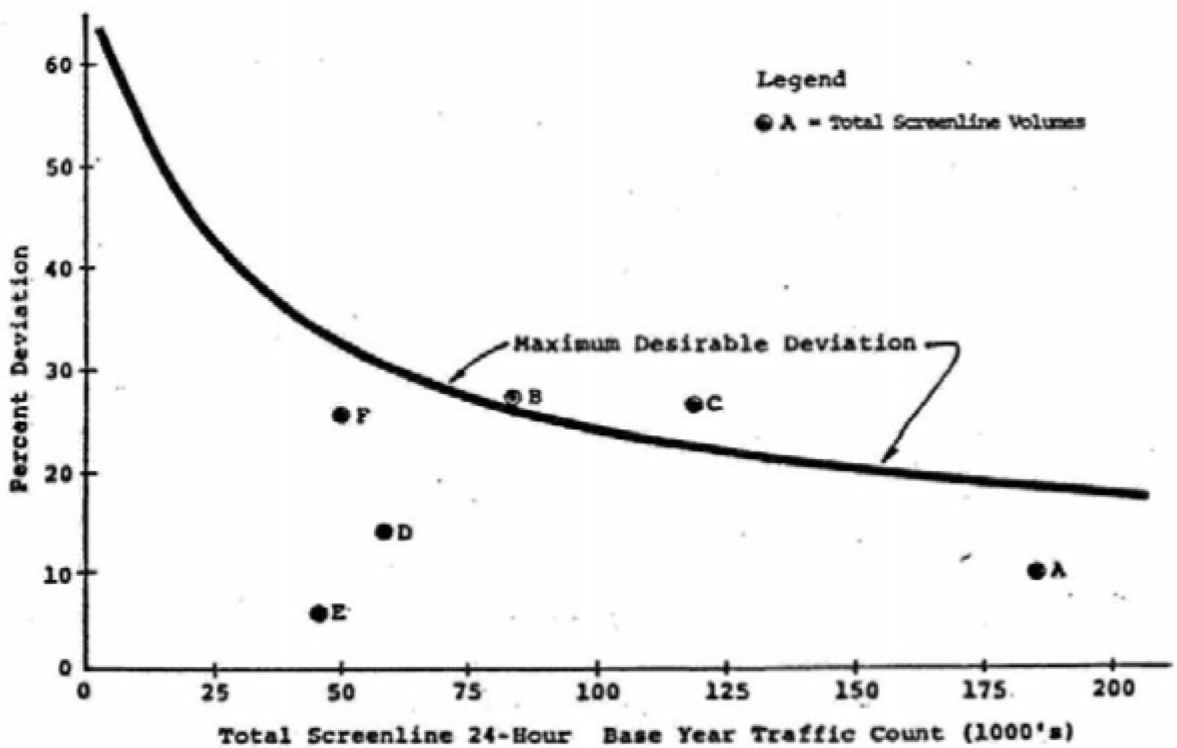
The overall (two-way) roadway validation results are shown in Table 31. The model/count ratio criteria are met for all time periods, except for the off peak period which exceeds the criteria by 0.01. Although all the other criteria are not all met for every time period, they are within the allowable error considering the household survey data from 2001 and the count data from 2007 to 2010. Future model calibration and validation using a consistent data set is recommended. The other criteria include percent of links and screenlines within the Caltrans Maximum Deviation. The Caltrans travel forecasting guidelines include a figure showing the maximum desirable deviation for links and screenlines between daily model volumes and traffic counts, where the acceptable deviation is inversely related to the traffic count (Figure 15).

The Caltrans guidelines were used as a baseline to derive similar guidelines for non-daily analysis periods (Table 32). The percent root mean square error (RMSE) provides a measure of accuracy based on the statistical standard error. The RMSE puts a greater emphasis on larger errors (plus or minus) that may cancel each other out in the total validation by road type. The correlation coefficient measures the magnitude of the relationship between the model volumes and traffic counts.

Figure 15 Maximum Desirable Daily Error for Links and Screenlines



Maximum Desirable Error for Link Volumes



Maximum Desirable Deviation in Total Screenline Volumes

TABLE 32
MAXIMUM DESIRABLE ERROR FOR LINKS AND SCREENLINES BY TIME OF DAY

Percent Deviation	Time of Count					
	Daily	AM Peak Period	PM Peak Period	Midday Peak Period	Off-Peak Period	Peak Hour
Links						
68%	1	1	1	1	1	1
63%	1,250	313	375	438	375	125
58%	2,500	625	750	875	750	250
52%	3,750	938	1,125	1,313	1,125	375
48%	5,000	1,250	1,500	1,750	1,500	500
44%	6,250	1,563	1,875	2,188	1,875	625
41%	7,500	1,875	2,250	2,625	2,250	750
38%	8,750	2,188	2,625	3,063	2,625	875
36%	10,000	2,500	3,000	3,500	3,000	1,000
34%	11,250	2,813	3,375	3,938	3,375	1,125
33%	12,500	3,125	3,750	4,375	3,750	1,250
31%	13,750	3,438	4,125	4,813	4,125	1,375
30%	15,000	3,750	4,500	5,250	4,500	1,500
29%	16,250	4,063	4,875	5,688	4,875	1,625
29%	17,500	4,375	5,250	6,125	5,250	1,750
28%	18,750	4,688	5,625	6,563	5,625	1,875
28%	20,000	5,000	6,000	7,000	6,000	2,000
27%	21,250	5,313	6,375	7,438	6,375	2,125
27%	22,500	5,625	6,750	7,875	6,750	2,250
26%	23,750	5,938	7,125	8,313	7,125	2,375
26%	25,000	6,250	7,500	8,750	7,500	2,500
25%	26,250	6,563	7,875	9,188	7,875	2,625
25%	27,500	6,875	8,250	9,625	8,250	2,750
24%	28,750	7,188	8,625	10,063	8,625	2,875

TABLE 32
MAXIMUM DESIRABLE ERROR FOR LINKS AND SCREENLINES BY TIME OF DAY

Percent Deviation	Time of Count					
	Daily	AM Peak Period	PM Peak Period	Midday Peak Period	Off-Peak Period	Peak Hour
24%	30,000	7,500	9,000	10,500	9,000	3,000
24%	32,500	8,125	9,750	11,375	9,750	3,250
23%	35,000	8,750	10,500	12,250	10,500	3,500
22%	37,500	9,375	11,250	13,125	11,250	3,750
22%	40,000	10,000	12,000	14,000	12,000	4,000
21%	42,500	10,625	12,750	14,875	12,750	4,250
21%	45,000	11,250	13,500	15,750	13,500	4,500
20%	47,500	11,875	14,250	16,625	14,250	4,750
20%	50,000	12,500	15,000	17,500	15,000	5,000
20%	52,500	13,125	15,750	18,375	15,750	5,250
19%	55,000	13,750	16,500	19,250	16,500	5,500
19%	57,500	14,375	17,250	20,125	17,250	5,750
18%	60,000	15,000	18,000	21,000	18,000	6,000
18%	62,500	15,625	18,750	21,875	18,750	6,250
17%	65,000	16,250	19,500	22,750	19,500	6,500
17%	67,500	16,875	20,250	23,625	20,250	6,750
16%	70,000	17,500	21,000	24,500	21,000	7,000
16%	72,500	18,125	21,750	25,375	21,750	7,250
15%	75,000	18,750	22,500	26,250	22,500	7,500
15%	77,500	19,375	23,250	27,125	23,250	7,750
15%	80,000	20,000	24,000	28,000	24,000	8,000
14%	82,500	20,625	24,750	28,875	24,750	8,250
14%	85,000	21,250	25,500	29,750	25,500	8,500
14%	87,500	21,875	26,250	30,625	26,250	8,750
14%	90,000	22,500	27,000	31,500	27,000	9,000

TABLE 32
MAXIMUM DESIRABLE ERROR FOR LINKS AND SCREENLINES BY TIME OF DAY

Percent Deviation	Time of Count					
	Daily	AM Peak Period	PM Peak Period	Midday Peak Period	Off-Peak Period	Peak Hour
14%	92,500	23,125	27,750	32,375	27,750	9,250
14%	95,000	23,750	28,500	33,250	28,500	9,500
14%	97,500	24,375	29,250	34,125	29,250	9,750
14%	100,000	25,000	30,000	35,000	30,000	10,000
Screenlines						
64%	1	1	1	1	1	1
63%	3,000	750	900	1,050	900	300
62%	4,000	1,000	1,200	1,400	1,200	400
61%	5,000	1,250	1,500	1,750	1,500	500
60%	6,000	1,500	1,800	2,100	1,800	600
59%	7,000	1,750	2,100	2,450	2,100	700
58%	8,000	2,000	2,400	2,800	2,400	800
57%	9,000	2,250	2,700	3,150	2,700	900
56%	10,000	2,500	3,000	3,500	3,000	1,000
55%	11,000	2,750	3,300	3,850	3,300	1,100
54%	12,000	3,000	3,600	4,200	3,600	1,200
53%	13,000	3,250	3,900	4,550	3,900	1,300
52%	14,000	3,500	4,200	4,900	4,200	1,400
51%	15,000	3,750	4,500	5,250	4,500	1,500
50%	15,625	3,906	4,688	5,469	4,688	1,563
49%	16,250	4,063	4,875	5,688	4,875	1,625
48%	17,500	4,375	5,250	6,125	5,250	1,750
47%	18,750	4,688	5,625	6,563	5,625	1,875
46%	20,000	5,000	6,000	7,000	6,000	2,000
45%	21,250	5,313	6,375	7,438	6,375	2,125

TABLE 32
MAXIMUM DESIRABLE ERROR FOR LINKS AND SCREENLINES BY TIME OF DAY

Percent Deviation	Time of Count					
	Daily	AM Peak Period	PM Peak Period	Midday Peak Period	Off-Peak Period	Peak Hour
44%	22,500	5,625	6,750	7,875	6,750	2,250
43%	23,750	5,938	7,125	8,313	7,125	2,375
42%	25,000	6,250	7,500	8,750	7,500	2,500
41%	27,500	6,875	8,250	9,625	8,250	2,750
40%	30,000	7,500	9,000	10,500	9,000	3,000
39%	32,500	8,125	9,750	11,375	9,750	3,250
38%	35,000	8,750	10,500	12,250	10,500	3,500
37%	37,500	9,375	11,250	13,125	11,250	3,750
36%	40,000	10,000	12,000	14,000	12,000	4,000
35%	42,500	10,625	12,750	14,875	12,750	4,250
34%	45,000	11,250	13,500	15,750	13,500	4,500
33%	47,500	11,875	14,250	16,625	14,250	4,750
32%	50,000	12,500	15,000	17,500	15,000	5,000
31%	55,000	13,750	16,500	19,250	16,500	5,500
30%	60,000	15,000	18,000	21,000	18,000	6,000
29%	65,000	16,250	19,500	22,750	19,500	6,500
28%	70,000	17,500	21,000	24,500	21,000	7,000
27%	75,000	18,750	22,500	26,250	22,500	7,500
26%	80,000	20,000	24,000	28,000	24,000	8,000
25%	90,000	22,500	27,000	31,500	27,000	9,000
24%	95,000	23,750	28,500	33,250	28,500	9,500
23%	110,000	27,500	33,000	38,500	33,000	11,000
22%	120,000	30,000	36,000	42,000	36,000	12,000
21%	135,000	33,750	40,500	47,250	40,500	13,500
20%	160,000	40,000	48,000	56,000	48,000	16,000

TABLE 32
MAXIMUM DESIRABLE ERROR FOR LINKS AND SCREENLINES BY TIME OF DAY

Percent Deviation	Time of Count					
	Daily	AM Peak Period	PM Peak Period	Midday Peak Period	Off-Peak Period	Peak Hour
19%	180,000	45,000	54,000	63,000	54,000	18,000
18%	195,000	48,750	58,500	68,250	58,500	19,500
17%	205,000	51,250	61,500	71,750	61,500	20,500

ROAD TYPE VALIDATION

The Federal Highway Administration[1] and Caltrans[2] recommend error limits for total error by functional classification (type of road). Results are evaluated for daily traffic, A.M. and P.M. peak three-hour periods, and A.M. and P.M. peak hours.

Calibration for speed and capacity by functional type, and a consistent count set is recommended for future model updates.

DAILY VOLUMES

The Fresno COG Model daily validation meets all of the FHWA targets for total volume by road type (Table 33). The daily validation also generally meets all targets for RMSE, except for on freeways. Consequently, the overall RMSE slightly exceeds the target.

TABLE 33
DAILY VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Freeway	1,210,764	1,263,585	4%	+/- 7%	25.6%	25.6%	15%
Highway	653,527	648,906	-1%	+/- 10%	38.5%	38.5%	40%
Expressway	887,317	994,077	12%	+/- 15%	29.6%	29.6%	40%

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[1] Federal Highway Administration, *Calibration and Adjustment of System Planning Models,* 1990.
[2] California Department of Transportation, *Travel Forecasting Guidelines*, 1992.

TABLE 33
DAILY VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Arterial	4,414,422	4,377,231	-1%	+/- 15%	36.4%	36.2%	40%
Collector	1,105,776	969,523	-12%	+/- 25%	50.2%	48.7%	50%
Freeway Ramp	4,578	5,394	N/A	+/- 25%	N/A	N/A	50%
TOTAL	8,611,599	8,564,481	-1%	+/- 5%	39.3%	38.5%	35%

PEAK PERIOD VALIDATION

The Fresno COG Model A.M. peak three-hour and P.M. peak three-hour validation is shown in Table 34 and Table 35. Both peak periods meet every FHWA target for volume by road type and total volume.

TABLE 34
A.M. PEAK THREE HOUR PERIOD VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Freeway	233,260	231,315	-1%	+/- 7%	29.9%	29.9%	15%
Highway	119,395	122,422	3%	+/- 10%	46.7%	46.7%	40%
Expressway	156,433	176,723	13%	+/- 15%	42.6%	42.6%	40%
Arterial	709,162	766,691	8%	+/- 15%	45.6%	45.1%	40%
Collector	185,723	167,637	-10%	+/- 25%	61.1%	59.4%	50%
Freeway Ramp	875	752	N/A	+/- 25%	N/A	N/A	50%
TOTAL	1,406,904	1,466,995	4%	+/- 5%	50.0%	49.3%	35%

TABLE 35
P.M. PEAK THREE HOUR PERIOD VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Freeway	266,624	267,246	0%	+/- 7%	23.2%	23.2%	15%
Highway	143,635	138,773	-3%	+/- 10%	42.1%	42.1%	40%
Expressway	194,526	203,018	4%	+/- 15%	26.5%	26.5%	40%
Arterial	988,490	926,402	-6%	+/- 15%	36.1%	35.8%	40%
Collector	242,869	223,464	-8%	+/- 25%	54.7%	51.9%	50%
Freeway Ramp	961	1,112	N/A	+/- 25%	N/A	N/A	50%
TOTAL	1,839,630	1,761,946	-4%	+/- 5%	38.6%	37.9%	35%

PEAK HOUR VALIDATION

The Fresno COG Model A.M. peak one hour and P.M. peak one hour validation is shown in Table 36 and Table 37. For the AM peak hour the expressway and arterial road types meet the FHWA target, and the total volume across all road types meets the FHWA target. For the PM peak hour the freeway, expressway, arterial, and collector road types meet the target, and the total volume across all road types meets the target.

TABLE 36
A.M. PEAK ONE HOUR PERIOD VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Freeway	92,165	111,681	21%	+/- 7%	63.4%	63.4%	15%
Highway	41,420	58,912	42%	+/- 10%	83.2%	83.2%	40%
Expressway	66,962	61,249	-9%	+/- 15%	44.9%	44.9%	40%
Arterial	307,301	274,577	-11%	+/- 15%	47.5%	46.8%	40%

TABLE 36
A.M. PEAK ONE HOUR PERIOD VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Collector	83,964	59,405	-29%	+/- 25%	65.6%	62.8%	50%
Freeway Ramp	362	212	N/A	+/- 25%	N/A	N/A	50%
TOTAL	593,065	567,289	-4%	+/- 5%	71.9%	70.4%	35%

TABLE 37
P.M. PEAK ONE HOUR PERIOD VALIDATION BY ROAD TYPE

Road Type	Traffic Volumes				Root Mean Square Error (RMSE)		
	Traffic Count	Counted Links Model Volume	Percent Difference	Target	Model (All)	Model (Count >1000)	Target
Freeway	92,943	98,204	6%	+/- 7%	28.9%	28.9%	15%
Highway	44,756	50,897	14%	+/- 10%	49.0%	49.0%	40%
Expressway	74,077	75,606	2%	+/- 15%	27.2%	27.2%	40%
Arterial	370,446	336,027	-9%	+/- 15%	39.2%	38.7%	40%
Collector	92,620	79,942	-14%	+/- 25%	59.0%	54.8%	50%
Freeway Ramp	331	528	N/A	+/- 25%	N/A	N/A	50%
TOTAL	676,106	641,963	-5%	+/- 5%	43.1%	41.9%	35%

SCREENLINES

Screenlines are imaginary lines, often along natural or man-made physical barriers (e.g., rivers, railroad tracks) that have a limited number of crossings. The screenlines "cut" the entire study area, intercepting all travel across them, thereby eliminating issues about individual route choice. Use of a system of screenlines allows systematic comparison of model estimated versus observed travel in different parts of the model area.

The Fresno COG Model has 20 screenlines, including several north-south and east-west cut-lines. The maximum desirable deviation for screenline volumes between model volumes and traffic counts is shown in Figure 15. These targets vary by total volume, with smaller deviations allowed for higher volume screenlines. The model is estimating daily volumes within these targets for 80% of analyzed screenlines (Table 38).

TABLE 38
DAILY SCREENLINE VALIDATION

Screenline	Model (2-Way)	Count (2-Way)	Model Deviation	Max Deviation	Within Deviation?
3	4,632	6,588	30%	60%	Yes
4	10,476	6,635	58%	60%	Yes
6	78,968	40,404	95%	36%	No
7	29,959	25,215	19%	42%	Yes
8	35,671	28,087	27%	41%	Yes
9	75,266	67,731	11%	29%	Yes
10	19,977	30,590	35%	40%	Yes
11	43,678	40,388	8%	36%	Yes
12	21,572	6,272	244%	60%	No
13	16,257	10,722	52%	56%	Yes

Note: screenlines for which 2-way counts were not available at all links were not included

GATEWAYS

Travel to and from Fresno County is represented by gateway zones at major road crossings of the county line. The Fresno COG Model currently has 30 gateways. The daily gateway validation was determined using the same maximum desirable deviation as for screenline volumes between model volumes and traffic counts (Figure 15). The model is estimating daily volumes within these targets for 97% of analyzed gateways (Table 39).

TABLE 39
DAILY GATEWAYS VALIDATION

Zone Number	External County	Gateway	Model Deviation	Max Deviation	Within Deviation?
43	Monterey	SR-198	12%	64%	Yes
44	San Benito	Panoche Road	18%	64%	Yes
45	San Benito	Ltl Panoche Road	12%	64%	Yes
61	Madera	SR-99	7%	30%	Yes
62	Madera	SR-41	5%	36%	Yes
63	Madera	County Road 206/ Millerton	22%	59%	Yes
64	Madera	Road 222/ Powerhouse Road	16%	64%	Yes
65	Tulare	SR-245	1%	64%	Yes
66	Tulare	Hill Valley/ Road 120	18%	63%	Yes
67	Tulare	Alta Avenue	30%	57%	Yes
68	Tulare	Reed/Road 52	20%	62%	Yes
69	Tulare	Mountain View/ Avenue 416	18%	55%	Yes
70	Tulare	SR 201/Sierra	23%	60%	Yes
71	Tulare	SR-99	21%	33%	Yes
72	Tulare	Road 8/10th Avenue	303%	64%	No
73	Kings	SR-43	19%	56%	Yes
74	Kings	Fowler Avenue	51%	64%	Yes
75	Kings	SR-41	29%	51%	Yes
76	Kings	Excelsior	21%	64%	Yes
77	Kings	Marks Avenue/22nd Avenue	29%	64%	Yes
78	Kings	Paige Avenue/Elder Avenue	9%	64%	Yes
79	Kings	SR-198	47%	59%	Yes
80	Kings	I-5	11%	40%	Yes
81	Kings	SR-269	7%	61%	Yes
82	Kings	SR-33	61%	64%	Yes
83	Kings	Jayne Avenue	39%	64%	Yes

TABLE 39
DAILY GATEWAYS VALIDATION

Zone Number	External County	Gateway	Model Deviation	Max Deviation	Within Deviation?
84	Merced	I-5	8%	39%	Yes
85	Merced	SR-33	53%	63%	Yes
86	Madera	13th Street	43%	59%	Yes
87	Madera	SR-145	13%	60%	Yes

PERCENT ERROR

The Caltrans travel forecasting guidelines include a figure showing the maximum desirable deviation for individual daily link volumes between model volumes and traffic counts (Figure 15). The suggested link-specific validation criterion is that 75 percent of freeway and principal arterials meet the maximum desirable deviation. The Fresno COG Model 2008 daily validation has 45 percent of links within the maximum desirable deviation when considering all road segments.

ACCOUNTING FOR TRAFFIC VALIDATION ERROR IN FORECASTS

The traffic validation indicates that the Fresno COG Model provides a good overall estimation of travel demand patterns in Fresno County. However, it is recommended that traffic forecasts on specific road segments use an adjustment process that accounts for validation errors, as described in the next section.

TRANSIT VALIDATION

Transit trips estimated from the mode choice model were assigned to the transit network. The results are summarized in Table 27. The model estimates total transit ridership within 10 percent of average daily observed ridership. This indicates that the model in its current state can provide reasonable overall estimates of changes in transit ridership on a corridor or subarea basis, particularly within the urban areas.

12. FORECAST APPLICATIONS

Potential travel model forecast applications include:

- Regional measures for input to air quality analysis
- Identify traffic "hot spots"
- Forecast effectiveness of major road or transit improvements
- Impacts of land use changes
- Compare land use or transportation policy alternatives using regional measures of effectiveness

ADJUSTMENT OF TRAFFIC ASSIGNMENT RESULTS

This section discusses procedures for adjusting model traffic forecasts for both link and turning movement volumes.

LINK VOLUMES

The raw outputs from the Fresno COG Model should rarely be applied directly in analysis. Although many methods exist and vary by project, three methods for post-processing model volumes are frequently used: the difference method, the ratio method, and the blended method, which is simply an average of the first two methods. In the difference method, forecast traffic volumes are calculated based on the difference between the base year count and model volume:

Adjusted Forecast Volume = Model Forecast Volume + (Base Year Count - Base Year Model Volume)

In the ratio method, forecast traffic volumes are calculated based on the ratio between the base year count and base year model volume:

Adjusted Forecast Volume = Model Forecast Volume × (Base Year Count ÷ Base Year Model Volume)

These methodologies are outlined in NCHRP 255. Although the most appropriate method is left to the judgment of the engineer depending on the project, there are guidelines that the Transportation Research Board has published based on the difference between counts and base model forecast: use ratio method if the difference is less that 50%, use difference method if the difference is greater than 150%, otherwise use a blend of both (average the results of the two methods).

If a new road or ramp connection is tested in a forecast, there would not be an existing traffic count and the model forecast volume would be used directly.

TURNING MOVEMENT VOLUMES

A common methodology for projecting turning movement volumes is to extract turning movements directly from the model, then post-process these volumes for each individual turning movement using the same NCHRP 255 methods described above (ratio, difference, or blended method). In the case of a new intersection or a leg is added to an intersection, adjustments may not be possible because there is no base for comparison. The reasonableness of the outputs should be checked based on knowledge of the area, comparisons to adjacent intersections, off-model calculations of the trip generation, distribution, and assignment of adjacent land use, or other methodologies, as deemed appropriate.

In addition, NCHRP 255 outlines the furnessing process, which may be appropriate if the following conditions are met:

1. The number of approach/departure legs at the intersection are consistent over time
2. The roadway system in the area does not cause traffic patterns to change
3. The land use development in the area does not cause traffic patterns to change

Furnessing is a process that balances the projected growth for each approach\departure of an intersection with the proportion of left, through, and right-turning vehicles, and minimizes the error between the count approach\departure and the forecast.

The Fresno COG staff and Model Steering Committee have developed “Recommended Procedures for Using Traffic Projections from the Fresno COG Travel Model”. This report is available on the Fresno COG web site.

HIGHSPEED RAIL POST-PROCESSER

To reflect travel out of the county that would utilize the Highspeed Rail (HSR) station, a post-processer was developed. The post-processer inputs are the location of the station, the daily boardings/alightings, the gateways the trips would have exited if not on HSR, and the through trips for the gateways that use HSR rather than driving. Drive trips are then assigned to access the HSR station rather than existing via auto, with VMT recalculated at the end of the process.

FORECAST ASSUMPTIONS

An initial set of forecasts for the Fresno COG Model was tested for the 2040 forecast year.

FUTURE ROAD NETWORKS

The future road networks are based on the current adopted Fresno County Regional Transportation Plan update (2011 RTP). Improvements are included in the travel model master road network, and improvements are only included in model forecast years beyond the project completion year.

FUTURE TRANSIT NETWORK

A potential future transit network is based on the draft "No Build" scenario from the Fresno Public Transit Infrastructure Study. The No Build transit network includes committed extensions of the 2009 transit network.

FORECAST RESULTS

The results of the travel forecasts can include the following:

- Traffic volumes on each link
- Congested speeds and travel times on each link
- Comparison of volume to capacity on each link
- Summary measures by TAZ in the geodatabase
- Transit ridership on bus routes
- Traffic volumes by vehicle occupancy (single, two-person, 3+ persons)
- Summary measures of effectiveness (MOE) for the entire county (or subareas) such as vehicle-miles of travel, person-hours of delay or average speed by road type

Appendix J Item 3: Growth Forecast

GROWTH FORECAST

POPULATION FORECAST

The forecasts used for the Fresno COG Regional Transportation Plan/Sustainable Communities Strategy were from the *San Joaquin Valley Demographic Forecasts: 2010 to 2050* prepared by The Planning Center, March 2012. The forecast was part of a San Joaquin Valley demographic study commissioned by the eight metropolitan planning organizations (MPOs) of the valley, in an effort to obtain recently-prepared projections. The latest State of California Department of Finance (DOF) projection at the time was released in July 2007 and did not take into account the 2007-2008 recession and the subsequent slow economic recovery, thus prompting the need for an updated forecast. In January 2013, the Department of Finance released their latest projection for Fresno County, which differed from The Planning Center forecasts by less than two percent for every year between now and the forecast horizon year of 2050, which helped confirm the validity of the Planning Center forecast for use in the RTP/SCS.

The Planning Center Study *San Joaquin Valley Demographic Forecasts: 2010 to 2050* is attached.

This study includes three primary forecasts of population, households and housing units. Other projections developed by The Planning Center, e.g., age distribution, average household size, household income, household type, race/ethnicity, are derived from the three primary forecasts. The Planning Center forecasts are based on several different projections including household trend, total housing unit trend, housing construction trend, employment trend, cohort-component model, population trend, average household size trend, and household income trend. The least-squares linear curve forms the basis for all projections because the forecasts are long-term and curve-fitting techniques (e.g., parabolic curve, logistic curve) do not provide reasonable long-term results. Three measures evaluate the adequacy of each projection: mean absolute percentage error (MAPE), F-test, and t-test.

Fresno County Population, Housing and Employment Forecasts

	Population	Housing Units	Employment
2005	872,569	294,156	335,159
2008	912,521	310,579	345,816
2020	1,082,097	363,142	363,581
2035	1,300,597	434,519	427,727
2040	1,373,679	458,330	449,111

EMPLOYMENT FORECAST

Employment was forecast by The Planning Center using the at-place employment data by sector from the State of California Employment Development Department. The model constructs a least-squares line for each economic sector and sums the results to generate a projection for total employment in the County. The least-squares line for total employment in Fresno County produces a MAPE of 2.21% and a standard error of .85%.

The resulting employment forecast is included in the table above.

HOUSEHOLD FORECAST

The household forecast was dependent on the expected increase in household size. According to the San Joaquin Valley Demographic Forecasts: 2010 to 2050 prepared by The Planning Center, household sizes in the San Joaquin Valley are projected to increase steadily—from approx. 3.1298 persons per household in 2008 to approx. 3.3515 in 2035. Thus, some of the expected total growth in household population for Fresno County will manifest not in new development but rather in existing housing units, as each household on average will contain more people.

To calculate the household population growth due to household size increase, Fresno COG used the following formula:

$$HH_{2008}(HHsize_N - HHsize_{2008})$$

Where

HH_{2008} = number of total households in Fresno County in 2008 (the base year) = *308,047*
$HHsize_N$ = projected average countywide household size for target year N
$HHsize_{2008}$ = average countywide household size in 2008 (the base year) = *3.1298*

Therefore, by this formula, the projected household population growth from 2008 to 2035 due to household size increase is *308,047 (3.3515 – 3.1298) = 68,289 persons*. Subtracting this value from the total projected growth in household population for the County represents the household population growth due to new development: *309,851 persons* by 2035.

The resulting household forecast is included in the table above.

Appendix J Item 4:
Fresno COG Target-setting

Fresno COG Target-Setting Processes

Under SB375, the California Air Resources Board (ARB) was required to develop greenhouse gas emission reduction targets for the 18 Metropolitan Planning Organizations (MPOs) in the State by September 30, 2010. The statue also provides that the MPO may recommend targets for its region for ARB to consider. The Fresno COG was actively engaged in the state-wide target-setting coordination process sponsored by the BIG-4 MPOs (SCAG, MTC, SACOG, and SANDAG), and with participation from ARB staff.

In November 2009, the Fresno County SB375 Task Force was formed to provide guidance to the target-setting process in Fresno County. The Task Force consisted of planning and public works staff from the 15 cities in Fresno County and the County, representatives from the San Joaquin Valley Air Pollution Control District (SJVAPCD), Caltrans, the Building Industry Association, transit agencies, environmental groups, and other community stakeholders. After six months of diligent scenario work, the Task Force reached consensus and unanimously recommended a target scenario out of three 3 scenarios developed, which was subsequently approved by Fresno COG's Transportation Technical Committee, Policy Advisory Committee and the Policy Board in April, 2010. Please refer to the attached "Council of Fresno County Governments SB375 Greenhouse Gas Emission Reduction Target Recommendation" for more information regarding the target recommendation, target-setting process, and technical tools and assumptions applied in the 2009 target recommendation from Fresno COG to ARB.

However, due to the fact that only a couple of MPOs in the Valley submitted target recommendations, the ARB did not have comprehensive scenario data for the entire San Joaquin Valley. Meanwhile, the Valley MPOs received $2.5 million from the Strategic Growth Council, and their traffic models were expected to be improved significantly in a year or two for measuring the types of smart growth policies expected by SB375. In the fall of 2010, the Valley MPOs were given targets of 5% reduction in 2020 and 10% reduction in 2035 as placeholders, and were informed that the placeholder targets would be reviewed in 2012. ARB again asked MPOs in the Valley to go through scenario exercise and provide data and information to inform ARB's Board at their meeting in January 2013.

The Fresno County SB375 Task Force was reconvened in October 2011. New tools and improved data were applied. Three scenarios were developed. More performance indicators were tested. After 10 months of scenario work, the Task Force recommended keeping the 5% and 10% targets for the Fresno County region based on the new scenario results, and a preferred target scenario was selected to forward to the ARB. The 2nd round of target-setting was wrapped-up by Fresno COG Policy Board approving the Task Force's target recommendation in September 2012. Due to the fact that the scenarios went through extensive committee process and public scrutiny, Scenario 2 and Scenario 3 were carried into the SCS process, which started in August 2012. Although Fresno COG did not submit a formal target recommendation report to the ARB as it did in 2009, the ARB staff was actively involved in the process. The scenario data and technical methodology were shared with the ARB. Fresno COG's scenario results were shared with the ARB through the valley-wide target recommendation process. Please refer to the attached power point presentation for the conclusion/recommendation of Fresno COG's 2nd round of target-setting.

At the valley level, the eight Valley MPOs continued to work together and in coordination with staff at ARB and the San Joaquin Valley Air Pollution Control District (SJVAPCD). Traffic models were substantially upgraded and standardized to better evaluate the type of transportation and land use policies likely to be considered in the SCSs. The SJVAPCD provided funding to valley MPOs to apply Envision Tomorrow, a sketch planning tool, in the scenario planning process. The tool enabled the MPOs to look at plans at a level as fine-grained as parcel level, and facilitated interactive dialogue among stakeholders. On December 14, 2012, the San Joaquin Valley Regional Policy Council adopted an SB375 implementation progress report and target recommendation for the Valley. The recommendation was to maintain the current 5% reduction in 2020 and 10% in 2035 on an aggregate valley-wide basis. ARB released a staff report on January 15, 2013, providing an update on the SB375 implementation efforts in the San Joaquin Valley. Please refer to the following link: http://www.arb.ca.gov/cc/sb375/finalstaffreport_011513.pdf for the ARB staff report and the target recommendation from the eight MPOs in the Valley.

In January 2013, ARB held its Board meeting in Bakersfield. The 5% and 10% targets were upheld as individual targets for the valley MPOs if MPOs chose to develop their individual SCSs. A valley-wide target would be considered by ARB if the valley MPOs decided to collectively develop a uniform valley-wide SCS.

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May 19, 2010

Ms. Mary D. Nichols, Chairperson
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Dear Chairperson Nichols:

RE: FRESNO COUNTY MPO REGION PROPOSED DRAFT TARGETS

We are pleased to submit suggested SB 375 greenhouse gas reduction targets for the Fresno COG region as allowed under SB375 and recommended by the Regional Targets Advisory Committee (RTAC). The Fresno COG Policy Board approved Alternative 1 as the target scenario on April 29, 2010.

Enclosed, please find the documentation for our findings.

In accordance with the "Recommendations of the Regional Targets Advisory Committee Pursuit to Senate Bill 375," we have worked closely with staff from our county and city jurisdictions, our local air district, the Building Industry Association, transit agencies, private developers, environmental groups and other community stakeholders to develop these targets. We have also been in continuous contact with your staff for their on-going review and guidance.

The 6-month long target-setting process in the Fresno COG region was a very engaging bottom-up public process. Through hard work, the Fresno COG region reached consensus on an ambitious and achievable target for the region. We have also realized the challenges ahead of us to implement SB375 under current economic conditions.

Thank you for giving us the opportunity to propose targets. We look forward to receiving the draft targets for the Fresno COG region and continuing to work with your staff on SB 375 activities.

Please feel me to contact me or Kristine Cai of my staff at 559-233-4148 ext. 215 if you have any questions at all.

Sincerely,

Tony Boren

Tony Boren
Executive Director

Enclosure: Documentation

Member Agencies: The cities of Clovis, Coalinga, Firebaugh, Fowler, Fresno, Huron, Kerman, Kingsburg, Mendota, Orange Cove, Parlier, Reedley, San Joaquin, Sanger, Selma & Fresno County

Council of Fresno County Governments

SB375 GREENHOUSE GAS EMISSION REDUCTION TARGET RECOMMENDATION

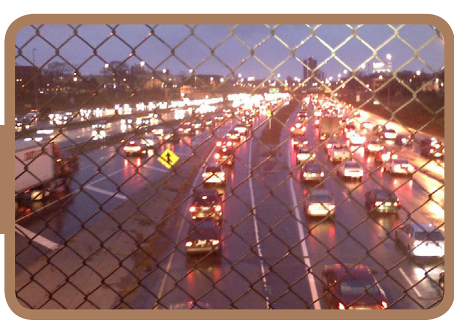


Table of Contents

List of Tables

List of Appendices

Background

In 2006, the Legislature passed AB 32-The Global Warming Solutions Act of 2006, which requires the State of California to reduce greenhouse gas (GHG) emissions to 1990 level by 2020. SB 375, a landmark legislation that aligns regional land use, transportation, housing and greenhouse gas emission reduction planning efforts, provides a means to achieve AB 32 goals from passenger vehicles and light trucks through the regional planning process.

Under SB 375, the California Air Resources Board (CARB) is required to develop GHG emission reduction targets for the 18 Metropolitan Planning Organizations (MPOs) in the State. CARB must set regional targets by September 30, 2010 (draft targets will be released to the regions by June 30, 2010). The statute also provides that the MPO may recommend a target for its region for CARB to consider. During the target setting process, CARB must take into consideration several factors such as vehicle efficiency and low carbon fuels. CARB must also convene a Regional Target Advisory Committee (RTAC) to recommend factors to be considered and methodologies to be used by CARB. CARB is also required to exchange technical information with each MPO and the affected air districts.

In its final report, the RTAC committee recommended 7 steps for the target setting process:

Step 1 MPOs Develop Draft Methodology and Targets for Emissions

MPOs prepare an analysis of their adopted fiscally constrained RTP, which includes its assessment of the location and intensity of future land use that is reasonably expected to occur. The analysis would include estimates of respective regional 2005 base year, 2020 and 2035 greenhouse gas emission levels (e.g., for defined “No Project” and “Project” alternatives included in an RTP EIR or other related assessment), using their existing models. MPOs would work together with ARB to ensure that this analysis uses consistent long-range planning assumptions statewide, to the degree practicable, including, but not limited to:

- Existing and forecasted fuel prices and auto operating costs
- Reasonably available federal and state revenues
- Assumptions about fleet mix and auto fuel efficiency standards provided by CARB
- Demographic forecasts (e.g., aging of population and changes to household income and cost of living)
- Assumptions about goods movement-related travel impacts (e.g., heavy-duty trucks, rail, seaports and airport)

Each MPO’s analysis would be made available to the public.

Step 2 CARB Reviews Draft Baseline Emissions from MPOs

CARB uses the results from Step 1 to compile greenhouse gas emission estimates for each of the MPOs individually in the base year of 2005 and the target years of 2020 and 2035. CARB staff would then meet with the MPOs to share those results, and make them available to the public for review. ARB staff would also compare baseline greenhouse gas emission estimates with MPO fuel use data for comparison. To the extent that there are differences, CARB will attempt to understand them. This would result in a greenhouse gas emissions “baseline” against which further reductions from regional strategies developed in Step 3 and 4 can be compared.

Step 3 MPOs Develop Performance Indicators for Comparing Scenarios

Using a bottom up approach with input from regional and local officials and stakeholders,
the MPOs would work with ARB to develop parameters for preparing sensitivity analyses and multiple scenarios to test the effectiveness of various approaches that would help identify the most ambitious achievable greenhouse gas emission reduction strategies for 2020 and 2035. CARB and MPOs are encouraged to coordinate and develop comparable packages across the regions. The policies and practices that could be incorporated into these alternative scenarios include, but are not limited to, those identified in the Best Management Practices (BMP) list and may include:

- Increased transportation funding and system investments in modes that will reduce greenhouse gas emissions, such as public transit, rail transportation, and non-motorized transportation
- Improved integration between land use and transportation policies, through means such as funding for supportive local infrastructure near public transit and funding for regionally coordinated preservation of natural areas
- Inclusion of policies that promote infill, higher densities, mixed uses, improved pedestrian and bicycle connections, and open space preservation
- Increased use of transportation demand management measures to reduce single-occupant vehicle (SOV) travel demand
- Increased use of transportation systems management measures that will improve system efficiency
- Including pricing options, such as express lanes, parking, and various fuel taxes
- Accelerated integration of more fuel efficient and clean fuels automobiles into the fleet mix than what is already required by adopted state vehicles and fuels programs
- Increased funding for and/or supply of housing affordable to the local workforce

In this step, the MPOs and CARB would also identify the data inputs and outputs that should be obtained from existing or new scenario assessments developed with existing travel demand and land use models, off-model tools, sketch planning analyses, or the BMP spreadsheet tool. The Committee recommends that the data outputs be related to the performance indicators discussed in the performance monitoring section later in the RTAC report and should be comparable from region-to-region, to the extent feasible. Outputs may include those listed in the Performance Monitoring section, and may include:

- Greenhouse gas levels at target years
- Transportation performance measures
- Economic performance measures
- Other environmental performance measures
- Social equity performance measures
- Housing production performance measures

In identifying the measures to be used in developing these alternative scenarios, MPO staffs and ARB staff would use information from existing scenario assessments and cost-effectiveness studies wherever possible. The list of measures, alternative scenarios and data outputs identified for each MPO will be made available for public comment.

Step 4 MPOs Submits Proposed Target to ARB by March 1, 2010

MPOs analyze the alternative scenarios using a sketch planning tool, BMP spreadsheet tool, or other acceptable means, and forward the results to ARB and make them available to the public, explaining the reasons for any difference in key outputs resulting from the various methodologies used to analyze scenarios. CARB would compile the results, and, combined with its review of empirical studies and other relevant information that relates to passenger vehicle and light truck greenhouse gas emissions (including new auto fuel efficiency standards and clean fuels), prepare a preliminary draft uniform statewide target for public review and comment. At this time, an MPO may also submit a proposed regional target pursuant to provisions of SB 375.

Step 5 MPOs Comment on ARB Draft Targets

ARB considers feedback from MPOs and other stakeholders on the preliminary draft uniform statewide target, as well as any formal regional target submittals received as part of Step 4, to assess whether any region's target should be adjusted either above or below the preliminary draft uniform statewide target. Such revisions would be subject to a "reasonably tough test" and would ensure that each region's target is the most ambitious achievable.

Step 6 ARB staff recommends draft targets to its Board by June 30, 2010.

Step 7 ARB works with MPOs to Develop Final Targets by Sept. 30, 2010

ARB, MPOs and others continue to exchange technical information and modeling results prior to final target setting by September 2010. MPO and ARB shall encourage public participation in formulating alternative scenarios and determining outputs within the timelines noted below. The process outlined above will require a significant effort by all participants within a relatively short period of time in order to allow ARB staff to submit draft targets to its Board by June 30, 2010 and final targets by September 30, 2010 in accordance with SB 375. Therefore, it is recommended that a specific schedule be developed by the participants, based on the following key milestones:

- Steps 1 through 4 should be completed as close to March 1, 2010 as possible (April 30, 2010 for the SCAG region);
- Steps 5 and 6 should be completed by June 30, 2010; and,
- Step 7 will be completed by September 30, 2010.

Fresno COG Target-Setting Process

Fresno COG has been actively involved in the statewide SB 375 target-setting coordination process, which is sponsored by the Big-4 MPOs (SCAG, MTC, SACOG and SANDAG) and with participation from the CARB staff. In addition to data and methodology sharing during the statewide coordination process, Fresno COG has also incorporated recommendations from the Big-4 Planning Working Group (PWG) and its sub technical group to the extent feasible to ensure the consistency of Fresno's process with the rest of the state. Such efforts include the reflection of the economic downturn in the population/employment forecast; modeling the future fuel price forecast agreed upon by the Committee; and approaches to capture inter-regional trips as recommended by the

RTAC without a working version of the statewide model, etc. Fresno COG is also part of the Mid-size MPO committee headed by the Santa Barbara Association of Governments, and has been a vital member of the San Joaquin Valley SB 375 planning efforts.

Internally, Fresno COG has taken a bottom-up approach by engaging its member agencies and other stakeholders in the region throughout the target-setting process. As early as in October of 2009 before the COG process was formally launched, pre-meetings were held with member agencies to inform them of the proposed approach COG planned regarding SB 375. Cities also provided COG with information on the status of their general plan updates and expressed concerns about the financial difficulty in conducting comprehensive general plan updates under current economic conditions.

In November 2009, the Fresno County SB 375 Task Force was formally organized. The Task Force consists of planning and public works staff from member agencies, representatives from the San Joaquin Valley Air Pollution Control District (SJVAPCD), Caltrans, the Building Industry Association (BIA), transit agencies, private developers, environmental groups, as well as other community stakeholders. CARB's regional liaison has also been participating in the Task Force meetings through the phone. The Task Force held monthly meetings from November through April, and has been instrumental in guiding the target-setting efforts in Fresno County. In addition to successfully working under a regional context and reaching consensus on an ambitious and achievable greenhouse gas reduction target for the Fresno County region, the Task Force also explored regional issues such as the relationship between SB 375 and Blueprint, Regional Housing Needs Assessment (RHNA) under SB 375, etc.

As part of the engagement efforts, Fresno COG issued a letter to its member agencies, explaining the SB 375 greenhouse gas reduction target setting process. The letter was requested by the Task Force representatives to be used to start internal discussion with their decision-making bodies. In addition, a public workshop was held in March 2010 for the general public. The event was well attended, and positive feedback was received about the outreach efforts.

After six months of scenario development, the Task Force reached consensus and unanimously recommended a target scenario which was subsequently approved by Fresno COG's Transportation Technical Committee, Policy Advisory Committee and the Policy Board in April, 2010.

Accounting for the Economic Downturn in Setting the Target

During several meetings with senior staff from the California Air Resources Board, it was emphasized that assumptions used in the target-setting process should reflect the recent economic downturn.

The latest State of California Department of Finance (DOF) population forecast was released in July 2007 before the start of the recession in December 2007. It fails to reflect the County's recent declining growth rates due to the economic downturn and the County's water crisis, a three-year drought compounded by a drastically-reduced water allocation to the area. As shown in Table 1, the DOF projection released in July 2007 predicted a 2000-2010 average annual growth rate of 2.03%. In comparison, the DOF's annual estimates, released in April 2010 well after the recession began, showed an actual growth rate was only 1.80%.

In December 2009, the Fresno County SB 375 Task Force reviewed the outdated DOF projection, and discussed what projection should be used for the Fresno County target-setting process. Six different alternative projections were considered:

1. The DOF projection for 2030 is delayed by five years, i.e., the 2030 projection would not be reached until 2035.

2. The current level of Fresno County net migration is reduced by 50% for the future. Census data indicate that California's long history of attracting immigrants will slow dramatically in the future.

3. The DOF projection growth rates are reduced by 25%. During the past four to five years the annual population growth rate has decreased 25% to 30%.

4. The DOF projection growth rates for Fresno County are reduced by the same percentage reduction between the DOF projection for San Joaquin County and SJCOG's own projection. The SJCOG was one of the three COGs in the San Joaquin Valley who intended to submit a target at the time.

5. The DOF projection growth rates for Fresno County are reduced by the same percentage reduction between the DOF projection for Kern County and Kern COG's own projection. The Kern COG was one of the three COGs in the San Joaquin Valley who intended to submit a target at the time.

6. The DOF projection growth rate for 2009-2020 is reduced by 25%, and the growth rate for 2020-2035 is reduced by 10%. During the past four to five years the annual population growth rate has decreased 25% to 30%. It is assumed that the reduction will slow to 10% after 2020.

These six population projection alternatives are summarized in Table 2.

The Task Force selected Alternative 6 as the population projection to be used for target-setting. It represents a reasonable midrange of all the alternatives. Later, in March 2010, Caltrans released their report "California County-Level Economic Forecast, 2010-2035" which contained a population projection for Fresno County very close to that selected by the Task Force. As shown in Table 1, the Caltrans projection for Fresno County is

1,132,643 for 2020 and 1,403,656 for 2035. This is very close to the Task Force-selected projection of 1,131,430 and 1,418,887. In contrast, the latest DOF forecasts population is much higher at 1,201,792 and 1,545,181.

This selected projection is to be used for target-setting purposes only. Jurisdictions within the County and the Fresno COG use other projections for their on-going projects. A formal study of the impact of the recession on the future growth will be conducted later this year, and will be applied in the future planning activities.

The population, housing and employment levels used for target-setting are listed on Table 3.

Table 1

COMPARISON OF POPULATIONS AND AVERAGE ANNUAL GROWTH RATES

Year	**DOF** Population Projection Released July 2007	Average Annual Growth Rate	**DOF** Population Estimates Released April 2010	Average Annual Growth Rate	**Caltrans** Population Projection Released March	Average Annual Growth Rate	**Target-Setting** Population Projection	Average Annual Growth Rate
2000	804,508		797,900					
2001			812,195					
2002			828,325					
2003			846,476					
2004			864,882					
2005		2.03%	881,324	1.80%				
2006	***907,551***		897,242		**905,880**		**897,416**	
2007			912,725					
2008			928,066					
2009			941,006					
2010	983,478		953,761					
2011								
2012								
2013		**2.03%**				**1.61%**		**1.67%**
2014								
2015								
2016								
2017								
2018								
2019								
2020	**1,201,792**				**1,132,643**		**1,131,430**	
2021								
2022								
2023								
2024								
2025								
2026								
2027		**1.69%**				**1.44%**		**1.52%**
2028								
2029								
2030	1,429,228							
2031								
2032								
2033								
2034								
2035	***1,545,181***				**1,403,656**		**1,418,887**	
2036								
2037								
2038								
2039								
2040	1,670,542							

Note: The DOF population projections for 2006 and 2035 are interpolations. The DOF did not publish projections for these years.

Table 2
SIX POPULATION PROJECTION ALTERNATIVES
CONSIDERED BY TASK FORCE

Year	1 If 2030 DOF not reached until 2035		2 If net migration is reduced by 50%		3 If reduce growth rates by 25%	
	Revised	Average Annual %	Revised	Average Annual %	Revised	Average Annual %
2009	942,298		942,298		942,298	
2020	1,151,883	1.76%	1,178,792	1.97%	1,131,430	1.60%
2035	1,429,228	1.45%	1,492,181	1.58%	1,366,663	1.27%

Year	4 If reduce growth rates like San Joaquin COG by 51.0% (2009-2020) and 28.3% (2020-2035)		5 If reduce growth rates like Kern COG by 35.57% (2009-2020) and 26.26% (2020-2035)		6 If reduce growth rates by 25.0% (2009-2020) and 10.0% (2020-2035)	
	Revised	Average Annual %	Revised	Average Annual %	Revised	Average Annual %
2009	942,298		942,298		942,298	
2020	1,062,236	1.05%	1,102,826	1.38%	1,131,430	1.60%
2035	1,241,096	1.04%	1,327,915	1.25%	1,418,877	1.52%

Table 3
POPULATION, HOUSEHOLDS AND EMPLOYMENT
FRESNO COUNTY
USED FOR TARGET-SETTING

Socio-Economic Data	2005	2020	2035
Population	897,416	1,131,430	1,418,887
Households	302,601	366,659	467,562
Employment	373,464	456,394	575,629

Methodology

Land Use Growth Allocation

Although the UPlan land use allocation model was used in Fresno COG's Blueprint modeling process, it was decided that for SB 375 purposes, UPlan cannot produce the fine-grained results needed to model local level land use development. In addition, UPlan lacks a market element in its growth allocation, which limits its implementation applicability into general plans. Also, the target-setting schedule did not afford the time nor budget to develop parcel-based land use data needed for such models as I-PLACE3S. Therefore, the traditional spreadsheet method was applied in the target-setting process to allocate the projected growth.

In developing the alternative land use scenarios, local planners were consulted on the location and timing of growth for each scenario. All scenarios were controlled to the same totals for population, households and employment for 2020 and 2035 as shown previously in Table 3. General plans, community plan, specific plans, and other plans and studies were used to determine the number of households by single and multiple family household by car ownership and employment by retail, service, education, government, education and other by traffic analysis zone (TAZ). The local planner input was translated into growth projections by TAZ for each scenario, which was then presented to the Task Force for verification.

Although the spreadsheet method was time-consuming and cannot provide summary data such as overall density, it does ensure a bottom-up process. The land use scenarios developed during the target process were envisioned by the local planners and the Task Force, which provides a connection to the incorporation of Sustainable Community Strategy (SCS) into the cities' and the county general plans.

Fresno COG Travel Demand Model

Fresno COG's 4-step travel demand model was used in the target-setting process. The model covers all of Fresno County, which is divided into 1,575 traffic analysis zones. The model roadway network includes over 6,800 nodes and over 17,000 links. Link types include freeway, freeway ramps, other state routes, expressway, arterial, collector, and local collector. The model estimates travel demand and traffic volume for the AM peak hour, PM peak hour, AM 3-hour peak period, PM 3-hour peak period and daily forecast. The model contains a mode split component that replicates major transit services in Fresno County, including the Fresno Area Express (FAX), Clovis Transit Stageline and Fresno County Rural Transit Agency. The mode choice model is a multinomial logic model, and has the following seven modes:

- Drive alone
- 2-person vehicle

- 3+ person vehicle
- Walk to Transit
- Drive to Transit
- Walk
- Bike

Similar to most of the other 4-step models, Fresno COG's model is capable of analyzing land use patterns at a macro level. However, the model is yet to be improved with its sensitivity to residential and employment density, job/housing diversity, distance to transit, walkable design etc., and therefore is supplemented by a 4D inline processor in the target-setting process. The model is also not capable of modeling Transportation System Management (TSM) and Transportation Demand Management (TDM) strategies, and such measures were post-processed using parameters developed in "Moving Cooler," which was published by the Urban Land Institute.

In addition, the model was tested to be reasonably sensitive to changes in auto operation cost. The future fuel price agreed upon by the Big-4 Planning Working Group was modeled in Fresno's scenarios.

Table 4
2005 Auto Operation Costs

Variable	
Analysis Year	2005
Cost Basis Year	2009
Fuel Price Per Gal for Analysis Year (in '09$)	$2.67
Avg. Auto Miles / Gal	20.6
Gas Cost Per Mile (in '09$)	$0.130
Tire+Maint Cost Per Mile (in '09$)	$0.065
Total Auto Ops Cost Per Mile (in '09$)	$0.194
Convert to RTP Model Cost Basis Year	0.799 ('09 to '00 $)
Fuel Price Per Gal in Model Cost Basis Year	$2.132
AO Cost Per Mile in Model Cost Basis Year	$0.155

Table 5
2020 Auto Operation Costs

Variable	
Analysis Year	2020
Fuel Price Per Gal for Analysis Year (in '09$)	$4.74
Avg. Auto Miles / Gal	25.5
Gas Cost Per Mile (in '09$)	$0.186
Tire+Maint Cost Per Mile (in '09$)	$0.081
Total Auto Ops Cost Per Mile (in '09$)	$0.267
Convert to RTP Model Cost Basis Year	0.799 ('09 to '00 $)
Fuel Price Per Gal in Model Cost Basis Year	$3.785
AO Cost Per Mile in Model Cost Basis Year	$0.213

Table 6
2035 Auto Operation Costs

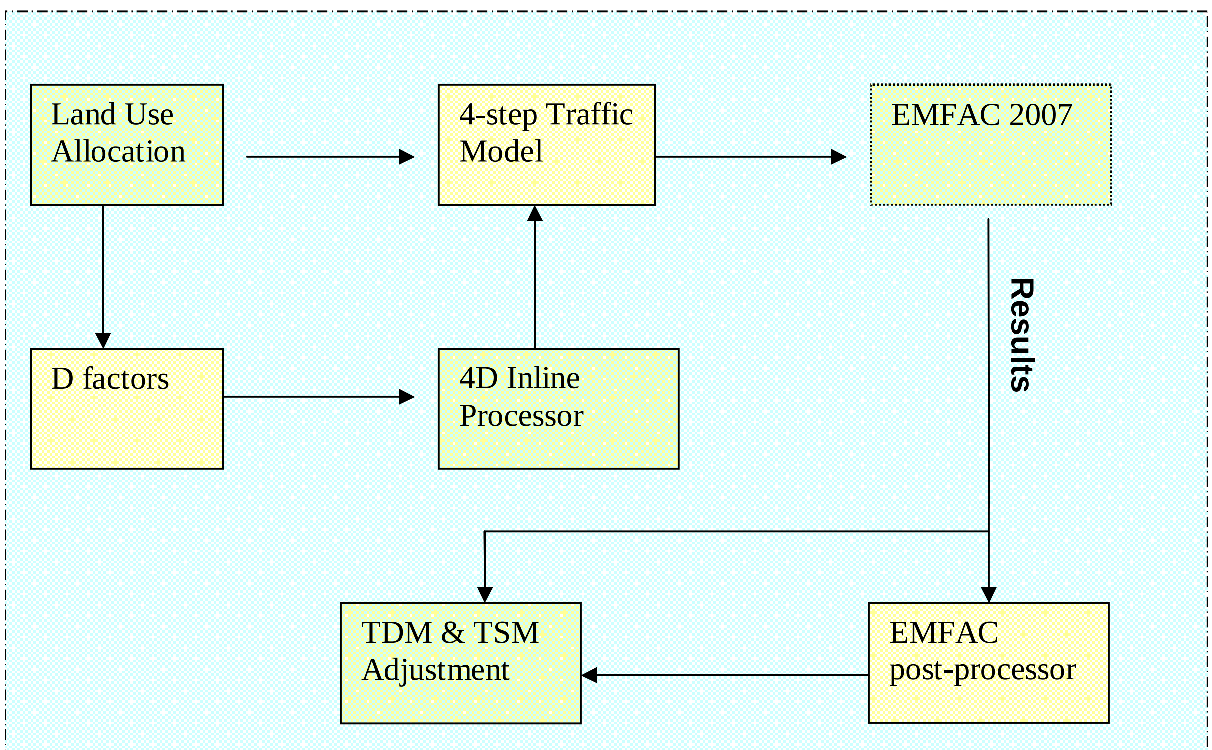
Variable	
Analysis Year	2035
Fuel Price Per Gal for Analysis Year (in '09$)	$5.24
Avg. Auto Miles / Gal	29.0
Gas Cost Per Mile (in '09$)	$0.18
Tire+Maint Cost Per Mile (in '09$)	$0.107
Total Auto Ops Cost Per Mile (in '09$)	$0.29
Convert to RTP Model Cost Basis Year	0.7986232 ('09 to '00 $)
Fuel Price Per Gal in Model Cost Basis Year	$4.18
AO Cost Per Mile in Model Cost Basis Year	$0.23

4D Enhancement to the 4-Step Traffic Model

Similar to the other 4-step models, Fresno COG's model does not have high level of sensitivity to changes in trip making resulting from smart-growth strategies. Fehr & Peers, a leading transportation consulting firm in research and application of D factors (such as Density, Diversity, Design, Destination, Distance to Transit, etc) that are related to smart-growth strategies, was retained to supplement COG's traffic model with a 4D Processor to reflect the changes in trips, mode, and vehicle occupancy due to implementation of smart growth strategies. Sensitivities of COG's model to such D factors were first tested, elasticity numbers were then developed, and a 4D enhancement inline processor was integrated into COG's model. The 4D process was applied in both of the alternative scenarios.

Please refer to Appendix I for documentation of the 4D methodology applied in Fresno COG's target-setting process.

Modeling Greenhouse Gas Emissions



When the land use growth allocation was developed for each scenario, D factors such as housing/employment density and job/housing mixes by TAZ were calculated, and design features for future scenarios were applied using common assumptions in the San Joaquin Valley. The D factors were then incorporated in the 4D inline processor in combination with the D elasticity numbers determined by the study.

After the model's transportation network was edited to incorporate additional roadways and transit projects, the 4-step model (with the 4D inline processor) was then run to produce total VMT and VMT by speed bin as required by EMFAC 2007. Then, the EMFAC post-processor was applied to account for vehicle technology and low carbon fuel, and the results were tabulated by GHG emissions for before and after the EMFAC post-processor was applied. Such GHG emissions were adjusted for the TDM and TSM measures that the traffic model cannot estimate.

Inter-Regional Trips

The RTAC recommended that an MPO should not be responsible for the GHG emissions generated from through trips (trips that begin and end outside the MPO region), and should take responsibility for half of the trips that start or end within the MPO region.

Since there is no consistent tool or methodology to calculate inter-regional trips when the target is being proposed at the regional level, Fresno COG offers 3 options to report and incorporate inter-regional trips into the proposed target.

Approach 1. Report all VMT within the Fresno County boundaries minus through trips

This approach includes 100% of internal-internal (II) trip and 100% of internal-external and external-internal (IXXI) trips within the Fresno County boundaries. It is assumed that 50% of IXXI trips within county boundaries are equivalent to 50% of IXXI trips outside of Fresno boundaries. This approach is consistent with the methodology recommended by the Big-4 MPOs Executive Directors' Committee.

Approach 2. Report VMT from internal travel and 50% of IXXI trips. IXXI trips are limited to traveling within the San Joaquin Valley.

This approach used the Statewide Travel Model developed by Dowling Associates in 2002. Although this version of the Statewide Travel Model is older, and has not been officially adopted by Caltrans, it is the only tool available to examine travel interaction between regions. Please refer to Appendix II for documentation on how data were generated using this version of the Statewide model. This approach considers only inter-regional trips within the San Joaquin Valley, which is similar to some mid-sized MPOs' methodologies of including only inter-regional travel to their immediately adjoining counties. Under Approach 2, 100% of II and 50% IXXI traveling between Fresno County and the rest of the San Joaquin Valley counties are reported.

Approach 3. Report VMT from internal travel and 50% of IXXI trips. IXXI trips reported in this approach are traveling between Fresno County and the rest of the state.

This approach also used the Statewide Travel Model developed by Dowling Associates in 2002, which again is the only tool available to look at statewide travel. The VMT reported under Approach 3 includes 100% of II and 50% of IXXI trips between Fresno County and the rest of the state.

Please refer to Appendix II for detailed documentation of the methodology for Approaches 2 and 3.

Currently, Caltrans and other state agencies are working on tools that could potentially address inter-regional travel issues. The statewide household travel survey and the statewide travel model being developed by UC Davis will be valuable resources to provide a solution to the inter-regional trip issues.

TDM and TSM Adjustment

For each planning scenario, post-processing was performed to account for the benefits of TDM and TSM measures that cannot be modeled directly by COG's 4-step model. The primary reference used to estimate the benefits of such measures was the publication by the Urban Land Institute's "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions." The report focuses on transportation related GHG emissions, and itemizes GHG emission reduction by specific transportation policies/measures.

Table 7
TDM and TSM Measures

Measures	Scenarios Applied	Deployment Level
ITS (Traffic Signal Synchronization)	Baseline, Alternative 1 & Alternative 2	Signal synchronization in the Metro areas only
Ramp Metering	Baseline, Alternative 1 & Alternative 2	Ramp metering on the freeways in the urban areas
San Joaquin Valley Air Pollution Control District Rule 9410 (employer-based trip reduction program)	Alternative 1 & Alternative 2	The program only applies to employers with 100 or more employees, which accounts for 40% of total workers in Fresno County
Vanpool/Car share	Baseline, Alternative 1 & Alternative 2	About 1.2% of Fresno County local sales measure, Measure C, ($20 million over 20 years) has been allocated to the car pool/van pool program

Based on the "Moving Cooler" definition of deployment level, ITS, Ramp Metering, and Vanpool/car share strategies in the planning scenarios are considered equivalent to the "expanded Current Practice Deployment", and the Air District Rule 9410 is considered to be "aggressive deployment", but only applied to 40% of the employment.

Table 8
TDM/TSM GHG Reduction in 2020 & 2035 by Strategy (at Expanded Current Practice and Aggressive Deployment Level in Metric Tons) based on "Moving Cooler" Report

Strategies	**Deployment Level**			
	2020		2030	
	Expanded Current Practice	Aggressive Deployment	Expanded Current Practice	Aggressive Deployment
Ramp Metering	<0.5		<0.5	
Signal Control Management	<0.5		<0.5	
Car-sharing	1		1	
Employer-based Commute Strategies		15		14
Computation of GHG Reductions				
Combined Reduction	7.8		7.4	
Baseline GHG	1700		1675	
Percent GHG reduction against baseline	-0.46%		-0.44%	

Source: "Moving Cooler," pages 44 and 45.

Note:
1. All the numbers in the above table is in million metric tons per year.
2. 0.4 million metric tons were assumed for Ramp Metering, Signal Control Management at expanded current practice deployment level.
3. SJVAPCD Rule 9410 is considered deployed at the aggressive level, but only applies to 40% of workers. Thus the tonnage for the employer-based commute strategies was multiplied by 40% to reflect the benefits of Rule 9410.

Scenarios

The Fresno COG staff worked with the Task Force and the planning staffs within the jurisdictions of Fresno County , and developed three scenarios:

1. Baseline Scenario
2. Alternative 1 Scenario
3. Alternative 2 Scenario

Table 9
Scenario Summary

	Scenarios		
	Baseline scenario (Adopted 2007 RTP)	Alternative 1 (Based on planning activities that have taken place since 2007 RTP plus intensifications in various locations throughout the County)	Alternative 2 (More aggressive corridor and activity center planning in the Metro areas.)
Blackstone/Ventura BRT	x	x	x
Shaw Ave. BRT			x
Improvement to existing transit		x	x
Air District Rule 9410 (employer-based trip reduction program)		x	x
Car Sharing	x	x	x
Operational Improvements (ITS & ramp metering)	x	x	x

<u>Baseline Scenario</u>

The baseline scenario reflects the Fresno COG 2007 Regional Transportation Plan. The *Recommendations of the Regional Targets Advisory Committee (RTAC) Pursuant to Senate Bill 375*, suggest that as part of Step 1:

> "MPOs prepare an analysis of their adopted fiscally constrained RTP, which includes its assessment of the location and intensity of future land use that is reasonably expected to occur. The analysis would include estimates of respective regional 2005 base year, 2020 and 2035…"

In 2004, the Fresno COG staff began working with the county jurisdictions to develop future socio-economic data for use in COG's transportation model. These socio-economic data were used for the Fresno COG 2007 RTP and became the basis for the target-setting baseline scenario.

The general plans adopted at the time were used to determine the available developable (vacant land) for each jurisdiction to determine the location of future potential growth.

The City of Fresno planning staff provided Fresno COG with data on their 2025 Fresno General Plan adopted two year before in 2002. This plan called for future expansions into their North Reserve Area (now called their Copper River area) and Southeast Reserve Area (now called SEGA or Southeast Growth Area). The Fresno planning staff also provided COG with assumptions on the number of housing units per acre for each land use designation, average household size, and the timing of development by geographic area.

The City of Clovis planning staff provided data on land use based on their Clovis General Plan adopted in 1993. The forecast to 2025 assumed the complete development of the Shepherd-168 Triangle, and the Northwest and Southeast Urban Centers (now known as the Loma Vista Specific Plan area), and the partial development of the Northeast Urban Center. The Clovis planning staff also provided density factors for their land use designations, as well as projected development timing by geographic area.

The thirteen smaller cities were asked to complete forms estimating population and household data by TAZ for the year 2020. Some cities had their staff or consultants complete the forms. Other cities requested that COG staff forecast the data for them, using material such as general plans and maps, lists of planned projects, population projections, etc.

The County of Fresno planning staff assisted COG in forecasting the population and household data for areas outside the cities' spheres of influence by providing a list of potential projects and the estimated population and/or number of housing units, employment, and timing of each project.

Alternative 1 Scenario

A second scenario, known as Alternative 1 was developed with density intensification and more mixed uses, incorporating the land use principles of the Fresno Blueprint. This alternative included general plan updates and new and updated specific plans that have taken place since the 2007 RTP, as well as corridor and activity center development and additional public transportation measures. Specifically included in Alternative 1 are the Southeast Growth Area (SEGA) and the Loma Vista Specific Plan both of which consist of mixed-used centers of housing and employment.

Alternative 1 also uses density increases and infill along major corridors, urban form areas and activity centers scattered throughout the metropolitan area. In all, 154 areas within the county are identified as having greater densities and/or more mixed use than the Baseline Scenario. Some of the elements of Alternative 1 such as the Southeast Growth Area (SEGA) plan and some corridor intensification plans have not been fully studied or adopted by their respective city councils. Other major sustainable projects included in this scenario are listed in Table 10.

After the modeling, Alternative 1 presented a marked improvement in GHG reduction over the Baseline Scenario.

Alternative 2 Scenario

Alternative 2 was structured with even more aggressive corridor and activity center planning in the metropolitan area, along with additional transportation measures. This scenario provided even more reductions in GHG emissions, but also requires land use changes which may not be supportable until more sophisticated development assessment and market demand analyses are employed. Under this scenario, 204 areas have greater densities and/or more mixed use than the Baseline Scenario.

A summary description of the land use in the three alternative scenarios is listed in Table 10.

Table 10
Summary of Land Use Changes by Scenario

DESCRIPTORS	SCENARIOS		
	BASELINE	ALTERNATIVE 1	ALTERNATIVE 2
SEGA (Southeast Growth Area) Generally bounded by Dakota, Jensen, Temperance and Highland; Jensen, North, Minnewawa and Temperance	Medium low and medium density residential	Eight mixed-use centers of commercial, office and mixed residential	Eight mixed-use centers of commercial, office and mixed residential
Loma Vista Specific Plan Area Generally bounded by Bullard, Dakota, Locan and McCall	Ag and rural to high density residential	Four master planned communities which includes high and very high density residential and mixed use/business campus use	Four master planned communities which includes high and very high density residential and mixed use/business campus use
Harlan Ranch Area east of DeWolf Bounded by Shepherd, SR 168 and DeWolf	Generally low density residential	A mix of low, medium, medium high, and high density residential	A mix of low, medium, medium high, and high density residential
Blackstone Corridor	Little new growth	Growth from Shaw to Downtown	Growth from Audubon to Downtown
Fresno Urban Form Areas Scattered throughout Fresno particularly along major corridors	No increased densities	10 square miles of infill and density intensification	26 square miles of infill and revitalization in activity centers and intensity corridors
Clovis - 5 square miles Scattered throughout Clovis	No increased densities	No increased densities	Density increases of 20-75%
Thirteen smaller cities	General plan uses at time of baseline development	Recent density increases in general plans	Recent density increases in general plans

Scenario Modeling Results

Due to the lack of a consistent methodology for calculating inter-regional trips as recommended by the RTAC, Fresno COG provides 3 versions of modeling results for the 3 scenarios studied using 3 different approaches to calculate inter-regional trips, as described in the Inter-Regional Trips section. The internal land use and transportation measures remain the same in the 3 scenarios. The results are also tabulated for before and after the EMFAC post-processor was applied to reflect the vehicle efficiency and low carbon fuel measures.

Approach 1: Reporting all VMT within Fresno County boundaries minus through trips

Table 11
VMT from Cars and Light Trucks (LDA, LDT1, LDT2 & MDV) in thousands

		2005		2020		2035
Baseline		15,402		19,327		24,550
Alternative 1				18,523		23,765
Alternative 2				18,374		23,735

Table 12
Total GHG Emissions (tons/day)

Before post-processor						
		2005		2020		2035
Baseline		7,210.01		8,904.93		11,352.47
Alternative 1				8,510.39		10,931.85
Alternative 2				8,458.57		10,929.47
After post-processor						
		2005		2020		2035
Baseline		7,210.01		6,527.04		7,310.82
Alternative 1				6,238.24		7,040.04
Alternative 2				6,200.31		7,038.51

Table 13
Per Capita GHG (pounds/day)

Before post-processor						
		2005		2020		2035
Baseline		16.07		15.74		16.00
Alternative 1				15.04		15.409
Alternative 2				14.95		15.406
After post-processor						
		2005		2020		2035
Baseline		16.07		11.54		10.31
Alternative 1				11.03		9.923
Alternative 2				10.96		9.921

Table 14
Percent Per Capita Reduction against 2005

Before post-processor						
		2005		2020		2035
Baseline				-2.04%		-0.41%
Alternative 1				-6.38%		-4.10%
Alternative 2				-6.95%		-4.12%
After post-processor						
		2005		2020		2035
Baseline				-28.20%		-35.87%
Alternative 1				-31.37%		-38.24%
Alternative 2				-31.79%		-38.26%

Approach 2: Reporting VMT from internal travel and 50% of IXXI trips. Inter-regional trips are limited to traveling within the San Joaquin Valley.

Table 15
VMT from Cars and Light Trucks (LDA, LDT1, LDT2 & MDV) in thousands

		2005		2020		2035
Baseline		15,843		19,909		25,309
Alternative 1				19,037		24,491
Alternative 2				18,902		24,467

Table 16
Total GHG Emissions (tons/day)

Before post-processor						
		2005		2020		2035
Baseline		7,458.23		9,236.43		11,772.38
Alternative 1				8,813.74		11,337.96
Alternative 2				8,765.10		11,336.54
After post-processor						
		2005		2020		2035
Baseline		7,458.23		6,769.66		7,581.14
Alternative 1				6,460.25		7,301.47
Alternative 2				6,424.65		7,300.56

Table 17
Per Capita GHG (pounds/day)

Before post-processor						
		2005		2020		2035
Baseline		16.62		16.33		16.59
Alternative 1				15.58		15.981
Alternative 2				15.49		15.979
After post-processor						
		2005		2020		2035
Baseline		16.62		11.97		10.69
Alternative 1				11.42		10.292
Alternative 2				11.36		10.291

Table 18
Percent Per Capita Reduction against 2005

Before post-processor						
		2005		2020		2035
Baseline				-1.77%		-0.17%
Alternative 1				-6.27%		-3.85%
Alternative 2				-6.78%		-3.86%
After post-processor						
		2005		2020		2035
Baseline				-28.01%		-35.71%
Alternative 1				-31.30%		-38.08%
Alternative 2				-31.67%		-38.09%

Approach 3: Reporting VMT from internal travel and 50% of IXXI trips. Inter-regional trips reported in this approach are traveling between Fresno County and the rest of the state.

Table 19
VMT from Cars and Light Trucks (LDA, LDT1, LDT2 & MDV) in thousands

		2005		2020		2035
Baseline		17,548		22,048		28,333
Alternative 1				21,177		27,515
Alternative 2				21,041		27,491

Table 20
Total GHG Emissions (tons/day)

Before post-processor						
		2005		2020		2035
Baseline		8,296.94		10,280.21		13,438.03
Alternative 1				9,857.57		13,219.43
Alternative 2				9,808.32		12,998.24
After post-processor						
		2005		2020		2035
Baseline		8,296.94		7,533.59		8,653.39
Alternative 1				7,224.21		8,519.21
Alternative 2				7,188.17		8,370.26

Table 21
Per Capita GHG (pounds/day)

Before post-processor						
		2005		2020		2035
Baseline		18.49		18.17		18.94
Alternative 1				17.42		18.634
Alternative 2				17.34		18.322
After post-processor						
		2005		2020		2035
Baseline		18.49		13.32		12.20
Alternative 1				12.77		12.008
Alternative 2				12.71		11.798

Table 22
Percent Per Capita Reduction against 2005

Before post-processor						
		2005		2020		2035
Baseline				-1.72%		2.44%
Alternative 1				-5.76%		0.77%
Alternative 2				-6.23%		-0.91%
After post-processor						
		2005		2020		2035
Baseline				-27.98%		-34.03%
Alternative 1				-30.94%		-35.06%
Alternative 2				-31.28%		-36.19%

Implication and Issues with Different Approaches of Representing Inter-regional Trips in the Target

As shown above, with the internal land use and transportation measures remaining the same in the scenarios, percent per capital GHG reductions vary, especially in 2035, by using different approaches of representing inter-regional trips. If either Approach 1 or 2 is chosen to represent the target, and in 2012 the new statewide model produces inter-regional trips number similar to Approach 3, Fresno will not be able to meet the target even if the land use and transportation measures stay the same in the SCS as in the recommended target scenario. If Approach 3 is chosen for the target, and the 2012 statewide model produce inter-regional trips number similar to Approach 1 or 2, then Fresno region, in 2035, could rely on baseline scenario to achieve the target as in the recommended Alternative 1.

Due to the uncertainty of the inter-regional trips methodology, it is recommended that the proposed targets be re-configured (only the inter-regional trips portion) when new inter-regional trips are available from the new statewide model, and the SCS will be developed to meet the revised target. If the new statewide model is not available until after SCS, then the inter-regional trips used in the recommended target should be also applied in the SCS process so local land use would not fall victim to the uncertain inter-regional trip issues.

Target Recommendation

During its meeting in April 2010, the Task Force unanimously selected Alternative 1 as the scenario for use in target-setting.

Based on the modeling results, the Alternative 1 scenario represents a combination of land use and transportation measures, consistent with the Fresno Blueprint, upon which to base an ambitious and achievable GHG emissions reduction target for this region. As stated before, Alternative 1 contains some elements such as the Southeast Growth Area (SEGA) plan and some corridor intensification plans that have not been fully studied or adopted.

Alternative 1 represents an ambitious and achievable scenario consistent with what the local market requires. In the on-going Fresno Public Transportation Infrastructure Study (PTIS), the consultant Strategic Economics concluded that Fresno has and will continue to have a low market demand to support transit-oriented development (TOD) with compact development and mixed uses:

> *"Compared to the United States, Fresno has a much higher share of family households with children. Fresno County households tend to earn lower median incomes on average, and are less likely to live alone. These demographic characteristics do not generate a significant share of conventional demand for TOD."*

Alternative 2 would require even more substantive modification of existing General Plans to achieve the higher densities, and is not yet supported by market based demand information to establish their ability to be implemented.

Although CARB had indicated during a special March 2010 meeting with the Task Force members that the cities would not be held to the land use scenarios developed during the target-setting process in the Sustainable Community Strategy (SCS) development in the 2014/2015 Regional Transportation Plan (RTP), the Task Force expressed serious concerns about the potentially inappropriate use of the specific land use information used to develop the individual scenario model runs. Since the emissions reduction targets are being developed in advance of the plans required under SB 375, and in advance of general plan updates under way or planned in the two major cities of the county, the task force did not want to preempt the full and complete development of those planning processes.

The task force also expressed strong concerns about other agencies or individuals taking the information and seeking to use it in ways not intended. During the March 2010 ARB/Fresno Task Force meeting, ARB staff stated that detailed land use information was not required in the target-setting documentation. For these reasons the task force recommended that no location-specific land use information, such as TAZ (traffic analysis zone) level spreadsheet or maps, be included in the target-setting document to CARB.

On April 16, the Transportation Technical Committee (TTC) and Policy Advisory Committee (PAC) approved Alternative 1 as the target scenario, and subsequently on April 29, the Policy Board approved the recommendation and instructed COG staff to submit the recommended target to CARB.

The recommended targets are presented in Table 23.

Table 23
Recommended GHG Emission Reduction Targets
for the Fresno MPO Region

		2020 Percent Per-Capita GHG Reduction from 2005	2035 Percent Per-Capita GHG Reduction from 2005
Approach 1: Reporting all VMT within Fresno County boundaries minus through trips			
	Before post-processor	-6.38%	-4.10%
	After post-processor	-31.37%	-38.24%
Approach 2: Reporting VMT from internal travel and 50% IXXI trips. Inter-regional trips are limited to traveling within the San Joaquin Valley.			
	Before post-processor	-6.27%	-3.85%
	After post-processor	-31.30%	-38.08%
Approach 3: Reporting VMT from internal travel and 50% IXXI trips with. Inter-regional trips reported in this approach are traveling between Fresno County and the rest of the state.			
	Before post-processor	-5.76%	0.77%
	After post-processor	-30.94%	-35.06%

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Appendix I

Report

FRESNO COG TDF MODEL: 4D PROCESSOR & SUPPORT

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May 2010

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. EXECUTIVE SUMMARY

This report documents the process used to develop estimates of greenhouse gas (GhG) emissions for the purpose of Senate Bill 375 target setting. To properly analyze land use alternatives, 4D model enhancements were necessary to improve the Fresno COG Travel Demand Forecasting Model's sensitivity to the four Ds of Smart Growth: Density, Diversity, pedestrian Design, and access to Destinations. The 4D enhancements allow the model to identify vehicle trip and VMT differences between land use scenarios to calculate changes in vehicles miles of travel (VMT) and GhG emissions as a result of implementing smart growth principles within the County.

FRESNO COG TDF MODEL

The Fresno COG TDF model is a four-step model for Fresno County with a 2003 base year and 2030 future year scenario. The model was built on a Cube/Voyager platform and includes trip generation, trip distribution, mode choice, and trip assignment steps. The model uses socioeconomic data as a factor in determining trip generation and trip distribution. For the purposes of SB 375 analysis, a 2005 base year was developed. Because the current economic climate has delayed new home construction for several years, buildout of the land use anticipated by 2030 year was assumed to have been delayed until 2035.

INTRODUCTION TO THE DS

The 4Ds represent Smart Growth principles that can affect travel behavior. The 4Ds are:

*Net Residential and Employment **D**ensity* – Denser developments generate fewer vehicle-trips than less dense developments.

*Jobs/Housing **D**iversity* – Having residences and jobs in close proximity will reduce the vehicle-trips generated by each, allowing some trips to be made using non-motorized transportation.

*Walkable **D**esign* – Many pedestrian and bicycle improvement projects are based on the assumption that improving the walking and bicycling environment will result in more non-auto trips and a reduction in auto travel.

***D**estination Accessibility* – Households situated near the regional center of activity generate fewer automobile trips and VMT than households located far from destination centers.

ELASTICITY SYNTHESIS AND RECOMMENDATIONS

We reviewed regional and national empirical research on the effects of smart growth development on travel behavior to develop elasticity values for the 4Ds. Elasticity values represent the observed changes in vehicle trips (VT) and vehicle miles traveled (VMT) as a result of changes to the built environment. Based on information from the 4D synthesis we selected elasticity values that would represent realistic changes in VT and VMT for the characteristics of Fresno County.

INITIAL SENSITIVITY TESTS

We ran four sets of sensitivity tests to determine the unmodified model's sensitivity to changes to the Ds. We found that the model was not adequately sensitive to Density or Diversity, but was sensitive to changes in Destination accessibility. The model's structure did not lend itself to testing for changes in Design. Based on the results of the sensitivity, we determined that we needed to apply the elasticity values to changes in Density, Diversity, and Design through model enhancements, but that elasticity values did not need to be applied to changes in Destination since the model already captured the associated trip reductions.

INTEGRATION OF 4D PROCESS INTO FRESNO COG TDF MODEL

We developed a script that identifies traffic analysis zones (TAZs) with changes to the Ds and applies appropriate elasticity values to the trip matrices for these TAZs. This process has been added to the full model run script after the Mode Choice component and before the Trip Assignment component. The process reads in the pre-D reduction trip matrices and applies elasticity values to the TAZs that have improvements in Density and Diversity. The resulting vehicle trips for that TAZ are modified, and this model step outputs an adjusted trip matrix which it then used in the Trip Assignment step. Since detailed site planning has not been done for most future growth, a uniform assumption was made that wherever Density and Diversity were being improved, Design was also being improved above the regional average. When actual street layouts and sidewalk coverage is determined, it will be possible to more precisely capture the effects of walkable Design.

POST-D SENSITIVITY TESTS

After integrating the D process into the model script, we ran the sensitivity tests again to determine whether the model was now sensitive to changes in density and diversity. With the process imbedded into the model script, the model is now sensitive to changes to the density and diversity Ds in addition to its existing sensitivity to regional destination.

COMPARISON OF PREFERRED ALTERNATIVE TO RTP ALTERNATIVE

With the D process integrated into the model, we compared the land use alternatives for Fresno County (Alternative 1 and Alternative 2) to the RTP (Base scenario).

2. FRESNO COG TRAVEL DEMAND FORECASTING MODEL

The Fresno COG Travel Demand Forecasting (TDF) model for Fresno County has evolved over time, with several updates. The most recent model was updated by Dowling Associates, Incorporated using the Cube/Voyager software program and released in 2009. It is a four step model, consisting of trip generation, trip distribution, mode choice, and trip assignment components.

The first step of the Fresno COG model is trip generation, which is completed in a Microsoft Excel spreadsheet. In this step, trip productions and attractions are calculated for each TAZ based on the land uses within that TAZ. The output of this step is the number of trip production and attractions by trip purpose (home-base-work, home-based-shopping, home-base-other, work-based-other, and other-based-other) for each TAZ.

In the trip distribution step distributes the trips produced by each TAZ throughout the model area. Friction factors, which identify the likelihood of a trip based on travel time, are used in determining the match of trip origins to trip destinations. Trip matrices, matrices which identify the number of trips going to each origin and destination, are produced as an output of this step.

The mode choice component of the model specifies which mode of travel each pair trip will use: walking, bicycling, transit, and driving (drive alone, carpooling with two people, or carpooling with three or more people). It takes into account factors such as auto operating cost, vehicle travel time, walking time to transit, waiting time for transit, and transit fares. The resulting outputs are an updated set of trip matrices by trip purpose that are separated by the different transportation modes.

The final model step is trip assignment. The trip matrices from the mode choice are read into the model and then the trips are assigned to the roadway network. The trip matrices themselves are limited to having the origin TAZ and destination TAZ. The assignment step is therefore used to determine routing, based on factors such as speed, congestion, and distance. Once this is completed, the number of trips for each roadway link is calculated.

Sensitivity tests were undertaken to identify whether the model did respond to the Ds, and if this were not the case, then it would be necessary to enhance the model to do so. The remainder of this report summarizes the Ds, identifies how the Ds would affect the anticipated results, compare the current model to anticipated results, and identify how to enhance the model to account for the Ds.

3. INTRODUCTION TO THE DS

The literature on neighborhood characteristics that affect trip generation is constantly evolving and additional variables that affect travel behaviors are being investigated. The variables described below define key land use and development characteristics that can be tied to a particular geographic area and that have been shown (via analysis of travel surveys and other empirical research) to affect trip-making and mode choice. These are suitable to be addressed in a regional TDF model.

*Net Residential and Employment **D**ensity* – Density is defined as the amount of land use within a certain (measurable) area, or how intense the development is within a confined area. This variable is measured in dwelling units or employment per acre. A wide body of research suggests that, all else being equal, denser developments generate fewer vehicle-trips per dwelling unit than less dense developments. Change in density is measured according to the following formula:

Change in Density = *Percent Change in [(Population + Employment) per Square Mile]*

*Jobs/Housing **D**iversity* – Diversity is the land use mix within a particular area, whether it be a homogenous residential neighborhood or a mixed-use area with apartments perched atop ground-floor retail. Research suggests that having residences and jobs in close proximity will reduce the vehicle-trips generated by each, by allowing some trips to be made on foot or by bicycle. This variable measures how closely the neighborhood in question matches the "ideal" mix of jobs and households, which is assumed to be the ratio of jobs to households measured across the region as a whole. Change in diversity is measured using the following formula:

Change in Diversity *= Percent Change in {1-[ABS(b*population – employment)/(b*population+employment)]}*
Where: ABS = absolute value; b= regional employment/regional population

*Walkable **D**esign* – Design is an indicator for the accessibility for pedestrians and bicyclists to access a given area. Many pedestrian and bicycle improvement projects are based on the assumption (supported by some research findings) that improving the walking/biking environment will result in more non-auto trips and a reduction in auto travel. The difficulty with using this variable in an equation is that there are many factors that influence the pedestrian experience and it is difficult to identify a single definition that captures them all. In any case, the walkable design variable, when isolated, usually has the weakest influence on the overall adjustment of the D variables; though it also seems to have important synergistic effects in conjunction with density and diversity. Change in design is measured as a percent change in design index.

Design Index *= 0.0195 * street network density + 1.18 * sidewalk completeness + 3.63 * route directness*

***D**estination Accessibility* – Accessibility is an indicator of a location's proximity to major destinations and access to those locations. Research shows that, all else being equal, households situated near the regional center of activity generate fewer auto trips and VMT than households located far from destination centers. When comparing different potential sites for the same type of development, this variable is very important. This variable can be quantified by estimating the total travel time to all destinations/attractions. Sensitivity to variations in regional accessibility is a characteristic of most calibrated and validated TDF models. Changes in destination accessibility are measured follows:

Destinations (accessibility) *= Percent Change in Gravity Model denominator for study TAZs "I" :*
*Sum[Attractions (j) * Travel Impedance(I,j)] for all regional TAZs "j"*

4. ELASTICITY SYNTHESIS

D ELASTICITY VALUES

An elasticity is the percentage change in one variable that results from a percentage change in another variable. The D elasticities are defined to reflect the percentage change in vehicle trips or vehicle miles of travel given a percentage change in density, diversity, design, and regional destination location. A minus (-) in front of an elasticity number indicates a reduction in VT or VMT; otherwise, the elasticity identified increases with the increase of a D variable.

SOURCES OF D ELASTICITY VALUES

We consulted four sources to identify elasticity ranges used, as described below:

- Ewing, Reid and Robert Cervero (2009). Travel and the Built Environment – A Meta-Analysis.[1]
- U.S. Environmental Protection Agency (2001). Index 4D Method.
- 2009 4D Analysis of SACOG Household Travel Survey 4D Analysis
- San Joaquin COG 4D Model Enhancements (2009). Prepared by Fehr & Peers.

Travel and the Built Environment

This report provides a meta-analysis of 4D elasticities used in over 50 planning studies. Studies included in the analysis were chosen because they had good sample sizes, controlled statistically for confounding influences on travel behavior, assessed statistical significance, and used disagreggated data (or data aggregated at a very local level) to analyze elasticity. The studies provided analysis on smart growth variables throughout the United States; some studies focused on a small selection of neighborhoods within a city, while others looked at changes in travel behavior within a larger region.

This synthesis provides elasticity ranges for each D variable based on a review of the published studies, which are provided in Table 1.

Index 4D Method

This document was prepared by Criterion Planners/Engineers and Fehr & Peers for the US EPA, and provides a national synthesis for 4D elasticities. Elasticities were derived for 27 studies published between 1991 and 1999 regarding smart growth and travel behavior, which covered local, regional, and national data. Elasticities were then synthesized for each D. The Index 4D provided elasticities for both vehicle trips (VT) and vehicle miles traveled (VMT). This information is provided in Table 2.

1. The final version of this report will be published in the Journal of the American Planning Association (Summer 2010).

TABLE 1:
ELASTICITIES FROM META-ANALYSIS OF PLANNING STUDIES

D variable	Number of Studies	VMT Elasticity Range
Density	25	-0.12 - 0.25
Diversity	22	-0.11 - 0.05
Design	16	-0.29 - 0.00
Destination	22	-0.27 - 0.06

Note: Elasticities included are limited to studies included in meta-regression.
Source: Ewing (2009), Fehr & Peers, 2010

TABLE 2:
ELASTICITIES FROM INDEX 4D

D variable	VT Elasticity	VMT Elasticity
Density	-0.043	-0.035
Diversity	-0.051	-0.032
Design	-0.031	-0.039
Destination	-0.036	-0.204

Source: US EPA (2001), Fehr & Peers, 2010

4D Analysis SACOG Household Travel Survey

In 2000-2002, Fehr & Peers and the Sacramento Council of Governments (SACOG) conducted preliminary research on the relationships between the built environment and travel survey data in the Sacramento region. In 2009, we enhanced this data with additional 4D survey information. Elasticities were derived from the travel survey information by trip purpose in addition to types of density, diversity, design, and destinations. A summary of VT and VMT elasticity ranges from this analysis are provided in Table 3.

San Joaquin COG 4D Model Enhancements

Fehr & Peers recently completed model enhancements to the San Joaquin Council of Governments' Travel Demand Forecasting Models to improve 4D sensitivity. For this project, we used data and equations from the Index 4D National Synthesis to derive vehicle trip elasticities for density, diversity, and design). It should also be noted that, for this model enhancement project, the model was not enhanced to modify the VMT elasticities – it was modified only to be sensitive to the VT elasticities. This information is provided in Table 4.

TABLE 3: ELASTICITIES FROM SACOG HOUSEHOLD TRAVEL SURVEY ANALYSIS		
D variable	**VT Elasticity Range**	**VMT Elasticity Range**
Density	-0.339 - -0.117	-0.444 - -0.133
Diversity	-0.059 - -0.044	-0.459 - -0.160
Design	-0.032 - 0.000	-0.032 - 0.000
Destination	-0.0822 - -0.041	-1.405 - -1.234
Source: SACOG Household Travel Surveys (2000-2002), Fehr & Peers, 2010		

TABLE 4: ELASTICITIES FROM SJCOG 4D MODEL ENHANCEMENTS	
D variable	**VT Elasticity**
Density	-0.04
Diversity	-0.06
Design	-0.02
Source: Fehr & Peers, 2010	

SYNTHESIS OF 4D ELASTICITIES

We summarized the elasticities from the four sources previously described to provide VT and VMT elasticity ranges that can be applied to the Fresno COG TDF model, shown in Table 5. As shown in this table, there are wide ranges in the elasticities derived between the four studies.

Additionally, we have found that 4D elasticities are not valid for extremely large changes in the 4D variables. For example if a zone is redeveloped from 1 unit per ten acres to one unit per acre, this is a nominal increase of 1000 percent, but one would not expect a 40% drop in vehicle trip generation implied by a -4% elasticity, since the area would still be fundamentally low density and auto-oriented. In view of this we recommend “ceiling and floor” values be applied when calculating large changes in D variables; these values are identified in Table 6.

TABLE 5:
SUMMARY OF ELASTICITY RANGES

D variable	VT Elasticity Range	VMT Elasticity Range
Density	-0.339 to -0.043	-0.444 to 0.25
Diversity	-0.059 to -0.044	-0.459 to 0.05
Design	-0.032 to 0.000	-0.29 to 0.00
Destination	-0.0822 to -0.020	-1.405 to 0.06

Source: Fehr & Peers, 2010

TABLE 6:
FLOOR AND CEILING VALUES FOR MAJOR CHANGES IN 4D VARIABLES

D variable	Minimum	Maximum
Change for ANY variable	-80%	500%
Change in trip generation related to ANY single D variable	-30%	30%
Change in TAZ trip generation for ALL D variables	-25%	25%

Source: Fehr & Peers, 2010

We would also note that when applying elasticity values, we used a regional average for TAZs whose D values are lower than the regional average. This is done so that a TAZ with little land use can still be sensitive to the Ds if it were to become dense or diverse compared to the regional average.

RECOMMENDED ELASTICITY VALUES

When selecting appropriate elasticity values, it is important to consider the locational context and existing travel behavior. Although changing land use according to smart growth principles affects travel behavior, there are other factors, such as job types and the regional built form that will also have an impact on how and where trips are made. While placing office buildings near residents can change the travel behavior for office workers, an agricultural employee's travel behavior would not change since the location of that job type is location-specific. Likewise, an existing urban center may show smaller changes in travel behavior with the implementation of the 4Ds since residents may already be using alternative transit modes. Therefore, it is important to be cognizant of Fresno County's employment profile – in which many employees work in location-specific natural resource industries – and select an elasticity value that would reflect foreseeable changes in travel behavior.

The San Joaquin COG elasticity values were recommended for use in the 4D model enhancement, since the urban form and travel characteristics in this area are most representative of those in Fresno County. Like

Fresno County, San Joaquin County is located in California's Central Valley, with substantial employment in agricultural and natural resources industries. The San Joaquin COG elasticity values were refined values from the Index 4D study, which provided extensive empirical research. In addition to confidence in the accuracy of the elasticity values for inclusion in the Fresno COG 4D enhancements; we also believe that it is beneficial to be consistent with other Central Valley MPOs.

5. INITIAL SENSITIVITY TESTS

Before applying elasticity values to the model, we conducted sensitivity tests to determine whether the model was already sensitive to 4D changes. Our initial review of the model documentation and structure did not indicate any built-in sensitivity to the Ds, so the sensitivity tests were applied to confirm that the model was not already sensitive to the smart growth principles.

The model is structured such that tests could be conducted for determining the model's sensitivity to density, diversity, and destination. However, since the model does not include pedestrian design factors, such as sidewalk completeness, it was not possible to conduct a design test. We conducted four sensitivity tests to test the three aforementioned "Ds": infill diversity, diversity in a select area, balanced land use (diversity), and change in regional destination. For the select diversity and balanced land use tests, we conducted multiple versions of the test to provide additional confidence that the tests were representative of the model as a whole and not an outlier.

MODEL TEST #1 – UNIFORM CHANGES IN DENSITY IN ALL TAZS

This test was conducted to evaluate the model's sensitivity to **density**. This variable is measured in dwelling units or employment per acre. A wide body of research suggests that, all else being equal, denser developments generate fewer vehicle-trips per dwelling unit than less dense developments.

For this particular test, uniform changes in density were applied throughout the model. This would create an "infill" scenario for Fresno County, whereby the land use in each TAZ is increased by the same percentage. We increased each land use category by 10%, so as not to disrupt the existing balance of land uses.

To conduct this test, we modified the following inputs in the land use (FC03_ZoneData.TXT) file by increasing them by 10%:

- Single family dwelling units (zero-, one-, and two or more-vehicle)
- Multi-family dwelling units (zero-, one-, and two or more-vehicle)
- Retail employment
- Service employment
- Government employment
- Education employment
- Other employment

Table 7 identifies the land use changes to the base model and test model, in addition to changes to the model's vehicle trip and VMT outputs.

As shown in this table, a 10% increase in overall density resulted in a similar increase in vehicle trips. While VMT increased on a model-wide level, the proportional increase was less than that of vehicle trips. The increase in density reduced average trip length by 0.86%, indicating that the model is slightly sensitive to changes in density applied to the entire region. The increase in density also reduced vehicle trips per population by 0.02% and VMT per population by 0.88%. The next test was to determine if the model was sensitive at a scale more characteristic of land development plans, i.e., one or a few TAZs.

TABLE 7:
TEST #1: UNIFORM DENSITY INCREASE

LAND USE INPUTS

	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	8,516	48,461	125,977	15,762	38,546	23,956	34,656	107,484	30,852	36,886	121,399	830,721
Test 1 Model	9,369	53,337	138,627	17,344	42,409	26,333	38,101	118,258	33,948	40,579	133,537	910,899
Difference	853	4,876	12,650	1,582	3,863	2,377	3,445	10,774	3,096	3,693	12,138	80,178
% Difference	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

TRAVEL OUTPUTS

	Base Model	Test 1 Model	Difference	% Difference
VT (II, IX, XI)	2,208,362	2,420,917	212,555	9.63%
VMT (II, IX, XI)	14,343,038	15,588,587	1,245,549	8.68%
VMT / VT (Average Trip Length)	6.49	6.44	-0.06	-0.86%
VT / Population	2.66	2.66	0.00	-0.02%
VMT / Population	17.27	17.11	-0.15	-0.88%

Source: Fehr & Peers, 2010

MODEL TEST #2 – CHANGES IN DENSITY IN SELECTED TAZS

This test was conducted to measure the model's sensitivity to specific changes in development density. This was done by changing land uses within one specific area, rather than throughout the entire model.

We ran three versions of this test. In the first sensitivity test, we selected three adjacent TAZs in North Fresno (806, 808, and 809). For the second test we selected three TAZs near the SR 180 / SR 41 / SR 168 freeway connection (1066, 1067, and 1070). For our final test we selected three TAZs near downtown Fresno (1126, 1128, and 1129). The selected TAZs were already diverse in nature; by increasing every land use category individually, the original land use diversity mix was maintained.

We modified the following inputs in the land use (FC03_ZoneData.TXT) file by increasing them by 200%:

- Single family dwelling units (zero-, one-, and two or more-vehicle)
- Multi-family dwelling units (zero-, one-, and two or more-vehicle)
- Retail employment
- Service employment
- Government employment
- Education employment
- Other employment

After completing a model run for both the unmodified and modified versions of the 2003 model, we ran a select zone assignment script to calculate vehicle trips and VMT attributable to the test TAZs.

Tables 8-10 identify land use changes and results of these tests. Since in each case the test TAZ's percentage increase in VT and VMT is less than the percentage increase in land use, the model shows minor sensitivity to changes in density of specific TAZs. However, the increased TAZ density only slightly reduced the modeled vehicle trips per population. Overall, this data suggests that the model does now show adequate sensitivity to a change in select density. In ease test case, vehicle trips per capita remains almost unchanged, while the elasticity selected for the Density variable (0.04) suggests that vehicle trips per capita should drop -8 percent.

TABLE 8:
TEST #2A: DENSITY INCREASE IN NORTH FRESNO TAZS (806, 808, 809)

LAND USE INPUTS												
	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	33	197	790	30	138	84	67	1,495	0	178	274	3,304
Test 1 Model	99	591	2,370	90	414	252	201	4,485	0	534	822	9,911
Difference	66	394	1,580	60	276	168	134	2,990	0	356	548	6,607
% Difference	200%	200%	200%	200%	200%	200%	200%	200%	0%	200%	200%	200%

TRAVEL OUTPUTS				
	Base Model	Test 1 Model	Difference	% Difference
VMT (II, IX, XI)	118,733	338,038	219,306	184.71%
VT Interzonal	23,474	69,697	46,224	196.92%
VT Intrazonal	140	1,139	1,000	714.75%
VMT / Population	35.94	34.11	-2	-5.10%
VT / Population	7.15	7.15	0	-0.01%

Source: Fehr & Peers, 2010

TABLE 9:
TEST #2B: DENSITY INCREASE IN CERTAIN TAZS (1066, 1067, 1070)

LAND USE INPUTS

	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	79	380	676	179	382	146	127	1,193	526	357	98	5,401
Test 1 Model	237	1,140	2,028	537	1,146	438	381	3,579	1,578	1,071	294	16,203
Difference	158	760	1,352	358	764	292	254	2,386	1,052	714	196	10,802
% Difference	200%	200%	200%	200%	200%	200%	200%	200%	200%	200%	200%	200%

TRAVEL OUTPUTS

	Base Model	Test 1 Model	Difference	% Difference
VMT (II, IX, XI)	146,526	419,520	272,993	186.31%
VT Interzonal	30,549	90,866	60,317	197.44%
VT Intrazonal	171	1,392	1,222	715.66%
VMT / Population	27.13	25.89	-1	-4.56%
VT / Population	5.69	5.69	0	0.11%

Source: Fehr & Peers, 2010

TABLE 10:
TEST #2C: DENSITY INCREASE IN DOWNTOWN TAZS (1126, 1128, 1129)

LAND USE INPUTS

	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	44	144	175	54	106	50	83	535	51	114	287	1,708
Test 1 Model	132	432	525	162	318	150	249	1,605	153	342	861	5,124
Difference	88	288	350	108	212	100	166	1,070	102	228	574	3,416
% Difference	200%	200%	200%	200%	200%	200%	200%	200%	200%	200%	200%	200%

TRAVEL OUTPUTS

	Base Model	Test 1 Model	Difference	% Difference
VMT (II, IX, XI)	60,829	178,367	117,538	193.23%
VT Interzonal	11,012	32,880	21,868	198.58%
VT Intrazonal	33	278	246	750.52%
VMT / Population	35.61	34.81	-1	-2.26%
VT / Population	6.47	6.47	0	0.07%

Source: Fehr & Peers, 2010

MODEL TEST #3 – OPTIMIZING LAND USE MIX (DIVERSITY) OF A SINGLE TAZ

Model Test 3 is a test for Diversity. Research suggests that having residences and jobs in close proximity will reduce the vehicle-trips generated by each, by allowing some trips to be made on foot or by bicycle. This variable measures how closely the neighborhood in question matches the "ideal" mix of jobs and households, which is assumed to be the ratio of jobs to households measured across the region as a whole.

To verify that the model was not already sensitive to the change in diversity, since documentation did not identify any inherent sensitivity, we developed a test to measure changes in vehicle trips by balancing land use to an optimal mix of commercial and residential land uses. A change in the ratio of internal trips to external trips would indicate that the model is sensitive to changes in diversity. If an area is mixed-use in nature, a sensitive model would internalize a greater percentage of trips compared to an area that has only one type of land use. This is because in a mixed-use area, a resident could potentially work and shop within his immediate vicinity while in a homogenous area the resident would need to travel outside of the TAZ to work or shop.

We conducted two different sets of this test. In the first set, we selected TAZ's that had only employment and optimized the diversity by adding residences; in the second set we selected TAZ's that had only residences and optimized diversity by adding employment.

Employment-only TAZs (added residences):

- TAZ 779 (North Fresno / Blackstone)
- TAZ 881 (Highway City)
- TAZ 1490 (South Fresno / Calwa)

Residential-only TAZs (added employment):

- TAZ 562 (North Clovis)
- TAZ 1120 (near Roeding Park)
- TAZ 1404 (Los Palmas)

The 2003 model's employment: household ratio is 1.27; therefore, we added either employment or households to each TAZ such that the employment: household ratio matched the model as a whole.

To determine changes in trip types, we used the assignment trip matrices to determine how many trips both originated and terminated in the test TAZ, and how many vehicle trips left the TAZ. Tables 11-13 identify land use changes and results.

As indicated in Tables 11-16, the model shows some sensitivity to changes in diversity. Although few trips are internalized with the inclusion of balanced land uses, the ratio of internal-to-external trips increased as diversity improved. The model is gravity-based and was developed such that it would model actual traffic patterns in the area, and it would be unrealistic to assume that everyone living next door to an office park or factory would work at that location. Thus, internal trip rates generally reflect only a small portion of all trips. However, despite the model's sensitivity to diversity changes, the percentage of internal trips with balanced land use is still lower than would be expected based on empirical research.

TABLE 11:
TEST #3A: DIVERSITY INCREASE IN ZONE 779

LAND USE INPUTS

	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	0	0	0	0	0	0	256	103	0	0	14	1
Test 1 Model	10	55	142	18	43	27	256	103	0	0	14	938
Difference	10	55	142	18	43	27	0	0	0	0	0	937

TRAVEL OUTPUTS

	Base Model	Test 1 Model	Difference	% Difference
VT Interzonal	5,523	7,367	1,844	33.39%
VT Intrazonal	18	32	14	77.79%
Internal Trips as Percent of Total Trips	0.33%	0.43%	N/A	N/A

Source: Fehr & Peers, 2010

TABLE 12:
TEST #3B: DIVERSITY INCREASE IN ZONE 881

LAND USE INPUTS												
	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	0	0	0	0	0	0	45	70	0	0	35	0
Test 1 Model	4	22	57	7	17	11	45	70	0	0	35	376
Difference	4	22	57	7	17	11	0	0	0	0	0	376

TRAVEL OUTPUTS				
	Base Model	Test 1 Model	Difference	% Difference
VT Interzonal	1,426	2,189	762	53.45%
VT Intrazonal	2	5	3	125.71%
Internal Trips as Percent of Total Trips	0.14%	0.23%	N/A	N/A

Source: Fehr & Peers, 2010

TABLE 13:
TEST #3C: DIVERSITY INCREASE IN ZONE 1490

LAND USE INPUTS												
	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	0	0	0	0	0	0	85	60	0	0	242	4
Test 1 Model	10	57	147	18	45	28	85	60	0	0	242	970
Difference	10	57	147	18	45	28	0	0	0	0	0	966

TRAVEL OUTPUTS				
	Base Model	Test 1 Model	Difference	% Difference
VT Interzonal	2,541	4,379	1,838	72.31%
VT Intrazonal	6	17	11	207.09%
Internal Trips as Percent of Total Trips	0.24%	0.39%	N/A	N/A

Source: Fehr & Peers, 2010

TABLE 14:
TEST #3D: DIVERSITY INCREASE IN ZONE 562

LAND USE INPUTS												
	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	0	3	27	0	1	1	0	0	0	0	0	99
Test 1 Model	0	3	27	0	1	1	4	13	4	5	15	99
Difference	0	0	0	0	0	0	4	13	4	5	15	0

TRAVEL OUTPUTS				
	Base Model	Test 1 Model	Difference	% Difference
VT Interzonal	252	571	319	126.54%
VT Intrazonal	0.34	2.81	2.47	726.47%
Internal Trips as Percent of Total Trips	0.13%	0.49%	N/A	N/A

Source: Fehr & Peers, 2010

TABLE 15:
TEST #3E: DIVERSITY INCREASE IN ZONE 1120

LAND USE INPUTS

	SFDU Detached			MFDU Attached			Employment					Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other	
Base Model	1	7	10	0	1	1	0	0	0	0	0	61
Test 1 Model	1	7	10	0	1	1	3	8	2	3	9	61
Difference	0	0	0	0	0	0	3	8	2	3	9	0

TRAVEL OUTPUTS

	Base Model	Test 1 Model	Difference	% Difference
VT Interzonal	124	318	194	156.65%
VT Intrazonal	0.01	0.07	0.06	600.00%
Internal Trips as Percent of Total Trips	0.01%	0.02%	N/A	N/A

Source: Fehr & Peers, 2010

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TABLE 16:
TEST #3F: DIVERSITY INCREASE IN ZONE 1404

LAND USE INPUTS											
	SFDU Detached			MFDU Attached			Employment				Population
	0 Auto	1 Auto	2+ Autos	0 Auto	1 Auto	2+ Autos	Retail	Services	Government	Education	Other
Base Model	5	32	23	6	8	7	0	0	0	0	0	371
Test 1 Model	5	32	23	6	8	7	11	33	10	11	38	371
Difference	0	0	0	0	0	0	11	33	10	11	38	0

TRAVEL OUTPUTS				
	Base Model	Test 1 Model	Difference	% Difference
VT Interzonal	633	1,402	769	121.58%
VT Intrazonal	0.20	1.34	1	570.00%
Internal Trips as Percent of Total Trips	0.03%	0.10%	N/A	N/A

Source: Fehr & Peers, 2010

MODEL TEST #4 – ACCESS REGIONAL DESTINATIONS

The final test that we conducted was for the sensitivity to access to regional Destinations**.** Research shows that, all else being equal, households situated near the regional center of activity generate fewer auto trips and VMT than households located far from destination centers. When comparing different potential sites for the same type of development, this variable is very important. This variable can be quantified by estimating the total travel time to all destinations/attractions.

Although model documentation did not identify any built-in sensitivity to this D, most calibrated models are sensitive to changes in destination accessibility. To verify this, we developed a test to measure changes in VMT and average trip lengths for a new TAZ. The TAZ would have a static set of land uses, but the location would differ between the activity center for Fresno County (e.g. downtown Fresno) and outer areas of the City. For this test we maintained the TAZ attributes for both tests to ensure that changes in VMT or trip lengths were not attributable to a change in a TAZs district.

We added TAZ 1726 and ran two iterations of the model. In the first run, TAZ 1726 was located in downtown Fresno. For the second run, TAZ 1726 was located in north Fresno, near Woodward Park.

After running the model, we ran the Select Zone assignment script to calculate VT and VMT specifically for TAZ 1726. This allowed us to extract the VT and VMT for trips traveling to or from TAZ 1726. Table 17 identifies the results of this test.

As shown in Table 17, the model is sensitive to access to regional destinations. With identical land use, the downtown location produced slightly fewer vehicle trips, likely a result of better access to public transit and walking. The VMT for the downtown TAZ was significantly less than the VMT for the north Fresno location. With better access to transit in addition to more destinations in the downtown area, residents of a city center are less likely to have to travel long distances to various attractions – such as work or shopping – whereas a resident of a suburb may work and shop in the city center, thus increasing VMT.

TABLE 17: TEST #4: REGIONAL DESTINATION			
TRAVEL OUTPUTS			
	Outskirts	**Downtown**	**Change (Downtown minus Outskirts)**
VT	8,403	8,306	-97 (-1.1%)
VMT	49,424	40,805	-8,619 (-17.4%)
VMT / VT (Average Trip Length)	5.88	4.91	-0.97 (-16.5%)
Source: Fehr & Peers, 2010			

SUMMARY OF SENSITIVITY TESTS

Our results of the sensitivity tests are as follows:

- The model shows some sensitivity to overall increases in density. The vehicle trip increases were proportionate to increases in land use, but the VMT increased at a lower rate than VT. As a result, the average trip length was reduced by 0.86%.
- The model shows some sensitivity to changes in density in selected TAZs. The directionality of the sensitivity is consistent with what would be expected, since VMT decreased; however, the directionality of change in average trip length was inconsistent across the different tests. The model is also not significantly sensitive to the effect of local density on trip generation.
- The model is sensitive to changes in diversity; with balanced land use, internal trips account for a slightly greater proportion of total trips. However, the percentage of internal trips within a TAZ with balanced land uses is still substantially lower than would be expected.
- The model is sensitive to destination accessibility. Although a TAZ in the downtown core has a similar number of vehicle trips compared to an identical TAZ in the city's outskirts, the average trip length is substantially lower for the downtown trips.

Based on the forgoing analysis, it was concluded that the model's sensitivity should be enhanced through an in-line model processor that accounts for changes in the Density and Diversity. Inspection of the model documentation and script revealed that there was no sensitivity to the Design measure; therefore this D characteristic should be included in the processor as well. The model does appear to the relative proximity to regional destinations, so no adjustments for this D characteristic appear warranted.

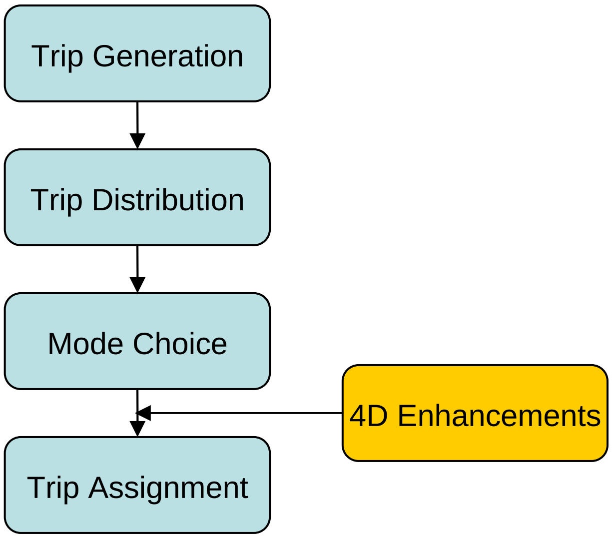
6. MODEL INTEGRATION

The sensitivity tests that were completed for the Fresno COG model indicated that the model was not adequately sensitive to changes in density and diversity, but showed appropriate levels of sensitivity to changes in destination accessibility. As a result, the model enhancement effort focused on improving the model's sensitivity to changes in density and diversity.

STRUCTURE OF MODEL ENHANCEMENTS

The 4D enhancement process was developed as a script that runs inline with the full Fresno COG model. The script was first tested as a stand-alone script and then integrated into the full model script. The 4D process occurs after the Mode Choice step and before Trip Assignment, as shown on Figure 1, below.

Figure 1: Model Steps



At this stage in the model process, trip matrices have been created by trip purpose and have been separated by mode choice: drive alone, shared ride (two person), shared ride (three person), transit (walk access), transit (drive access), walk, and bike. The trip matrices are separated into number of vehicle trips. Each trip matrix has an origin TAZ and a destination TAZ; the trip routing is determined in the trip assignment step.

As previously noted, the model elasticity values being used for the enhancements are consistent with the San Joaquin COG Model Enhancement elasticity values. The elasticity values and whether they are included in the enhancement efforts are identified in Table 18.

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TABLE 18: 4D ELASTICITIES		
D Variable	**Selected Elasticity (VT)**	**Embedded in Script?**
Density	-0.04	Yes
Diversity	-0.06	Yes
Design	-0.02	Yes
Destination	-0.04	No – model already sensitive
Source: Fehr & Peers, 2010		

SUMMARY OF LAND USE SCENARIO DEVELOPMENT

Fresno COG developed three scenarios for testing as part of their GhG target setting process; each scenario is tested in both 2020 and 2035:

- 2020 Baseline
- 2020 Alternative 1
- 2020 Alternative 2
- 2035 Baseline
- 2035 Alternative 1
- 2035 Alternative 2

The Baseline scenarios were developed from the currently adopted 2007 Regional Transportation Plan (RTP) and already include smart growth improvements in several areas. Alternative 1 and Alternative 2 were developed independently of, and contain smart growth improvements beyond, the Baseline scenario.

Typically, alternative scenarios for 4D analysis are developed starting with the baseline scenario's land use and changing TAZs only where smart growth is anticipated; differences in a TAZs density, diversity, and design are then calculated by comparing the alternative scenario's land use file to that of the baseline scenario. This methodology ensures that there are no unintentional differences between the baseline and the alternatives.

However, the land use for Alternative 1 and Alternative 2 was developed independently from the Baseline scenario land use. Initial review of the Baseline, Alternative 1, and Alternative 2 land use files revealed several unintentional differences in TAZ land use between the Baseline scenarios and the alternative scenarios. To accommodate for these differences, the Density and Diversity of different growth areas in Alternatives 1 and 2 were compared to the Density and Diversity of those same growth areas under baseline conditions. Reductions in vehicle trips due to the Ds were only assigned to TAZs in areas where changes in Density and Diversity were expected; scores for Density and Diversity were assigned to each TAZ outside of the inline processor. The inline processor used these scores to accordingly modify the trip matrices. Table 19 shows the areas for each studied scenario in which improved planning for Density and Diversity were expected.

TABLE 19:
TAZS WITH SMART GROWTH IMPROVEMENTS

Area	# of TAZs with Smart Growth Improvements		
	Baseline	Alternative 1	Alternative 2
Central Area	--	70	78
Clovis	--	--	23
Edison Community Plan	39	39	46
Fancher Creek	1	1	4
Firebaugh	--	4	4
Harlan Ranch	2	2	2
Loma Vista	2	2	2
Mendota	--	2	2
Midrise Highrise	--	26	22
Reedley	--	2	2
SEGA	19	19	20
Selma	--	1	1
Urban Form	--	49	59
West Area	63	63	65

Source: Fehr & Peers, 2010

INPUTS FOR 4D MODEL ENHANCEMENT

Many of the inputs needed to complete the 4D model enhancement are part of the unmodified Fresno COG model runs. These include:

- Roadway network – FCXX.net
- Land use file – FCXX_ZoneData.txt – an output of the trip generation spreadsheet
- Daily vehicle trip matrices – outputs from the Mode Choice step:
  - FCXX_VTrips_HW.mat
  - FCXX_VTrips_HS.mat
  - FCXX_VTrips_HO.mat
  - FCXX_VTrips_WO.mat
  - FCXX_VTrips_OO.mat

In addition to these files, a 4D data file (FCXX_TAZData.dbf) was created for each scenario that contains each TAZs density and diversity scores.

OUTPUTS FOR 4D MODEL ENHANCEMENT

The 4D process has several major outputs.

- Land use file – FCXX_ZoneData.dbf
- 4Ds summary spreadsheet – FCXX_ALT_Ds.dbf
- 4Ds adjustment summary spreadsheet – FCXX_VT_ADJ.dbf (located in the “MatrixTrips” folder)
- Daily vehicle trip matrices – outputs from the Mode Choice step:
  - FCXX_VTrips_HW_ADJ.mat
  - FCXX_VTrips_HS_ADJ.mat
  - FCXX_VTrips_HO_ADJ.mat
  - FCXX_VTrips_WO_ADJ.mat
  - FCXX_VTrips_OO_ADJ.mat
  - FCXX_VTrips_TOT_ADJ.mat

FCXX_ZoneData.dbf is a reproduction of FCXX_ZoneData.txt into .dbf format for easier processing. FCXX_ALT_Ds.dbf and FCXX_VT_ADJ.dbf are intermediary checks for quality assurance. The former file identifies the D adjustments for each TAZ, while the latter file identifies the vehicle trip reductions by TAZ.

We have updated the model script for the Trip Assignment step so that the input files read into this step are the adjusted trip matrices (FCXX_VTrips_HW_ADJ.mat, et cetera) rather than the trip matrix outputs from the Mode Choice step.

MODEL ENHANCEMENT PROCESS

The model enhancement process takes place in three major parts.

PART A – Defining Inputs, Calculating Ds, and Calculating Trip Adjustments

Before any calculations are made in the model, the user specifies the parameters for the 4D enhancement by identifying the number of TAZs and the names of the test and base scenarios. This portion of the script has been set for Fresno COG in evaluating the alternatives compared to the Baseline Scenario, but can be adjusted to test various scenarios.

Because of unintentional differences in TAZ land use between the Baseline scenarios and the alternative scenarios, Density and Diversity scores were calculated outside of the model script. The model script reads in these Density and Diversity scores and, based on the elasticities selected for use in this, calculated the trip adjustments expected for each TAZ.

Part B – Applying Trip Adjustments to Trip Matrices

Upon completing Part A, we have identified the vehicle trip adjustment factors for each TAZ by trip purpose. In Part B, adjustments are applied to the trip matrices that were created in the Mode Choice step of the full model run.

The trip matrices from the mode choice step and the D adjustment factors from Part A are read into the process. Overall floor and ceiling values are also defined at this time to ensure that the cumulative adjustment remains realistic with implementation of the Ds.

In applying the vehicle trip adjustments, first the change in vehicle trips is calculated by multiplying the adjustment factor by the unadjusted trips using the following formula:

Change in Trips = Unadjusted Trips x (Adjustment Factor-1)

If there is a trip reduction, the change in trips will be a negative. This value is then added to the unadjusted trip value to calculate the number of vehicle trips after D implementation. The product of this step is a set of working matrices that have adjusted trip values for automobile-based trips.

Overall floor and ceiling values are then applied to ensure that the change in overall vehicle trips is reasonable within the context of smart growth principles and research. Earlier in the enhancement process, we defined floor and ceiling values for a single D. But we also want to apply a floor and ceiling value to the overall change. For instance, if a TAZ changes greatly by becoming both very dense and very diverse, we do not want trip reductions to be reduced to an unrealistic level by compounding the adjustments from both Ds. We therefore calculate the adjusted trip volumes relative to the floor and ceiling values. In cases that the adjustments exceed the ceiling value or are below the floor value, the appropriate factor is applied. When the floor or ceiling values are not met, then the initial adjusted trip value is maintained. The floor and ceiling values selected for use were -25% and +25%.

7. FUTURE ENHANCEMENTS FOR MODEL APPLICATION

The purpose of the 4D Inline Processor is to provide sensitivity to local land use factor that affect travel choices. Most regional TDF models tend to have large TAZs. All the land is treated as being at a single point (the centroid); a TAZ with a dense development concentrated in one part of the TAZ is modeled the same as a TAZ with the same population spread evenly throughout its area even though for walking trips the two situations are completely different. Thus having information about the actual "on-the ground" density of developed areas – ideally parcel level data – would enhance the calculation of the Density variable.

Interactions between different non-residential land uses (e.g. offices and restaurants) can also be enhanced with more refined land use data – ideally parcel-based. For example, retail tends to be treated as a single category, but some types of retail (restaurants and convenience stores) are located near other employment specifically to increase interaction. More detailed information on land use and employment types – again ideally at the parcel level -- would enhance the calculation of the Diversity measures, and could facilitate additional measures of complementary land use mixing that can internalize trips and shift them to walk and bike.

The effect of design on travel choice is a function of the completeness and directness of pedestrian networks. Like most regional models, the COG model does not include information about sidewalks and other walkways, and many local streets and pathways used by pedestrians are not included in the network. While it is not realistic to include every link in a regional model, inclusion of information about the entire network would enhance the calculation of the Design variable.

8. COMPARISON OF ALTERNATIVES

ANALYSIS SCENARIOS

We received land use data from Fresno COG for three scenarios; each of which was tested in both 2020 and 2035:

- 2020 Baseline
- 2020 Alternative 1
- 2020 Alternative 2
- 2035 Baseline
- 2035 Alternative 1
- 2035 Alternative 2

Land use for each scenario was developed by Fresno COG using a spreadsheet. We completed the following model runs:

- 2005 (Base Year) without D Enhancement
- 2020 Baseline without D Enhancement
- 2020 Alternative 1 with D Enhancement
- 2020 Alternative 2 with D Enhancement
- 2035 Baseline without D Enhancement
- 2035 Alternative 1 with D Enhancement
- 2035 Alternative 2 with D Enhancement

MODEL POST-PROCESSING

After completing the model runs, we ran VMT scripts. For SB-375 reduction target setting, Fresno County is not responsible for any through (XX) trips, and is only responsible for 50% of internal-external (IX, XI) trips. The scripts account for total VMT and IXXI-reduced VMT. We identify VMT per capita based on the model land use assumptions for household population: 897,416 in 2005, 1,131,430 in 2020, and 1,418,887 in 2035 for all scenarios. Results from the model run are identified in Table 20.

TABLE 20: VMT OUTPUTS		
Scenario	**VMT**	**VMT/Capita**
Base 2005	21,047,628	23.45
2020 Baseline	27,126,845	23.98
2020 Alternative 1	26,345,052	23.28
2020 Alternative 2	26,171,425	23.13
2035 Baseline	34,395,777	24.24
2035 Alternative 1	33,650,056	23.72
2035 Alternative 2	33,618,632	23.69
Source: Fehr & Peers, 2010		

As shown in the table above, the Baseline scenarios produce a higher VMT per-capita than their respective Alternative scenarios. It should be noted that additional adjustments were made to these VMT estimates based on intrazonal travel by Fresno COG.

9. GREENHOUSE GAS AND EMISSIONS DIFFERENCES

APPROACH

After finishing the model runs for each scenario, we ran a VMT post-processor to assign VMT by speed bin, based on congested speeds on the model's roadway network. This information was used by Fresno COG as inputs into EMFAC to calculate Greenhouse Gas emissions estimate for submittal to CARB.

REDUCTIONS

Greenhouse Gas Emissions per capita are calculated based on VMT by speed bin. Different speeds produce different levels of GhGs, since vehicles idling or driving at very high speeds generally produce higher emissions than vehicles driving at free flow speeds around 40 miles per hour.

Based on our analysis, we expect to see a reduction in GhG between the Baseline scenarios and their respective Alternative scenarios. We would anticipate that the GhG per capita for the Alternative scenarios to be comparable to existing levels.

Appendix II

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Dowling Associates, Inc.

Date: May 7, 2010

Memorandum

To:	Cari Anderson, CAC
CC:	Mike Bitner, Fresno COG
From:	Kym Sterner
Reference:	San Joaquin Valley SB 375 Target Setting Assistance P08086.04
Subject:	Application of the Statewide Model for Interregional Travel

Dowling Associates applied a version of the California Statewide Model to estimate the VMT associated with interregional travel (IXXI) to and from each of the 8 MPOs within the San Joaquin Valley (SJV) region. This memorandum briefly summarizes the assumptions and process and recommends improvements to the Statewide Modeling element of the interregional trip evaluation (does not affect MPO modeling).

Objective

The MPO models in the SJV region do not track trips beyond the extents of model borders, which is usually their MPO boundary. In addition, even though through trips (XX trips) are forecast in the MPO models, VMT associated with these trips are not included in the SB375 forecasts. Therefore, if only the MPO models are employed for the forecasting of interregional trips, the VMT associated with the full length of trips between non-adjacent counties is unaccounted for. For example, trips between Fresno and Bakersfield are only accounted for within the Fresno COG MPO model boundary and the Kern COG MPO model boundary. The length of the trip through Kings or Tulare Counties isn't considered. Another tool is required to estimate the VMT for travel between these counties. Discussions between the MPOs led to the decision to use the California Statewide Model (STM) for the purpose of fully tracking trips within and to/from the SJV region.

Land Use Assumptions in the Statewide Travel Demand Model

Within the San Joaquin Valley Region

Each of the 8 MPOs provided land use by traffic analysis zone in their local travel demand model format for a base year (usually 2005), 2020, and 2035. Using a process consistent with that used for the BluePrint Study, Dowling Associates aggregated the land use into the statewide model household and employment categories (total households, retail, service, and other employment) by statewide model traffic analysis zone.

Outside the San Joaquin Valley Region

For counties outside of the SJV region, original statewide model land use inputs were interpolated/extrapolated using 2007 Department of Finance (DOF) forecasts. For simplicity, it was assumed that the population and employment ratio would remain consistent.

Recommended Potential Improvements to the Statewide Model Land Use Assumptions

Obtain land use data from MPOs outside of the SJV.

Network Assumptions in the Statewide Travel Demand Model

Given the short time frame required for estimation of interregional travel, the network assumptions are consistent with the original statewide model assumptions. The year 2000 network was used for 2005 forecasts and the future financially constrained network was used for 2020 and 2035.

Recommended Potential Improvements to the Statewide Model Network Assumptions
Incorporate individual MPO RTP network assumptions into the Statewide Model.

Statewide Travel Demand Model Validation

The version of the statewide model used for this task includes the estimation of county to county work flows based on the 2000 Census Journey to Work data. However, several of the MPOs voiced concerns over the validation of the statewide model to base year counts. It was agreed, given the quick turn-around time required for this task, that review and validation of the statewide model was not possible within the available time-frame.

That said, even though each of the MPO models have been validated at their county cordons to base year counts, most (all?) adjacent MPOs in the SJV region have not necessarily agreed upon or validated county crossing to consistent future year forecasts. Therefore, it is expected that, depending upon the process used to develop county line forecast volumes (usually an input into the MPO models), adjacent MPOs would have very different forecasts at their shared county borders for 2020 and 2035. It could be argued that use of the statewide model at least ensures consistent assumptions at the MPO cordons.

Recommended Potential Improvements to Statewide Model Validation
Have adjacent MPOs agree on county cordon volumes for 2005, 2020 and 2035 and validate statewide model to these forecasts. Review county to county flows and determine if reasonable.

Daily Vehicle Trip Assignments by County in the Statewide Model

Dowling Associates developed scripts to track trips to/from each of the 8 MPOs within the SJV region. Trips were tracked that have an origin or a destination within each of the MPOs, as well as whether the other end originates or is destined for another MPO within or outside of the SJV region. VMT from interregional travel to/from each MPO was calculated on a link basis within each MPO as well as for the rest of the state (MTC, SACOG, SCAG, SanDAG, and remaining).

Recommended Potential Improvements to Statewide Modeling
Determine exclusions for non MPO trips within an MPO (e.g., tribal and federal lands) by TAZ.

Calculation of Interregional VMT using the Statewide Travel Demand Model

Within the Individual SJV MPOs

It was agreed that the individual MPO travel demand models are the best source for ***intra*** MPO travel as well as the portion of interregional travel that occurs on links within each MPO. Therefore, the methodology developed and applied for the MPO models should stand.

Outside Individual SJV MPOs

Even with the known limitations of this version of the Statewide Travel Demand Model it was also agreed that the statewide model would be the best available tool to estimate the ***additional VMT associated with interregional travel (IXXI) that is not accounted for in the individual MPO travel models***. By definition, this IXXI travel would be XX travel through some counties and would not be attributed on either end to those counties.

The VMT related to interregional travel (IXXI) on links outside of the MPO have been estimated using three different methodologies:

1. **Total VMT** - VMT associated with travel ***to/from*** SJV region (trips where either the origin or the destination are within SJV) ***on all statewide links***, outside of the origin MPO and the destination MPO.

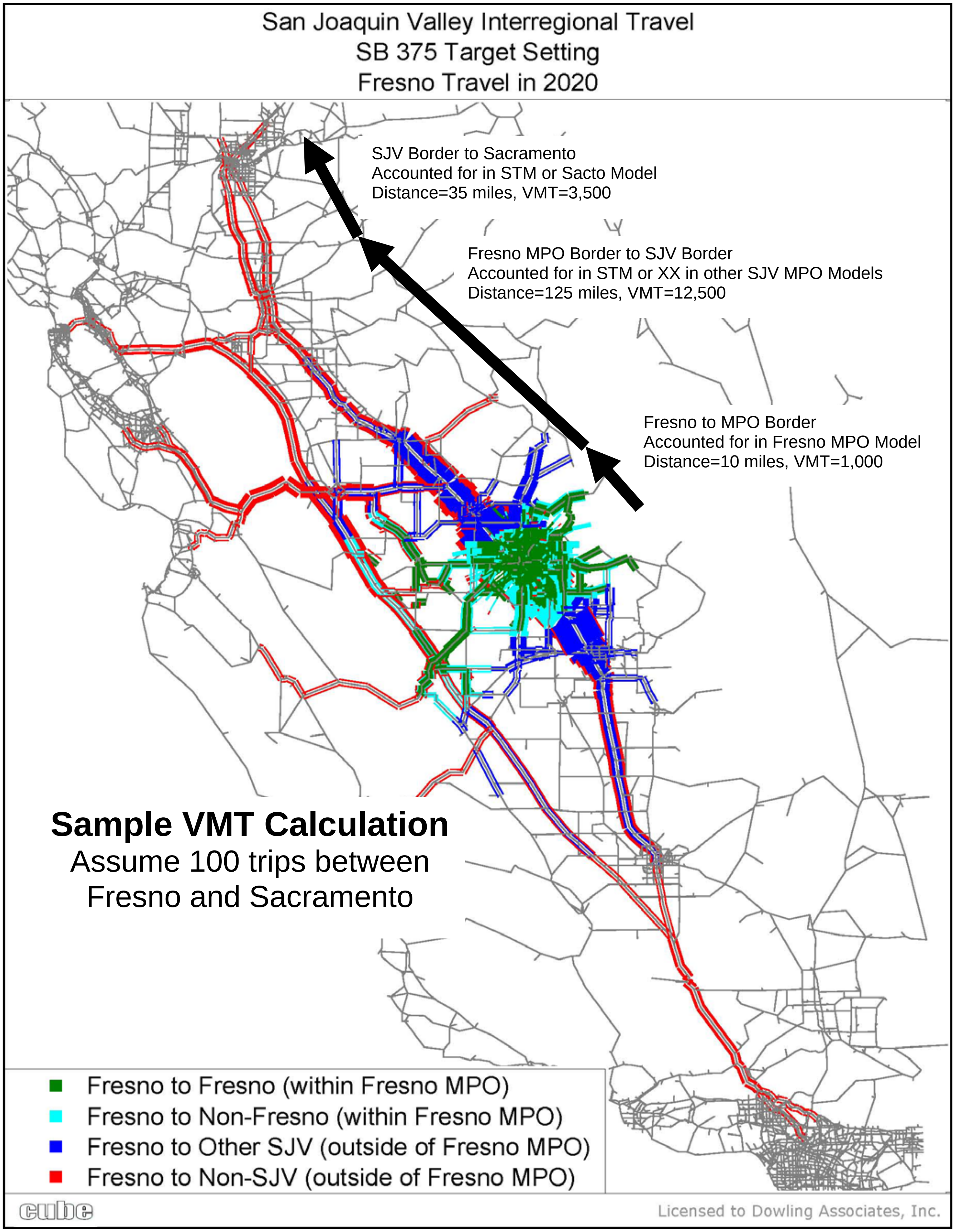
2. **VMT on SJV Links** – VMT associated with travel ***to/from*** SJV region (trips where either the origin or the destination are within SJV) ***on SJV links***, outside of the origin MPO and the destination MPO.

3. **SJV Only VMT** - VMT associated with travel ***within*** SJV region (trips where both the origin and the destination are within SJV) ***on SJV links***, outside of the origin MPO and the destination MPO.

In order to clarify, below is a sample calculation of VMT for an assumed 100 trips traveling from a Fresno origin to a Sacramento destination. The same example is shown graphically on the next page. As can be seen below, for long distance trips to and from the SJV region, most of the VMT is associated with portion of the trips outside the coverage of the individual MPO models.

Sample VMT Calculations for Interregional Trips (IXXI)
SJV Origin to Non SJV Destination

Fresno-Sacramento	Distance for trip portion (miles)	VMT Estimates: All Trips All Links	All Trips SJV Links	SJV Trips SJV Links
Within Fresno MPO	10	1,000	1,000	1,000
Other SJV	125	12,500	12,500	0
Non SJV	35	3,500	0	0
Totals	170	17,000	13,500	1,000
% of Total		**100%**	**79%**	**6%**


San Joaquin Valley Interregional Travel
SB 375 Target Setting
Fresno Travel in 2020
SJV Border to Sacramento
Accounted for in STM or Sacto Model
Distance=35 miles, VMT=3,500
Fresno MPO Border to SJV Border
Accounted for in STM or XX in other SJV MPO Models
Distance=125 miles, VMT=12,500
Fresno to MPO Border
Accounted for in Fresno MPO Model
Distance=10 miles, VMT=1,000
Sample VMT Calculation
Assume 100 trips between
Fresno and Sacramento
Fresno to Fresno (within Fresno MPO)
Fresno to Non-Fresno (within Fresno MPO)
Fresno to Other SJV (outside of Fresno MPO)
Fresno to Non-SJV (outside of Fresno MPO)
cube
Licensed to Dowling Associates, Inc.

SB375 Implementation

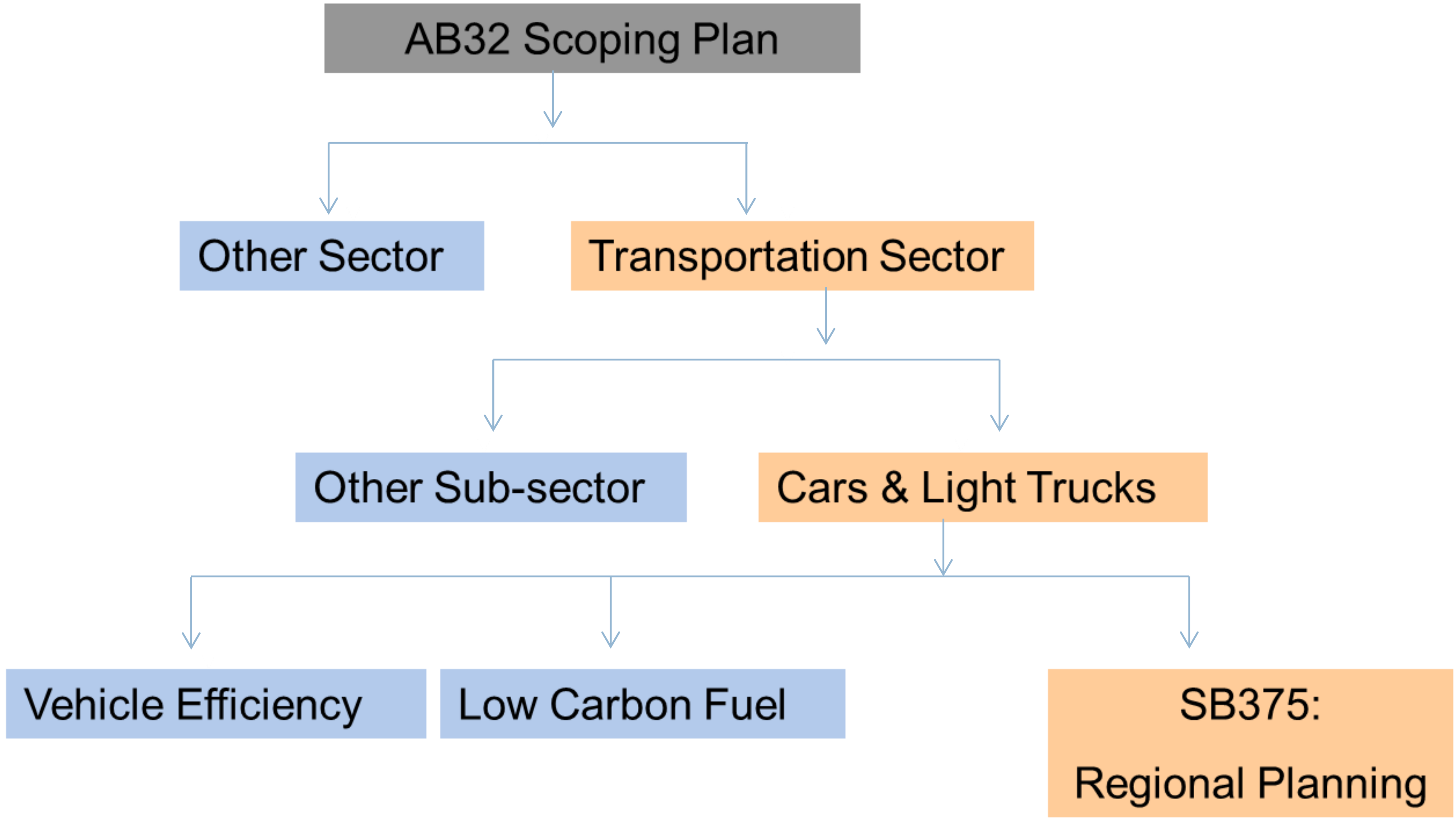
GREENHOUSE GAS REDUCTION TARGET RECOMMENDATION FOR THE FRESNO REGION

August 2012

Fresno Council of Governments

Background

- SB375 – greenhouse gas reduction from passenger vehicles through integrated land use and transportation planning
- SB375 accounts for about 3% reduction in the recommended 2020 GHG reduction in the AB32 Scoping Plan


AB32 Scoping Plan
Other Sector
Transportation Sector
Other Sub-sector
Cars & Light Trucks
Vehicle Efficiency
Low Carbon Fuel
SB375:
Regional Planning

Affected Parties

- California Air Resources Board (CARB/ARB):
  - Set targets for the 18 MPOs in California
  - Determines whether the Sustainable Communities Strategy (SCS), if implemented, meets the targets
- Metropolitan Planning Organization (MPO)s:
  - Recommend ambitions and achievable targets for their regions
  - Develop SCS in their Regional Transportation Plan (RTP), or Alternative Planning Strategy (APS) if the SCS can't meet the targets
- Local Governments
  - Implementation by updating General Plans
  - Adopt more sustainable growth strategies that will help reduce GHG emission
  - Voluntary

How does SB375 Impact the Local Governments?

- Local governments keep land use authority
- Local governments are encouraged to look at more sustainable growth, but their general plans do not have to conform to the SCS
- No penalties

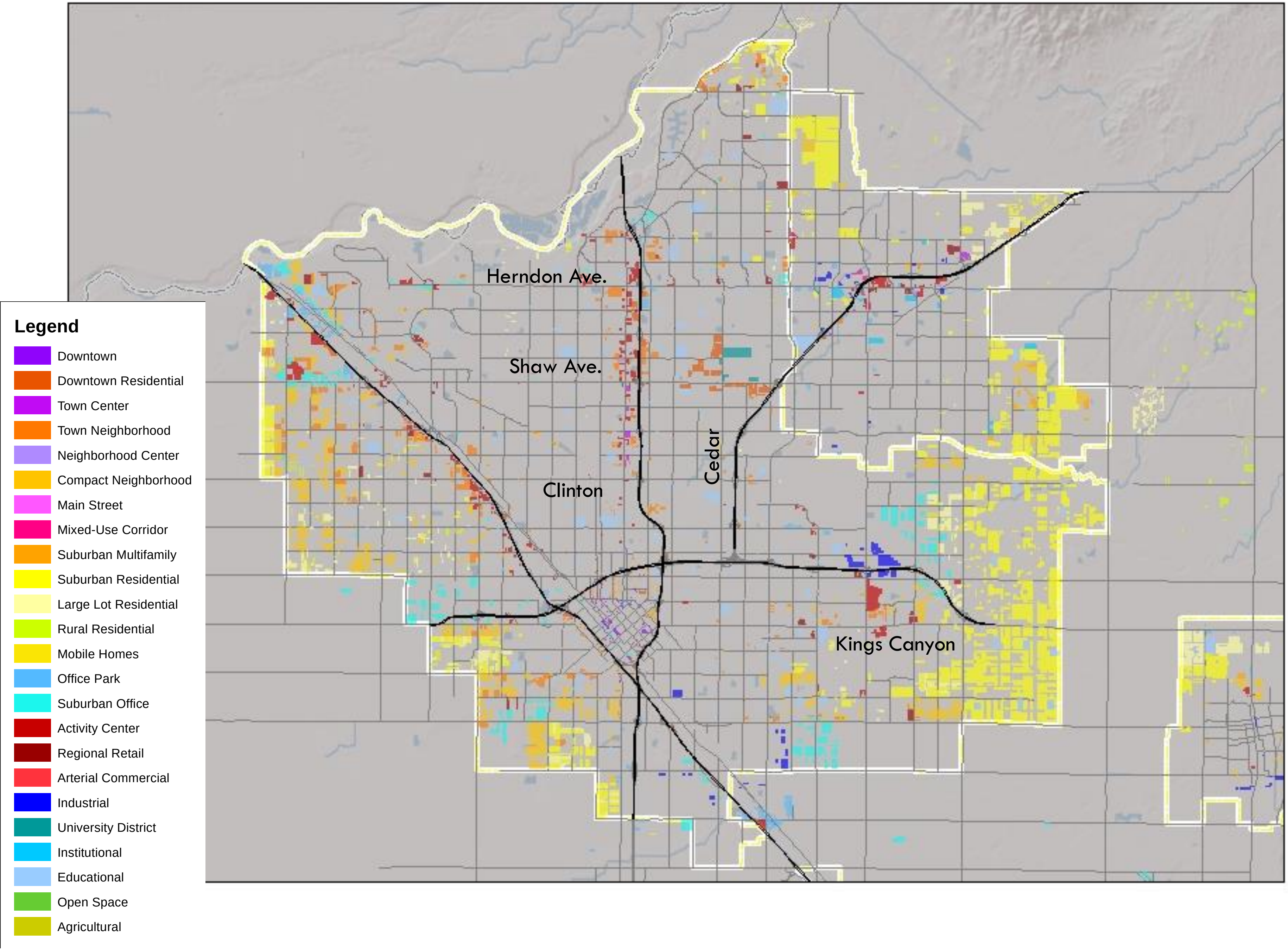
Target Setting in 2010

- In 2010,CARB gave the San Joaquin Valley placeholder targets of 5% reduction in 2020 and 10% reduction in 2035
- CARB allowed the Valley to make new recommendation to them in 2012, because of the inconsistent target recommendation efforts in the Valley in 2010

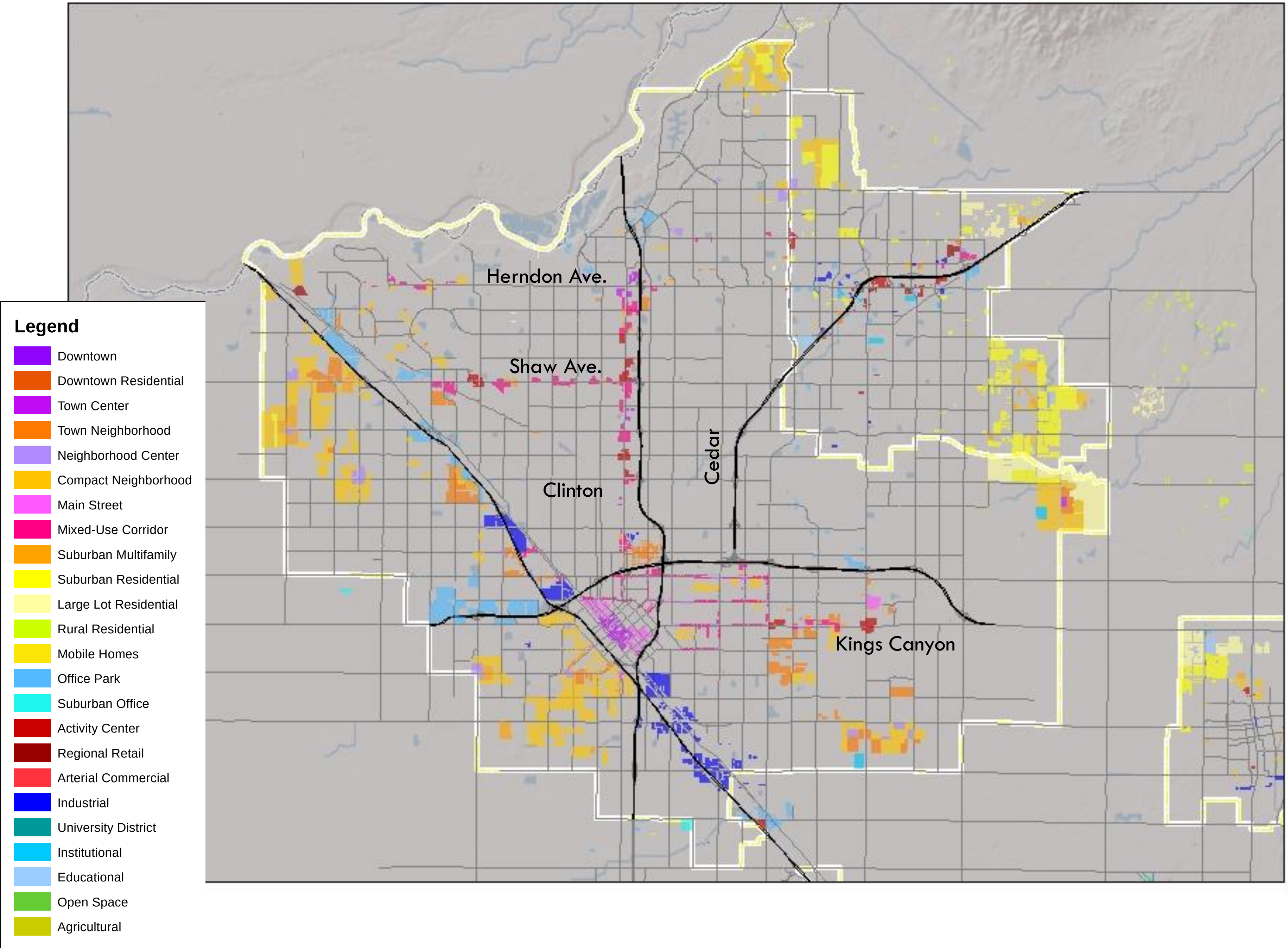
2012 Target Recommendation from Fresno COG

- Scenario 1: adopted general plans
- Scenario 2: proposed new land use
- Scenario 3: What it takes-ambitious but not achievable

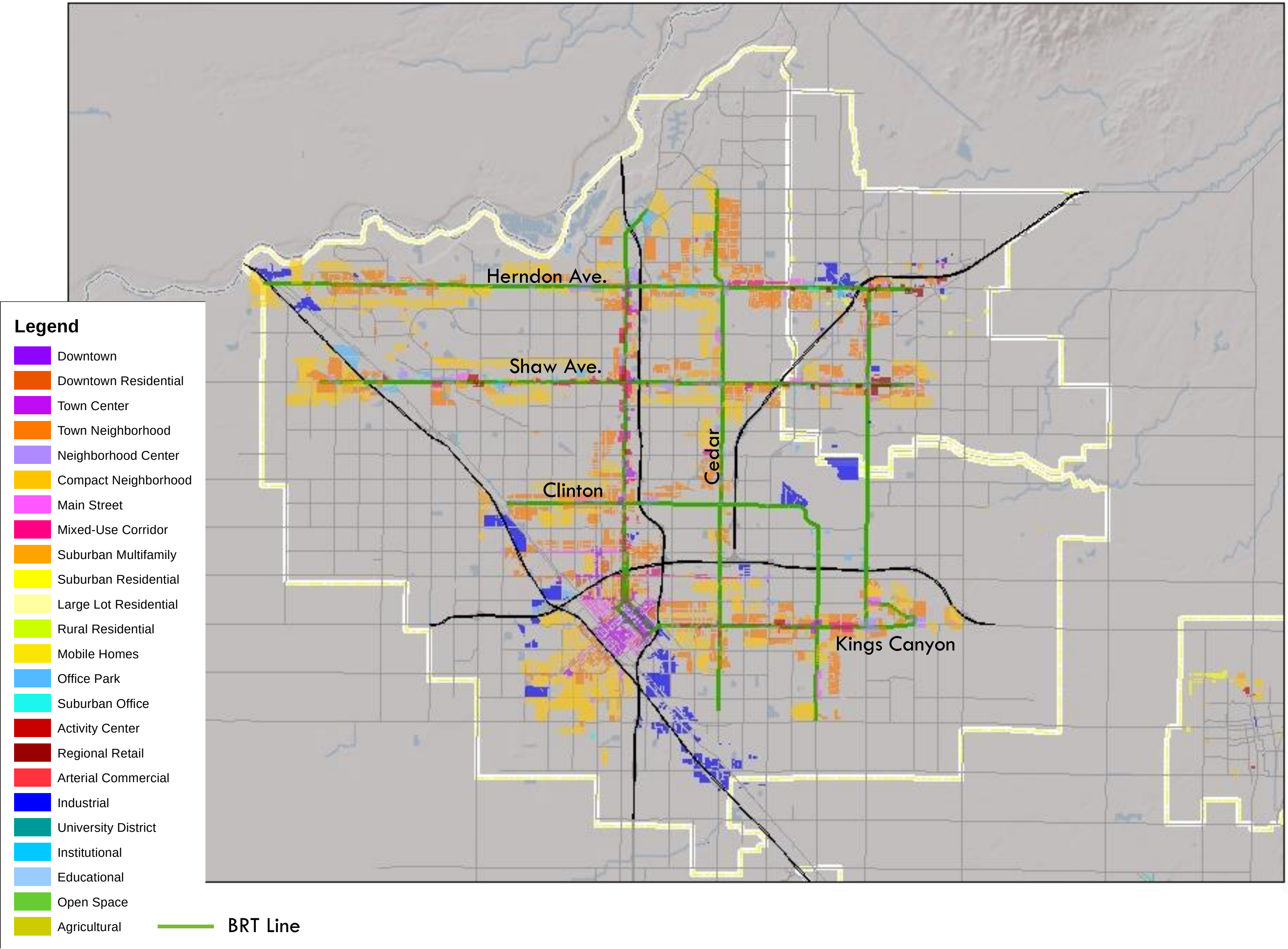
Fresno & Clovis SOI // Scenario 1



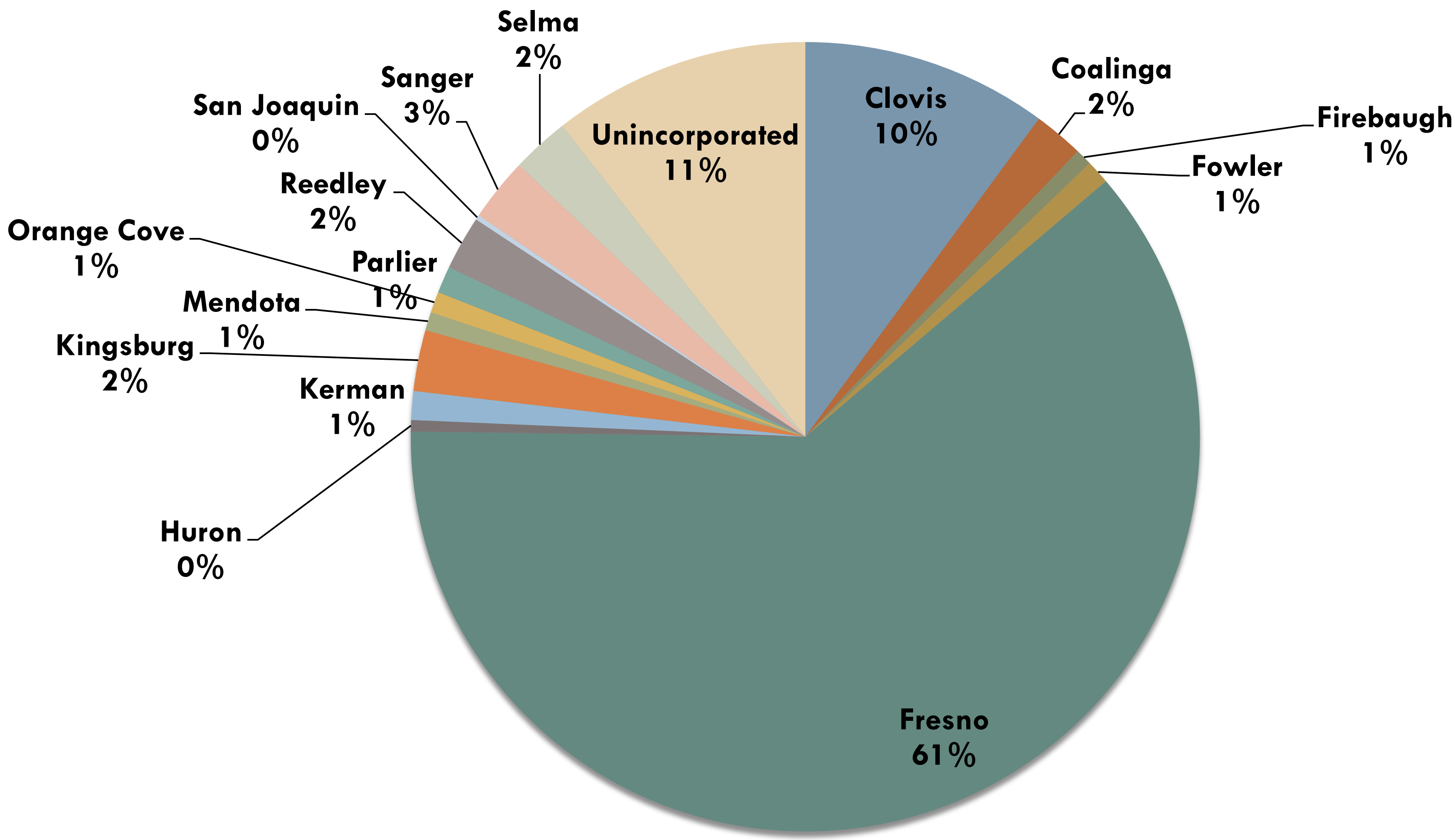
Fresno & Clovis SOI // Scenario 2



Fresno & Clovis SOI // Scenario 3

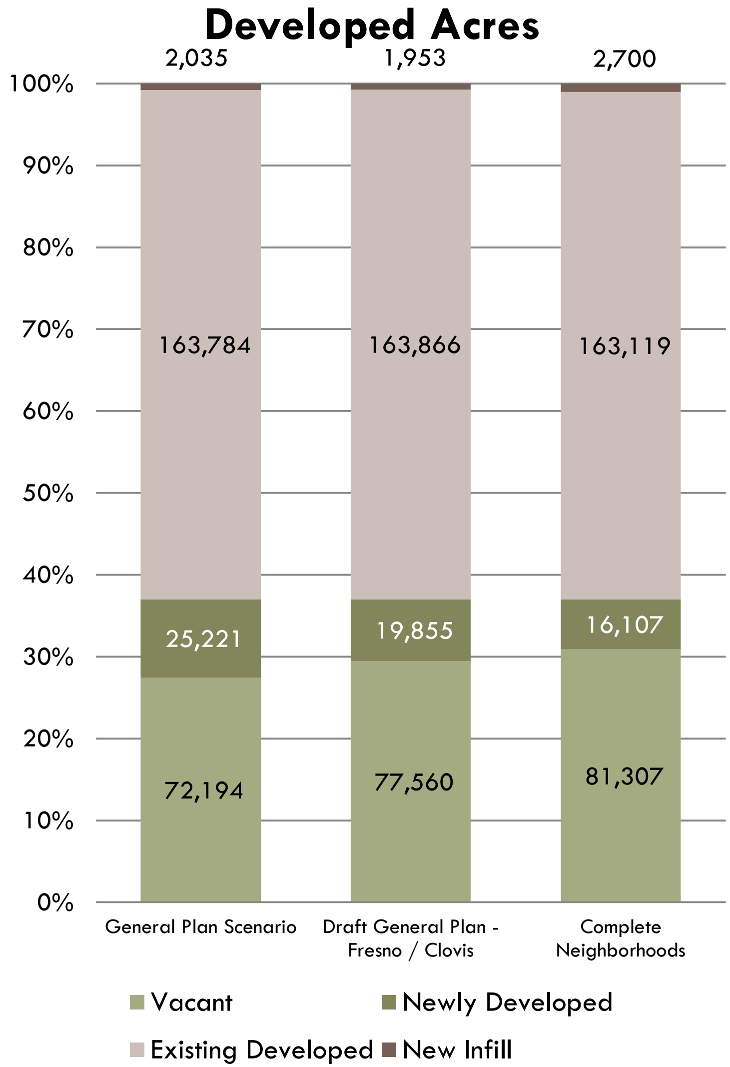


Housing Unit Forecast by SOI



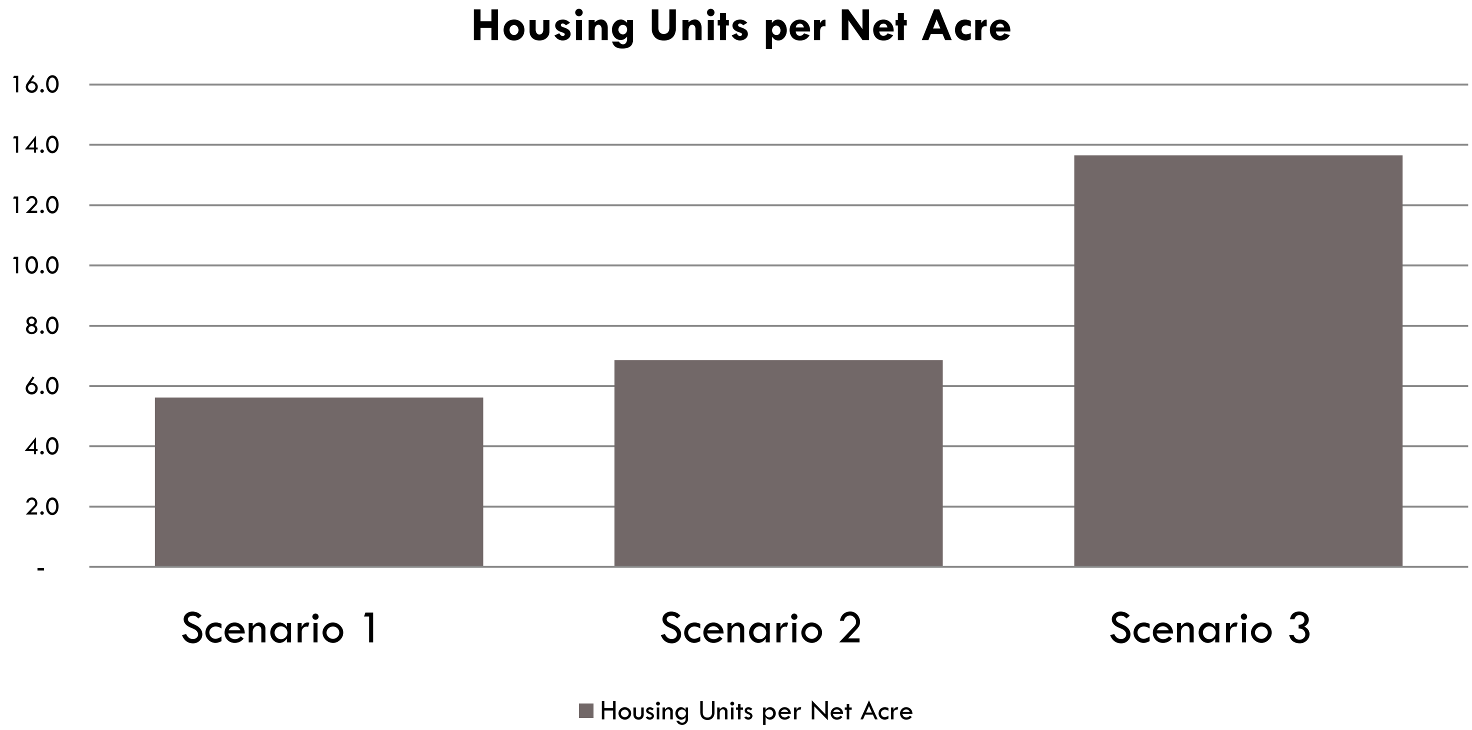
Land Consumption

- Scenario 1: 15% increase in urban area
- Scenario 2: 12% increase
- Scenario 3: 10% increase
  - Scenario 3 has a 35% increase in infill over scenario 1 & 2



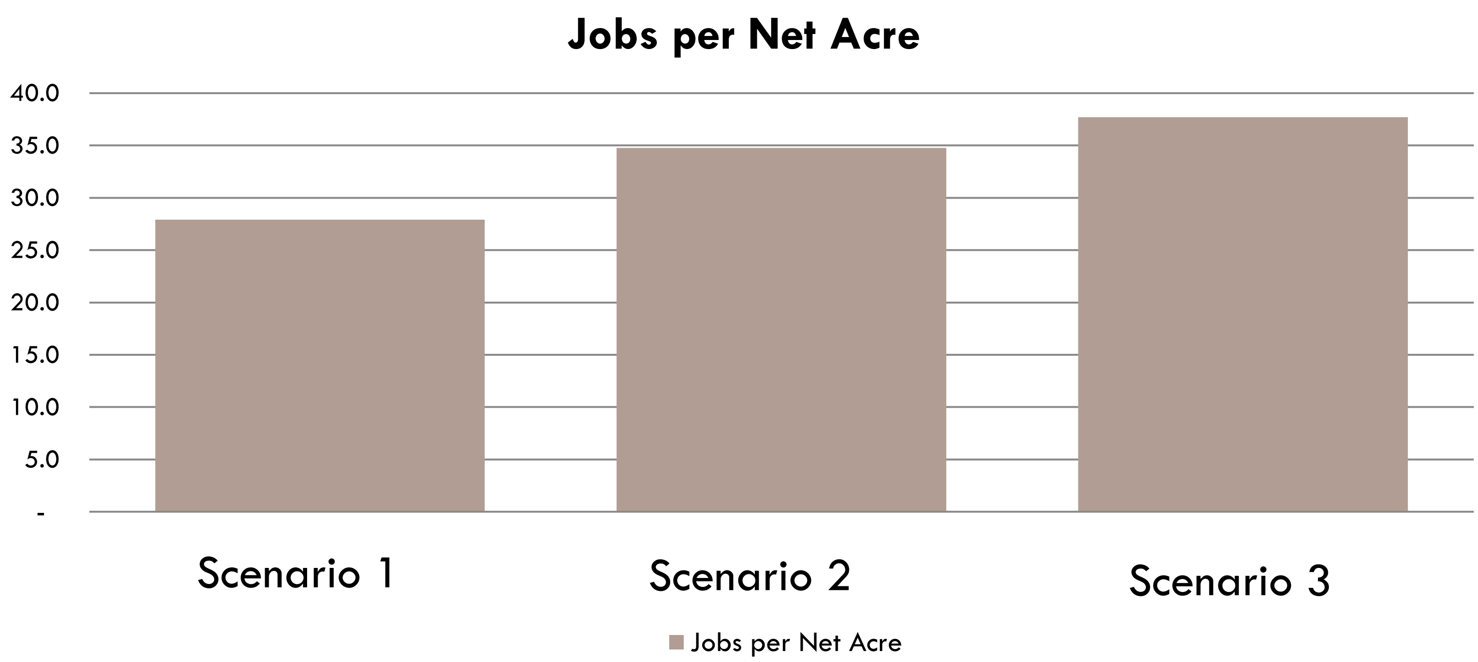
Housing Density

- Continued increase in overall housing density
- Scenario 3: significantly shifts to smaller units and increases modest density multifamily

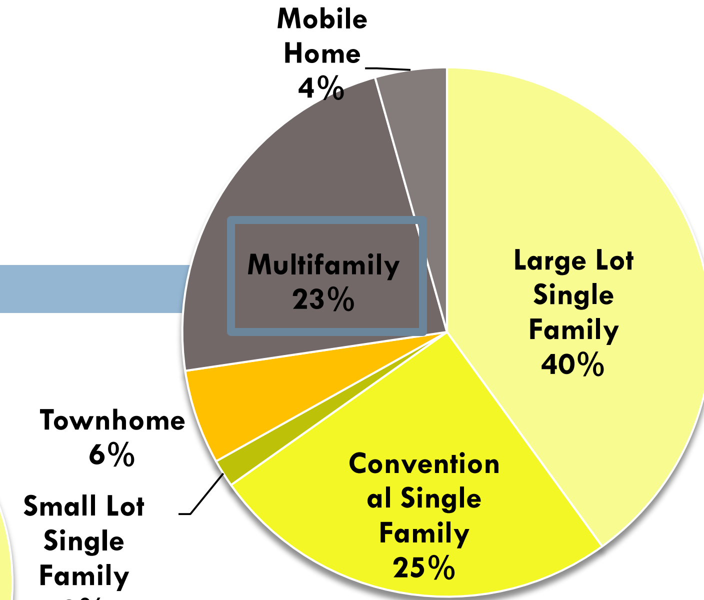


Job Density

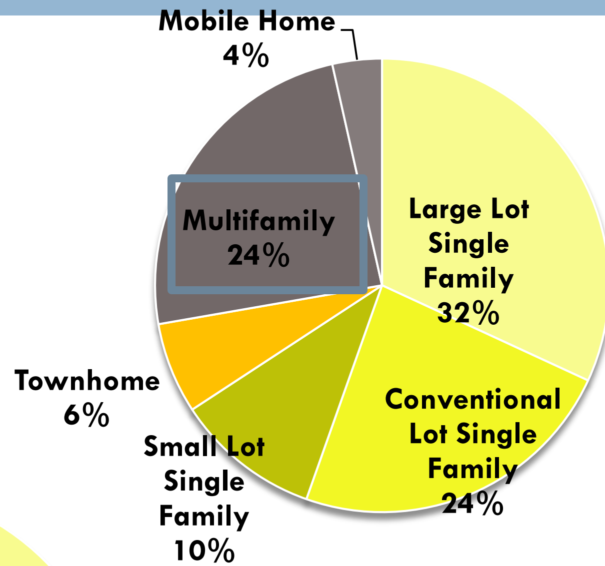
- Interestingly, job density did not increase significantly.



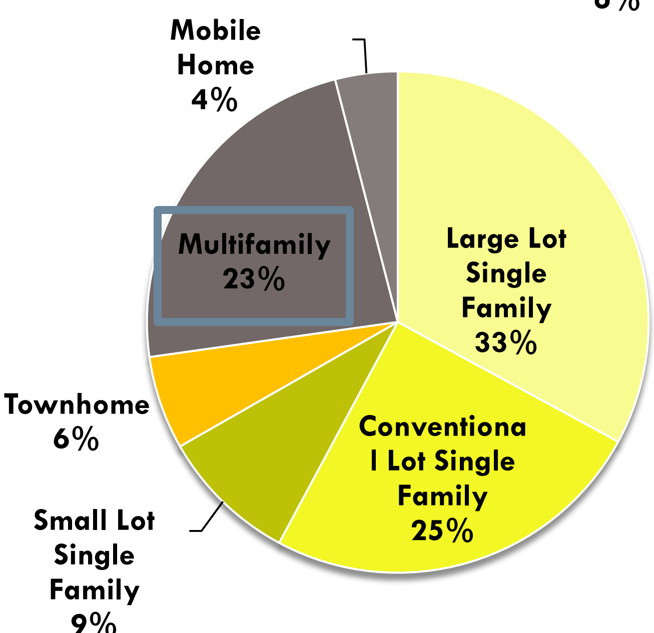
Fresno County
Existing Housing Mix



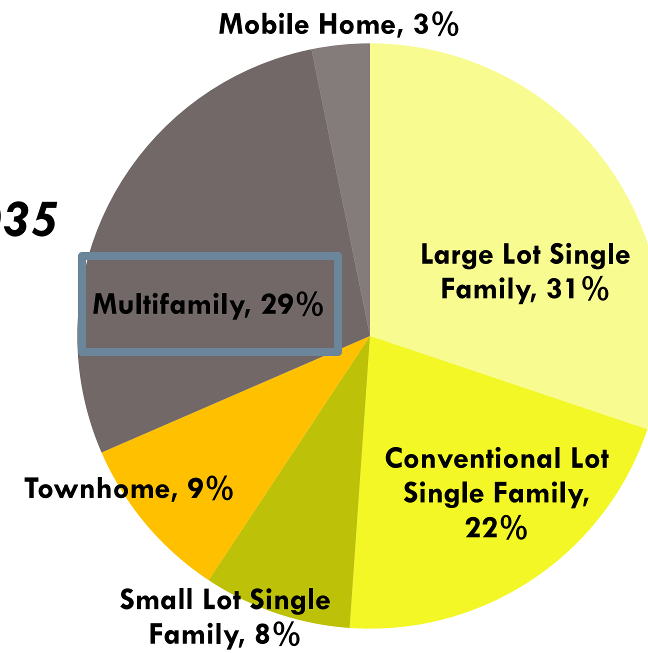
Existing Housing



Scenario 2: New Total 2035

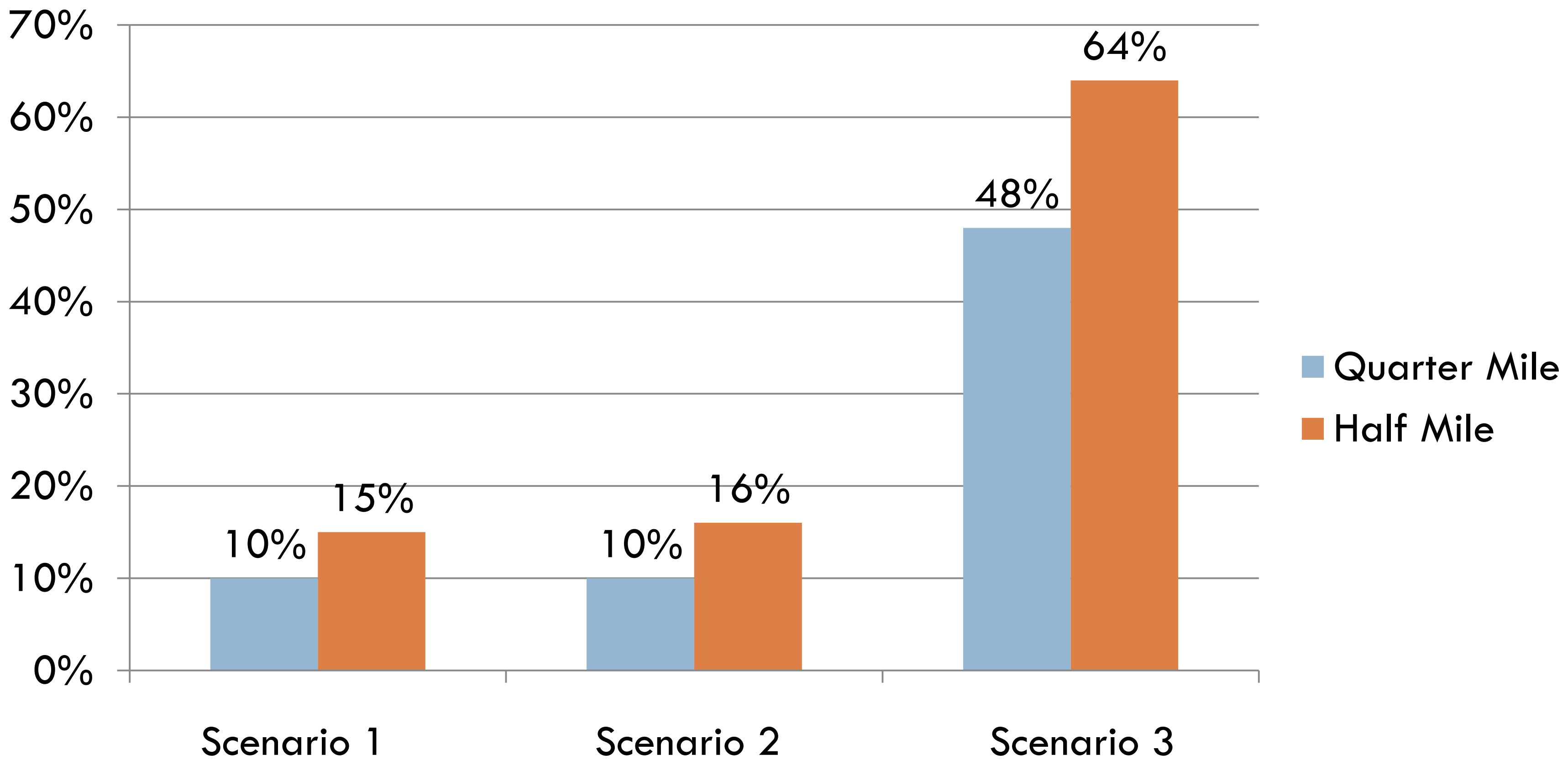


Scenario 1: New Total 2035



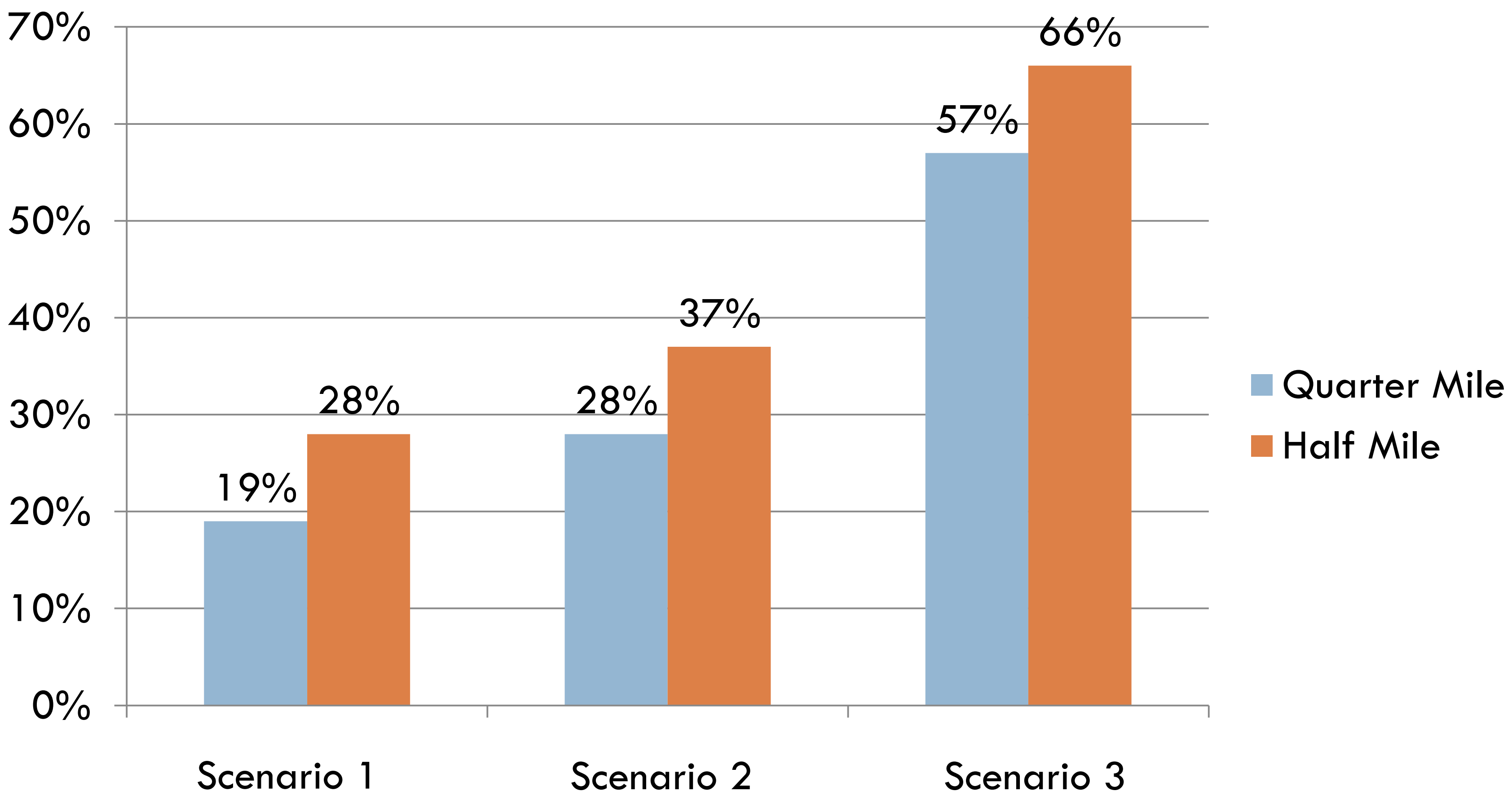
Scenario 3: New Total 2035

Percent Housing Units within BRT corridor buffer



Percentage of new growth

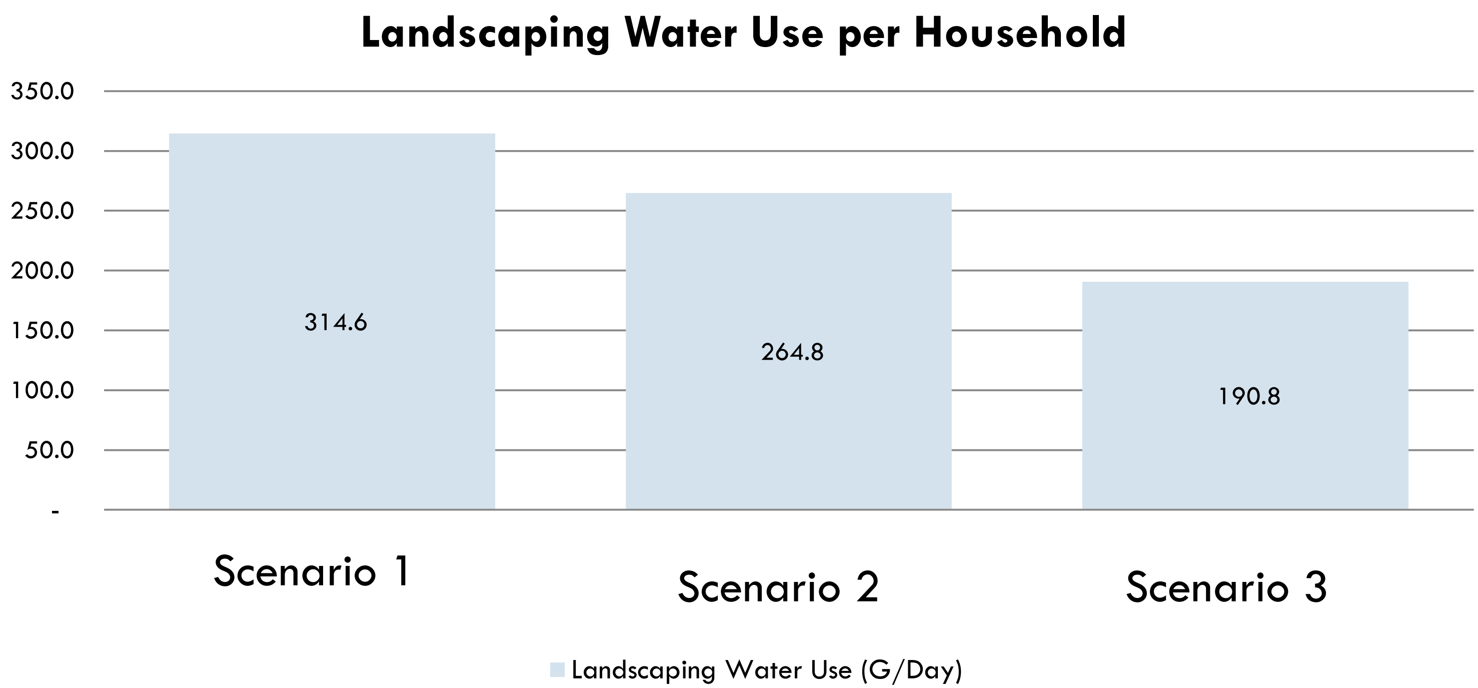
Percent Employment within BRT corridor buffer



Percentage of new growth

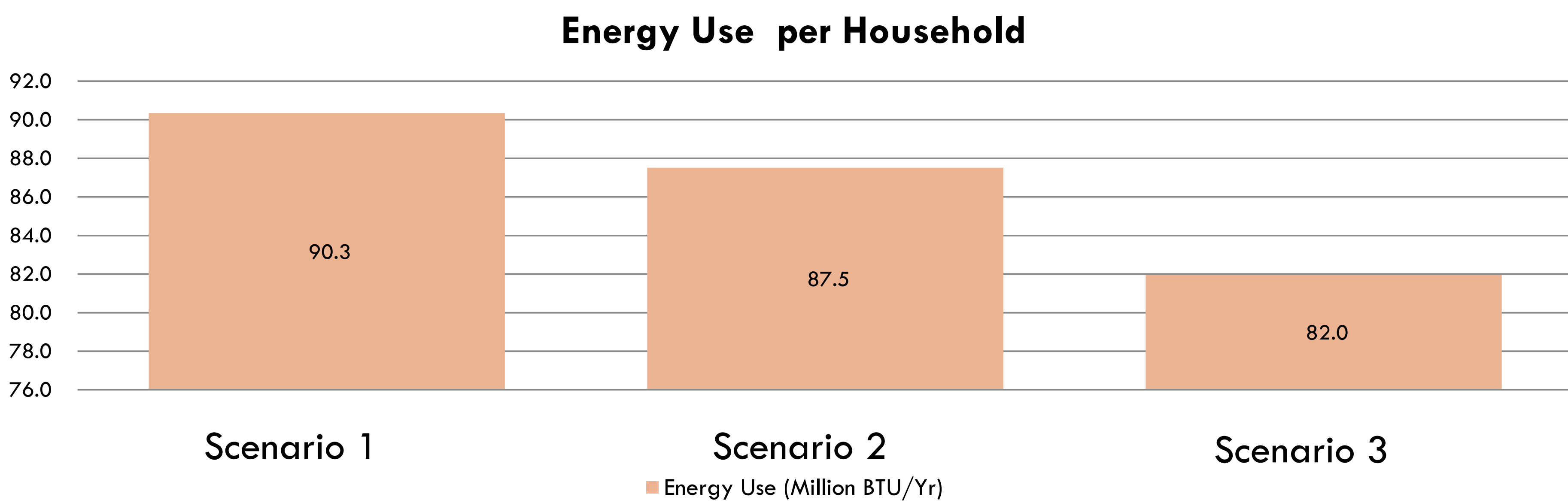
Landscaping Water Use

- Significant reduction in lawn area between scenarios



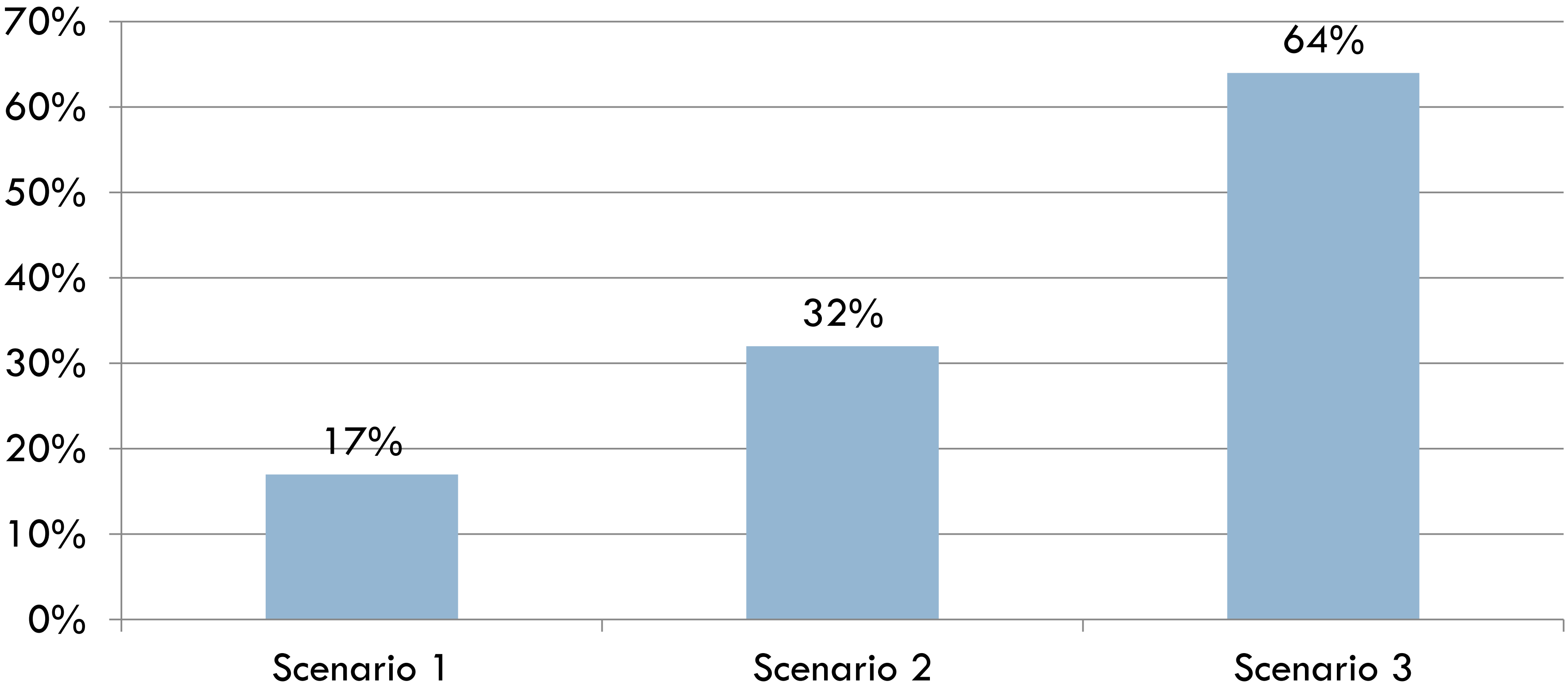
Building Energy Use

- Energy efficiency increases with smaller units and shared walls in multifamily



Land Use Mix – Walkability

- Land area with high degree of mixed-use
- Tripling of mixed-use between Scenario 1 – 3



VMT Per Capita Reduction Compared to 2005

	2020	2035
Scenario 1	-3.9%	-6.4%
Scenario 2	-4.7%	-7.6%
Scenario 3	-7.4%	-12.1%

Bike & Ped Mode Share

	Base Year	Scenario 1	Scenario 2	Scenario 3
2005	7.3%			
2020		7.4%	7.6%	7.9%
2035		7.4%	7.7%	8.1%

Transit Mode Share

	Base Year	Scenario 1	Scenario 2	Scenario 3
2005	1.5%			
2020		1.5%	1.5%	1.7%
2035		1.4%	1.5%	1.8%

GHG Per Capita Reduction Compared to 2005

	2020	2035
Scenario 1	-4.7%	-7.7%
Scenario 2	-5.7%	-9.4%
Scenario 3	-8.3%	-13.3%

SB375 Task Force Recommendation

- 5% reduction for 2020 and 10% reduction for 2035
- Scenario 2 as the preferred scenario to be submitted to ARB to support the target recommendation

Fresno COG Process

- TTC/PAC & Policy Board in September
- Data sharing with CARB
- Move forward with RTP/SCS efforts

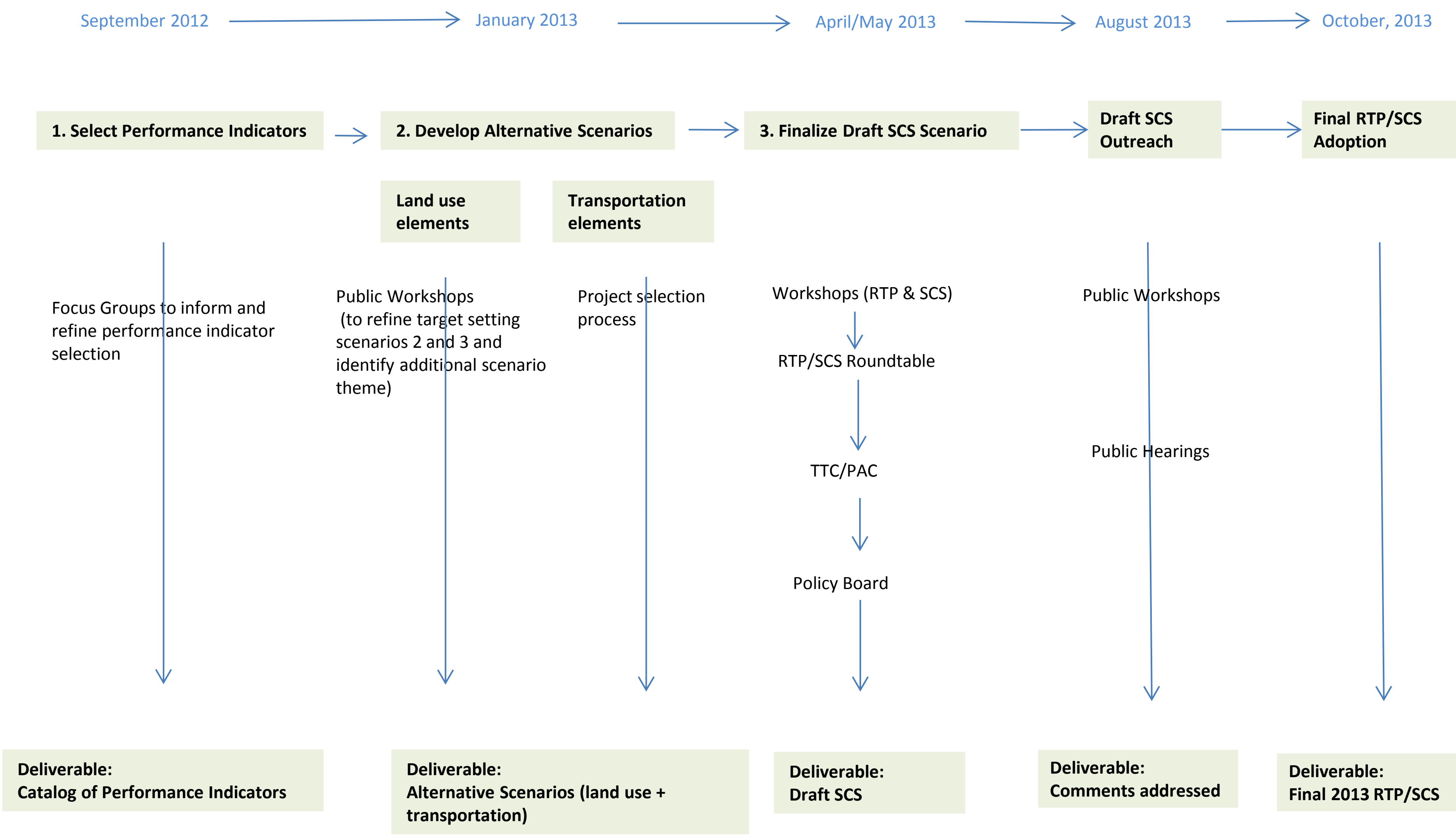
Valley-wide Target Setting

- Other MPOs in the Valley are still working on the scenarios
- MPO Directors have not decided on how to work together: i.e. single county targets, sub-regional targets or valley-wide targets
- Valley-wide target format will be considered in October at the San Joaquin Valley Policy Council meeting
- CARB Board will consider Valley target recommendation in November

SCS Development Status in the State

- SANDAG's RTP/SCS was sued and is still in litigation
- SCAG & SACOG have been approved
- MTC has adopted draft SCS, and is working on the EIR
- San Joaquin Valley MPOs will adopt their RTP/SCS by 2013

Fresno COG SCS Development Process



Appendix J Item 5:
Land-use Modeling

Envision Tomorrow

Development Types

The following development types were used in the preferred RTP-SCS scenario for the Fresno County region:

Development Types	Vacant Gross Density		Redev Gross Density		Housing Mix					Employment Mix		
					Housing Unit Percent by Type					Employee Percent by Type		
	Housing Units / Gross Acre	Jobs / Gross Acre	Housing Units / Gross Acre	Jobs / Gross Acre	Multi-Family	Town Home	Single Family	Small Lot Single Family	Large Lot Single Family	Retail	Office	Industrial
Town Center	19.75	50.00	16.79	42.50	100.00%	-	-	-	-	27.32%	72.68%	-
Neighborhood Center	13.34	19.31	10.01	14.48	89.08%	10.92%	-	-	-	50.58%	49.42%	-
Town Neighborhood	11.69	2.42	5.85	1.21	55.64%	13.65%	30.72%	20.28%	10.44%	72.51%	27.49%	-
Mixed-Use Corridor	14.27	37.51	9.27	24.38	100.00%	-	-	-	-	29.28%	70.72%	-
Main Street	6.27	32.04	3.14	16.02	100.00%	-	-	-	-	57.81%	42.19%	-
Office Park	-	33.84	-	8.46	-	-	-	-	-	9.69%	80.93%	9.38%
Suburban Office	-	19.14	-	3.83	-	-	-	-	-	4.88%	79.49%	15.63%
Activity Center	-	19.05	-	4.76	-	-	-	-	-	58.12%	39.35%	2.53%
Arterial Commercial	-	12.94	-	1.94	-	-	-	-	-	100.00%	-	-
Regional Retail	-	10.56	-	2.11	-	-	-	-	-	100.00%	-	-
Educational	-	2.98	-	2.98	-	-	-	-	-	-	100.00%	-
Institutional	-	2.56	-	1.54	-	-	-	-	-	2.86%	97.14%	-
Industrial	-	9.53	-	2.38	-	-	-	-	-	0.30%	21.08%	78.63%
Urban Multifamily	38.99	-	-	-	100.00%	-	-	-	-	-	-	-
Suburban Multifamily	22.48	-	11.24	-	100.00%	-	-	-	-	-	-	-
Compact Neighborhood High	14.00	-	3.50	-	46.27%	31.14%	22.60%	22.60%	-	-	-	-
Compact Neighborhood	8.60	-	3.01	-	-	15.86%	84.14%	76.52%	7.62%	-	-	-
Suburban Residential	3.86	-	-	-	-	-	100.00%	11.81%	88.19%	-	-	-
Large Lot Residential	2.08	-	-	-	-	-	100.00%	-	100.00%	-	-	-
Rural Residential	0.49	-	-	-	-	-	100.00%	-	100.00%	-	-	-

Town Center

(Avg. Density: 16-19 HU/acre, 42-50 jobs/acre)

Town Centers are the highest-intensity development type used in the SCS for the Fresno County region. The best examples of this development type would be central Downtown Fresno. They are employment centric, though they also provide multi-family housing opportunities located very close to jobs and services. Buildings are typically 5 stories or less. Such communities are highly walkable and benefit from high-capacity transit and bus facilities.

Neighborhood Center

(Avg. Density: 10-14 HU/acre, 14-20 jobs/acre)

Neighborhood Center serves as a walkable center for small community or neighborhood services including retail and offices. Buildings are about two to three stories tall and can include mixed uses, including live-work developments. This development type also includes residential development such as duplexes and townhouses.

Town Neighborhood

(Avg. Density: 5-12 HU/acre, 1-3 jobs/acre)

Downtown Neighborhoods include areas with apartments, condos, and townhouses. There may be some mixed use buildings with retail on the ground floor. Street connectivity is relatively favorable, allowing for a walkable environment and transit options.

Mixed Use Corridor

(Avg. Density: 9-15 HU/acre, 24-38 jobs/acre)

Mixed Use Corridor refers to a mix of new and older development in a linear fashion along corridors that are often served by transit. They are usually pedestrian-oriented with a mix of housing, retail and office amenities.

Main Street

(Avg. Density: 3-7 HU/acre, 16-33 jobs/acre)

Main Streets include a mix of uses and interconnected street network. Main Streets primarily function as service destinations rather than centers of employment. Buildings typically stand one to three stories tall and include townhouses or apartments above storefronts.

Office Park

(Avg. Density: 8-34 jobs/acre)

Office Parks are comprised of low to medium density office buildings surrounded by surface parking. Generally located near highways for easy auto-access, transit and walking options are limited. Office parks lack residential or retail uses.

Suburban Office

(Avg. Density: 3-20 jobs/acre)

Suburban Office complexes generally contain low-density, single-story office buildings, and can be found in suburban areas. The development type is on average about half the density of Office Park.

Activity Center

(Avg. Density: 4-20 jobs/acre)

Activity centers include an agglomeration of large-scale retail buildings, office buildings and multifamily housing. Land uses are separated from each other by parking areas, freeways or arterials. Activity centers are usually positioned at intersections of highways or arterials, sometimes along major transit corridors.

Arterial Commercial
(Avg. Density: 1-13 jobs/acre)

Arterial commercial development takes a linear form along both sides of a major road or highway. Connections in this development type consist mostly of highways and frontage roads.

Regional Retail
(Avg. Density: 2-11 jobs/acre)

Regional Retail development is generally characterized by low-density commercial such as pharmacies, grocery stores, and large format retail. It lacks any residential use.

Educational
(Avg. Density: 2-3 jobs/acre)

Educational development refers to schools, universities, and other learning institutions. Such campuses generally contain significant amounts of open space or parks for recreational use.

Institutional
(Avg. Density: 1-3 jobs/acre)

The Institutional development type can contain a mix of government and quasi-government uses, such as museums, government facilities, and the like. Such campuses are often low-density office and educational.

Industrial
(Avg. Density: 2-10 jobs/acre)

The Industrial development type is made up of a mix of low and medium density industrial buildings. This type often consists of industrial yards and campuses separate from other uses due to the nature of the industrial use. This development type is often near highways with large surface parking for autos and trucks.

Urban Multifamily
(Avg. Density: up to 39 HU/acre)

Urban Multifamily is characterized by high-density apartment complexes located in central urbanized areas and city centers. Units are generally small, multifamily rental dwellings. Buildings are typically no more than 4 stories.

Suburban Multifamily
(Avg. Density: 11-23 HU/acre)

Suburban Multifamily development refers to medium-high density apartment complexes located in suburban areas. Buildings can be multi-storied but are characterized by single story dwellings. Such development can accommodate on average about half the number of units per acre as Urban Multifamily.

Compact Neighborhood High

(Avg. Density: 3-14 HU/acre)

This development type can contain a mix of residential uses, including single-story multifamily rentals, attached single-family units such as duplexes and townhomes, and small-lot urban single-family units.

Compact Neighborhood

(Avg. Density: 3-9 HU/acre)

Compact Neighborhoods are medium-density residential areas comprised of small lot single-family dwellings, townhomes and duplexes. Street connectivity is relatively favorable, allowing for a walkable environment and transit options.

Suburban Residential

(Avg. Density: less than 4 HU/acre)

Suburban residential includes a mix of single-family, detached homes. Street networks include many cul-de-sacs, which is typical of post-World War II suburbs. Suburban residential areas are designed for automobile travel. Street connectivity and walkability are generally low.

Large-Lot Residential

(Avg. Density: less than 3 HU/acre)

Large-lot residential subdivisions consist entirely of single-family, detached homes. Large-lot subdivisions are typically isolated or far from employment and retail services. With one acre lots and larger, this development type is characterized by very large residences without sidewalks. Travel to and from destinations is usually by automobile.

Rural Residential

(Avg. Density: less than 1 HU/acre)

Such development consists of detached single-family dwellings on large, rural lots. Rural residential lots are on average four times the size of those in Large-Lot Residential, and can be several miles from the nearest town or community center.

Developing Land Use Scenarios

Fresno COG staff used Envision Tomorrow to generate land-use scenarios consistent with the targets set forth in the methodologies above. The datasets were created to reflect the SCS target year of 2035. Each scenario uses a split-parcel dataset representing base-year (2008) development; parcel features within this dataset were assigned land-use development types, which provides housing and/or employment estimates for that parcel. These features were aggregated by Traffic Analysis Zone (TAZ) and combined with the base-year (2008) data to create land-use inputs for the regional traffic model.

Extrapolating Land-Use Data for Other Target Years

To emulate the growth trend for all years between 2008 and 2040, Fresno COG staff assigned an attractiveness score to each Traffic Analysis Zone (TAZ) in Fresno County. This score represents which TAZs are likely to develop sooner rather than later: The higher the attractiveness score, the sooner a TAZ is expected to reach capacity. This attractiveness score is based on the following formula:

$$A = \frac{1}{D_{CEN}} + \frac{1}{D_{ART}} + \frac{1}{D_{HWY}}$$

Where

A = attractiveness score
D_{CEN} = centroid distance from a city or community center
D_{ART} = centroid distance from an arterial road
D_{HWY} = centroid distance from a state highway or interstate

The attractiveness scores were then adjusted so that each represents a value between 1 and 100.

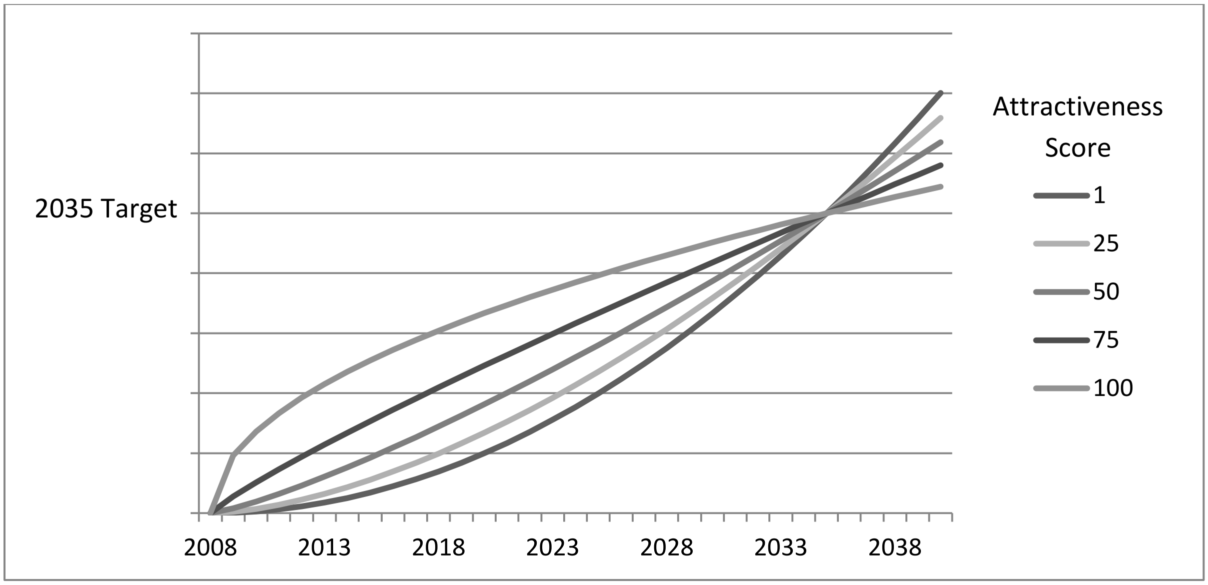
To create a land-use dataset that simulates the approximate growth pattern for a given target year N (where 2008 ≤ N ≤ 2040), the 2035 housing and employment totals for each TAZ are adjusted according to the following formula:

$$T_N = \left(T_0^{\left(\frac{1}{2-\frac{3A}{200}}\right)} * \frac{N-2008}{27} \right)^{2-\frac{3A}{200}}$$

Where

T_N = TAZ target total for year N
T_0 = TAZ existing total for base year (2008)
A = TAZ attractiveness score
N = target year

This formula behaves much like $T_N = cN^2$ for low attractiveness scores, and much like $T_N = c\sqrt{N}$ for high attractiveness scores.



Once the targets for the TAZs have been calculated, they are proportionately adjusted such that their sum meets the countywide population and employment targets for the target year.

Special Considerations for Employment during Great Recession

According to data from The Planning Center, employment totals for the Fresno County region dropped after 2008 and did not surpass 2008 totals until the year 2016. Thus, the formula illustrated above would not yield realistic employment results for these years. Thus, when extrapolating results from 2009 through 2015, the following formula is used when determining employment values:

$$T_N = -\left(T_0^{\left(2-\frac{3A}{200}\right)} * \frac{N-2008}{27}\right)^{\frac{1}{2-\frac{3A}{200}}}$$

Where

T_N = TAZ target total for year N
T_0 = TAZ existing total for base year (2008)
A = TAZ attractiveness score
N = target year

This formula behaves like an inverted form of the formula illustrated above, where regions with high attractiveness scores are less likely to lose employment.

Appendix J Item 6:
Fresno COG Off-model Tools

Technical Appendix - Off-model Procedures

In conjunction with the Fresno COG travel demand model, a number of off-model tools were employed to address issues where travel demand model cannot sufficiently cover, such as ride-sharing (i.e. car pool, van pool), employer-based commute strategies, bicycle and walk facility enhancement, ITS deployments.

San Joaquin Valley Air Pollution Control District Rule 9410

The eTRIP Rule (Rule 9410, Employer Based Trip Reduction), was adopted by the Air District in 2009. The rule will require larger employers to establish an Employer Trip Reduction Implementation Plan (eTRIP) to encourage employees to reduce single-occupancy vehicle trips, thus reducing pollutant emissions associated with work commutes.

Per the final (2009) Air District staff report on Rule 9410, Rule 9410 would apply to an estimated 1,883 worksites throughout the Valley, representing a wide range of sectors and accounting for approximately 500,000 commuting employees. This rule distinguishes those facilities into two tiers. Tier One Worksites are those with 100-249 eligible employees and Tier Two Worksites have 250 or more eligible employees. There are an estimated 1,342 Tier One Worksites and 541 Tier Two Worksites. Fresno has nearly 25 % of the Valley population, so it is assumed that Fresno has 25% of the 8-county shares of worksites.

The VMT reduction of work commutes was estimated based on model reported average home-based work trip length, countywide worksite numbers, and average number of employees per worksite by tier. The VMT reduction was applied to the total VMT by scenario before it was feed to EMFAC emission model, where GHG and criteria pollutant emissions were calculated.

Vanpool Reduction

Fresno COG has a robust carpool/vanpool program to promote ride-sharing. Fresno COG is a member of the California Vanpool Authority (CalVans), and has participated in the vanpool program extensively. According to CalVans report, vanpool accounted for 51,424,724 reduced VMT annually in 2012 in Fresno County, which translate to 197,787 daily VMT reduction. It is expected that the level of reduction will remain steady in the future, therefore the same percentage of VMT reduction was applied to all scenarios.

Moving Cooler

Moving Cooler was a report developed by Cambridge Systematics, and was intended to assess the effectiveness of various GHG reduction strategies on a national level. The strategies FresnoCOG considered were: active transportation modes (i.e. working and bicycling), operational and intelligent transportation system (ITS) strategies (i.e. ramp metering, variable message signs, signal control management, and traveler information).

The effect of GHG reduction was based on an aggressive deployment of these strategies in Fresno COG's SCS scenarios and on an expanded current practice deployment in the status quo scenario. Moving Cooler estimated GHG reductions were applied to GHG emission figures produced by EMFAC model.

Bicycle and Walk Trip Adjustments

The VMT reductions identified by Moving Cooler for active transportation modes were converted to bicycling and walking trips based on their respective average trip lengths. These additional trips were aggregated to the total active transportation trips to improve their mode share for all SCS scenarios.

Appendix J Item 7:
SCS Alternative Scenarios

Scenario A

Planning Strategy

The goals of Scenario A are as follows:

- To reflect the public's vision for their region's growth.
- To represent a realistic proportion between metropolitan and non-metropolitan growth.
- Where public vision may differ from local planners, to strive to reach a reasonable yet aggressive compromise.

Public SCS Planning Workshop

To garner the public's vision for growth in Fresno County, Fresno COG hosted a scenario planning workshop in November 2012. This exercise allowed the workshop's participants to place development "chips" on maps of Fresno County and its cities/communities. Each group of participants were given a choice between employing a more aggressive/compact development strategy or following a more traditional growth strategy, represented by separate groups of development chips that each represented the total housing and employment growth targets from 2008 to 2035.

Thirteen groups participated, each submitting a set of maps representing their group's vision for growth in Fresno County. These results were digitized and analyzed to create a single dataset representing the collective input from all the groups. This dataset was then proportionately adjusted to accurately reflect the population and employment targets, using the following methodology:

- The development in the metropolitan area (the cities of Fresno and Clovis) was scaled to match the same total targets for household population and employment in the metropolitan area used in Scenario B.
- The development throughout the rest of the County was likewise scaled to match the total Scenario B targets for that region.

Developing the Land Use Scenario within the Metropolitan Area

In general, the preferred land-use alternative plans for the cities of Fresno and Clovis proved robust enough to accommodate the public's development vision represented by the aggregated maps from the planning workshop. Thus, these preferred land-use alternative plans were used to guide development for Scenario A.

The following methodologies were used to allocate growth in the metropolitan area for Scenario A:

- The dataset representing the total aggregated growth from all workshop participant groups was divided into the following neighborhoods: Bullard, Clovis, Downtown, Edison, Fresno High, Hoover, Inner Clovis, Loma Vista, McLane, Northwest Urban, Roosevelt, SEGA, West, and

Woodward Park. Population and employment targets for each neighborhood were totaled and further categorized into targets for mixed-use development, retail employment, office employment, industrial employment, compact residential, and traditional residential.

- Three of the neighborhoods (Fresno High, Hoover, and Inner Clovis) were already developed nearly to capacity and did not have enough vacant land to accommodate the growth targets from the workshop dataset. The remaining growth for these neighborhoods was distributed proportionately to the remaining neighborhoods.

Developing the Land Use Scenario outside the Metropolitan Area

The public input for growth in the smaller cities and communities in Fresno County was far less robust and complete than in the metropolitan area; therefore, employing the same methodology used for the metropolitan area in this region would create a highly unbalanced and unrealistic vision. Thus, the following methods were used to create the land used scenario in the smaller cities and communities:

- During the exercise, Fresno County was separated into three regions, each with its own map: the metropolitan area (the cities of Fresno and Clovis), the west side (cities and communities west of CA state route 99), and the east side (cities and communities east of CA state route 99). It was assumed that when a group did not allocate any growth to an entire region, its intention was for the communities in that region to develop according to normal growth patterns, rather than receive no growth at all. To represent this "normal growth", Fresno COG "borrowed" some growth for these regions from Scenario B. For the non-metropolitan cities and communities in Fresno County, the amount of "normal" growth compared to the growth allocated through public participation was determined by the number of blank maps, which was 11 out of 26 (42.3%). Therefore, 42.3% of the growth in the non-metropolitan region for Scenario A is "borrowed" from Scenario B; the remaining 57.7% of the growth is represented by the development chips placed onto the maps by the public.
- To prevent unusual and unrealistic growth patterns, the projected population and employment growth targets for each city or community was constrained to represent no more than double their respective targets in Scenario B. For example, if a community was allocated a household population growth of 100 persons and 50 jobs in Scenario B, it could grow by no more than 200 persons and 100 jobs in Scenario A.
- Development types representing unusually high development densities for the non-metropolitan area were "scaled down" to corresponding development types, as follows:
    - Downtown = Town Center
    - Downtown Residential = Town Neighborhood
    - Mixed-Use Corridor = Neighborhood Center
    - Neighborhood Center = Town Neighborhood
    - Office Park = Suburban Office

Scenario B

Planning Strategy

The goals of Scenario B are as follows:

- To present a possible land use scenario that is consistent with the vision of local planners.
- To ensure that each city/community receives its fair share of growth, according to historical trends.
- To adhere to blueprint principles.

Determining Household Population Growth Distribution to the Municipal Jurisdictions in Fresno County

To distribute the total household population growth target among the incorporated cities and the unincorporated area in Fresno County, Fresno COG used data from three independent sources and combined them in a weighted percentage distribution. The datasets used, their relative significance in the total distribution calculation, and how they were used are as follows:

Decennial Census (45% significance)
Fresno COG compared total household population numbers from the 2000 and 2010 decennial census datasets from the U. S. Census Bureau to determine the share of Fresno County's growth by percentage for each incorporated city and the unincorporated area.

California Department of Finance (45% significance)
The growth in housing units from 2007 to 2012 was used in a similar fashion to create a distribution methodology between the incorporated cities and the unincorporated area.

2008 Base Land Use Modeling Data (10% significance)
The growth results from the first two datasets were slightly weighted by each jurisdiction's share of the existing housing units for 2008, by percent. These numbers were taken from the base land use dataset used by Fresno COG's regional traffic model.

Determining Household Population Growth Distribution to the Unincorporated Communities in Fresno County

To further divide the unincorporated growth into communities, only the California Department of Finance methodology was used. The resulting population growth totals were further adjusted through collaboration with Fresno County planning staff to more accurately reflect expected growth for future development sites (such as the Friant Ranch and Millerton communities).

Determining Employment Growth Distribution to the Municipal Jurisdictions in Fresno County

In a similar manner to the methodology for household population growth distribution, Fresno COG used two methodologies and combined them in a weighted percentage distribution to determine employment growth distribution by jurisdiction. The methodologies used, their relative significance in the total distribution calculation, and how they were used are as follows:

Housing Unit to Employment Ratio (75% significance)
Fresno COG used the 2008 land use dataset from the regional traffic model to determine each incorporated city's ratio of housing units to jobs, and allocated the employment growth projection according to these percentages.

Commute Estimates to the City of Fresno (25% significance)
This method used data from analysis done by Dowling Associates Inc. on the number of employees from each city/community in Fresno County who work in their community of residence compared to the number who commute to the City of Fresno.

Determining Employment Growth Distribution to the Municipal Jurisdictions in Fresno County

To further divide the unincorporated employment growth into communities, two methods were used and weighted evenly:

Commute Estimates to the City of Fresno (50% significance)
See description above.

Direct Relationship to Housing Growth (50% significance)
Each community's respective share in the total unincorporated housing growth was applied to distribute the total unincorporated employment by the same proportion.

Guidelines Followed when Developing the Land Use Scenario

- Development types and densities followed as closely as possible each city's current general plan, or each community's specific plan—or, in the cases of the cities of Fresno and Clovis which are considering revisions to their general plans, their most preferred land use alternative at the time of scenario development.
- In general and where possible, infill development and growth closer to city/community centers were preferred to sprawl development.
- In general and where consistent with local planning visions, mixed-use development was preferred to traditional residential or commercial development.

Scenario C

Planning Strategy

The goals of Scenario C are as follows:

- To remove growth from the foothill development areas and add growth to the City of Fresno's BRT corridor and other activity centers.
- Where possible, to present a possible land use scenario that is consistent with the vision of local planners.

Growth Allocation Methodology as Compared to Scenario B

In general, the development of Scenario C roughly follows the methodology of Scenario B, with the following amendments:

- Growth in the unincorporated region was allocated only to the following ten communities: Biola, Caruthers, Del Rey, Easton, Friant, Lanare, Laton, Riverdale, Shaver Lake, and Tranquillity.
- The population growth target due to new development for the City of Fresno was increased to receive an additional 4% of the County's total share. Most of this development was provided by growth taken from the unincorporated communities not listed above; the small difference needed to reach this full target was taken proportionally from the remaining incorporated cities.
- Once household population targets were determined, employment targets were arrived at by the same methodology as employed in Scenario B.
- Where possible and reasonable when compared with general and specific plans, compact and mixed-use development was preferred to traditional development.

Scenario D

Planning Strategy

The goals of Scenario D are as follows:

- To represent a more aggressive application of smart-growth principles such as compact and mixed-use development.
- To remove growth from the foothill development areas and distribute it to existing cities and communities.

Growth Allocation Methodology as Compared to Scenario B

Scenario D differs in its growth allocation and growth pattern, most notably in the following ways:

- All of the new growth allocated to the foothill communities of Friant Ranch, Millerton, and the proposed pharmacy school is removed and distributed to the remaining cities and communities according to the following methodology:
    - 60% was distributed to the incorporated cities, proportional to the total new growth population in Scenario B for each city.

    - 40% was distributed to the unincorporated communities identified in Scenario B, proportional to the total new growth populations in Scenario B for each community.
- Once household population targets were determined, employment targets were arrived at by the same methodology as employed in Scenario B.
- Growth patterns reflect a strong preference for compact and mixed-use development, representing roughly a 30% increase in residential density in the metropolitan area (the cities of Fresno and Clovis) and a 50% increase in residential density in the remaining cities and communities (as compared to Scenario B).
- Scenario D uses two new development types that are not present in Scenarios A, B or C, representing highly-compact, mixed-use, downtown development that is highly visionary for the Fresno County region.

Appendix J Item 8: Fresno SCS Performance Measures

Sustainable Communities Strategy Performance Measures

	Performance Measure/Indicator	Definition	Analysis	Scenario A	Scenario B	Scenario C	Scenario D	Status Quo
Land Use (Location Efficiency)	Transit-oriented development	Share of the region's growth in households and employment within half-mile of Bus Rapid Transit (BRT)	Using GIS, identify the planning areas intersecting a half-mile buffer around the scenario's BRT lines; compare total housing units and jobs against their respective scenario countywide totals.	HU: 27,475 (28.0%) EMP: 35,805 (43.7%)	HU: 20,389 (21.3%) EMP: 29,958 (36.6%)	HU: 26,416 (27.1%) EMP: 34,646 (42.3%)	HU: 33,415 (31.1%) EMP: 43,518 (53.1%)	HU: 5,787 (6.4%) EMP: 9,969 (12.2%)
	Residential density	Average residential density for new growth	Divide total new housing units by the sum acres of the scenario's planning areas that have non-zero residential growth.	8.3 HU/acre	7.4 HU/acre	8.5 HU/acre	10.2 HU/acre	4.6 HU/acre
	Percent of work trips less than 3 miles	Share of total work trips which are fewer than 3 miles	Percentage of work-based trips that are less than 3 miles long out of total work-based trips based on work trip length distribution provided by the traffic model.		17%			
	Work trip length distribution	Statistical distribution of work trip length in the region	Work-based trips length distribution provided by the traffic model.		8.9 miles on average (more details in distribution curves)			
	Housing	Percent of housing by types (SF/TH/MF)	The results for this indicator were provided by Envision Tomorrow.	44.1%/9.0%/46.9%	53.1%/9.1%/37.8%	45.1%/8.3%/46.6%	36.6%/14.6%/48.8%	77.7%/7.3%/15.1%
	Compact development	Growth in population compared with acres developed	Divide total population growth by the sum acres of the scenario's planning areas that have non-zero residential or employment growth.	27.6 ppl/acre	21.1 ppl/acre	24.7 ppl/acre	31.1 ppl/acre	13.9 ppl/acre
	Housing in terms of market demand	Housing types based on market study	Compare scenario housing mix with projected 2010-2040 consumer demand results from The Concord Group's market demand analysis, 2012 (SF/TH/MF).		SCS: 53%/9%/38% Demand: 57%/18%/25%			
	Access to transit line	New housing development within half-mile of transit stops	Using GIS, identify planning areas that intersect a half-mile buffer around existing and planned transit stop locations throughout Fresno County. (Sources: FAX bus stops, Clovis Transit stops, FCRTA stops, proposed BRT stops)		34,036 HU (35.5%)			
Transportation (Mobility, Accessibility, and Reliability)	(Recurrent) person delay per capita	Daily delay per capita in minutes	Per capita daily delay was calculated by dividing total daily delay, provided by the traffic model, by total population for each analysis year.		17.4 min			
	Total Person delay	Excess travel time resulting from the difference between a reference speed and actual speed	Total daily person delay based on delay by facility type (freeway, arterial, collector, etc.) and mode (drive alone, 2-person car pool, etc.) provided by the traffic model.		377689 hours/day			
	Travel time distribution for work and non-work trips	Travel time distribution for work and non-work trips	Travel time distribution by trip purpose (work-based and non-work-based) provided by the traffic model.		HBW: 16.6 min / HBO: 21.1 min / NHB: 16.4 min (more details in distribution curves)			
	Average distance for work or non-work trips in miles	The average distance traveled for work or non-work trips separately	Average trip lengths for work-based and non-work-based trips based on the trip length distribution provided by the traffic model.		HBW: 8.9 mi / HBO: 11.6 mi / NHB: 8.3 mi			
	Average work trip travel time	In minutes	Average trip length in time (minutes) for work-based trips, estimated by the traffic model.		16.6 min			
	Average work trip speed by mode	In mph by mode	Average speed in mph for work-based trips made in auto modes (drive alone, carpool), estimated by the traffic model.		Drive Alone: 31.3 mph / Carpool: 31.9 mph			
	Percent of work trips accessible in 30 minutes	In peak periods by mode (drive alone, carpool, and transit)	Percentage of work-based trips that are shorter than 30 minutes, estimated by mode by the traffic model.		Drive alone:94%/Carpool:			
	Percent of non-work trips accessible in 15 minutes	By mode (drive alone, carpool, and transit)	Percentage of non-work-based trips that are shorter than 15 minutes, estimated by mode by the traffic model.		Drive alone: 47%/Carpool 45%/Transit:7%/Walk:12			
	Vehicle Miles Traveled (VMT)	Total VMT and per capita VMT, per capita VMT reduction against 2005	Per capita VMT are calculated by dividing total daily VMT, provided by the traffic model excluding through traffic VMT, by the total population of the analysis year. Year 2005 value was back-casted to serve as a reference point for per capita VMT reduction.	23,584,242 miles / 18.1 miles / -11.88%	23,766,798 miles / 18.3 miles / -11.20%	23,416901 miles / 18.0 miles / -12.5%	23,724,332 miles / 18.2 miles / -11.36%	24,437,535miles / 18.8 miles / -8.69%
	Congested Vehicle Miles Traveled (VMT)	Congested VMT total and per capita, percentage of total auto/transit travel in congested conditions (peaks, all day)	Congested travel when V/C is greater than 0.75, summarized in total congested VMT, per capita congested VMT, and percentage of congested VMT in total VMT. Data was estimated by the traffic model by facility by different time periods (a.m. peak hour, p.m. peak hour, daily, etc.)		Daily Freeway: 3,762,593 / Daily Local: 2,804,821 (other time of day available)			
	Commute Travel (work trip) mode share	Weekday commute trips by mode, commute mode share	Mode share (drive alone, carpool, transit, bike and walk) among home-based work trips, estimated by the traffic model.		Drive Alone 81.9% / Carpool 13.4% / Transit 1.5% / Walk 2.5% / Bike 0.7%			
	Non-Commute Travel (non-work trip) mode share	Weekday non-commute trips by mode, non-commute mode share	Mode share (drive alone, carpool, transit, bike and walk) among all trips other than home-based work trips, estimated by the traffic model.		Drive Alone 28.4% / Carpool 62.3% / Transit 1.6% / Walk 5.7% / Bike 2.0%			
Healthy Environment	Criteria pollutants emissions	CO, NOX, PM2.5, PM10, and VOC	Criteria pollutants emissions were output from emission model EMFAC2011, which takes input such as facility type, speed profile, and VMT provide by the traffic model.	CO: 40 tons/ PM10: 7.9 tons / PM2.5: 1.0 tons / NOx: 11.6 tons (All Pass Conformity)	CO: 40 tons/ PM10: 7.9 tons / PM2.5: 1.0 tons / NOx: 11.6 tons (All Pass Conformity)	CO: 40 tons/ PM10: 7.8 tons / PM2.5: 1.0 tons / NOx: 11.5 tons (All Pass Conformity)	CO: 40 tons/ PM10: 7.9 tons / PM2.5: 1.0 tons / NOx: 11.6 tons (All Pass Conformity)	CO: 41 tons/ PM10: 8.2 tons / PM2.5: 1.0 tons / NOx: 11.9 tons (All Pass Conformity)
	Greenhouse gas reduction	Per capita greenhouse gas reduction against 2005	Greenhouse gas (GHG) emission was provided by emission model EMFAC2011, which takes input such as facility type, speed profile, and VMT provide by the traffic model. Per capita GHG emission was calculated by dividing total GHG by total population for each analysis year. Year 2005 values were back-casted to serve as a reference point for per capita GHG reduction.	-11.62%	-10.97%	-12.13%	-11.02%	-8.42%
	Fuel Consumption	On-road fuel consumed in gallons per capita	Total fuel (gasoline and diesel) consumption estimated by emission model EMFAC2011, which takes input such as facility type, speed profile, and VMT provide by the traffic model. Per capita fuel consumption was calculated by dividing total fuel in gallons by total population for each analysis year.		0.78 gallon			
	Transit productivity	Weekday passenger boarding	Total daily transit boarding figures provided by the traffic model.		47,186			
	Impervious surface	Total acres of impervious surface built from new growth	The results for this indicator were provided by Envision Tomorrow.		7,867 acres			
	Active Transportation and Transit Travel	Weekday person trips by transit, walk and bike modes	Daily personal trips made by active transportation (walking and biking) and transit modes provided by the traffic model.	transit: 49,247 / walk: 180,813 / bike: 57,081	transit: 47,186 / walk: 176,199 / bike: 56,212	transit: 48,796 / walk: 178,010 / bike: 56,751	transit: 51,461 / walk: 188,519 / bike: 59,461	transit: 40,660 / walk: 149,330 / bike: 54,610
	Near-roadway exposures	Percent of new housing within 1,000 feet of freeway or major roadway	Using GIS, identify the planning areas intersecting a 1,000-ft. buffer around existing state highways and interstates; compare total housing units against countywide total.		78,505 HU (81.9%)			
	Percent investment in active transportation	Investment in active transportation (sidewalks, bike lanes, etc.) as compared to total plan	Percentage of investment in planned transportation projects devoted to active transportation (biking and walking) as compared to total investments based on RTP financial plan.		2.52%			
Social Equity	Accessibility	Average A.M. peak work trip time by mode by Environmental Justice (EJ) and Non-EJ Traffic Analysis Zones (TAZ)	Numbers designated as countywide Non-EJ TAZs (EJ TAZs)		Drive Alone 19(15) / Carpool 18(17) / Transit 29(29)			
	Mobility	Average P.M. peak trip time by mode , by EJ and non-EJ TAZ	Numbers designated as countywide Non-EJ TAZs (EJ TAZs)		Drive Alone 20(17) / Carpool 20(19) / Transit 31(30)			
	Cost-effectiveness	Average Additional Daily Transit Passenger Miles Traveled (PMT) per $1,000 Investment	Numbers designated as countywide Non-EJ TAZs (EJ TAZs)		40.38(45.6)			
	Equity	Comparison of percentage of passenger miles traveled (PMT) and expenditures for EJ and non-EJ TAZ	Numbers designated as countywide Non-EJ TAZs (EJ TAZs)		132,498/$12.01(152,161/$10.46)			
	Reliability	Percent of VMT operating at level of service E or worse on links inside EJ and non EJ TAZ	Numbers designated as countywide Non-EJ TAZs (EJ TAZs)		33.27(9.80)			
	Consumer satisfaction	Average Vehicle Hours of Delay (VHD) for EJ and non-EJ TAZ	Numbers designated as countywide Non-EJ TAZs (EJ TAZs)		378,633(15,431)			
Resource Conservation	Land consumption	Acres of land consumed due to new development	Sum of vacant acres in planning areas with nonzero residential or employment growth.	11,226 acres	14,675 acres	12,542 acres	9,961 acres	22,308 acres
	Important Farmland	Total acres of important farmland (prime, unique and state-wide importance) consumed due to new growth	Using GIS, sum acres of the intersection of planning areas with nonzero residential or employment growth overlaid with applicable important farmland features. (Source: FMMP 2010)	102 acres	91.9 acres	74.1 acres	21.0 acres	345 acres
	Environmental resource land	Total acres of resource areas (CNDDB, critical habitat, FEMA, habitat connectivity, riparian forest, vernal pool & wetland, or input to be determined by Greenprint Committee)	Using GIS, sum acres of the intersection of planning areas with nonzero residential or employment growth overlaid with applicable features from the following datasets: CNDDB, Critical Habitat, FEMA floodzones, Habitat Connectivity, Riparian Forests, Vernal Pools, and Wetlands. (Sources: CA Dept. of Fish and Game, NOAA Fisheries, FEMA, USDA)		CNDDB 5,550 acres, CritHab 434 acres, FEMA 2,810 acres, HabConn 1,067 acres, RipFor 12.4 acres, VrnlPool 41.4 acres, Wetland 31.7 acres			
	Water consumption	Daily water consumption by new housing development based on national average rates	The results for this indicator were provided by Envision Tomorrow.		30,950,000 Gal/day			