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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

Council of Fresno County Governments

SB375 GREENHOUSE GAS EMISSION REDUCTION TARGET RECOMMENDATION

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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

	1 If 2030 DOF not reached until 2035		2 If net migration is reduced by 50%		3 If reduce growth rates by 25%	
Year	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%

	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)	
Year	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

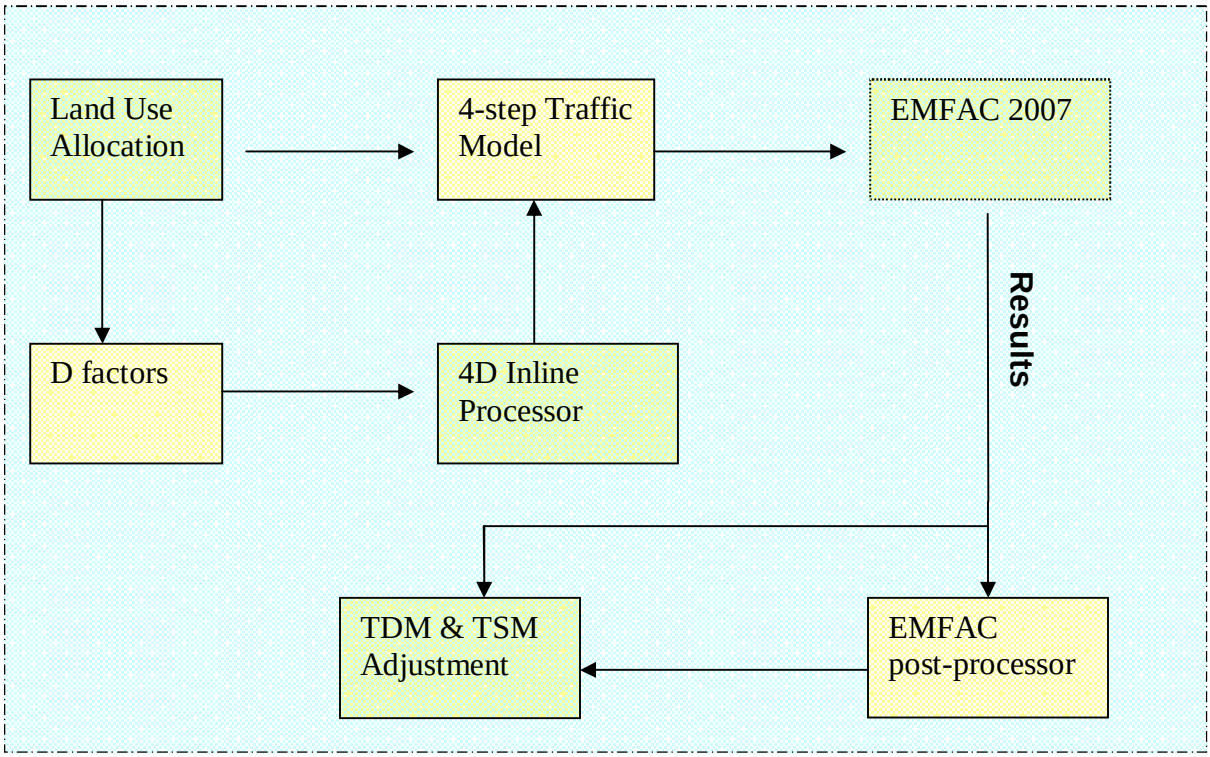
Variable	
Analysis Year	2035
Fuel Price Per Gal for Analysis Year (in '09$)	$5.24
Avg. Auto Miles / Gal	29.0
Gas Cost Per Mile (in '09$)	$0.18
Tire+Maint Cost Per Mile (in '09$)	$0.107
Total Auto Ops Cost Per Mile (in '09$)	$0.29
Convert to RTP Model Cost Basis Year	0.7986232 ('09 to '00 $)
Fuel Price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

Baseline Scenario

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	2035
		Percent Per-Capita GHG Reduction from 2005	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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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

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.

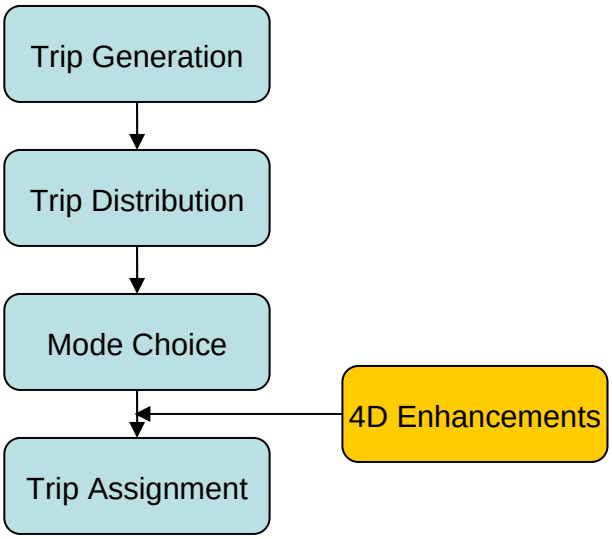
6. MODEL INTEGRATION

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.

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.

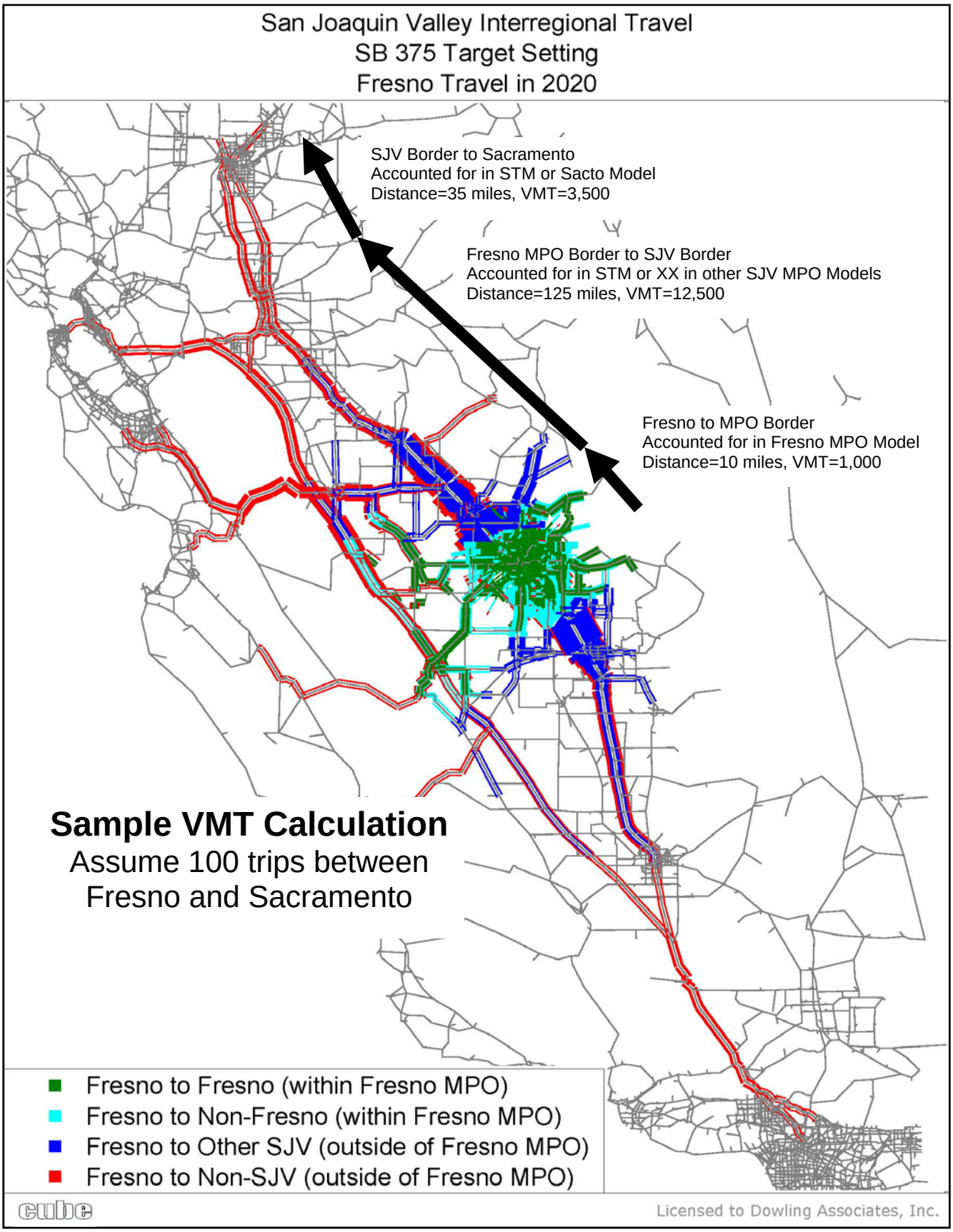
2. **VMT on SJV Links** – VMT associated with travel ***to/from*** SJV region (trips where either the origin or the destination are within SJV) ***on SJV links***, outside of the origin MPO and the destination MPO.

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
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