INFORMATIONAL REPORT ON THE SAN DIEGO ASSOCIATION OF GOVERNMENTS' DRAFT SB 375 SUSTAINABLE COMMUNITIES STRATEGY

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California Environmental Protection Agency

Air Resources Board

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The San Diego Association of Governments (SANDAG) has prepared a draft Regional Transportation Plan (RTP or plan), including a Sustainable Communities Strategy (SCS) designed to meet the requirements of the Sustainable Communities and Climate Protection Act of 2008 (SB 375). The draft RTP includes a determination that the SCS would meet the regional greenhouse gas (GHG) emissions reduction targets established by the Air Resources Board (ARB or Board). ARB staff has reviewed the draft SCS and the quantification of the greenhouse gas reductions expected from implementation of the plan. This report describes the nature of the review and staff conclusions about the greenhouse gas reductions expected from the draft SCS for the San Diego region.

As required by SB 375, the ARB set regional GHG emissions reduction targets (targets) for 18 metropolitan planning organizations (MPOs) in California. These regional targets, set for 2020 and 2035, were defined by the Board as a percent reduction in per capita GHG emissions from passenger vehicles from a base year of 2005. ARB is required to review the regional plans to determine whether the SCS, if implemented, would meet the regional targets. To inform the Board and the public about ARB staff's review process, a report entitled "Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies (SCS) Pursuant to Senate Bill (SB) 375" was released in July 2011.

The ARB staff review focuses on the technical aspects of the regional modeling and supporting analyses that underlie the GHG quantification. This includes the modeling results, model inputs, and other supporting analyses. The review methodology is intended to provide the framework for a transparent evaluation of the reductions in GHG emissions expected from an SCS. The four specific technical components of ARB staff's review method are: the travel model, data inputs and assumptions, sensitivity analyses, and regional performance indicators.

The quantification of GHG emissions from passenger vehicles uses the same approach relied upon in the planning process for air quality standards. The MPO travel demand models project vehicle travel, expressed as vehicle miles traveled (VMT), which is combined with ARB vehicle emissions factors to quantify regional emissions. For GHG quantification, the results from the travel demand model are supplemented with additional modeling tools to better account for changes in GHG emissions from SCS strategies. This is necessary because current travel demand models are not sufficiently sensitive to reflect all improvements to the transportation system or land use pattern that would reduce GHG emissions. ARB's Regional Targets Advisory Committee recognized the need to use supplemental analytical tools while continuing to improve travel demand models, and the Board recognized the improvement efforts as part of the initial target setting process.

As required by Government Code Section 65080(b)(2)(J)(i), MPOs have provided ARB with descriptions of the technical methodologies intended to be used to estimate the GHG emissions from an SCS. These methodologies rely on the use of the MPO travel demand models used in the transportation planning process. ARB has agreed that using the current MPO travel demand models is the most appropriate method for quantifying GHG emissions, with the recognition that the models are region-specific, MPOs are working to improve the models, and that supplemental analyses may be needed. Staff's review approach reflects the current MPO quantification methodologies using travel demand models, and provides an independent assessment of the GHG emissions quantification. ARB staff has completed this technical review in order to make a recommendation to the Board as to whether to accept the SANDAG quantification of GHG emissions from the SCS. As specified in Government Code Section 65080(b)(2)(J)(ii), ARB's review role is "acceptance or rejection of the MPO determination that the strategy (SCS) would, if implemented, achieve the greenhouse gas reduction targets".

SANDAG was already in the process of developing its required RTP update when ARB set the regional GHG reduction targets. While some modeling scenarios were available in the target setting process, significant new work has been done in preparation of the draft SCS. ARB staff has been reviewing the technical foundation of the SANDAG emissions quantification on a parallel track in order to report to the Board prior to SANDAG action on the draft SCS. ARB staff's review indicates that SANDAG applied its methodology as proposed, using its travel demand model, off-model tool, and appropriate model inputs, assumptions, and sensitivity analyses.

The quantification of GHG emissions from the draft San Diego SCS indicates that the ARB target of a 7 percent per capita reduction in 2020 and a 13 percent per capita reduction by 2035 would be met with SCS implementation. Therefore, if SANDAG approves the draft SCS, ARB staff will recommend that the Board accept the SANDAG finding that implementation of the SCS would meet the targets. If SANDAG modifies the draft SCS, ARB staff will review the changes to determine the impact on greenhouse gas emissions. ARB staff will inform the Board of the outcome, including any need to reconsider whether the final SCS would meet the target.

Although the staff review shows that the draft SCS would meet ARB targets, the trend in per capita GHG emissions is unexpected. The San Diego SCS would achieve double the 2020 target and just meet the target in 2035. During the target setting process, including in meetings of ARB's Regional Targets Advisory Committee, there was an expectation that the benefits of an SCS would increase with time given the nature of land use patterns and transportation systems. ARB set regional targets with that expectation. SANDAG has characterized the trend as largely the result of a slow economic recovery combined with early investments in public transportation including mid-coast light rail, I-5 bus rapid transit, and other transit projects. Since the SANDAG assumptions about economic recovery prior to 2020 are similar to other economic forecasts, much of the focus has been on the per capita GHG emissions trend between 2020 and 2035, and beyond. Related to the future forecasts for the region, there has also been concern that portions of the SANDAG travel demand model are proprietary, which does not provide for transparency in the modeling process. SANDAG has acknowledged these comments as they relate both to their existing modeling system and the next generation of travel models currently under development for the next planning process.

Improvements to SANDAG's modeling system are well underway, with development of an activity-based model that will do a better job quantifying travel behavior, evaluating different land use scenarios, and addressing issues such as induced demand. SANDAG staff is also pursuing improved tools to supplement travel model outputs, and to integrate land use and freight models with the region's travel model systems. These improvements are essential for future SCS development.

The San Diego SCS is the first to be developed and reviewed by the Board. Since the enactment of SB 375, ARB has worked to support implementation by funding research and model improvements, developing a technical review methodology, participating in interagency workgroups, and holding public meetings on ARB implementation activities. As part of the review process, ARB staff has evaluated public comments and SANDAG responses where possible. The development of a draft SCS for San Diego has involved new planning activities at the State, regional, and local levels, and enhanced coordination among the major MPOs in California. This commitment to SB 375 implementation sets the stage for a long-term planning effort as ARB updates the regional GHG targets and RTPs are periodically revised.

The San Diego land use planning update begins with the Regional Comprehensive Plan (RCP). The RCP update includes another round of regional visioning about future land use patterns and development. This presents an opportunity for all jurisdictions represented by SANDAG to focus more attention on the post-2020 land use pattern and transportation system to improve the per capita GHG reductions in 2035 and beyond. The RCP update will also set the stage for ARB's 2014 target update, which includes the development of target-setting scenarios and recommendations from SANDAG. ARB staff anticipates that more sophisticated modeling tools and information will be available for the San Diego region to help inform the Board's reconsideration of the current greenhouse gas reduction targets. The promise of an SCS is that over time changes in the transportation system and land use pattern will result in decreasing per capita greenhouse gas emissions. The land use scenario planning process provides a way for regions to explore options for growth that can achieve greater greenhouse gas reductions. San Diego's next planning process would benefit from additional land use scenario planning coupled with a reassessment of the transportation system to further support the region's sustainability goals.

I. SAN DIEGO'S LAND USE AND TRANSPORTATION PLANS

The San Diego region's draft Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS) represents an important next step towards realizing the region's vision for sustainability, with a long-range strategy that encompasses a 40-year planning horizon. This is the first SCS developed to meet the passenger vehicle greenhouse gas emissions reduction targets set by ARB. Regional efforts to develop the draft plan were already underway when ARB established targets in September 2010.

The draft RTP has a planning horizon of 2050, with voter-approved local transportation improvement revenues providing most of the funding. Under State law the SCS is a required element of the RTP and must address GHG reduction target years of 2020 and 2035. The draft RTP provides both interim and long-term goals for the region, and includes progress metrics tied to infill density and smart growth patterns, increased transit in proximity to new development, and decreased per capita GHG emissions from vehicle miles traveled**.** The long-term elements of the plan will continue to evolve as the RTP is updated every four years.

A. Regional Planning Process

SANDAG, as the MPO for the San Diego area, is responsible for transportation planning and the development of the region's SCS. Locally elected officials from San Diego County and the 18 cities in the region are represented on the SANDAG Board. SANDAG coordinates the region's transportation planning, growth management efforts, and habitat conservation activities helping to promote a regional vision for the San Diego area's future.

Over the past few decades, SANDAG's efforts have led to an increasingly comprehensive regional planning process. By 2035, SANDAG now forecasts that the region's population will grow by almost 900,000 and with it, the need for another 273,000 housing units and the creation of over 300,000 new jobs. With this population increase, the region is faced with continuing pressure to build additional transportation infrastructure, and add new housing, jobs, and commercial/retail facilities. To respond to such regional growth projections, in 2000 SANDAG developed a REGION2020 Growth Management Strategy. As part of this effort, the agency worked with its local governments to develop principles for smart growth for the region, and obtained resolutions of support for the strategy from all 19 local jurisdictions.

Building on the REGION2020 strategy, SANDAG adopted the region's first Regional Comprehensive Plan (RCP) in 2004. The RCP is a long-range planning document which focuses on how the region will accommodate its growing population while balancing needs for housing, employment, habitat preservation, agriculture, open space, and infrastructure. It identifies where growth should be directed and where it should be avoided, emphasizing smart growth to accommodate the anticipated increase in population.

The RCP planning process was extensive, representing a collaboration of individuals, stakeholders, planning directors, public works directors, city managers, community-based organizations, elected officials, neighboring counties, and representatives from tribal governments, Mexico, and State and federal agencies. The RCP called for the development of a Smart Growth Concept Map, which was adopted in 2006 and updated in 2008, and the creation of a Smart Growth Incentive grant program. Both currently help local governments to implement the RCP goals.

SANDAG's latest planning document, the draft RTP/SCS, incorporates land use patterns envisioned by the RCP. Over half of the over 2.7 million acres of land in San Diego county are already developed or in use. The majority of the developed area is used for parks and military lands, followed by single-family residential uses. New development is concentrated in the western third of the county in a more compact form within increased residential densities. Nearly 470,000 acres of land throughout the region are unavailable for development due to preservation or protection requirements, physical limitations such as steep slopes, or other development restrictions.

As the transportation system is built to accommodate these land use patterns, by 2050 more than 80 percent of new homes are envisioned to be multi-family units located near transit; the percentage of all residents who will use transit would almost double from 6 to 11 percent; and nearly one out of every three trips will be made using a mode of transportation other than driving alone.

The SANDAG draft SCS presents a picture of the changing land use and transportation patterns of the region that continues to move in the direction of smart growth. It commits increased revenues to the improvement of the roadway and public transportation network to support future land use patterns consistent with jobs and housing needs and protection of valuable open space and conservation areas. While the specific mix and timing of transportation projects may be adjusted over time and local general plans updated, the transportation and land use pattern in the SCS provides a solid foundation for future planning.

B. San Diego Transportation System

The transportation system serving the San Diego region today is a complex and expansive multimodal network that supports the region's economic base and the demand for personal travel. The transportation network facilitates the movement of people throughout the region for a variety of purposes, and is essential for freight transport and continued economic development. Similar to the region's land development patterns, the major transportation facilities and services are located in the western third of the region to best serve the largest and fastest growing population areas.

The multi-modal transportation system includes an interconnected system of roads, transit, rail, maritime, aviation, and non-motorized facilities and infrastructure. It is the product of decades of transportation investments and projects approved through previous regional transportation plans, and has been shaped by the policies, laws, and regulations at the federal, State, and local levels.

The regional roadway system is an interconnected network of interstate freeways, highways, toll roads, arterial streets, and local streets. This roadway network allows for the movement of private and commercial vehicles, buses, and heavy trucks. The regional public transit system includes local and regional bus operations, regional and interregional commuter rail services, and light rail service. The freight railroad network includes three freight rail lines. Non-motorized transportation facilities include walkways, bikeways, and associated infrastructure. This vast system serves the region's 18 cities and the county's unincorporated areas, as well as interregional and cross-border commuting.

Like all other MPOs, SANDAG's transportation plans and programs have been shaped over the last two decades by the federal government's series of Transportation Equity and Efficiency Acts. These acts made significant changes to the planning process for transportation, adding enhanced environmental planning requirements, greater attention to multimodal capacity, and consistency between transportation improvements and planned growth patterns.

Starting in 1988, San Diego's transportation planning process was also influenced by a local sales tax initiative. The region's TransNet program, a half-cent sales tax measure is providing the revenue needed to improve the region's transportation system, including relieving roadway congestion, and building a more robust public transportation system that includes new light rail and bus rapid transit services, improvements to existing commuter rail and light rail services, new carpool/express lanes along many of the major transportation corridors, and environmental and smart growth programs. TransNet was renewed in 2004 by more than two-thirds of San Diego county voters, and now extends through 2048.

SANDAG's draft RTP has a planning horizon of 2050 to reflect anticipated revenue from TransNet through the year 2048 and ties the transportation system improvements to the land use patterns reflected in the Regional Comprehensive Plan and Smart Growth Concept Maps. The draft RTP extends well beyond the GHG target year of 2035, providing a long term perspective that will be updated on a regular basis.

SANDAG's draft RTP is based on a revenue-constrained transportation network of public transit, managed lanes and highways, local streets, bikeways, and walkways partially funded through the TransNet ballot measure and state and federal sources. The draft RTP reflects the planned expenditure of nearly $200 billion to support comprehensive transportation network system improvements, with over 40 percent of the total spent on transit, more than in any previous RTP. The draft RTP also contains the region's largest investment in bicycle and pedestrian infrastructure to date. Other TransNet funded projects approved by the public include transit expansion and improvements that reflect a substantial investment in rail, bus, bus rapid transit, streetcars, and bike and walk facility projects. They are intended to increase the attractiveness of non-auto travel in areas that are planned for more compact and mixed-use development, as well as highway expansion projects to address congestion relief.

SANDAG's draft RTP also identifies a number of policies and strategies that will help guide their future transportation project investments, which are supported by federal, state, and local funds. Transportation demand management (TDM) strategies are included to help reduce or eliminate traffic congestion during peak periods of demand and improve the efficiency of the existing system by encouraging non-auto modes of travel and shifting travel demand to non-peak hours. These strategies include telecommuting, vanpools, carpools, buspools, bike lockers and bike stations, and bike sharing and car sharing programs.

The draft RTP also relies on transportation system management (TSM) strategies to maximize the efficiency of the existing and future transportation network through strategies that include signal and ramp metering, performance monitoring, advanced vehicle and roadside communication, traveler information services, bottleneck relief, and incident management.

Finally, the draft RTP proposes pricing strategies to reduce the demand on the transportation system which will reduce vehicle miles traveled, and relieve traffic congestion during peak periods of demand. These include varying prices within corridors that have managed lanes. Operation of high occupancy toll (HOT) lanes provides incentives for using public transit and sharing rides.

C. Key Elements of the San Diego Sustainable Communities Strategy

SB 375 requires California MPOs to include in their RTP, a Sustainable Communities Strategy that integrates land use, housing, and transportation planning. SANDAG's draft RTP includes an SCS that would meet the ARB targets for GHG reductions, if implemented as planned. It quantifies the region's passenger vehicle GHG emissions for 2020 and 2035 by modeling the transportation network and other transportation measures and policies along with the forecasted development pattern.

SANDAG identifies five "building blocks" for the draft SCS: a land use pattern, a transportation network, transportation demand management, transportation system management, and pricing policies. The land use pattern accommodates the region's future employment and housing needs, while protecting sensitive habitats and resource areas. It includes smart growth land use strategies adopted as part of the RCP and reflected in the region's Smart Growth Concept Map and local general plans, enabling new development to be more compact and accessible to public transit and non-motorized travel modes.

The draft SCS accommodates the region's anticipated housing needs and the State's regional housing allocation requirements, includes a transportation network to address regional mobility needs, shows the general location of land uses, and identifies residential and building densities in the region. The projections used to model land use patterns focus new development in and near existing urban areas, and reflect regional habitat conservation programs and open space plans that preserve over half of the region as undeveloped land.

Consistent with regional land use pattern in the SCS, the transportation system in the RTP supports anticipated new development concentrated in the western third of the county, with a more compact form and increased residential densities. The proposed transportation system accommodates the region's population growth of an additional 900,000 people in 2035 along with the need for another 273,000 housing units and the creation of over 300,000 new jobs. It does this by providing for transit in close proximity to more than 80 percent of all housing in both 2020 and 2035.

> By 2035, 80 percent of housing in the San Diego region will be within ½ mile of transit stations

D. SANDAG'S Public Participation Process

SB 375 requires that during development of the SCS, MPOs consult with elected officials in the region, develop and implement a public participation plan, and conduct outreach and workshops throughout the region.

To support the development of its SCS and address statutory requirements, SANDAG expanded their existing public outreach and involvement program. In June 2011, SANDAG held five sub-regional public meetings/workshops to provide information and gather input for the development of the plan. These workshops provided the public with information on the transit and transportation networks, the environmental impacts, and the GHG target setting process, which is a requirement for the SCS. Development of the draft SCS involved the participation of a diverse group of representatives from the low income, minority, senior, and disabled communities, including eight community based organizations whose participation was supported by grants provided by SANDAG.

II. ARB STAFF REVIEW OF THE DRAFT SAN DIEGO SCS

A. Overview

The Sustainable Communities and Climate Protection Act calls for ARB's "acceptance or rejection of the MPO's determination that the strategy (SCS) would, if implemented, achieve the greenhouse gas emission reduction targets" in 2020 and 2035. ARB staff prepared this report to inform the Board and the public about SANDAG's draft SCS, the method ARB staff used to assess SANDAG's determination that the SCS would meet its targets, and the results of staff's technical evaluation of SANDAG's quantification of passenger vehicle GHG reductions.

SANDAG's quantification of GHG emissions from the draft SCS is central to its determination that implementation of the SCS would meet the targets. The transportation modeling system, including the model, its inputs and performance indicators, and sensitivity analyses, provides the technical foundation for this determination.

ARB staff's evaluation indicates that SANDAG has demonstrated that the draft SCS, if implemented, would meet the GHG emissions targets for 2020 and 2035. SANDAG made its determination using the methodology submitted to ARB as required by Government Code section 65080(b)(2)(j)(ii). SANDAG uses a model and modeling approach that meets current standards and accepted practice; the inputs and assumptions are reasonable and appropriate for regional analyses; the sensitivity analyses demonstrate adequate model sensitivity to transportation strategies; and an evaluation of the performance indicators support the predicted GHG reductions resulting from the draft SCS.

1. Application of ARB Staff Review Method to the San Diego SCS

The method ARB staff used to review the quantification of greenhouse gas reductions in SANDAG's draft SCS was made available to the public in the July 2011 document entitled "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies Pursuant to SB 375".

SANDAG's quantification of GHG emissions from the draft SCS relies on the results of its travel demand model and supplemental technical analyses. The travel demand model employs a set of algorithms and model inputs to project changes in land use, transportation systems, and travel activity. Inputs include data sets, such as base year population, the number and sizes of households, and planning assumptions about future year land use, housing, and transportation policies. Model outputs include metrics such as VMT, vehicle trips, and average speed. The VMT outputs of the travel model are then converted to GHG emissions for the target years by applying GHG emission factors from ARB's vehicle emissions model, EMFAC.

Model outputs can also be converted into other key metrics, or performance indicators, that describe the forecasted regional changes in travel behavior and regional vehicle activity patterns in 2020 and 2035. To assess the responsiveness of the model to changes in key inputs, sensitivity analyses are often used. They involve systematically changing a model input variable, such as VMT, to observe the changes to the model outputs. ARB staff requested and received sensitivity analyses from SANDAG which are included in this review.

The ARB staff methodology for SCS review focuses on the technical aspects of the regional modeling and supporting analyses that underlie the quantification of GHG reductions. ARB's methodology provides a framework for reviewing the VMT-related emissions expected from an SCS and is structured to look at model inputs, application of the model, and modeling results. ARB staff evaluated how SANDAG’s travel demand model, off-model tools, and other forecasting models operate and perform, and how well they provide for quantification of the GHG emission reductions associated with the draft SCS. ARB staff also examined additional general questions such as: How well does the model work to replicate observed results? What is the quality of the data inputs and how do they compare with the empirical literature? Is the model relatively sensitive to changes in variables?

Specific to the modeling, we were interested in answering questions such as:

- Are the model inputs and assumptions reflective of real world conditions?
- What is the basis for future year projections?
- Does the draft SCS analysis consider and account for timing of plan elements?
- Do the modeling results and other analyses adequately reflect the impacts of the SCS on GHG emissions?
- Does the modeling approach show that the draft SCS, if implemented, would achieve the 2020 and 2035 targets?

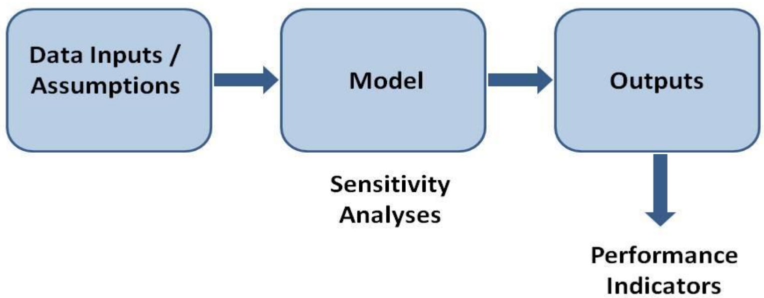
To help answer these and other questions, ARB staff used publicly available information in SANDAG's draft SCS and accompanying documentation provided by SANDAG staff. In response to ARB staff requests (see Appendix D), SANDAG provided additional clarifying information and updated its initial documentation.

Following the July methodology, ARB staff evaluated four central components of SANDAG's quantification methodology and supporting analyses:

- Modeling Tools
- Data Inputs and Assumptions
- Sensitivity Analyses
- Performance Indicators

Figure 1 illustrates how these components relate to each other.

Figure 1. Components of Modeling System



a) Modeling Tools

ARB staff reviewed SANDAG's model documentation and model validation reports, and consultant and peer review reports to assess whether SANDAG's model reflects existing and future conditions, as well as the likely traveler response to the draft SCS strategies. Staff also examined SANDAG's off-model documentation and results of its consultant review to determine if appropriate tools were used to account for the impacts of its draft SCS on GHG emissions. SANDAG's modeling practice was also reviewed in light of the California Transportation Commission (CTC) RTP Guidelines, the Federal Highway Administration (FHWA) modeling guidelines, and other key modeling guidance and documents.

b) Data Inputs and Assumptions

ARB staff assessed a subset of SANDAG's input data sets and assumptions to confirm that the model inputs were appropriately used in SANDAG's model, and represent current and reliable data. Staff evaluated the underlying data sources, assumptions used to modify the data, and the forecasts used to calculate data in future years. This involved using publicly available, authoritative sources of information, such as national and statewide data, and considering additional regionally specific forecasting approaches.

c) Sensitivity Analysis

In July 2011, SANDAG released the “SANDAG Transportation Model Sensitivity Analysis and Report.” ARB staff evaluated the results of SANDAG’s sensitivity analyses, which examined the responsiveness of the travel demand model to systematic changes in input values for ten model variables:

- Auto operating costs (fuel component only)
- Parking costs
- Income distribution
- Transit fares
- Transit frequency
- Transit access (wait times and transfers)
- Transit access (walk factors)
- Network assignment
- Roadway capacity
- Trip generation discounts (e.g., effects of e-commerce and telecommuting)

Tests for each variable and the changes in model outputs are described in SANDAG’s report.

ARB staff reviewed the results of SANDAG’s sensitivity analyses to assess whether the model was generally sensitive to the changes by verifying that the direction of change was consistent with the relevant empirical literature. Staff also assessed whether the magnitude of the changes observed was appropriate (otherwise known as “appropriately sensitive”), based on elasticities reported in the empirical literature. An “elasticity” is an economic concept that quantifies the relationship between the choices people make and the cost of those choices. In transportation, this concept is used to quantify how changes in the cost of travel influence an individual’s choice about the amount that they will travel. Elasticities can also be used to describe the relationships between changes in land use or transportation variables other than cost, and their likely impact on travel behavior. For example, variables could include changes in frequency of transit or roadway capacity.

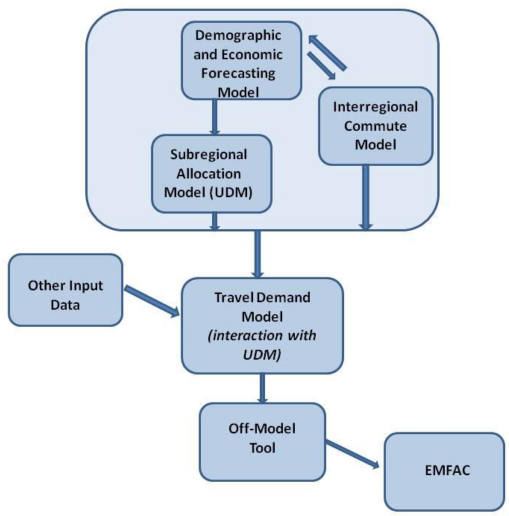
Staff compared the results of SANDAG’s model sensitivity runs with comparable empirical studies. Where available, staff applied the elasticities described in these studies to the changes in inputs used in the SANDAG test runs in order for staff to calculate an expected range of changes in outputs (e.g., VMT, trips). Staff compared the expected output ranges to the modeled outputs from the SANDAG sensitivity runs to determine if the model is “appropriately sensitive” for the variable. For the variables where the body of relevant empirical literature is limited or not directly appropriate to the unique profile of the SANDAG region, ARB staff used the available literature as a supplementary tool to corroborate or to build on the findings in SANDAG's sensitivity analysis.

d) Regional Performance Indicators

SANDAG used several indicators that are indicative of SCS performance to determine whether they provide supportive, qualitative evidence that the SCS could meet its GHG targets. These performance indicators include passenger VMT, commute trip mode share, residential density, distance of housing and employment from transit stations, and bike and walk trips. ARB staff conducted a qualitative evaluation to determine if increases or decreases in individual indicators are directionally consistent with SANDAG's modeled GHG emissions reductions. Staff relied on the relationships expressed in the empirical literature between these metrics and VMT and/or GHG emissions to understand whether the changes are consistent with the GHG emission reduction trends.

B. SANDAG's Modeling Approach

Figure 2. SANDAG Modeling Tools



SANDAG's modeling approach consists of several tools that are used to estimate GHG emissions in the draft SCS. Three models are used to project future regional economic and demographic characteristics, inter-regional commute patterns, and growth allocation by land uses, which then become inputs into the travel demand model, along with other key model input data. The travel demand model was then used to forecast future travel activity. Where the travel model did not respond sufficiently to changes in model inputs, an off-model tool was used to adjust travel model results. SANDAG then applied ARB's vehicle emissions model (EMFAC) to estimate passenger vehicle CO2 emissions from changes in VMT and speeds. Figure 2 illustrates these models.

1. Forecasting Tools

The SANDAG Board of Directors approved the 2050 Regional Growth Forecast in February 2010 for use in the draft RTP. These forecasts are revised every 3 to 5 years to reflect updated data, changing trends, and current policies. SANDAG's growth forecast modeling system consists of three models: the Demographic and Economic Forecasting Model (DEFM) that projects future economic and demographic characteristics in the region; the Inter-regional Commute Model (IRCM) that accounts for individuals who work in the region but live outside its boundaries; and the sub-regional Urban Development Model (UDM) to allocate growth within the region.

The DEFM is an econometric forecasting model with a demographic module that produces a forecast of the future economy. This forecast includes the composition of that future economy, i.e., the industries and other economic sectors that are dominant in the region, those sectors that are secondary, and other levels of the region's economic structure. DEFM also produces a demographic forecast that is consistent with the region's economic forecast. DEFM produces these forecasts based on relationships between historical changes in the region's economy and historical changes in the U.S. economy. The demographic module uses a cohort-survival model to forecast population by age, gender, and ethnicity. A cohort-survival model is a method for forecasting future population based on the survival of the existing population and births during the planning period. DEFM produces extensive data including the population by size and composition, employment by industrial sector, household and personal income, housing units by structure type, vacancy status and persons per household, labor force, and school enrollment.

The Inter-regional Commute Model (IRCM) accounts for individuals who work in San Diego County but live outside its boundaries. It predicts the residential location of workers based upon accessibility to job sites, home prices, and the availability of residential land. Inputs to IRCM include future job and residential sites, and potential residential sites in the county, and nearby Orange County, southwest Riverside County, Imperial County, and Tijuana/Northern Baja California. The model also accounts for relative home prices across these areas.

The Urban Development Model (UDM) allocates changes in the region's economic and demographic characteristics to areas within the region. Key inputs to UDM include the current spatial distribution of jobs, housing units, income, and population, land use inputs that include the plans and policies of the 18 cities and the County of San Diego, and current and future transportation infrastructure. The UDM outputs are used as one of the inputs to SANDAG's travel demand model. The travel model results are then looped back to the UDM to further refine the inputs. For example, the UDM uses commute trip travel times to connect residential location and work location. As the output of the UDM changes the location of residential and work development, travel times predicted by the travel model can change.

Housing units and employment capacity in the region reflect current local land use plans and policies, as well as the implementation of smart growth development strategies throughout the region. Determining the amount and location of housing units and employment capacity in the region are key to allocating the long-range regional forecasts to jurisdictions, communities, and neighborhoods. Likewise, housing unit and employment capacity represent key policy inputs to the forecasting process. Local governments provide these inputs to SANDAG which are then used in both the UDM and the IRCM to forecast urban and inter-regional development.

Compared to previous growth forecasts for the San Diego region, the 2050 Regional Growth Forecast used for the draft RTP provides for a longer time horizon (forty years, as compared with twenty five years in previous forecasts). In developing the 2050 Regional Growth Forecast, SANDAG staff consulted with local jurisdictions to understand how local land use plans and policies might change and evolve in the next forty years. The 2050 Growth Forecast also includes draft local plan updates and redevelopment assumptions within existing plans. Based on these assumptions, the 2050 Growth Forecast presumes that more existing lands may be re-developable through 2050.

2. Travel Demand Model

Each of the 18 MPOs in California uses and maintains a travel demand model for development and evaluation of its RTP. The four-step travel demand model SANDAG used for its SCS development and GHG emissions quantification is based on the TransCAD platform. The travel demand model plays an integral role in transportation planning by providing the technical foundation and data upon which the RTP, and therefore the SCS, is built. The travel demand model, along with associated emissions models, is used for evaluation of progress towards federal air quality standards. The model fully integrates geographic information systems (GIS) and travel demand modeling capabilities and requires a significant amount of input data and computer run time.

The regional transportation network is developed and integrated into the travel demand model to illustrate current and future highway and transit facilities, which include 16,218 lane miles of freeways, arterials, and local roads within a region of about 4,200 square miles. As mentioned previously, the results from the socio-economic and land use forecast models also serve as inputs into SANDAG's travel demand model. Travel survey data from SANDAG's 2006 San Diego Household Travel Study were used to estimate the model parameters and to calibrate each step of the model. To reduce the travel model run time, SANDAG aggregated parcel level information to three spatial boundaries: 33,353 Master Geographic Reference Areas (MGRA), 4,682 Transportation Analysis Zones (TAZ), and 2,000 Transportation Distribution Zones (TDZ). The MGRA is the lowest level of aggregation where walk and bike activities are estimated and fed into the mode choice step, followed by the TAZ, and then the TDZ levels. These three zoning systems should be comparable so that when they predict the flow of travel between the zones, the VMT and GHG emissions estimates are comparable.

The travel demand model consists of four major modeling steps: trip generation, trip distribution, mode choice, and trip assignment.

Step One: Trip generation in the SANDAG model estimates the number of person or vehicle trips for activities, such as traveling to and from work, school, shops, and recreation. In its analysis, SANDAG estimated the number of trips taken in the San Diego area by applying trip rates at the TAZ level, which includes unique socio-economic status and land use types. Trip production and attraction rates were based on dwelling unit types, land use categories, and total employment. Trip rates were calculated based on SANDAG's 1995 and 2006 Travel Behavior Survey, Caltrans' 2000-2001 California Statewide Travel Survey and other travel studies.

SANDAG also incorporated unique trip generation modules for beaches, military installations, and universities. Non-residential trip rates were estimated based on land use categories. Trips from external zones, or those outside San Diego County, were based on traffic counts at the county boundary. For future years, SANDAG assumed a trip reduction of about 3-5 percent to account for telecommuting and e-commerce for certain trip types and land use categories (trip discount rates). To account for future demographic and economic changes, SANDAG used the DEFM to estimate trip generation at the regional level. SANDAG's methodology for forecasting household trip generation rates follow the process outlined in TRB Special Report 288 (Chapter 4, 2007).

To better estimate GHG reductions associated with SCS strategies, the trip generation component of SANDAG's next generation model should be made sensitive to mixed land uses, especially in the zones with transit-oriented development. Caltrans, in collaboration with UC Davis, is currently developing a methodology to estimate trip generation rates associated with smart growth land use that may be informative in testing future model sensitivity.

Step Two: Trip distribution in the SANDAG model then assigns the person or vehicle trips from the previous step to specific destinations based on the shortest travel path, considering both time and distance, as well as land use characteristics. SANDAG performed this step of the model at the TDZ level, using a doubly constrained gravity model to forecast the number of trips from one zone to all other zones in the region. A doubly constrained gravity model accounts for trips from point A to point B to equal the total number of origins and destinations. SANDAG calculated the shortest path, which minimizes obstacles that influence travel time and distance, otherwise known as impedance, between zones in a highway network based on duration and distance, valued at $0.35 per minute and $0.15 per mile, respectively (SANDAG's 2030 Regional Growth Forecast Update: Process and Model Documentation, 2008). SANDAG also calculated transit impedance between pairs of transit access points based on fare price, walk time, wait time, the number of transfers, and in-vehicle time. To reflect different levels of congestion, SANDAG developed two types of inter-zonal impedance matrices for peak and off-peak periods. Intra-zonal impedance factors were also added. In developing the impedance factors, SANDAG's model uses distance, in-vehicle travel time, and out-vehicle travel time. Time-of-day factors were derived from the Caltrans traffic count data and their performance measurement system (PeMS). SANDAG also estimated separate shortest paths between non-motorized zones (NMZs), which are areas that are not accessible to automobiles.

The capability to determine the influence of land use on trip distribution is built directly into SANDAG's model, allowing trip distribution to react to changes in land use and the transportation system by taking into consideration the characteristics and tools of urban planning -- diversity, density, distance, and design (4D). In 2008, SANDAG evaluated its 4D model functions by testing the relationship between the 4D characteristics of urban form with trip length and mode choice. In the first model iteration, SANDAG used the free flow speed and generalized impedance matrices to distribute the trips between zones. In the subsequent model iterations, SANDAG calculated congested travel time by trip assignment. For future years, SANDAG kept these impedance matrices constant. SANDAG found that the analysis demonstrated a strong relationship between trip length, mode choice, and density. Fewer than 10 percent of all trips were found to be intra-zonal, consisting largely of home-based school trips and a few special trip purposes. Using the results of this evaluation, SANDAG calibrated its trip distribution step to match survey data by employment density, dwelling unit density, and intersection density and to match observed trip length frequencies from SANDAG's 1995 Travel Behavior Survey and the Caltrans' 2000-2001 California Statewide Travel Survey.

Overall, the modeled average trip lengths by trip purpose closely follow the observed data from the 2006 San Diego Household Travel Survey, within a 10 percent range and the overall coincidence ratio (how closely the modeled data matches the observed data) is 0.9 (i.e. 90% match), as shown in SANDAG's Travel Model Validation Report.

Step Three: In the mode choice step, the SANDAG model takes trips generated from the previous step and assigns them to different modes for inter-zonal trips based on available transportation modes, trip purposes, and socio-economic characteristics. Three types of primary modes (auto, transit, and non-motorized) were further divided into 25 sub-modes. SANDAG used a nested logit modeling structure to estimate mode shares for two time periods, three income levels, and six trip purposes, which are consolidated from the ten trip purposes used in the trip generation and distribution steps in an effort to reduce computing time. Three types of costs are considered as well: auto operating cost, parking cost, and tolls. SANDAG used a constant auto operating cost of \$0.135 per mile in 1999 dollars (SANDAG's 2030 Regional Growth Forecast Update: Process and Model Documentation, 2008, p84), and assumed the increase in fuel price will be compensated by the use of more fuel-efficient vehicles. Time-of-day factors derived from traffic count data were used to allocate the trips to four different peak and off-peak time periods.

The mode choice model was calibrated using the data from SANDAG's 1995 Travel Behavior Survey, a 2000 market research survey, and Caltrans's 2000-2001 California Statewide Travel Survey. A transit ridership survey that was conducted in 2006 was used to validate the transit component of the mode choice model. Mode shares predicted in SANDAG's model for transit and non-motorized transport vary in response to changes in the 4D variables. The mode shares also change with changes in socio-economic inputs to the travel demand model.

Overall, the mode share predicted by SANDAG's model in the base year (2008) is similar to the observed data from the 2001 Caltrans household travel surveys. However, one component of the mode share - total transit ridership in the region – exceeded the observed boarding data from the transit ridership survey by 15 percent. ARB staff noted other anomalies in the transit ridership as well, and raised these as questions with SANDAG staff. SANDAG staff explained that these differences might be attributable to a significant difference in the fuel price during the 2006 transit ridership survey when compared with 2008 levels.

ARB staff also reviewed the NCHRP 535 report and Deakin and Harvey (1993) when evaluating how SANDAG's model addressed mode choice. In the NCHRP report, the authors review the travel demand and emission forecasting procedures used by MPOs and other practitioners to evaluate the impacts of traffic-flow improvements in the United States. Staff concluded that the procedures used in developing the mode choice model in the SANDAG transportation model are consistent with these documents, and that, overall, the mode choice results are consistent with observed data.

To better estimate the GHG reductions associated with SCS strategies in the future, SANDAG should take into consideration the change in travel cost and household size when deriving auto occupancy rates by trip purpose in its mode choice step. Currently, SANDAG's model uses constant auto occupancy by trip purpose in this step, which has the potential to either increase or decrease the number of vehicle trips and resultant GHG emissions in a corridor. Further, to provide greater confidence in the results of its modeling related to mode choice, SANDAG should devote more resources into model validation of this step, especially as it relates to better understanding and addressing the anomalies concerning validation of transit ridership as discussed above.

Step Four: The last step in SANDAG's model is traffic assignment at the TAZ level, which estimates the resulting volume of traffic and travel time for each portion of the travel network (or link) for a specific time period as a result of these trips. A critical input to this step is vehicle trips by mode, and a coded transportation network that includes transit. SANDAG's Trip Assignment model has four feedback iterations, feeding back into the trip distribution and mode choice steps until equilibrium is achieved and the model has identified the most ideal and shortest routes between trip origins and destinations. SANDAG performed separate assignments for different time periods, adjusting the output for travel time and hourly distribution.

SANDAG used an advanced Multi-Modal Multi-Class Assignment (MMA) function to assign traffic volume on the transportation network to allow for consideration of HOV lanes, toll lanes, and transit for each class of vehicles. In SANDAG's model, the same assignment function is used for different facility types with a change in intersection and link delays. To test the stability of the assignment process, SANDAG used convergence criteria of 0.001 and estimated the congested speed and volume/capacity ratio for the entire travel network. SANDAG found a strong correlation (0.91) between the modeled and observed volumes, which indicates that the model closely follows the observed data.

SANDAG partially addresses induced demand in its model through a feedback mechanism that inputs congested travel speeds into the trip distribution and mode choice to account for travelers who changed their travel routes and modes in response to changed travel times. Induced demand is the increase in traffic over time that may result from new or widened roadways. A consultant review of SANDAG's methodologies for analyzing GHG emissions conducted in September 2010 referred to SANDAG's procedures as consistent with the "state-of-the-practice." ARB staff expects the next generation of travel models in the region will provide greater capability to account for induced demand. According to another report by FHWA, current travel demand models account for some, but not all, of the travel behaviors that may contribute to the increased traffic from induced demand. FHWA acknowledges the current technical limitations of analysis methods, which preclude precise accounting for some of these travel decisions.

3. Off-Model Tool

SANDAG used an off-model tool to better account for changes in GHG emissions and other model outputs when the travel demand model did not respond sufficiently to SCS strategies. For instance, while SANDAG accounted for bicycle and pedestrian trips (non-motorized trips) in the four-step travel demand model, the model was not sensitive to associated infrastructure investments and programs. Additionally, while the SANDAG travel demand model considered carpooling during mode choice and network assignment, it was insensitive to associated marketing programs. In both cases, SANDAG used an off-model tool to account for these programs. The off-model tool was used to estimate the GHG emission reductions from bike and pedestrian infrastructure improvements, Safe Routes to School, carpools, vanpools, and bus pools. Together, the estimated GHG emission reductions using the off-model tool accounted for approximately 0.8lbs per capita in 2020 and 1.3lbs per capita in 2035 of the targets. These reductions account for approximately 20 percent of the SCS GHG reductions in 2020 and 40 percent in 2035.

To estimate the number of bicycle trips resulting from increased bicycle infrastructure, SANDAG applied an equation (Dill and Carr 2003), which associates a one percent increase in commute bicycle trip mode share with each additional one mile of bicycle facilities per square mile. SANDAG then converted the increased bicycle trips into VMT reductions by multiplying the bicycle trips and average bicycle trip distance (2.13 miles) referenced in the 2009 National Household Travel Survey report. Similarly, to estimate VMT reduction from increased pedestrian infrastructure, SANDAG assumed a 10 percent, 20 percent, and 30 percent increase in walking trips by 2020, 2030 and 2050, respectively. For its Safe Routes to School strategy, SANDAG assumed a 10 percent increase in walk/bike trips by 2020, a 20 percent increase by 2035, and a 30 percent increase by 2050 as well based on research for all public K-8 school-age trips.

For vanpools, SANDAG assumed that the existing program would be expanded by 70 percent by 2020 and 174 percent by 2035 based on historical growth rates from 1990-2010. Based on a regional study, SANDAG also assumed that future levels of carpool usage will have a retention rate after the subsidy ends and an annual background growth rate of two percent based on a regional study. For its buspool program, SANDAG assumed linear growth, with a goal of transporting 40 percent of military personnel in the region via buspools by 2035. SANDAG asserts the feasibility of this goal based on the concentrations of military housing, employment locations in the region, and the assumed implementation of mandates requiring military personnel in the region to opt for alternate modes of commute to work.

In 2010, SANDAG contracted with a consultant to conduct an assessment of their off-model tool. The review found the assumptions underlying the levels of implementation for vanpool and carpool to be reasonable, with the assumed levels for the buspool measure necessitating a military trip reduction mandate for its personnel. For the bicycle, pedestrian, and Safe Routes to School measures, the review found the technical methods to be sound, and provided some suggestions that SANDAG implemented, as applicable, for updating deployment levels, mode shares and other factors.

SANDAG's assumptions for the vanpool and carpool measures are reasonable, as are the buspool implementation levels if the military creates a trip reduction mandate for its personnel. SANDAG also used the appropriate information and studies to estimate the reductions from improvements in bicycle infrastructure.

Regarding pedestrian trips, SANDAG used assumptions for Safe Routes to School that are similar to those employed by the Metropolitan Transportation Commission, the Bay Area's MPO. However, even with information provided by SANDAG, the basis of SANDAG's assumptions remained unclear.

In preparation for the SCS quantification update in 2014, SANDAG should provide better documentation of its assumptions and inputs associated with use of any off-model tools, and its next generation model should be designed to predict travel behavior associated with changes to investments in bike and pedestrian infrastructure, and implementation of demand management strategies.

4. Model Validation and Peer Review

SANDAG validated their model following CTC and FHWA guidelines to test the capability of SANDAG's travel demand model to predict future travel behavior. The validation process involves comparing model outputs for the base year with observed or empirical travel data. The CTC 2010 RTP guidelines, which include both requirements and recommendations, direct large MPOs like SANDAG with rapid growth, large population centers, and established transit systems to employ enhanced modeling capabilities and validation procedures. SANDAG's travel model meets these requirements. The model must also respond reasonably to the time, cost, and other factors that affect travel choices. To address this, SANDAG's model uses capacity sensitive assignments to estimate the peak and off-peak link volumes and speeds.

Overall, the SANDAG travel demand model satisfies the requirements of the CTC 2010 RTP guidelines, as shown in Appendix B. SANDAG used the latest land use, population, employment, and other network-based assumptions in their travel demand model, consistent with the 2010 RTP guidelines. A letter from Caltrans District 11 that was submitted to SANDAG on July 8, 2011 supports ARB staff's conclusion. Appendix B describes the requirements in the Guidelines that SANDAG's model applied, as well as the CTC recommendations that SANDAG incorporated into the model.

SANDAG validated their model by comparing the output of their travel demand model to observed traffic count data from the 1995 and 2006 SANDAG household travel surveys, Caltrans's 2000-2001 California Statewide Travel Survey, the 2009 SANDAG onboard transit passenger survey, the 2008 American Community Survey, and the 2009 National Household Travel Survey. ARB staff recommends that for its next RTP, SANDAG use more recent travel surveys to validate the model with the travel survey year coinciding with the model validation year. Currently, the California Department of Transportation is conducting the California Household Travel Survey for the entire state, including the San Diego region. The survey is expected to be available by March 2013.

SANDAG's travel model was peer reviewed in 2005 pursuant to FHWA's guidelines. A peer review panel selected by SANDAG concluded that the travel demand model is consistent with the state-of-the-practice. In addition to static model validation, SANDAG conducted dynamic validation of the model. Dynamic validation tests the sensitivity of the model using changes in various parameters such as auto operating costs, parking costs, transit fares, roadway capacity, or the travel network. While SANDAG's model validation document is informative, it omits some parameters that would be helpful for understanding model performance. These parameters include, for example, statistics that describe model performance, such as a comparison of observed versus modeled vehicle speeds.

5. Planned Modeling Improvements

SANDAG is currently developing their next generation transportation modeling system that will provide better integration of land use and transportation activities using an activity-based model (ABM) for transportation, and a Production Exchange and Consumption Allocation System (PECAS) for land use. These model improvements will enhance the quality of their analytical tools to better inform regional decision makers. SANDAG is also exploring next generation models to improve the sensitivity of their model system to non-motorized transportation and other smart growth strategies.

When fully operational, the ABM will operate at a detailed temporal and spatial resolution, and will be integrated with the PECAS land use model. SANDAG's PECAS model will forecast the change in commercial, residential, and industrial floor space by type, price of land, and developmental activities in response to demand generated by economic activity. Outputs from the PECAS model are intended to be fed back into the demographic forecasting model and the ABM. These models provide improved sensitivity to various inputs, allowing greater capability to test various smart growth policies and demand management strategies. Further, the ABM and PECAS models will allow for analysis at the person-by-person trip level, increasing the model's sensitivity to bike and walk trips.

In 2014, ARB anticipates reviewing and revising as appropriate the regional targets it established in 2010. As part of this process, ARB staff will request that SANDAG develop target setting scenarios using the most current modeling tools and updated data/inputs available.

In particular, SANDAG's methodological approach should focus on specific areas that can lead to more robust and explainable results over the current model:

- Updated demographic and transportation surveys
- Additional sensitivity analyses to reveal more information about its model's sensitivity to SCS strategies, particularly land use strategies for which information is currently limited, as well as analyses of road pricing strategies, and HOV lanes
- More refined data that can explain the magnitude of GHG reductions attributable to land use changes
- Better accounting of how congestion relief influences vehicle trips and development (induced demand)
- Better accounting of economic impacts on growth projections

C. SANDAG's Modeling Inputs and Assumptions

SANDAG's draft SCS is built on several foundational inputs and assumptions that influence a wide range of the strategies relevant to GHG emission reductions. These inputs and assumptions underlie SANDAG's modeling approach, and are used by SANDAG's travel model to project changes in the land use and transportation systems. They include demographic, transportation network, travel, and cost inputs and assumptions. ARB staff evaluated the appropriateness of the data on which these assumptions and inputs are based, and how well the model responds to changes in these inputs and assumptions as demonstrated by SANDAG's sensitivity analyses.

1. Demographic Inputs and Assumptions

Demographic inputs and assumptions describe the number and key characteristics of the people living and working in the San Diego region. ARB staff focused its review on the population, household, and employment inputs to the model. Staff also evaluated SANDAG's sensitivity test on income distribution which provides insight into the influence that changes in the distribution of incomes among households in the region would have on travel behavior.

a) Population

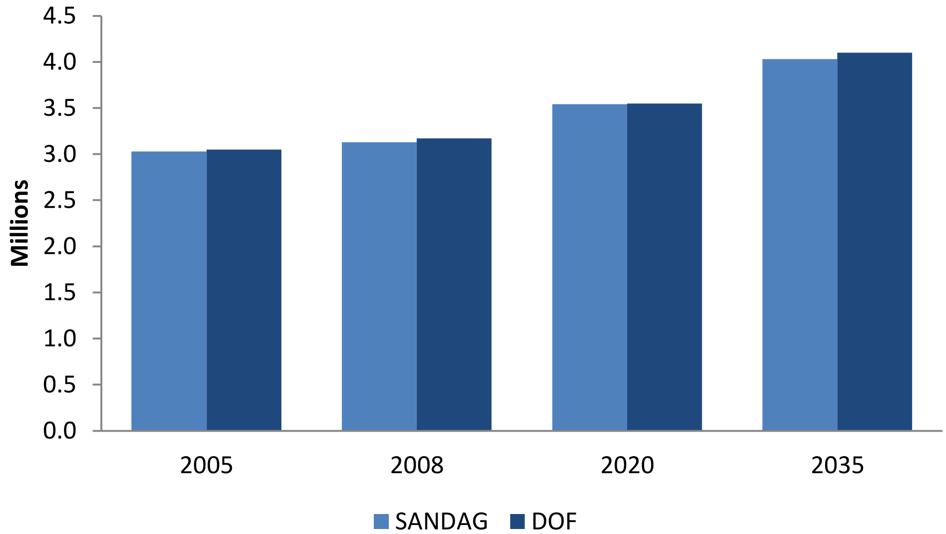
Population is a basic component of how present and future demand for transportation is estimated, since regional travel patterns are closely linked to population growth over time. SANDAG forecasts population using its Demographic and Economic Forecasting Model (DEFM) which combines an econometric forecasting module and a demographic module. In the DEFM, changes in population are forecast using three key elements of population change: births, deaths, and domestic and international migration.

SANDAG forecast domestic migration based on the quality of the regional economy. For instance, migration into the region occurs if the region's economy outperforms the national economy. Migration decreases if the region's economy performs worse than the nation as a whole. SANDAG estimated international migration using U.S. Census Bureau forecasts, based on the assumption that the region will maintain its historic share of U.S. international migration. The SANDAG model also accounted for special populations, such as military personnel and university students.

SANDAG's population forecasting methods are consistent with those used by the U.S. Census Bureau, California Department of Finance (DOF) and California Department of Transportation (Caltrans). SANDAG's forecast tracks closely with these sources. Staff also consulted two sources: *State and Local Population Projections and Household Demography and Household Modeling*, both part of the Plenum Series on Demographic and Population forecasting methods which describes the spectrum of demographic methods and the applications of these techniques.

SANDAG forecasts that their region's population will grow from 3.1 million in 2008, to slightly over 3.5 million by 2020, to 4 million by 2035. This represents a 28.6 percent increase over the 2008 to 2035 period. Both DOF and Caltrans arrive at similar numbers. Additionally, the U.S. Census shows 3.095 million people in the San Diego area in 2010, which matches closely with the trend as well. Figure 3 illustrates the population estimates for DOF and SANDAG, showing that the data points are close in value.

Figure 3. Population Estimates and Projections, 2005, 2008, 2020, and 2035: SANDAG and California Department of Finance

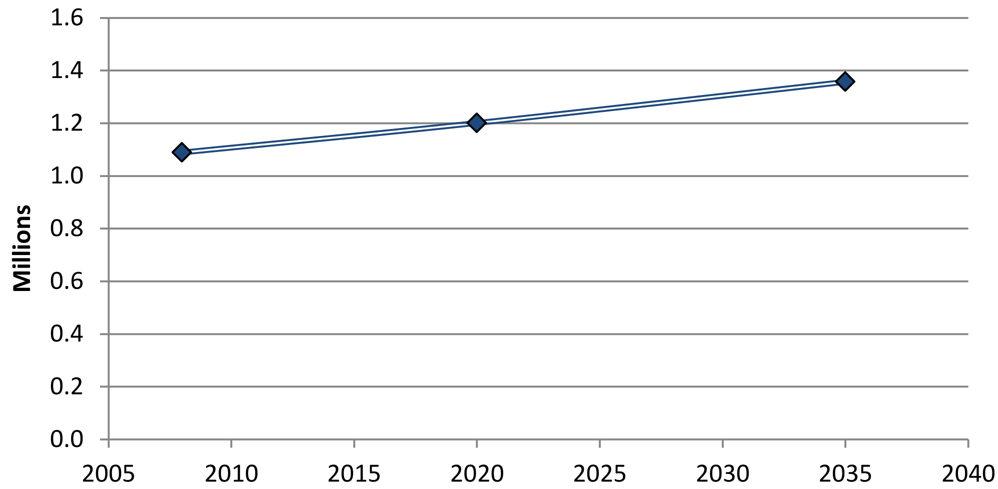


b) Households

A household consists of a group of people occupying a housing unit, and can include both family and non-family members. Households are an important assumption in travel models because the number of households is related to the number of trips that occur in the region. SANDAG's calculation of the number of households is tied directly to their population calculations. Beginning with the total population in each year, SANDAG subtracts out the population living in group quarters. Group quarters are places where people live or stay, in a group living arrangement that is owned or managed by an organization (e.g., a nursing home or military barracks). From the adjusted population figures, SANDAG uses head of household rates by age, gender, and ethnicity to arrive at the number of households.

ARB staff compared SANDAG's household forecast (see Figure 4) to Caltrans' community level forecasts, and they are similar in both value and trend. The Caltrans forecast is based on a UCLA Ander forecast which uses historic annual changes in economics, including population, employment and households to project total households. SANDAG's projection is 10 percent higher than the Caltrans/UCLA projections. In addition, ARB staff relied on the sources outlined in the population section of this staff report, as household forecasts depend largely on the population forecasts.

Figure 4. SANDAG's Household Forecasts, 2008, 2020, and 2035



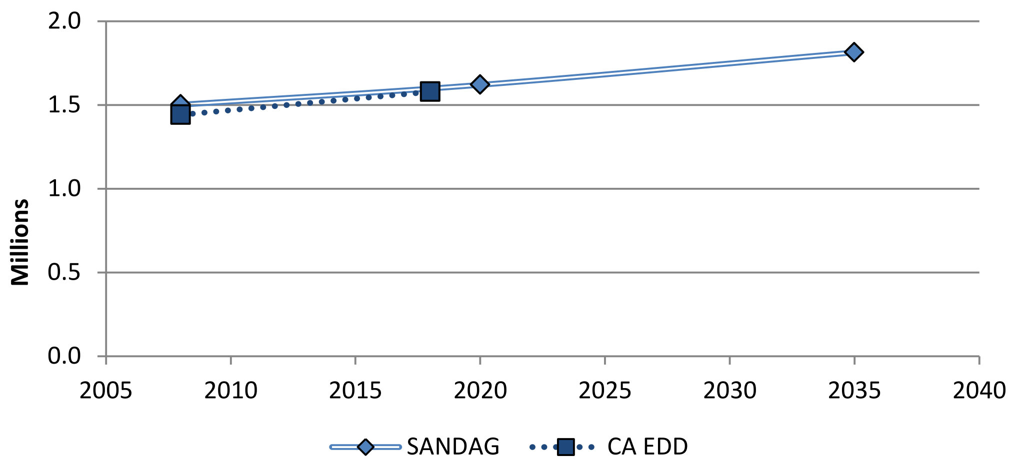
c) *Employment*

Employment describes the total number of workers in a region and influences the number of commute trips generated. SANDAG forecasts employment using the DEFM. DEFM is a more advanced model than trend extrapolation and well above the state-of-the-practice. This analytic framework, known as input-output or inter-industry analysis, captures the interrelationship among industries in an economy. When performing an input-output analysis, the economic area, in this case the San Diego region, is divided into a number of industries or "producing sectors". In its analysis, SANDAG identified 50 industries from the North American Industrial Classification System (NAIS) with an additional six categories for government. The output for each industry is forecast from a composite index of international, national, and local demand, productivity levels, and the relative competitiveness of the San Diego economy. Finally, using projected values for labor productivity, SANDAG arrives at a forecast for the total number of employees in the region.

ARB staff compared SANDAG's forecast with those of the California Employment Development Department (EDD) and Caltrans' California County-Level Economic Forecast for 2010-2035 (Figure 5). Staff also consulted *Input-Output Analysis: Foundations and Extensions,* which is a widely used textbook and reference for modeling national and regional economies.

As Figure 5 illustrates, SANDAG expects that employment will grow from 1.5 million in 2008, to a little over 1.6 million by 2020, and to 1.8 million by 2035. This change over the 27 year period represents a 20.8 percent increase. The data points follow a similar trend to data provided by both Caltrans and EDD of increasing employment. In 2035, Caltrans projects employment of 1.813 million and SANDAG projects 1.703 million: a difference of 6.5 percent.

Figure 5. San Diego County Employment Projections, 2008-2035: SANDAG and California EDD



d) Income Distribution Sensitivity Tests

Household income can be used as a predictor of a household's decision between driving or taking transit. Studies have shown that as household incomes decrease, transit commute mode shares often increase and VMT decreases. Similarly, VMT goes up and transit commute mode share goes down for households that fall into the higher income categories (Goodwin, et al. 2004). SANDAG's regional growth forecast includes data in ten different income groups, which SANDAG staff has condensed into three categories: high, middle, and low income. SANDAG conducted four sensitivity tests to determine if its model was responding appropriately to changes in the income distribution by altering the income range breakpoints in the model (i.e. changing the dollar level endpoints used to define each income category).

Table 1. Results of SANDAG Income Distribution Sensitivity Tests

Test	VMT (thousands)
Very Low Income Scale	77,492
Low Income Scale	87,514
Middle Income Scale	99,544
Baseline	104,082
High Income Scale	112,030

Table 1 illustrates that SANDAG's model responds as expected – VMT decreases as average incomes decrease, and conversely, VMT increases with higher income. However, ARB staff could not identify directly relevant empirical literature that describes income in a similar manner to determine if the model appropriately reflects the magnitude of changes observed from this variable.

2. Transportation Network Inputs and Assumptions

The transportation network is a map-based representation of the streets and highways that connect the region. The network consists of a series of links each containing information about number of lanes, traffic volumes, and vehicle speeds. The travel model uses this network to model the impacts of transit (buses, bus rapid transit), TDM, and TSM strategies on travel patterns throughout the region. ARB staff reviewed SANDAG's highway network and link capacity assumptions. Staff also evaluated SANDAG's sensitivity tests for assigning travel to the network and roadway capacity to understand how responsive the model is to strategies that affect these model parameters.

a) Highway Network

The highway network portrays the supply of streets and highways in the SANDAG region. It consists of links and nodes representing intersections. Links (streets) can include length (distance), average free flow speed, congested speed and capacity (in terms of vehicles or trips per hour per lane). Highway networks are developed for specific analysis years and represent both the existing and planned highway system.

The SANDAG model includes more than 34,000 highway network links that represent existing and planned freeways, toll lanes, HOV lanes, managed lanes, ramps, and surface streets. SANDAG obtained this information from the SanGIS (San Diego Geographic Information Source), which is a joint power agency that provides GIS information to cities and counties. SANDAG updated the information from SanGIS with high-resolution digital aerial photography. Network characteristics such as street name, functional classification, link length, posted speed, number of lanes, number of auxiliary lanes, median type, one/two-way operation, and type of intersection control are included in the network.

ARB staff compared SANDAG's description of its highway network development with the NCHRP 365 report, which describes travel demand modeling theory and techniques and their common applications by transportation planning agencies, and observed data for key modeling parameters at the national level. SANDAG coded the highway network consistently as required for travel demand modeling. It has also provided all the attributes required for modeling. SANDAG has followed the acceptable practice, consistent with the NCHRP 365 report.

b) Link Capacity

Link capacity is defined as the number of vehicles that can pass a certain point in an hour. It is used to estimate congested speeds on a transportation network. Procedures to estimate link capacity are described in the Highway Capacity Manual (HCM, 2000). In SANDAG's model, intersection capacity and mid-link capacity were calculated for each direction of a link on an hourly basis. Link capacity is then converted to AM peak, PM peak, and off-peak period capacities using hourly time period factors.

Table 2. Roadway Capacity Used in SANDAG Model

Roadways	SANDAG Capacity (vehicles/hour/lane)	HCM Maximum Capacity Ranges (vehicles/hours/lane)
Freeways *- Auxiliary lanes* *- HOV/managed lanes*	1900-2100 *(1900)* *(1600)*	<2400
Urban streets	950-1500	1900

As shown in Table 2, the roadway link capacities for SANDAG's model fall within the commonly used values for different roadway capacities as indicated in the Highway Capacity Manual. For the purposes of model development, it is reasonable to utilize capacities that are similar to those described in the HCM and SANDAG's data is consistent with HCM.

c) Free Flow Speed

Free flow speed is used to calculate the shortest travel time between two points in the highway network. In SANDAG's model, the posted speed limit of each link is used as the free flow speed, with the exception of HOV lanes. For HOV lanes, free flow speed is assumed to be 5 mph higher than the posted speed limit to reflect in the model the likelihood that drivers will choose HOV lanes over general-purpose lanes.

As speed is a critical input for GHG emissions estimation and using the posted speed limit may overestimate or underestimate emissions, speed studies that collect measured speed data would provide a better representation of free flow speeds for modeling purposes.

d) Network Assignment Sensitivity Tests

As described in the modeling tools section, trips are assigned to portions of the travel network for a specific period of time to estimate traffic volumes and travel time for each link. SANDAG prepared two sensitivity test runs that looked at the impacts of deleting two segments of the model travel network: a section of El Camino Real (from Marron Road to Carlsbad Village Drive) and the I-805 overpass over Mission Valley (Mission Valley viaduct), with buses allowed to continue to use the viaduct (See Table 3). As a general modeling practice, it is expected that the model should redistribute auto trips as accessibility to the network is decreased.

The I-805 segment deletion scenario resulted in a greater change to VMT than the scenario deleting the segment of El Camino Real, as there are more alternative travel routes in the network for arterials than for freeways. Trips previously assigned to the El Camino Real segment were reassigned to other arterials, while many more of the trips assigned to the I-805 segment were shifted to transit. The model output also shows changes in truck hours of delay and changes in travel time per person trip, with the impacts from deleting the I-805 viaduct greater than those from deleting the section of El Camino Real.

Table 3. Results of SANDAG Network Assignment Sensitivity Runs

Test	Modeled Total VMT (thousands)	Daily Truck Hours of Delay	Average Travel Time per Person Trip (Minutes)
Delete Section of El Camino Real	104,079	10,627	16.4
Baseline	104,082	10,582	16.4
Delete I-805 Mission Valley Viaduct	103,640	12,365	16.5

SANDAG's tests show that the model is generally sensitive to changes in network assignment. However, due to the lack of empirical literature with which to compare, it is not possible to determine an expected degree of sensitivity to changes in this variable.

e) Roadway Capacity Sensitivity Tests

Roadway capacity reflects how easily vehicles travel through a transportation system. Studies have found that traffic will generally move a lower capacity facility type (local streets and roads) to a larger facility type (highways) (Bass et al, 1994). SANDAG ran two sensitivity tests to assess the impact of doubling the number of lanes on highways or arterials compared to the baseline network, up to a maximum of eight lanes per direction. SANDAG staff provided ARB staff with the changes in lane miles in the SANDAG region for the increase in highway capacity test (see Appendix D). As shown in Table 4, the increase in highway lane miles from the baseline results in a three percent increase in VMT.

Table 4. Results of SANDAG Road Capacity Sensitivity Runs

Test	Modeled Total VMT (thousands)	Expected Total VMT* (thousands)
Increase in highway capacity	107,132	104,706 - 107,579 (short-run) 106,517 - 109,328 (long run)
Baseline	104,082	--

*ARB staff calculated VMT based on elasticity of 0.1 to 0.56 percent change in VMT per 1 percent change in lane miles (short run) and 0.39 to 0.84 (long run).

Empirical studies on the vehicle travel impacts of increasing highway capacity in California report short-run elasticities ranging from 0.1 to 0.56, and long-run elasticities from 0.39 to 0.84 (Cervero and Hansen (2002), Cervero (2002)). Short-run impacts are those resulting from a policy over a period of less than five years, while long-run effects are realized over five or more years. SANDAG's modeled results fall within the range of expected VMT based on the empirical literature for both short- and long-term timeframes.

3. Travel Inputs and Assumptions

The number of trips associated with various land uses, and the time and length of those trips based on trip destinations, are fundamental assumptions that influence the amount of travel within a region.

a) Trip Generation Rates

Trip generation rates are used to estimate the number of trips generated by land use and dwelling unit types, and form the basis for the demand for travel in the region. SANDAG's travel demand model utilizes average weekday trip generation rates from household travel surveys and related studies. SANDAG's trip generation rates are shown in Table 5.

Table 5. Weekday Trip Generation Rates (trips by land use)

Land use	Units	2008 SANDAG Model	2001 Caltrans*
Single-family	Dwelling unit	12.2	10.7
Multi-family	Dwelling unit	8.7	7.7
Mobile home	Dwelling unit	6.6	N/A
Wholesale trade	Acre	43.4	N/A
Neighborhood Commercial	Acre	1311.9	N/A
Govt. office	Acre	1048.2	N/A

* Caltrans trip generation rates do not include walking and biking.

SANDAG's transportation model does not distinguish between the zero vehicles household and multiple vehicles household nor does it differentiate between household sizes. Instead it allocates the same trip rates based on the dwelling unit type. As a result, SANDAG's trip generation rates are relatively insensitive to changes in auto-ownership and household size.

A comparison of SANDAG's trip generation rates to those of independent data sources, such as Caltrans' 2000-2001 California Statewide Travel Survey, indicates that SANDAG's trip generation rates for home-based trip generation are similar to observed data and are reasonable for use in this travel modeling system.

b) Trip Time and Distance Distribution

Travel time and distance are inputs to SANDAG's trip distribution model, and are estimated using the highway network. Travel time tables are used to determine the average trip length and the distribution of trip lengths for each trip purpose which are used to calibrate the trip distribution model. SANDAG used its 2006 San Diego Household Travel Survey to calibrate the trip distribution model. Tables 6 and 7 show the average trip length by purpose, and average trip duration by mode, respectively, for the San Diego region.

Table 6. Average Trip Length by Purpose

Trip purpose	SANDAG model (miles)
Home-based work	11.8
Home-based college	10.1
Home-based school	2.9
Home-based other	5.0
Non home based	5.2
Serve passenger (drop off trips)	4.4

Table 7. Average Trip Duration by Mode in SANDAG Region

Mode	Commute trips (minutes)	Non-commute trips (minutes)
Drive alone	21.3	10.9
Carpool 2+	21.4	10.9
Carpool 3+	21.3	10.9
Walk	18.2	9.6
Bike	18.9	10.0
Transit	57.3	34.3
Average	23.4	11.0

SANDAG's modeled average trip lengths by trip purpose closely follow the observed data from their 2006 San Diego Household Travel Survey within a 10 percent range. In addition, SANDAG's modeled average commute trip times are consistent with the range observed in the NCHRP Report 365, which reports an observed average home-based work trip time of 20-30 minutes.

4. Cost Inputs and Assumptions

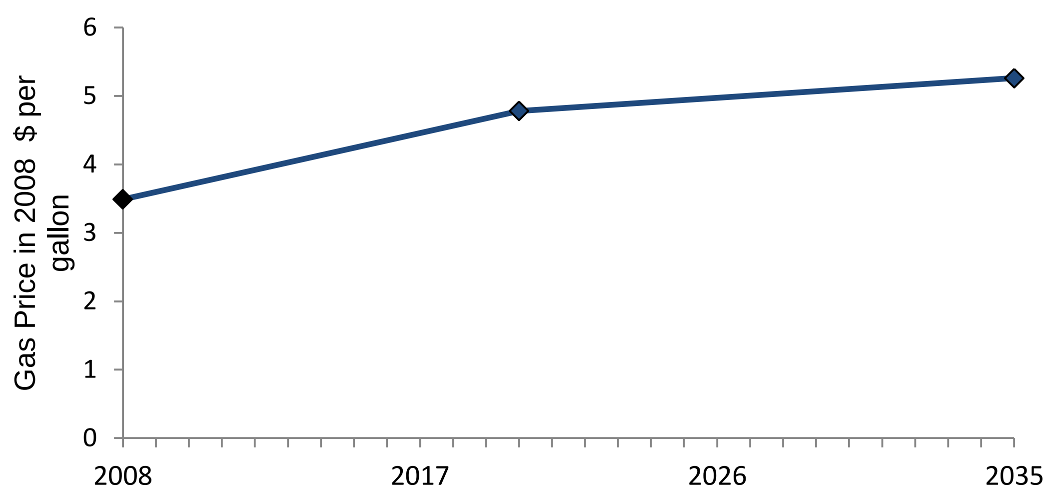
An individual's travel behavior can be influenced by variations in the cost of driving. This cost is included in SANDAG's travel model through gasoline price and other variables that influence auto operating costs, such as tolls and parking costs. The sensitivity test conducted by SANDAG is informative regarding how travel behavior in the model is influenced by fuel price.

a) Gasoline Price

The price of fuel is the amount consumers pay at the pump for regular grade gasoline, as expressed in dollars per gallon. As the price of gas increases, drivers tend to switch to cheaper alternative modes of travel or make shorter and less frequent trips. Lower gas prices can result in more traffic than forecasted and increased driving.

SANDAG followed a methodology agreed upon by the California MPOs for forecasting gas prices (Figure 6). This method used the high and low forecasts from the US Department of Energy (DOE), took 75 percent of the difference between the high value and the low value, and added this to the low value. They then added 25 cents to account for the higher cost of California gasoline, relative to the national average.

Figure 6. SANDAG's Gas Price Forecast, in 2008 Dollars per Gallon



ARB staff reviewed documentation provided by the DOE, CEC, and SANDAG. Staff also consulted authoritative sources prepared under the Travel Model Improvement Program (TMIP), a joint program of the Federal Highway Administration, Federal Transit Administration, Office of the Secretary of Transportation, U.S. Department of Energy, and the U.S. Environmental Protection Agency that provides technical assistance to support transportation planning agencies. TMIP's technical synthesis resources outline potential methodologies and approaches to determine current and forecast future year gas prices (Transportation Model Improvement Program, 2007). SANDAG employed a combination of the methods recommended by the TMIP: using a committee of experts (MPO committee), fixing the gas price to inflation, and using econometric models (DOE forecasts). TMIP also recommended linear regression of past years' prices or expressing the base year value in constant dollars.

SANDAG's gas price forecast is larger than the CEC range, but within the DOE range. Both CEC and DOE are recognized as leaders in the energy field. The difference between the low and high CEC forecast in 2030 is 51 percent and the low and high DOE forecast is 163 percent, demonstrating a level of uncertainty in forecasting fuel prices.

b) Auto Operating Costs Sensitivity Tests

SANDAG staff ran four sensitivity tests focused on fuel prices to determine whether the model responds appropriately to changes in auto operating costs. Fuel prices were changed to 50 percent, 75 percent, 125 percent and 150 percent of the baseline fuel price of $3.48 per gallon (in 2009 dollars).

As shown in Table 8, when operating costs dropped to 50 percent and 75 percent of the baseline costs, VMT increased 12 percent and 6 percent respectively. Conversely, when these costs rose to 25 and 50 percent above the baseline, VMT decreased by 5 and 10 percent, respectively.

Table 8. Results of SANDAG Auto Operating Costs Sensitivity Runs

Test	Modeled VMT (thousands)	Expected Short-Run VMT range* (thousands)	Expected Long-Run VMT range** (thousands)
50 percent of baseline cost	116,741	105,123 – 111,888	109,806 - 121,776
75 percent of baseline cost	110,139	104,602 – 107,985	106,944 -112,929
Baseline	104,082	--	--
125 percent of baseline cost	98,604	100,179 - 103,561	95,235 -101,220
150 percent of baseline cost	93,825	96,276 - 103,041	86,388 – 98,357

*ARB staff calculated based on short-run elasticities of -0.02 to -0.15
**ARB staff calculated based on long-run elasticities of -0.11 to -0.34

The empirical literature includes a range of elasticities for changes in vehicle travel over the short-run (less than five years) relative to fuel price, including -0.02 to -0.09 (Small and Van Dender 2005) and -0.15 (Agras and Chapman, 1999). The long-run elasticities (greater than five years) from these studies are -0.11 to -0.34 (Small and Van Dender 2005) and -0.32 (Agras and Chapman, 1999). In other words, VMT changes in response to changes in the fuel price component of auto operating costs and are directionally consistent with the trends noted in the empirical literature for long-run elasticities. The long-term behavioral changes in travel from increases or decreases in auto operating costs are most relevant for the SCS. SANDAG estimates these changes by running its model to a stable equilibrium, and the long-run elasticities in the literature best represent the outcome of this process.

c) Parking Cost Sensitivity Tests

SANDAG also performed four tests to examine the model's response to changes in parking cost of 50, 75, 125, and 150 percent of baseline parking costs in select areas of the urban portion of the San Diego region. An analysis of this variable provides additional insight into how the model responds to changes in cost. Parking costs were changed for Centre City San Diego, Lindbergh Field, some universities, and business districts in Escondido, Oceanside, La Jolla, La Mesa, and Hillcrest. These include privately owned parking lots, as well as on-street parking spaces with meters. The expectation is that transit mode share will increase to areas with high parking costs, but could also result in trips redistributing to areas with a lower travel cost. VMT and VHT should show modest changes (Spears et al. 2010). As shown in Table 9, the results of SANDAG's runs are consistent with this overall trend, varying only slightly in response to changes in parking costs.

Table 9. Results of SANDAG Parking Cost Sensitivity Runs

Test	Modeled Regionwide VMT	Modeled Regionwide Commute Transit Share	Modeled Urban Commute Transit Share	Modeled Urban Commute SOV Share	Modeled All Trips Transit Share (Daily)
50 percent of baseline	104,086,133	8.4%	9.5%	77.6%	1.6%
75 percent of baseline	104,081,529	8.5%	9.6%	77.3%	1.6%
Baseline	104,081,786	8.6%	9.7%	77.2%	1.7%
125 percent of baseline	104,071,237	8.7%	9.9%	76.9%	1.7%
150 percent of baseline	104,057,815	8.8%	10.0%	76.8%	1.7%

These minor changes are likely the result of relatively small changes in parking costs compared to the region overall, and the comparatively small areas over which parking costs are adjusted within the urban area. Additional data is needed about the parking policy being implemented and how it is reflected in the model, in order to establish a better understanding of the relationship between parking cost, travel, and transit ridership.

D. SCS Performance Indicators

ARB staff evaluated changes in a key subset of indicators that are indicative of SCS performance to determine whether they provide supportive, qualitative evidence that the SCS could meet its GHG targets. Staff determined if the indicators were directionally consistent with SANDAG's modeled GHG emissions reductions, as well as the general relationships between those indicators and GHG emissions identified in the empirical literature. This assessment relies on key empirical studies for each indicator that illustrate qualitatively how changes in these performance indicators would increase or decrease VMT and/or GHG emissions. The indicators include: commute trip mode share, residential density, distance of housing and employment from transit stations, and bike and walk trips.

The results of staff's evaluation are described below, organized by land use and transportation-related indicators. A discussion of staff's analysis of the key model inputs, assumptions, and sensitivity analyses related to these indicators is also described within the relevant sections to provide additional insight on the model's performance for these indicators.

1. Land Use Indicators

In order to determine the benefits of the development pattern in the draft SCS on GHG emissions from passenger vehicles, SANDAG's modeling approach relied on the modeling inputs and assumptions discussed previously, as well as information specifically related to land use. These data include the outputs of two of SANDAG's forecasting models (IRCM and UDM), which assign characteristics and locations for the population and households in the region. These data serve as inputs into the travel demand model along with other key inputs and assumptions, such as the number of households and the trip generation rates per land use type. SANDAG did not perform sensitivity analyses for individual land use variables, which would provide information on the magnitude of impact land use strategies have on the modeled outputs. Rather, SANDAG modeled an alternative land use scenario for its EIR alternatives analysis that reflected the potential impact on VMT of smart growth strategies as a whole in the region.

As a result, staff focused its evaluation on two performance indicators that are related to land use: changes in residential density and housing and employment near transit stations.

a) Residential Density

Compared to current conditions, SANDAG's land use assumptions result in an increased density of new development, more urban infill, and a reduction in the minimum lot size requirements by 2020 and 2035. These changes influence travel, since increases in residential density generally reduce the average trip length, and could eventually result in decreased regional VMT. Brownstone and Golob analyzed National Household Travel Survey (NHTS) data and observed that denser housing development significantly reduces annual vehicle mileage and fuel consumption, which directly results in the reduction in GHG emissions. They also reported that households in areas with 1,000 and more units per square mile drive 1,171 fewer miles, and consume 64.7 fewer gallons of fuel than households in less dense areas. Boarnet and Handy (2010) report that, on average, doubling residential density reduces VMT in the range of 5 to 12 percent. Litman (2010) reported that increased population density leads to a 0.2 to 1.45 percent decrease in the demand for car travel.

The region's countywide residential density will increase between 2008 and the 2020 by 2 percent and by 5 percent in 2035. Countywide population density (population per acre) also increases by 2.7 percent and 5.9 percent from the base year to 2020 and 2035, respectively. It should be noted that sub-regional densities (e.g. city-level, or urban vs. rural) would be more effective for describing the growth patterns within the regions and between urban and rural development areas, but that information was not available from SANDAG for this analysis.

b) Housing and Employment Near Transit Stations

In the SANDAG region, the anticipated percentage of housing and employment within a half mile of a transit station is projected to increase slightly between 2008 and 2035. The percentage of housing and employment within a half mile of a transit station increases over time. Housing within a half mile of a transit station increases from 79 to 80 percent between 2008 and 2020. Employment within a half mile of a transit station increases from 86 to 89 percent between 2008 and 2020, and slightly decreases from 89 to 88 percent between 2020 and 2035. SANDAG staff indicated that, in the absence of the draft SCS policies, the percentages of employment and housing within a half mile of a transit station would significantly decrease from 86 to 83 percent and from 79 to 76 percent, respectively, between 2008 and 2035.

The empirical literature provides supporting evidence for the reduction trend in GHG emissions in the region resulting from the concentration of housing and employment near transit stations reflected in the draft SCS. This is a commonly-used performance measure for evaluating the effectiveness of transit oriented development (TOD). The empirical literature indicates that commuters living within a TOD area use transit two to five times more than do other commuters in the region. Moreover, the literature shows that proximity of housing and employment to transit stations is highly correlated with transit ridership. Kolko (2011) found that transit ridership sharply increases as housing and employment within a one mile radius of transit stations increase. Tal, et al. (2010)

suggests a six percent VMT decrease per mile closer to a rail station starting at 2.25 miles from the station, and a two percent VMT decrease per 0.25 mile closer to a bus stop starting at 0.75 miles from the stop.

2. Transportation-Related Indicators

SANDAG used a number of different tools and information sources to describe the transportation-related components of SANDAG's draft SCS and the resulting GHG emission reduction benefits in 2020 and 2035. These include the travel demand model and off-model tool, as well as data inputs and assumptions specifically related to transportation.

The strategies in SANDAG's draft SCS that relate to the transportation system impact transit and non-motorized transportation, and help manage the overall transportation system, through carpools, vanpools, buspools, telecommuting, congestion relief, and pricing.

Staff evaluated SANDAG's sensitivity runs for the trip generation discounts used to reflect telecommuting and e-commerce strategies. These are factors that reduce or increase trip production and attraction rates in the model and are applied to commute trips for office workers and shoppers. Studies show that telecommuting reduces the number of commute trips from home to work, with potential commute-related VMT reductions ranging from a 48.1 percent reduction in household VMT per telecommuter per day (Kitamura et al. 1991) to a 90.3 percent reduction in commute VMT per telecommuter per day (Henderson & Mokhtarian 1996). SANDAG ran two tests in which they removed and doubled the trip generation discounts. When the discount was removed, VMT and peak commute trips increased. The results show changes to VMT as a result of eliminating or doubling the trip generation discount. Since trip generation discounts are not analogous to numbers of telecommuters, which is the metric used in the empirical literature, staff cannot make a determination on the appropriateness of the model's sensitivity to this factor.

ARB staff's analysis of SANDAG's sensitivity test for changes in roadway capacity shows that the travel demand model is appropriately sensitive to increases in highway capacity, and thus is sensitive to bottleneck relief and capacity-increasing projects. Staff's evaluation of SANDAG's sensitivity tests for auto operating cost and parking cost reveal that the model is sensitive to changes in cost.

Staff also reviewed available documents that describe SANDAG's approach for addressing induced demand in its modeling tools. As previously mentioned, SANDAG uses a feedback mechanism between the trip distribution and mode choice steps of their modeling process to address induced demand, which is consistent with the accepted practice for 4-step models. SANDAG's model improvement plan to move to an activity-based model will enable a more sophisticated treatment of induced demand.

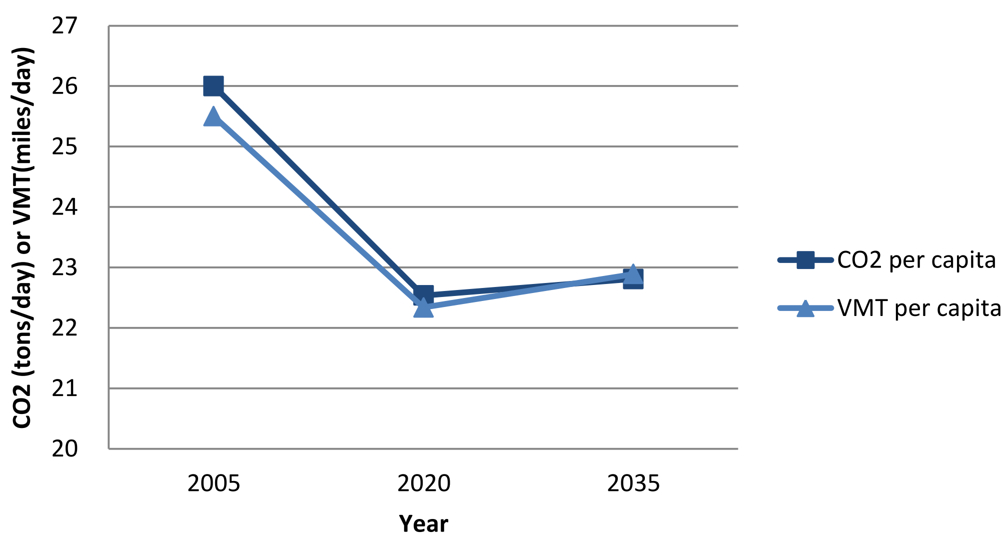
Several of the key performance indicators for the SANDAG SCS are related to transportation. Staff evaluated them, along with the supporting data inputs, assumptions, and sensitivity analyses.

a) Passenger Vehicle Miles Traveled

The SANDAG SCS reports a VMT per capita trend that closely follows CO2 per capita emissions, where there is a decline in both per capita CO2 and VMT between 2020 and 2035, and a slight increase between 2035 and 2050 (see Figure 7). As described more fully in section E of this report, this trend differs from ARB staff expectations of a steady decline in both over time.

VMT and CO2 emissions are similar because the quantification of CO2 emissions from passenger vehicles is a function of VMT and vehicle speeds, although they are not directly proportional to each other. Roadway conditions, traffic congestion, maintenance activities, and construction on any given road segment will affects the speed profile of that road, and can impact the vehicle's GHG emissions.

Figure 7. Per Capita Passenger VMT and CO_2 Trends



b) Commute Trip Mode Share - Carpooling

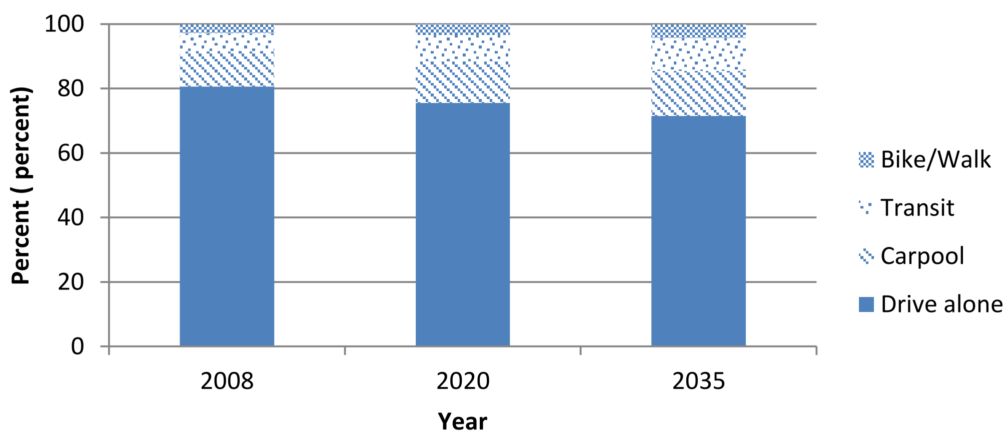
SANDAG's SCS describes changes in the commute trip modes, with significant increases in the carpool mode shares by 2035. Carpool mode shares increase from 10.6 percent for 2008 to 12.9 and 14 percent for 2020 and 2035, respectively, as shown in Figure 8. Increased carpool mode share replaces some of the drive alone trips, and may result in lower VMT and GHG emissions per commuter if workers do not choose to increase the length of their commute in response to carpooling. This trend further supports the GHG emissions reductions reported in the SANDAG SCS, and emphasizes the importance of continued improvement of tools that can quantify the relationship between mode shifts and trip length impacts.

c) Commute Trip Mode Share – Transit and Bike/Walk

Staff reviewed two regional performance indicators to understand whether the changes in transit-related metrics are consistent with the GHG emissions reported by the draft SCS: the change in commute trip mode share for transit and the change in bike/walk from proximity to housing and employment near transit stations. (See also discussion in the Land Use Indicators section of this staff report).

SANDAG's projections show changes in the means by which people travel between home and work or school, known as commute trip modes or commute modes, including driving alone, carpooling, taking transit (including bus and rail), and using non-motorized forms of travel (including walking and biking). Driving alone and carpooling make up the dominant share of the total commute (i.e., more than 90 percent of the commute mode share is from a combination of driving alone and carpooling in most urban areas).

Figure 8. Commute Trip Mode Share in the San Diego Region



As shown in Figure 8, more than 80 percent of trips in the San Diego region were made by the drive alone mode in 2008. At the same time, 11 percent, 5.7 percent, and 2.7 percent were made by the carpool, transit and bike/walk modes, respectively. By implementing various strategies such as expanding transit infrastructure and carpool programs, and building bike/walk facilities, the number of trips taken by driving alone decreases between 2008 and 2020 by 6.3 percent and 11.3 percent between 2008 and 2035. Meanwhile, the carpool, transit, and bike/walk mode shares increase 28.4 percent, 78.9 percent, and 55.6 percent, respectively, between 2008 and 2035. Based on this information, the shift in modes away from drive alone should be shifting to trips by carpools, transit, and bike/walk modes.

Although the change in mode share cannot generally be used to quantify a change in GHG emissions, studies indicate that GHG emissions per person would decrease as the automobile mode share decreases and the transit and bike/walk mode shares increase. Johnston et al. found that a 9 percent increase in the mode share for public transit reduces VMT by about 12 percent in 25 years. In the San Diego region, a 4.8 percent increase in the transit mode share is forecasted by 2035. Meanwhile, per capita VMT in the region decreases by 6.7 percent. This is fairly consistent with the Johnston et al. study, and provides additional supportive evidence for the overall GHG emission reduction trend.

To provide additional insight on the performance of this SCS indicator to the SCS quantification of the targets, ARB staff evaluated several of the key data inputs used to model the transit system, as well as the three transit-related sensitivity analyses conducted by SANDAG.

Data Input: Transit Network

The SANDAG regional transit network includes each route and mode in detail for bus, trolley and commuter rail with station elevation, and distance to platforms, as well as attributes such as frequency of service, stop type, and park-and-ride availability. The transit network in the SANDAG region represents seven transit modes with 2,500 transit access points. Bus travel time is estimated using the number of bus stops and road and/or highway travel time from the travel model traffic assignment steps. SANDAG obtained the transit infrastructure information from the SanGIS (San Diego Geographic Information Source) and updated it with high-resolution digital aerial photography. Transit systems that operate on regular streets and/or freeways are directly linked to the relevant portions of the highway network. Other modes that operate on a separate right-of-way, such as trolley and commuter rail lines, are coded as separate parts of the network. The transit network also depicts access to transit by walk access and auto access points. The transit network coding follows the recommendations and practices described in the NCHRP 365 report.

Data Input: Transit Frequency

Transit frequency indicates how often trains and buses arrive at the same destination in a given time period. Increases in transit frequency improve the attractiveness of transit as a transportation mode, which in turn generally increases the level of transit ridership. SANDAG estimated transit frequencies based on the existing transit schedules. For future years, frequencies are estimated based on policies, such as a minimum 15-minute interval, or are calculated based on the vehicle capacity and forecasted ridership from previous model runs.

Data Input: Transit Speed

Transit speeds are used to estimate travel times between the shortest or most direct path between two transit access points. SANDAG's model follows procedures for estimating transit speed that are consistent with the practices followed by other MPOs in the nation (for example the procedures described by the Florida Department of Transportation in "Calibration of Highway/Transit Speed Relationships for Improved Transit Network Modeling in FSUTMS", Lehman Center for Transportation Research, March 2005). SANDAG used 35 mph and 62 mph for transit on freeway and HOV lanes, respectively. The SANDAG model also assumes a 10 percent reduction in travel time for bus rapid transit due to the allocation of a priority lane. Stop delays, fixed delays, and dwell time for passenger boarding and alighting are considered in calculating the average speed for transit.

Data Input: Trip Time and Distance Distribution

Travel time and distance inputs into the SANDAG's trip distribution model include trip duration by mode choice, including transit and bike/walk. The average trip length and trip duration fall within the range of the observed data from the U.S. Census Bureau's 2006-2008 American Community Survey.

Transit Fares Sensitivity Tests

SANDAG performed four sensitivity tests to examine the model's sensitivity to changes in transit fares. These tests changed transit fares to 50 percent, 75 percent, 125 percent, and 150 percent of baseline transit fares. As shown in Table 10, the number of transit trips increased as the transit fares decreased.

Table 10. Results of SANDAG Transit Fares Sensitivity Runs

Test	Modeled Regionwide All Transit Trips (Daily, thousands)	Expected Transit Trip Range* (thousands)
50 percent of baseline	441	380 – 525
75 percent of baseline	392	365 - 438
Baseline transit fare	350	--
125 percent of baseline	317	263 - 335
150 percent of baseline	294	175 - 320

*Based on elasticites of 0.17 – 1.0 percent increase in ridership per percent decrease in fare

The empirical literature indicates that higher transit ridership should be coupled with decreasing transit fares, with increasing fares resulting in lower transit ridership. The empirical literature cites research showing an expected elasticity of between 0.17 percent for rail ridership (McCollom and Pratt, 2004) and 1.00 percent for bus ridership over the long run (Paulley et al. 2006). ARB staff applied these elasticities to the changes in transit fares, with a resulting range of trips that is consistent with the results of SANDAG's sensitivity runs.

Transit Frequency Sensitivity Test

SANDAG ran four sensitivity tests to determine the model's responsiveness to changes in transit service frequency. These tests involved changes to the Coaster commuter rail line (North County Transit District Route 398) and the Metropolitan Transit System's (MTS) bus route #7. The Coaster route is the only commuter rail service in the region, and the MTS route is one of the busiest local bus routes in the region. For both routes, the scenarios included a run that decreased service frequency by 50 percent and one that increased service frequency by 50 percent. As shown in Table 11, increases in transit frequency resulted in increased ridership.

Table 11. Results of SANDAG Transit Frequency Sensitivity Runs

Test	Modeled Ridership (Peak)	Modeled Ridership (Off Peak)	Modeled Ridership (Daily)	Expected Ridership (Peak)*	Expected Ridership (Off Peak)*	Expected Ridership (Daily)
50 percent decrease from baseline for Coaster	2380	234	2615	400 - 3751	96 - 899	496 - 4649
Baseline service	5001	1198	6199	--	--	--
50 percent increase from baseline for Coaster	8020	2684	10704	6251 - 9602	1498 - 2300	7749 - 11902
50 percent decrease from baseline for MTS Route 7	1227	1353	2580	225 - 2386	254 - 2700	479 - 5085
Baseline service	2807	3176	5982			
50 percent increase from baseline for MTS Route 7	4431	6754	11185	1534 - 5389	1691 - 6098	3225 - 11485

*ARB staff calculated transit ridership based on elasticities of 0.3 to 1.42 percent increase in ridership for 1 percent increase in transit service frequency.

Information from the UCD-UCI "Policy Brief on the Impacts of Transit Service Strategies Based on a Review of the Empirical Literature" indicates that for every one percent increase in service frequency in an urban area, a corresponding increase in ridership should fall somewhere within a range of 0.3 percent to 1.42 percent. The modeled results for peak ridership fall within the expected range of changes in ridership for peak and daily trips based on the UCD-UCI research. In some cases, the results for daily ridership are outside of the range, but within 10 percent of the expected results based on the empirical literature. Most of the modeled results for off-peak ridership are not consistent with the empirical literature. The majority of the ridership for the Coaster occurs during peak periods, while off-peak ridership is higher for the MTS Route 7.

Transit Access – Wait and Transfer Time Sensitivity Tests

SANDAG modeled two tests that vary wait and transfer times for transit passengers, reducing times by 50 percent and increasing times by 50 percent. Wait and transfer times are key components of total travel time, in addition to the actual travel time in transit. SANDAG's test runs for this parameter exhibited changes in total VMT, all trips within the region, and the transit mode share for commutes. Table 12 displays the modeled changes in trips.

Table 12. Results of SANDAG Transit Access – Wait and Transfer Time Sensitivity Runs

Test	Modeled Total VMT	Modeled Regionwide All Trips (Daily)	Expected Regionwide All Trips (Daily)*
50 percent decrease from baseline	103,397,441	417,056	418,280 – 554,790
Baseline time	104,081,786	350,025	--
50 percent increase from baseline	104,506,243	301,162	145,260 - 281,770

*ARB staff calculated regional trips based on an elasticity of -0.39 to -1.17percent change in ridership (adult trips) per 1 percent change in wait time

ARB staff found one study in the literature that examines the impacts of transfer and wait times (Paulley 2006). According to this study, decreases in travel time should result in an increase in commute transit mode share ridership, while an increase in the total travel time would decrease the commute transit mode share. The degree of change in SANDAG staff's test results is low compared to the range of results that would be expected based on the range of elasticities from the Paulley study. As seen in Table 12, although the modeled transit ridership falls outside of the expected range, it is within ten percent for both scenarios. Based on the empirical literature, it may slightly underestimate the benefits of this variable as the modeled results are close but outside the range of the expected ridership.

Transit Access – Walk Factors Sensitivity Tests

SANDAG's model appears to be generally sensitive to changes in transit access walk factors, but there was insufficient information for staff to evaluate the magnitude of change in the sensitivity runs. SANDAG assessed how its model responds to changes in the physical environment that impact the duration of pedestrian trips to transit urban and suburban areas. SANDAG staff modeled two tests that adjusted the urban and suburban walk factors in the mode choice model. These factors assign a time surcharge of 1.1 in urban areas and 1.3 in suburban and rural areas to the walk-to-transit mode. They assume different street patterns, with a grid pattern for the urban walk factors while the suburban walk factors have no grid street pattern.

In the first scenario, SANDAG applied only urban walk factors to the whole region, while in the second scenario, SANDAG applied only suburban walk factors to the whole region. It is assumed that applying urban walk factors only compared to suburban walk factors only would result in lower VMT and higher transit mode shares. As shown in Table 13, the model outputs change as the different walk factors are applied. The suburban walk factors scenario was much closer to baseline than the urban walk factors scenario, given that the San Diego region is considered largely suburban.

Table 13. Results of SANDAG Transit Access – Walk Factors Sensitivity Runs

Test	Modeled Total VMT (thousands)	Modeled Regionwide Commute Transit Trips Mode Share (Peak)	Modeled Regionwide All Transit Trips Mode Share (Daily)
Application of urban walk factor only	103,730	9.7%	1.9%
Baseline	104,082	8.6%	1.7%
Application of suburban walk factor only	104,149	8.4%	1.6%

Several studies in the empirical literature show a connection between street connectivity and VMT (Handy et al., 2010. Policy Brief on the Impacts of Network Connectivity Based on a Review of the Empirical Literature). However, ARB staff could not identify comparable peer-reviewed literature against which to examine SANDAG's results, in part because it is not clear which SCS policies are incorporated into the walk factor, or to what degree they are implemented in SANDAG's modeling approach.

d) Housing and Employment Near Transit Stations

As previously reported, the anticipated increase in housing and employment near transit stations provide additional supportive evidence for the reported reduction trend in GHG emissions in the region.

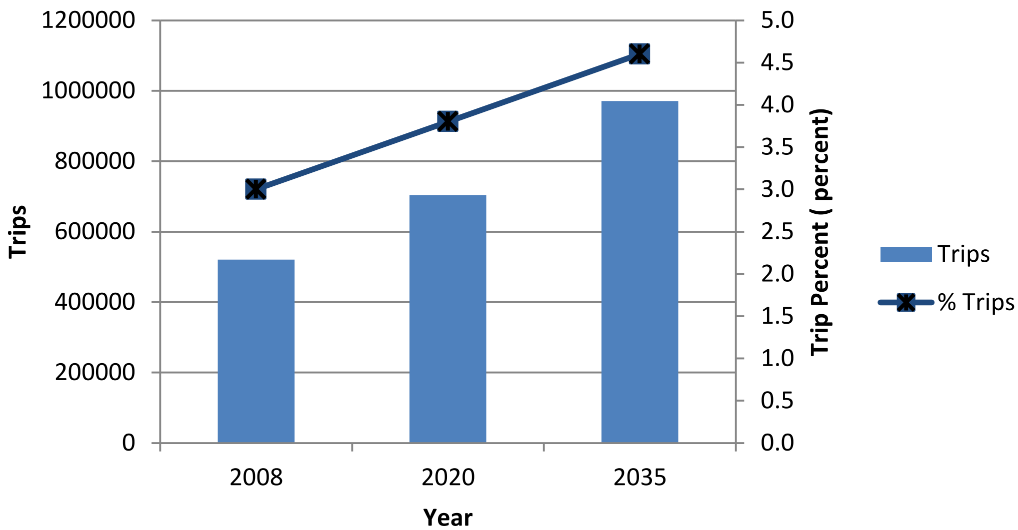
e) Bike and Walk Trips

The trends in SANDAG's model outputs from changing bike and walk trips are consistent with the trends seen in the empirical literature, and support the reported GHG emission reductions in the region. SANDAG's draft SCS identifies a number of non-motorized transportation strategies to improve the pedestrian environment of streets and neighborhoods, and to expand regional bikeway corridors and facilities for intercommunity bicycle travel.

The relevant empirical research reviewed by ARB staff show that bicycle infrastructure projects and an improved walking environment should result in decreased vehicle activity. Dill and Carr (2003) reported that increasing the number of miles of bike lanes by one percent per square mile decreases commuting VMT by one percent. Strategies for improving the walking environment also have the potential to reduce the number of vehicle trips. Sciara (2010) reported that a 1 percent increase in sidewalk coverage, length, or width results in an increase of 0.09 to 0.27 percent in walking.

As indicated in Figure 9, if these strategies are implemented in the San Diego region, the number of bike/walk trips will sharply increase from the 2008 base year by 35 and 86 percent for 2020 and 2035, respectively. The bike/walk mode share is also expected to increase from the base year by 27 percent for 2020 and 53 percent for 2035 in the San Diego region.

Figure 9. Bike/Walk Trips and Mode Share in the San Diego Region



E. Meeting ARB Targets

The quantification of GHG emissions from the draft San Diego SCS indicates that the ARB target of a 7 percent per capita reduction in 2020 and a 13 percent per capita reduction by 2035 would be met with SCS implementation. SANDAG quantified the GHG emissions based on the results of its travel demand model, using the technical methodology provided on May 5, 2010 to ARB as required by California Government Code section 65080(b)(2)(I)(i). ARB staff reviewed SANDAG's application of their methodology, including the data inputs and assumptions, and found that the methodology was applied as expected. The GHG quantification shows that the San Diego SCS would achieve double the 2020 target and just meet the target in 2035. While the quantification was done using an appropriate technical methodology, the 2035 result was unexpected in light of the 2020 emission reduction estimate.

During the target setting process, including in meetings of the Regional Targets Advisory Committee, there was an expectation that the benefits of an SCS would increase with time given the nature of land use patterns and transportation systems. ARB set regional targets with that expectation. While early work on the San Diego RTP seemed to indicate that trend, when the draft SCS was completed the 2020 benefits were much greater than expected and slightly greater than the 2035 benefits.

In response to public comment SANDAG staff has explained the trend with the following:

> *"The early gains in GHG reductions are the results of a slow economic recovery while significant investments are being [made] in the regional transportation network. (These transportation projects include a number of public transportation investments, including the Mid-Coast Light Rail, I-15 Bus Rapid Transit (BRT) and South Bay BRT among others.) At the same time, due to economic conditions: fewer residents are working and residents who are working are making less income. As such, fewer workers are driving alone and more workers are carpooling or taking public transit. By 2035 and 2050, the economy catches up and more workers begin driving again."*
>
> *(SANDAG Draft 2050 RTP/SCS Public Comments and Responses, p. 510)*

Improvements to SANDAG's modeling system are well underway, with development of an activity-based model that will do a better job quantifying travel behavior, evaluating different land use scenarios, and addressing issues such as induced demand. SANDAG staff is also pursuing improved tools to supplement travel model outputs, and to integrate land use and freight models with the region's travel model systems. These improvements are essential for future SCS development.

The San Diego land use planning update begins with the Regional Comprehensive Plan (RCP). The RCP update includes another round of regional visioning about future land use patterns and development. This presents an opportunity for all jurisdictions represented by SANDAG to focus more attention on the post-2020 land use pattern and transportation system to improve the per capita GHG reductions in 2035 and beyond. The RCP update will also set the stage for ARB's 2014 target update, which includes the development of target-setting scenarios and recommendations from SANDAG. ARB staff anticipates that more sophisticated modeling tools and information will be available for the San Diego region to help inform the Board's reconsideration of the current greenhouse gas reduction targets. The promise of an SCS is that over time changes in the transportation system and land use pattern will result in decreasing per capita greenhouse gas emissions. The land use scenario planning process provides a way for regions to explore options for growth that can achieve greater greenhouse gas reductions. San Diego's next planning process would benefit from additional land use scenario planning coupled with a reassessment of the transportation system to further support the region's sustainability goals.

Since the SANDAG assumptions about economic recovery prior to 2020 are similar to other economic forecasts, much of focus has been on the per capita GHG emissions trend between 2020 and 2035, and beyond. Related to the future forecasts for the region, there has also been concern that portions of the SANDAG travel demand model are proprietary, which does not provide for transparency in the modeling process. SANDAG has acknowledged these comments as they relate both to their existing modeling system and the next generation of travel models currently under development for the next planning process.

III. STAFF RECOMMENDATIONS

The quantification of GHG emissions from the draft San Diego SCS indicates that the ARB target of a 7 percent per capita reduction in 2020 and a 13 percent per capita reduction by 2035 would be met with SCS implementation. Therefore, if SANDAG approves the draft SCS, ARB staff will recommend that the Board accept the SANDAG finding that implementation of the SCS would meet the targets. If SANDAG modifies the draft SCS, ARB staff will review the changes to determine the impact on greenhouse gas emissions. ARB staff will inform the Board of the outcome, including any need to reconsider whether the final SCS would meet the target.

APPENDIX A. ROADMAP TO ARB STAFF EVALUATION OF THE SANDAG SCS

The following table summarizes ARB staff's evaluation of SANDAG's Draft SCS according to the four evaluation components contained in ARB's SCS Evaluation Methodology (July 2011), and points to sections of the staff report where the detailed information can be found.

Evaluation Components	Questions from ARB's Evaluation Methodology that apply to SANDAG's SCS	ARB Staff Report References
Modeling Tools	Were the basic components of the models and four-step travel demand process explained?	• **Pages 12-19**
	Was the travel model calibrated?	• **Pages 12, 14 and 28**
	Was the travel model validated and peer-reviewed?	• **Pages 17-18**
	How did you handle forecasting of external, inter-regional trips?	• **Page 10-12**
	How were model outputs converted into GHG emissions? What model/tools were used for this purpose?	• **Pages 6-7 and 10**
	How and what smart growth policies were quantified in the current models?	• **Pages 1-5 and 12-17**
	Were any off-model tools used, and for which strategies?	• **Pages 16-17**

Evaluation Components	Questions from ARB's Evaluation Methodology that apply to SANDAG's SCS	ARB Staff Report References
Data Inputs and Assumptions	What were the sources of transportation and land use model inputs and assumptions? Were inputs and assumptions used appropriate and verifiable with publicly available data?	• **Pages 10-11 and 19-21, Population** **Pages 21-22, Households** **Pages 22-23, Employment** **Pages 24-25, Highway Network** **Page 25, Link Capacity** **Page 25-26, Free Flow Speed** **Pages 27-28, Trip Generation Rates** **Page 28-29, Trip Time and Distance Distribution** **Pages 30-31, Gasoline Price** **Page 39, Transit Network** **Page 39, Transit Frequency** **Pages 39, Transit Speed**
	What level of funding is assumed in SCS development, implementation and model improvement, and in what timeframe?	• **Page 3**
	How were economic changes (e.g., recession) reflected? How were economic changes verified?	• **Pages 10-12 and 43-45**

Evaluation Components	Questions from ARB's Evaluation Methodology that apply to SANDAG's SCS	ARB Staff Report References
Sensitivity Analysis	How were model sensitivity analyses conducted, and what variables were tested?	• **Page 9**
	How do model sensitivity analysis results, such as elasticity, compare to the empirical literature findings?	• **Pages 23-24, Income Distribution** **Page 26, Network Assignment** **Page 27, Roadway Capacity** **Pages 31-32, Auto Operating Costs** **Pages 32-33, Parking Costs** **Page 35, Trip Generation Discounts** **Page 39, Transit Fares** **Pages 40-41, Transit Frequency** **Page 41, Transit Access – Wait and Transfer Time** **Pages 41-42, Transit Access – Walk Factors**

Evaluation Components	Questions from ARB's Evaluation Methodology that apply to SANDAG's SCS	ARB Staff Report References
Performance Indicators	Do the performance indicators provide evidence to show that the regional changes in transportation and land use trends anticipated by the SCS reasonably predict changes in GHG emissions? Are the relationships between performance indicators and per capita CO2 outputs directionally consistent with what would be expected based on what is reported in independent studies?	• **Page 36, Change in Passenger Vehicle Miles Traveled** **Pages 33-34, Change in Residential Density** **Pages 34-35, Change in Housing and Employment Near Transit Stations** **Page 36, Change in Commute Trip Mode Share - Carpooling** **Pages 37-38, Change in Commute Trip Mode Share - Transit and Bike/Walk**
	What are the key indicators that best explain the GHG reduction impacts of the SCS (land use and transportation inputs)?	• **Pages 2-5 and 33-43**

APPENDIX B. 2010 CTC RTP GUIDELINES ADDRESSED IN SANDAG'S DRAFT RTP

This Appendix describes the requirements in the Guidelines that SANDAG's model applied, as well as the CTC recommendations that SANDAG incorporated into the model.

Requirements	• Each MPO shall model a range of alternative scenarios in the RTP Environmental Impact Report based on the policy goals of the MPO and input from the public. • MPO models shall be capable of estimating future transportation demand at least twenty years into the future. (Title 23 CFR Part 450.322(a)) • The MPO, the state(s), and the public transportation operator(s) shall validate data utilized in preparing other existing modal plans for providing input to the regional transportation plan. In updating the RTP, the MPO shall base the update on the latest available estimates and assumptions for population, land use, travel, employment, congestion, and economic activity. (See Section 6.25 for additional guidance on SCS Planning Assumptions.) The MPO shall approve RTP contents and supporting analyses produced by a transportation plan update. (Title 23 CFR Part 450.322(e)) • The metropolitan transportation plan shall include the projected transportation demand of persons and goods in the metropolitan planning area over the period of the transportation plan. (Title 23 CFR Part 450.322(f)(1)). • Each MPO shall quantify the reduction in greenhouse gas emissions projected to be achieved by the SCS. (California Government Code Section 65080(b)(2)(H)) • Network-based travel models shall be validated against observed counts (peak and off-peak, if possible) for a base year that is not more than 10 years prior to the date of the conformity determination. Model forecasts shall be analyzed for reasonableness and compared to historical trends and other factors, and the results shall be documented. (Title 40 CFR Part 93.122 (b)(1)(i)) (p. 44). • Land use, population, employment, and other network-based travel model assumptions shall be documented and based on the best available information. (Title 40 CFR Part 93.122 (b)(1)(ii)). • Scenarios of land development and use shall be consistent with the future transportation system alternatives for which emissions are being estimated. The distribution of employment and residences for different transportation options shall be reasonable. (Title 40 CFR Part 93.122 (b)(1)(iii)).

	• A capacity-sensitive assignment methodology shall be used, and emissions estimates shall be based on a methodology which differentiates between peak- and off-peak link volumes and speeds and uses speeds based on final assigned volumes. (Title 40 CFR Part 93.122 (b)(1)(iv)) • Zone-to-zone travel impedances used to distribute trips between origin and destination pairs shall be in reasonable agreement with the travel times that are estimated from final assigned traffic volumes. (Title 40 CFR Part 93.122 (b)(1)(v)). • Network-based travel models shall be reasonably sensitive to changes in the time(s), cost(s), and other factors affecting travel choices. (Title 40 CFR Part 93.122 (b)(1)(vi)). • Reasonable methods in accordance with good practice shall be used to estimate traffic speeds and delays in a manner that is sensitive to the estimated volume of travel on each roadway segment represented in the network-based travel model. (Title 40 CFR Part 93.122 (b)(2)) • Highway Performance Monitoring System (HPMS) estimates of vehicle miles traveled (VMT) shall be considered the primary measure of VMT within the portion of the nonattainment or maintenance area and for the functional classes of roadways included in HPMS, for urban areas which are sampled on a separate urban area basis. For areas with network-based travel models, a factor (or factors) may be developed to reconcile and calibrate the network-based travel model estimates of VMT in the base year of its validation to the HPMS estimates for the same period. These factors may then be applied to model estimates of future VMT. In this factoring process, consideration will be given to differences between HPMS and network-based travel models, such as differences in the facility coverage of the HPMS and the modeled network description. Locally developed count-based programs and other departures from these procedures are permitted subject to the interagency consultation procedures of §93.105(c) (1)(i). (Title 40 CFR Part 93.122 (b)(3)) • Socioeconomic models shall include capabilities to measure the impacts of transportation investments on low income and minority communities as required under federal and state law.
Recommendations	• Walk and bike modes should be explicitly represented. • Small Traffic Analysis Zones (TAZ) should be used, to increase sensitivity to infill potential near to rail stations and in Bus Rapid Transit (BRT) corridors. Parking quantity and cost should be represented in the travel model. • The carpool mode should be included, along with access-to-transit sub modes. • Feedback loops should be used and take into account the effects of corridor capacity, congestion and bottlenecks on mode choice, induced demand, induced growth, travel speed and emissions.

	• The regions should implement simple land use models that recognize the effects of transportation on development location and density for the next RTP and develop formal economic land use models in the next few years. • Freight models should be implemented in the short term and commodity flows models within a few years. • Simple Environmental Justice analyses should be done using travel costs or mode choice log sums, as in Group C. Examples of such analyses include the effects of transportation and development scenarios on low-income or transit-dependent households, the combined housing/transportation cost burden on these households, and the jobs/housing fit. (See Section 3.6, Reference 11, for additional guidance)

APPENDIX C. REFERENCES AND DOCUMENTATION

"About SANDAG: History." SANDAG. San Diego Association of Governments. Accessed 28 July 2011. <http://www.sandag.org/index.asp?fuseaction=about.history>

Agras, Jean, and Duane Chapman. "The Kyoto Protocol, CAFE Standards, and Gasoline Taxes." Contemporary Economic Policy, 17.3 (July 1999): 296-308.

Arrington, G.B., and Robert Cervero. "Effects of TOD on Housing, Parking, and Travel. Transit Cooperative Research Program Report 128." Washington, D.C.: Transportation Research Board, 2008.

Boarnet, Marlon G., and Susan Handy. "Draft Policy Brief on the Impacts of Residential Density Based on a Review of the Empirical Literature." University of California, Irvine and Davis. 25 June 2010. Web. Accessed 27 July 2011. <http://www.arb.ca.gov/cc/sb375/policies/density/density_brief.pdf>

Brownstone, David, and Thomas F. Golob. "The Impact of Residential Density on Vehicle Usage and Energy Consumption." Journal of Urban Economics, 65 (2009): 91-98.

California Air Resources Board. "Recommendations of the Regional Targets Advisory Committee (RTAC) Pursuant to Senate Bill 375: A Report to the California Air Resources Board." 2009. Web. Accessed 21 July 2011. <http://www.arb.ca.gov/cc/sb375/rtac/report/092909/finalreport.pdf>

California Department of Finance. "Population Projections for California and its Counties 2000-2050, by Age, Gender and Race/Ethnicity." Sacramento, California. July 2007. Web. Accessed 18 July 2011. <http://www.dof.ca.gov/research/demographic/reports/projections/p-3/>

California Department of Transportation. "California County-Level Economic Forecast 2010-2035." Mar. 2010. Web. Accessed 28 July 2011. <http://www.dot.ca.gov/hq/tpp/offices/ote/socio_economic_files/2010/Caltrans_2009_Final.pdf>

California Department of Transportation. "2000-2001 California Statewide Travel Survey: Weekday Travel Report." June 2003. Web. Accessed 18 July 2011. <http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001_StwTravelSurveyWkdayRpt.pdf>

California Energy Commission. "2009 Integrated Energy Policy Report, Final Commission Report." CEC–100–2009–003-CMF. 2009. Web. Accessed 18 July 2011. <http://www.energy.ca.gov/2009publications/CEC-100-2009-003/CEC-100-2009-003-CMF.PDF>

California Transportation Commission. “2010 California Regional Transportation Plan Guidelines.” Apr. 2010.

Cambridge Systematics, Inc. “Senate Bill 375 Target Setting Methodology Review and Recommendations. Final Report.” Oakland, CA. 10 September 2010.

Cambridge Systematics, Inc. “Travel Model Validation and Reasonableness Checking Manual, Second Edition.” FHWA-HEP-10-042. Washington, D.C.: Federal Highway Administration, 2010.

Davidson, Bill, et al. “4D Model Development.” 31 Mar. 2010. Report to San Diego Association of Governments by Parsons Brinckerhoff. Print. Also available at <http://www.sandag.org/uploads/publicationid/publicationid_1602_13320.pdf>

Deakin, Elizabeth, Greig Harvey, and Alex Skabardonis. “Manual of Regional Transportation Modeling Practice for Air Quality Analysis.” Washington, D.C.: The National Association of Regional Councils, 1993.

Dill, Jennifer and Theresa Carr. “Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them – Another Look.” Transportation Research Board. 2003. Web. Accessed 29 July 2011. <http://nexus.umn.edu/Courses/pa8202/Dill.pdf>

Dowling, Richard, Robert Ireson, Alexander Skabardonis, David Gillen, Peter Stopher. “Predicting Air Quality Effects of Traffic-Flow Improvements: Final Report and User’s Guide.” Washington, D.C.: Transportation Research Board, 2005.

Ewing, Reid, and Robert Cervero. “Travel and the Built Environment: A Synthesis.” Transportation Research Record 1780 (2001): 87-114.

Goodwin, Phil, Joyce Dargay, and Mark Hanly. “Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review.” Transport Reviews, 24.3 (2004): 275–292.

Handy, Susan, Steve Spears, and Marlon G. Boarnet. “Draft Policy Brief on the Impacts of Transit Service Strategies Based on a Review of the Empirical Literature.” University of California, Davis and Irvine. 17 Dec. 2010. Web. Accessed 27 July 2011. <http://www.arb.ca.gov/cc/sb375/policies/transitservice/transitservice_brief.pdf>

Handy Susan, Gil Tal, and Marlon G. Boarnet. “Draft Policy Brief on the Impacts of Network Connectivity Based on a Review of the Empirical Literature.” University of California, Davis and Irvine. 22 Nov. 2010. Web. Accessed 27 July 2011. <http://www.arb.ca.gov/cc/sb375/policies/connectivity/netconnectivity_brief.pdf>

Handy, Susan, Gil Tal, and Marlon G. Boarnet. “Draft Policy Brief on the Impacts of Telecommuting Based on a Review of the Empirical Literature.” 16 Dec. 2010. Web. Accessed 27 July 2011. <http://www.arb.ca.gov/cc/sb375/policies/telecommuting/telecommuting_brief.pdf>

Henderson, D.K. and Mokhtarian, P.L. “Impacts of Center-Based Telecommuting on Travel and Emissions: Analysis of the Puget Sound Demonstration Project.” Transportation Research D 1(1) (1996): 29-45.

Horowitz, Alan. “NCHRP Synthesis 358: Statewide Travel Forecasting Models: A Synthesis of Highway Practice.” Washington, D.C.: Transportation Research Board of the National Academies, 2006.

Hughes, Jonathan E., Christopher R. Knittel, and Daniel Sperling. “Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand.” National Bureau of Economic Research, Working Paper No. 12530. 2006.

Imhoff, Evert van, Anton Kuijsten, Pieter Hooimeijer, and Leo van Wissen (Eds.). Household Demography and Household Modeling. New York: Plenum Press, 1995.

Johnston, Robert A., Shengyi Gao, and Michael J. Clay. “Modeling Long-Range Transportation and Land Use Scenarios for the Sacramento Region, Using Citizen-Generated Policies.” Research Report UCD-ITS-RR-08-13. University of California, Davis. 26 Mar. 2005.

Kitamura R., P. Mokhtarian, R. Pendyala, and K. Goulias. “An Evaluation of Telecommuting as a Trip Reduction Measure.” Proceedings of the 19th Annual Meeting of the Planning and Transport Research and Computation (PTRC), Education and Research Services Limited, University of Sussex, Brighton, England, Sept. 1991, 69-80.

Kolko, Jed. “Making the Most of Transit: Density, Employment Growth, and Ridership around New Stations.” Public Policy Institute of California. Feb. 2011.

Litman, Todd. “Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior.” Victoria Transportation Policy Institute. 21 July 2011. Web. Accessed 1 Aug. 2011. < http://www.vtpi.org/elasticities.pdf>

Loudon, William, et al. “Assessment of Local Models and Tools for Analyzing Smart Growth Strategies.” California Department of Transportation. 27 July 2007.

Martin, William A. and Nancy A. McGuckin. “NCHRP Report 365: Travel Estimation Techniques for Urban Planning.” Transportation Research Board. National Cooperative Highway Research Program. Washington D.C.: National Academy Press, 1998.

McCollom, Brian E. and Richard H. Pratt. “Traveler Response to Transportation System Changes: Chapter 12 - Transit Pricing and Fares. TCRP Report 95.” Washington, D.C.: Transit Cooperative Research Program, Transportation Research Board, 2004.

Miller, Ronald E., and Peter D. Blair. Input-Output Analysis: Foundations and Extensions (2 ed.). New York: Cambridge University Press, 2009.

Paulley, Neil, et al. “The demand for public transport: The effects of fares, quality of service, income and car ownership.” Transport Policy 13.4 (2006): 295-306.

San Diego Association of Governments [California]. “2000 State of the Region Report: Measuring the San Diego Region’s Livability.” Sept. 2000. Web. Accessed 29 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_215_943.pdf>

San Diego Association of Governments [California]. “2050 Regional Growth Forecast Process and Model Documentation.” San Diego Association of Governments. 10 June 2010. Web. Accessed 29 June 2011. <http://www.sandag.org/uploads/publicationid/publicationid_1490_11298.pdf>

San Diego Association of Governments [California]. *“2050 Regional Transportation Plan Fact Sheet.”* Apr. 2011. Web. Accessed 29 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_1548_12474.pdf>

San Diego Association of Governments [California]. “Draft Environmental Impact Report: 2050 Regional Transportation Plan and Sustainable Communities Strategy.” June 2011. Web. Accessed 30 June 2011. <http://www.sandag.org/uploads/2050RTP/EIR_ALL.pdf>

San Diego Association of Governments [California]. “Draft Sustainable Communities Strategy Fact Sheet.” June 2011. Web. Accessed 29 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_1581_12970.pdf>

San Diego Association of Governments [California]. “Final Regional Comprehensive Plan for the San Diego Region.” July 2004. Web. Accessed 29 July 2011. <http://www.sandag.org/programs/land_use_and_regional_growth/comprehensive_land_use_and_regional_growth_projects/RCP/rcp_final_complete.pdf>

San Diego Association of Governments [California]. *“Habitat Conservation Planning Fact Sheet.”* Mar. 2006. Web. Accessed 25 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_335_1058.pdf>

San Diego Association of Governments [California]. “MOBILITY 2030: The Transportation Plan for the San Diego Region. Final.” Apr. 2003 .Web. Accessed 27 Aug. 2011. <http://www.sandag.org/index.asp?projectid=197&fuseaction=projects.detail>

San Diego Association of Governments [California]. “Our Region. Our Future. 2050 Regional Transportation Plan. Draft.” 15 Apr. 2011.Web. Accessed Apr. 15, 2011. <http://www.sandag.org/uploads/2050RTP/Draft_2050_RTP_Complete.pdf>

San Diego Association of Governments [California]. “Results of the 2009 Onboard Transit Passenger Survey for the San Diego Region.” Feb. 2011. Web. Accessed 28 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_1575_12871.pdf>

San Diego Association of Governments [California]. “Riding to 2050: San Diego Regional Bicycle Plan.” 2010. Web. Accessed 6 July 2011. <http://www.sandag.org/uploads/projectid/projectid_353_10862.pdf>

San Diego Association of Governments [California]. SANDAG. “Board of Directors Meeting: Voting Results, Feb. 26, 2010.” Web. Accessed 27 July 2011. <http://www.sandag.org/uploads/meetingid/meetingid_2514_10790.pdf>

San Diego Association of Governments [California]. “SANDAG Transportation Model Sensitivity Analysis and Report.” 29 July 2011. Web. Accessed 29 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_1597_13158.pdf>

San Diego Association of Governments [California]. “TransNet Fact Sheet.” July 2011. Web. Accessed 28 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_615_3566.pdf>

San Diego Association of Governments [California]. “San Diego Association of Governments Travel Demand Model Validation Report.” June 2011. Web. Accessed 18 July 2011. <http://www.sandag.org/uploads/publicationid/publicationid_1589_13039.pdf>

SanGIS. San Diego Geographic Information Source - The Region's Source for Geographic Data. 2007. Online database. Accessed 20 July 2011. <www.sangis.org>

Schniepp, Mark. “County Level Economic & Demographic Forecasts State of California: Structure of the Model, Model Specification, and Case Study.” 30 May 2000.

Web. Accessed 18 July 2010.
<http://www.dot.ca.gov/hq/tpp/offices/ote/socio_economic.html>

Sciara, Gian-Claudia, Susan Handy, and Marlon Boarnet. "Draft Policy Brief on the Impacts of Pedestrian Strategies Based on a Review of the Empirical Literature." University of California, Davis. 24 Jan. 2011. <http://www.arb.ca.gov/cc/sb375/policies/ped/ped_brief.pdf>

Senate Bill No. 375 (Chapter 728, Statutes of 2008), as amended.

Small, Kenneth, and Kurt Van Dender. "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect." The Energy Journal, 28.1 (2007).

Smith, S. K., J. Tayman, and D.A. Swanson. State and Local Population Projections: Methodology and Analysis. New York: Kluwer Academic/Plenum Publishers, 2001.

Spears, Steven, Marlon Boarnet, and Susan Handy. "Draft Policy Brief on the Impacts of Parking Pricing Based on a Review of the Empirical Literature." 25 June 2010. <http://www.arb.ca.gov/cc/sb375/policies/pricing/parkingpricing_brief.pdf>

Tal, Gil, Susan Handy, and Marlon G. Boarnet. "Draft Policy Brief on the Impacts of Transit Access (Distance to Transit) Based on a Review of the Empirical Literature." 22 June 2010. <http://www.arb.ca.gov/cc/sb375/policies/transitaccess/transitaccess_brief.pdf>

Transportation Model Improvement Program. "Technical Synthesis Topic: Fuel Price Synthesis: Determining Current and Future Gas Prices." Aug. 2007. Web. Accessed 18 July 2011. <http://tmip.fhwa.dot.gov/resources/clearinghouse/docs/tmip/technical_syntheses/2007/august.htm>

Transportation Model Improvement Program. "Technical Synthesis Topic: Employment Data." Feb. 2008. Web. Accessed 18 July 2011. <http://tmip.fhwa.dot.gov/resources/clearinghouse/docs/tmip/technical_syntheses/2008/february.htm>

Transportation Research Board. Highway Capacity Manual 2000. Washington D.C., 2000. Print.

U.S. Census Bureau. "2010 Census, Profile of General Population and Housing Characteristics: Demographic Profile Data, San Diego County, CA." 2010. Web. Accessed 18 July 2011. <http://factfinder2.census.gov/>

U.S. Census Bureau. "2006-2008 American Community Survey 3-Year Estimates." Online database. Accessed 19 July 2011.

<http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=&_lang=en&_ds_name=ACS_2009_5YR_G00_&ts>

U.S. Energy Information Administration, Office of Integrated Analysis and Forecasting. "International Energy Outlook 2010." July 2010. Web. Accessed 18 July 2011. <http://205.254.135.24/oiaf/ieo/>

APPENDIX D. SANDAG'S RESPONSE TO ARB DATA REQUEST

This Appendix contains SANDAG's responses to ARB staff's data requests to supplement staff's evaluation of SANDAG's quantification of GHG emissions. The requests are consistent with the evaluation methodology.

Modeling Parameters	2008 (base year)	2020 (with Project)	2020 (without Project)	2035 (with Project)	2035 (without Project)	Data Source(s)
DEMOGRAPHIC						
Total population	3,131,552	3,535,000		4,026,131		SANDAG, 2050 RGF
Persons per household *(excludes GQ population)*	2.82	2.84		2.85		SANDAG, 2050 RGF
Total number of households *(excludes GQ population)*	1,074,896	1,200,966		1,357,084		SANDAG, 2050 RGF
Total number of jobs	1,501,080	1,619,615		1,813,372		SANDAG, 2050 RGF
Average unemployment rate (%)	6.0%	5.3%		4.7%		SANDAG, 2050 RGF
Average household income ($) (median)	$ 51,919	$ 58,739		$ 69,162		SANDAG, 2050 RGF
LAND USE						
Total housing units *(excludes GQ)*	1,140,654	1 ,262,488		1,417,520		SANDAG, 2050 RGF
Total dwelling units *(housing units + GQ)*	1,238,221	1,392,420		1,570,476		SANDAG, 2050 RGF
Total acreage developed	1,872,917	1,931,211		2,050,178		SANDAG, 2050 RGF
Total residential acreage developed	335,895	403,440		544,868		SANDAG, 2050 RGF
Net residential acreage developed	184,015	199,695		217,486		SANDAG, 2050 RGF
Total acreage available for new development	386,266	327,972		209,005		SANDAG, 2050 RGF
Percent housing ~~population~~ within 1/4 mile of transit stations	60%	61%	58%	62%	58%	SANDAG, 2050 RGF
Percent housing ~~population~~ within 1/2 mile of transit stations	79%	80%	77%	80%	76%	SANDAG, 2050 RGF
Percent employment within 1/4 mile of transit stations	71%	75%	71%	74%	69%	SANDAG, 2050 RGF
Percent employment within 1/2 mile of transit stations	86%	89%	85%	88%	83%	SANDAG, 2050 RGF
Multifamily dwelling units	405,023	493,243		624,419		SANDAG, 2050 RGF
Single family (total) dwelling units	692,382	728,566		755,477		SANDAG, 2050 RGF
Single family detached dwelling units	557,472	--		--		SANDAG, 2050 RGF
Single family attached dwelling units	134,910	--		--		SANDAG, 2050 RGF
Acreage of land zoned (used and available) for mixed use	6,154	6,154		6,154		SANDAG, 2050 RGF

Modeling Parameters	2008 (base year)	2020 (with Project)	2020 (without Project)	2035 (with Project)	2035 (without Project)	Data Source(s)
Average density - dwelling units per developed (residential) acre	3.4	3.1		2.6		SANDAG, 2050 RGF
Net residential density	6.2	6.3		6.5		SANDAG, 2050 RGF
TRIP DATA (Modeling Output)						
Average auto trip length (miles) *(SOV + HOV)*	6.5	6.5	6.5	6.7	6.6	SANDAG Travel Demand Model
Average walk trip length (miles)						
Average transit trip length (miles)	6.9	9.1	8.0	8.9	7.5	SANDAG Travel Demand Model
Average auto travel time (minutes)	12.6	13.2	12.7	14.1	13.6	SANDAG Travel Demand Model
Average walk travel time (minutes)						
Average transit travel time (minutes)	51.1	52.7	53.9	48.2	51.9	SANDAG Travel Demand Model
Average travel time & trip length for commute by mode						
Auto (Trip Length)	13.6	13.3	13.2	13.2	13.0	SANDAG Travel Demand Model
Carpool (Trip Legth)	14.0	14.6	14.0	14.1	14.0	SANDAG Travel Demand Model
Transit (Trip Length)	9.9	11.6	10.7	11.3	10.0	SANDAG Travel Demand Model
Auto (Travel Time)	24.0	25.0	24.2	26.3	25.9	SANDAG Travel Demand Model
Carpool (Travel Time)	24.0	24.9	24.1	27.2	26.1	SANDAG Travel Demand Model
Transit (Travel Time)	59.3	58.6	60.7	53.7	58.6	SANDAG Travel Demand Model
PERCENT PASSENGER TRAVEL MODE SHARE (Daily Mode Shares)						
SOV	52.4%	51.0%	52.6%	50.2%	53.1%	SANDAG Travel Demand Model
HOV (+HOT)	42.5%	42.8%	42.5%	42.7%	42.5%	SANDAG Travel Demand Model
HOT						
Public transit (Regular Bus) *(Transit + School + Private)*	1.4%	1.3%	1.2%	1.0%	1.1%	SANDAG Travel Demand Model
Public transit (Express Bus)	0.1%	0.1%	0.0%	0.2%	0.0%	SANDAG Travel Demand Model
Public transit (BRT)	0.0%	0.3%	0.1%	0.4%	0.1%	SANDAG Travel Demand Model
Public transit (Rail) *(commuter + light rail)*	0.6%	0.7%	0.5%	0.9%	0.5%	SANDAG Travel Demand Model
Non-Motorized: Bike	0.3%	0.9%	0.3%	1.7%	0.3%	SANDAG Travel Demand Model
Non-Motorized: Walk	2.7%	2.9%	2.6%	2.9%	2.4%	SANDAG Travel Demand Model
CO2 and vehicle miles traveled (Modeling Output)						
Total CO2 emissions per weekday for passenger vehicles (ARB vehicle classes LDA, LDT1, LDT2, and MDV) (tons)	39,210.0	39,831.0	41,517.8	45,916.2	48,778.5	SANDAG Travel Demand Model

Modeling Parameters	**2008 (base year)**	**2020 (with Project)**	**2020 (without Project)**	**2035 (with Project)**	**2035 (without Project)**	**Data Source(s)**
Total Internal CO2 emissions per weekday for passenger vehicles (tons) *(I-I + I-X + X-I in SD Region)*	39,014.0	39,631.8	41,310.2	45,686.6	48,534.6	SANDAG Travel Demand Model
Total IX / XI trip CO2 emissions per weekday for passenger vehicles (tons)						
Total XX trip CO2 emissions per weekday for passenger vehicles (tons)	196.1	199.2	207.6	229.6	243.9	SANDAG Travel Demand Model
VEHICLE MILES TRAVELED (Modeling Output)						
Total VMT per weekday for passenger vehicles (ARB vehicle classes of LDA, LDT1, LDT2 and MDV) (miles)	76,509,000	78,961,898	82,398,025	92,153,291	97,565,639	EMFAC2007
Total internal VMT per weekday for passenger vehicles (miles)	76,126,455	78,567,089	81,986,035	91,692,525	97,077,811	EMFAC2008
Total IX/XI VMT per weekday for passenger vehicles (miles)	-	-	-	-	-	
Total XX VMT per weekday for passenger vehicles (miles)	382,545	394,809	411,990	460,766	487,828	SANDAG Travel Demand Model
CONGESTED TRAVEL MEASURES (Modeling Output)						
Congested weekday VMT on freeways (miles, V/C ratios >1.0)	4%	2%	3%	4%	9%	SANDAG Travel Demand Model
Congested VMT on all other roadways (miles, V/C ratios >1.0)	3%	1%	2%	3%	6%	SANDAG Travel Demand Model
TRANSPORTATION SYSTEM						
Freeway general purpose lanes --mixed flow, auxiliary, etc. (lane miles)	2,356	2,449	2,435	2,499	2,435	SANDAG Travel Demand Model
Freeway managed lanes--HOV, HOT, Tolled, etc. (lane miles)	61	239	100	355	100	SANDAG Travel Demand Model
Regular transit bus operation miles *(seat miles)*	2,575,274	4,155,618	2,550,817	5,530,279	2,550,817	SANDAG Travel Demand Model
Bus rapid transit bus operation miles *(seat miles)*	75,578	1,118,406	355,683	1,216,403	355,683	SANDAG Travel Demand Model
Express bus operation miles *(seat miles)*	231,139	333,999	365,745	1,423,390	365,745	SANDAG Travel Demand Model
Transit rail operation miles *(seat miles)*	2,823,966	3,680,281	2,823,966	7,898,339	2,823,966	SANDAG Travel Demand Model
Bike lane miles						
Miles of sidewalk						
INVESTMENT						
Highway capacity expansion ($)		$7,189,000		$13,707,000		SANDAG 2050 RTP
Highway rehab/ops/maint ($)		$1,904,000		$5,366,000		SANDAG 2050 RTP
Other road capacity expansion and rehab/ops/maint (Local streets) ($)		$6,307,000		$15,435,000		SANDAG 2050 RTP

Modeling Parameters	2008 (base year)	2020 (with Project)	2020 (without Project)	2035 (with Project)	2035 (without Project)	Data Source(s)
Transit capacity expansion ($)		$5,034,000		$13,990,000		SANDAG 2050 RTP
Transit operations ($)		$3,739,000		$12,308,000		SANDAG 2050 RTP
Bike and pedestrian projects ($)		$449		$1,332,000		SANDAG 2050 RTP
Other (TDM/TSM) ($)		$330		$868,000		SANDAG 2050 RTP
TRANSPORTATION USER COSTS AND PRICING						
Vehicle operating costs (1999$ per mile)	$ 0.18	$ 0.21	$ 0.21	$ 0.20	$ 0.20	SANDAG Travel Demand Model
Gasoline price (1999$ per gallon)	$ 2.70	$ 3.70	$ 3.70	$ 4.07	$ 4.07	SANDAG Travel Demand Model
Parking price (1999$ per day)	Varies ($0 to $12.50)	Varies ($0 to $12.50)	Varies ($0 to $12.50)	Varies ($0 to $12.50)	Varies ($0 to $12.50)	SANDAG Travel Demand Model
Toll price (1999$) (SR 125 Trip Cost Range)	Varies ($0.39 to $3.50)	Varies ($0.39 to $3.50)	Varies ($0.39 to $3.50)	Varies ($0.39 to $3.50)	Varies ($0.39 to $3.50)	SANDAG Travel Demand Model
Congestion price ($ per mile) - (Managed Lanes)	Varies ($0.08 to $0.35)	Varies ($0.10 to $0.26)	Varies ($0.10 to $0.26)	Varies ($0.10 to $0.26)	Varies ($0.10 to $0.26)	SANDAG Travel Demand Model

Follow-Up on Additional Technical Questions for SANDAG

On July 19, 2011, SANDAG staff provided a response to additional questions posed by ARB staff to clarify information provided by SANDAG in various documents related to the Draft 2011 RTP/SCS. The following information contains SANDAG's description of the travel demand model and sensitivity analysis. Answers to these questions assisted ARB staff to better understand technical facts contained in SANDAG documents, and to proceed with the ongoing evaluation of SANDAG's SCS with respect to the quantification of greenhouse gas emissions. SANDAG's responses are in red.

B. Questions on Description of SANDAG's Travel Demand Model

1. How many lane miles of roadways are coded in the highway network by functional classes? (RTP Draft)

Functional Class	2008	2020	2035
~~Freeways~~ Highways (Non-toll, toll and managed)	2,463	2,765	2,932
Prime	1,059	1,269	1,280
Major Arterial	3,036	3,415	3,701
Collector	1,900	2,179	2,088
Local collector	1,955	2,027	2,485
Rural collector	703	698	356
Local roads	834	860	1,063
Fwy-Fwy ramps	125	139	148
Local ramps	404	434	446
~~Access roads~~ Zone Connectors	3,739	3,731	3,675

1a. How many transit service miles are coded into the transit network by mode type? (RTP Draft)

Mode	2008	2020	2035
Commuter Rail	899	1,677	2,179
Light Rail	11,078	13,843	32,852
Regional BRT	0	17,350	18,281
Corridor BRT	0	6,321	36,846
Express Bus	61,262	6,458	6,294
Local Bus	13,015	112,314	149,467
OTHER??? (TKI)			

2. What are the trip production rates by trip types?

See file rates.xlsx (P+A Pct = 1000 = 100.0%, Within Production line trip types add to 1000 = 100.0%)

Trip Purpose	Trip production rates
Home based work	
Home based school	
Home based college	
Home based other	
Home based shop	
Other – Other	
Serve passenger	
Visitors	
Airport	

3. What are the trip attraction rates by land use categories?

See file rates.xlsx (P+A Pct = 1000 = 100.0%, Within Production line trip types add to 1000 = 100.0%)

Land use Categories	Trip attraction rates
Restaurants	
Offices	
Education	
Industrial	
Hospitals	
Recreational	
Retail sites	
Other	

4. How many intra-zonal trips are produced in SANDAG region?

	2008	2050
Home-Work	1%	1%
Home-College	0%	1%
Home-School	18%	16%
Home-Shop	7%	8%
Home-Other	6%	6%
Work-Other	11%	10%
Other-Other	15%	14%
Serve Passenger	13%	12%
Visitor	13%	11%
Airport	0%	0%

Total	10%	9%

Note that our current model does not model college students who reside on-campus.

5. How did you generate the income distributions of trip production by households in trip generation model?

   Household incomes distributions are supplied from the DEFM and UDM land use models. Using trip rates by income group from the rates file (see question #2) the distribution of trips by income group is supplied to the mode choice model by zone.

6. Is the trip generation model sensitive to zero household auto ownership?

   Auto ownership is not explicitly considered in the SANDAG Travel Demand Model. Income is used as a proxy for auto ownership in the mode choice step of the model.

7. How did you generate the impedance by 4D categories in trip distribution model?

   See Trip Distribution Calibration on page 18 of the SANDAG 4D DocumentationFinal.pdf

8. How the K-factor was used to calibrate the trip distribution model?

   K-factors are not used in the Series 12 version of the SANDAG model.

9. What is the average vehicle occupancy by trip purpose?

Trip Purpose	Vehicle Occupancy (2035)
Home based work	1.196
Home based school	3.389
Home based college	1.449
Home based other	2.036
~~Home based shop~~	-
~~Other – Other~~ Non-Home Based	1.899

Serve passenger	2.967
~~Visitors~~	-
~~Airport~~	-

10. How did you derive the time of day factors?

    Time of day factors are derived from count data. Caltrans traffic census, PeMS, and transit Passenger Counting Program data provide hourly or peak data that can be used to derive time of day factors.

11. Does the SANDAG model use the same volume delay function for all facility type?

    The volume delay function used is the TransCAD Logit Based Volume Delay Function. The same function is used for all facility types but has the unique characteristic of using both link delay and intersection delay. This allows the same delay function to be used for both freeway facilities and arterial facilities.

12. How many screenlines were used in SANDAG model validation?

    On page 26 of the SANDAG Travel Demand Model Validation Report the model is compared by link to observed counts for 3551 links. We did not have time to include a screenline comparison in the report. In the RTP Draft we have 11 screenline locations for which we report mode share and person trips.

13. How many model iterations were performed?

    For trip distribution, the gravity model is allowed to iterate and run to convergence for all trip types. This can range anywhere from 5 to 125 iterations depending on trip purpose and year.

    For feedback loops the SANDAG travel demand model uses 4 feedback loops. For highway assignment, a convergence criteria of 0.001 is used. For a 2008 model run this results in iterations of 11 during the off-peak period, 26 in the A.M. period, and 26 in the P.M. period

14. How many person trips are estimated by trip purpose?

Trip Purpose	2008	2020	2035
Home-based work	1,895,423	1,954,208	2,189,287
Home-based school + college	1,070,255	1,171,716	1,268,237
~~Home-based shopping~~	-	-	-
Home-based others	4,953,333	5,332,474	9,409,669
Non home-based other	7,683,868	8,312,325	6,132,805
Serves Passenger	1,622,202	1,754,963	1,987,637

D. Questions on SANDAG's Description of Sensitivity Analysis

1. Section 3.10 describes model sensitivity by changing freeway and arterial capacities. Would it be possible that SANDAG provides ARB highway lane-miles by capacity scenarios, so that ARB could quantify the percentage changes of capacity from the baseline for sensitivity analysis?

Functional Class	Baseline	Increase Highway	Increase Arterial
~~Freeways~~ Highways (Non-toll, toll and managed)	2,938	3,981	2,938
Prime	1,280	1,280	1,742
Major Arterial	3,701	3,701	5,639
Collector	2,008	2,008	3,297
Local collector	2,485	2,485	4,903
Rural collector	356	356	711
Local roads	1,063	1,063	2,076
Fwy-Fwy ramps	148	148	148
Local ramps	446	446	446
~~Access roads~~ Zone Connectors	3,675	3,675	3,675

Land Use		Rates			Trip Ends											
Code	Name	DU	Acre	Emp	Production/Attraction	Pct (1000)	Home-Work	Home-College	Home-School	Home-Shop	Home-Other	Work-Other	Other-Other	Serve Passenger	Visitor	Airport
101	SINGLE FAMILY	12	0	0	P	830	170	19	98	163	303	10	47	175	9	6
					A	170	30	0	0	5	290	137	235	295	8	0
102	MULTI-FAMILY	8.7	0	0	P	851	211	24	61	164	326	13	52	131	15	3
					A	149	68	0	0	2	314	149	292	165	10	0
103	MOBILE HOME PARK	6.6	0	0	P	900	134	10	67	332	328	7	20	88	8	6
					A	100	128	0	0	0	537	67	182	74	12	0
104	LOW INCOME	6.6	0	0	P	900	134	10	67	332	328	7	20	88	8	6
					A	100	128	0	0	0	537	67	182	74	12	0
105	MID INCOME	8.7	0	0	P	851	211	24	61	164	326	13	52	131	15	3
					A	149	68	0	0	2	314	149	292	165	10	0
106	HIGH INCOME	13	0	0	P	820	166	19	96	160	297	10	66	171	9	6
					A	180	27	0	0	5	266	125	300	270	7	0
1401	JAIL	0	17.8	1	P	224	0	0	0	0	0	0	1000	0	0	0
					A	776	371	0	0	0	287	54	288	0	0	0
1402	DORMITORY	0	0	0	P	851	211	24	61	164	326	13	52	131	15	3
					A	149	68	0	0	2	314	149	292	165	10	0
1404	MONASTERY	0	5.4	0	P	851	211	24	61	164	326	13	52	131	15	3
					A	149	68	0	0	2	314	149	292	165	10	0
1409	OTHER GROUP QUARTERS	0	4.4	0.4	P	884	221	25	64	172	341	13	8	137	16	3
					A	116	95	0	0	3	439	208	11	230	14	0
1501	LOW-RISE HOTEL OR MOTEL	0	336	16	P	761	0	0	0	0	0	34	62	0	896	8
					A	239	199	0	0	7	299	145	195	117	38	0
1502	HIGH-RISE HOTEL	0	1608	17	P	758	0	0	0	0	0	34	67	0	891	8
					A	242	195	0	0	7	293	142	212	114	37	0
1503	RESORT	0	158	8.7	P	762	0	0	0	0	0	34	60	0	898	8
					A	238	201	0	0	7	301	146	189	118	38	0
2001	HEAVY INDUSTRY	0	68.8	2.7	P	278	0	0	0	0	0	964	1	0	35	0
					A	722	583	0	0	0	103	191	0	83	40	0
2101	INDUSTRIAL PARK	0	176	6	P	450	0	0	0	0	0	881	119	0	0	0

Land Use		Rates			Trip Ends											
					A	550	497	0	0	14	159	165	95	70	0	0
2102	PLANNED INDUSTRIAL	0	192	6.5	P	454	0	0	0	0	0	801	199	0	0	0
					A	546	459	0	0	13	147	152	164	65	0	0
2103	LIGHT INDUSTRY	0	85.7	3.8	P	424	0	0	0	0	0	882	68	0	19	31
					A	576	600	0	0	38	128	95	49	54	36	0
2104	WAREHOUSING	0	56.2	0	P	498	0	0	0	0	0	854	146	0	0	0
					A	502	567	0	0	33	91	36	140	133	0	0
2105	PUBLIC STORAGE	0	28.1	0	P	498	0	0	0	0	0	854	146	0	0	0
					A	502	567	0	0	33	91	36	140	133	0	0
2201	EXTRACTIVE INDUSTRY	0	1.3	4.1	P	278	0	0	0	0	0	965	0	0	35	0
					A	722	583	0	0	0	102	191	0	84	40	0
2301	JUNKYARD/DUMP/LANDFILL	0	15.5	19	P	299	0	0	0	0	0	802	169	0	29	0
					A	701	542	0	0	0	95	180	72	67	44	0
4101	COMMERCIAL AIRPORT	0	0	0	P	0	0	0	0	0	0	0	1000	0	0	0
					A	1000	0	0	0	0	0	0	0	0	0	1000
4103	GENERAL AVIATION AIRPORT	0	6.1	9.5	P	158	0	0	0	0	43	162	418	0	377	0
					A	842	74	0	0	0	159	116	77	360	214	0
4104	AIRSTRIP	0	0.7	6.6	P	177	0	0	0	0	35	134	520	0	311	0
					A	823	69	0	0	0	151	110	128	340	202	0
4111	TRANSIT STATION	0	280	10	P	183	0	0	0	0	34	130	534	0	302	0
					A	817	70	0	0	0	152	111	119	344	204	0
4112	RIGHT-OF-WAY	0	0	0	P	184	0	0	0	0	34	129	538	0	299	0
					A	816	70	0	0	0	152	111	120	343	204	0
4113	COMMUNICATION OR UTILITY	0	3.2	1.4	P	106	0	0	0	0	74	279	0	0	647	0
					A	894	80	0	0	0	173	126	0	390	231	0
4114	PARKING	0	0	0	P	184	0	0	0	0	34	129	538	0	299	0
					A	816	70	0	0	0	152	111	120	343	204	0
4119	OTHER TRANSPORTATION	0	108	12	P	176	0	0	0	0	36	138	505	0	321	0
					A	824	71	0	0	0	154	113	106	349	207	0
4120	MARINE TERMINAL	0	14	39	P	302	0	0	0	0	0	796	175	0	29	0
					A	698	541	0	0	0	95	177	73	77	37	0
5001	WHOLESALE TRADE	0	43.4	4.6	P	371	0	0	0	0	0	407	593	0	0	0
					A	629	111	0	0	235	267	0	345	0	42	0
5002	REGIONAL COMMERCIAL	0	722	21	P	259	0	0	0	0	0	99	817	0	84	0
					A	741	80	0	0	244	122	113	281	41	119	0
5003	COMMUNITY COMMERCIAL	0	821	37	P	285	0	0	0	0	0	164	787	0	48	1

Land Use		Rates			Trip Ends											
					A	715	64	0	0	241	178	130	311	18	58	0
5004	NEIGHBORHOOD COMMERCIAL	0	1312	49	P	288	0	0	0	0	0	161	791	0	47	1
					A	712	64	0	0	240	176	129	316	18	57	0
5005	SPECIALTY COMMERCIAL	0	1233	34	P	287	0	0	0	0	0	162	790	0	47	1
					A	713	64	0	0	240	176	129	316	18	57	0
5006	AUTO COMMERCIAL	0	446	21	P	278	0	0	0	0	0	175	773	0	51	1
					A	722	66	0	0	248	182	134	292	19	59	0
5007	STREETFRONT COMMERCIAL	0	1279	34	P	296	0	0	0	0	0	231	741	0	12	16
					A	704	64	0	0	139	233	204	309	36	15	0
5008	SERVICE STATION	0	4131	294	P	284	0	0	0	0	0	256	714	0	12	18
					A	716	66	0	0	145	243	213	279	38	16	0
5009	OTHER COMMERCIAL	0	119	7.4	P	284	0	0	0	0	0	256	714	0	12	18
					A	716	66	0	0	145	243	213	279	38	16	0
5010	VACANT COMMERCIAL	0	0	0	P	290	0	0	0	0	0	158	795	0	46	1
					A	710	63	0	0	238	175	128	321	18	57	0
6001	HIGH RISE OFFICE	0	2624	10	P	408	0	0	0	0	0	654	284	0	45	17
					A	592	299	0	0	5	115	194	192	97	98	0
6002	LOW RISE OFFICE	0	292	9.5	P	393	0	0	0	0	0	657	318	0	18	7
					A	607	235	0	0	53	257	166	201	50	38	0
6003	GOV'T OFFICE OR CENTER	0	1048	12	P	350	0	0	0	14	0	584	302	0	80	20
					A	650	212	0	0	0	268	149	163	79	129	0
6004	HIGH RISE OFFICE	0	6300	10	P	408	0	0	0	0	0	652	286	0	45	17
					A	592	298	0	0	5	115	193	194	97	98	0
6101	CEMETERY	0	4.3	7.7	P	700	0	0	0	0	0	868	132	0	0	0
					A	300	452	0	0	0	240	0	287	0	21	0
6102	CHURCH	0	52.8	26	P	178	0	0	0	0	0	240	760	0	0	0
					A	822	21	0	0	0	371	112	161	333	2	0
6103	LIBRARY	0	434	19	P	295	0	0	0	0	0	206	794	0	0	0
					A	705	24	0	0	0	530	113	328	0	5	0
6104	POST OFFICE	0	1096	12	P	286	0	0	0	0	0	79	921	0	0	0
					A	714	45	0	0	19	394	166	363	12	1	0
6105	FIRE OR POLICE STATION	0	309	7.7	P	271	0	0	0	0	0	350	650	0	0	0
					A	729	182	0	0	17	394	0	239	168	0	0
6108	MISSION	0	50.9	18	P	297	0	0	0	0	0	561	432	0	7	0

Land Use		Rates			Trip Ends											
					A	703	185	0	0	31	489	35	180	70	10	0
6109	OTHER PUBLIC SERVICE	0	396	13	P	298	0	0	0	0	0	557	436	0	7	0
					A	702	184	0	0	31	487	35	183	70	10	0
6501	MAJOR HOSPITAL	0	327	6.1	P	279	0	0	0	0	0	470	519	0	11	0
					A	721	225	0	0	0	396	117	198	52	12	0
6502	HOSPITAL	0	326	6.1	P	278	0	0	0	0	0	473	516	0	11	0
					A	722	226	0	0	0	396	117	197	52	12	0
6509	OTHER HEALTH CARE	0	481	16	P	310	0	0	0	0	0	355	640	0	5	0
					A	690	150	0	0	10	315	131	284	99	11	0
6701	MILITARY USE	0	0	0	P	321	0	0	0	0	0	740	242	0	11	7
					A	679	463	0	0	63	99	133	114	107	21	0
6801	SDSU OR UCSD	0	0	0	P	243	0	0	0	0	0	473	509	0	18	0
					A	757	159	494	0	0	0	137	164	33	13	0
6802	UNIVERSITY OR COLLEGE	0	180	14	P	253	0	0	0	0	0	578	305	0	18	99
					A	747	90	606	0	0	0	67	102	124	11	0
6803	JUNIOR COLLEGE	0	257	24	P	159	0	0	0	0	0	275	715	0	10	0
					A	841	81	667	0	4	0	65	134	42	7	0
6804	SENIOR HIGH SCHOOL	0	534 7	43	P	152	0	0	0	0	0	225	764	0	2	9
					A	848	33	0	610	0	0	46	135	175	1	0
6805	JUNIOR HIGH OR MIDDLE SCHOOL	0	419 7	36	P	179	0	0	0	0	0	253	744	0	3	0
					A	821	38	0	390	3	0	47	161	358	3	0
6806	ELEMENTARY SCHOOL	0	211 7	31	P	144	0	0	0	0	0	255	744	0	1	0
					A	856	34	0	469	0	0	60	123	314	0	0
6807	SCHOOL DISTRICT OFFICE	0	251	8.6	P	398	0	0	0	0	0	619	357	0	17	7
					A	602	226	0	0	51	248	159	232	48	36	0
6809	OTHER SCHOOL	0	200	25	P	164	0	0	0	0	0	169	824	0	7	0
					A	836	80	0	0	0	189	102	161	463	5	0
7201	TOURIST ATTRACTION	0	0	23	P	350	0	0	0	0	0	182	380	0	438	0
					A	650	131	0	0	0	168	34	204	0	463	0
7202	STADIUM OR ARENA	0	24.2	3.2	P	207	0	0	0	0	0	262	561	0	177	0
					A	793	81	0	0	9	471	70	145	90	134	0
7203	RACETRACK	0	13.6	0	P	211	0	0	0	0	0	255	573	0	172	0
					A	789	81	0	0	9	469	69	149	90	133	0
7204	GOLF COURSE	0	0	0	P	224	0	0	0	0	0	228	618	0	154	0
					A	776	78	0	0	9	453	67	177	87	129	0

Land Use		Rates			Trip Ends											
7205	GOLF CLUB HOUSE	0	708	0	P	224	0	0	0	0	0	228	618	0	154	0
					A	776	78	0	0	9	453	67	177	87	129	0
7206	CONVENTION CENTER	0	893	24	P	224	0	0	0	0	0	228	618	0	154	0
					A	776	78	0	0	9	453	67	177	87	129	0
7207	MARINA	0	40.5	17	P	118	0	0	0	0	0	597	0	0	403	0
					A	882	95	0	0	11	550	81	1	105	157	0
7208	OTC	0	6.4	0	P	212	0	0	0	0	0	252	578	0	170	0
					A	788	80	0	0	9	467	69	152	90	133	0
7209	CASINO	0	0	8.2	P	222	0	0	0	0	0	221	628	0	151	0
					A	778	76	0	0	11	443	67	179	64	160	0
7210	OTHER RECREATION-HIGH	0	58.7	59	P	224	0	0	0	0	0	228	618	0	154	0
					A	776	78	0	0	9	453	67	177	87	129	0
7211	OTHER RECREATION-LOW	0	6.6	6.6	P	224	0	0	0	0	0	228	618	0	154	0
					A	776	78	0	0	9	453	67	177	87	129	0
7601	ACTIVE PARK	0	66.5	0	P	295	0	0	0	0	0	97	480	0	423	0
					A	705	48	0	0	0	359	21	199	111	262	0
7602	PASSIVE PARK	0	0	0	P	0	0	0	0	0	0	0	1000	0	0	0
					A	1000	0	0	0	0	0	0	1000	0	0	0
7603	OPEN SPACE PRESERVE	0	0	0	P	214	0	0	0	0	0	0	1000	0	0	0
					A	786	127	0	0	81	411	112	269	0	0	0
7604	ACTIVE BEACH	0	3.5	0	P	285	0	0	0	0	0	94	491	0	415	0
					A	715	45	0	0	0	340	20	196	78	321	0
7605	PASSIVE BEACH	0	2	0	P	286	0	0	0	0	0	94	491	0	415	0
					A	714	45	0	0	0	341	20	197	79	318	0
7606	LANDSCAPED OPEN SPACE	0	0	0	P	214	0	0	0	0	0	0	1000	0	0	0
					A	786	127	0	0	81	411	112	269	0	0	0
7607	RESIDENTIAL RECREATION	0	0	0	P	295	0	0	0	0	0	97	481	0	422	0
					A	705	48	0	0	0	358	21	200	111	262	0
7609	LANDSCAPED OPEN SPACE	0	0	0	P	214	0	0	0	0	0	0	1000	0	0	0
					A	786	127	0	0	81	411	112	269	0	0	0
8001	ORCHARDS OR VINEYARD	0	0.1	1.5	P	187	0	0	0	0	0	696	304	0	0	0
					A	813	157	0	0	112	168	92	306	165	0	0
8002	INTENSIVE AGRICULTURE	0	0.3	1.2	P	187	0	0	0	0	0	1000	0	0	0	0
					A	813	228	0	0	161	242	132	0	237	0	0
8003	FIELD CROPS	0	0.1	2.1	P	214	0	0	0	0	0	608	392	0	0	0
					A	786	163	0	0	116	174	95	282	170	0	0

Land Use		Rates			Trip Ends											
9101	INACTIVE USE	0	0	0	P	214	0	0	0	0	0	0	1000	0	0	0
					A	786	127	0	0	81	411	112	269	0	0	0
9109	CONSTRAINED VACANT	0	0	0	P	0	0	0	0	0	0	0	1000	0	0	0
					A	1000	0	0	0	0	0	0	1000	0	0	0
9200	WATER	0	0	0	P	214	0	0	0	0	0	0	1000	0	0	0
					A	786	127	0	0	81	411	112	269	0	0	0
9500	UNDER CONTRUCTION	0	5.9	0	P	289	0	0	0	0	0	632	368	0	0	0
					A	711	261	0	0	0	270	244	148	77	0	0
9700	MIXED USE 67% STREETFRONT	0	862	23	P	299	0	0	0	0	0	226	747	0	11	16
					A	701	63	0	0	138	231	202	315	36	15	0
9701	MIXED USE 77% STREETFRONT	0	989	26	P	299	0	0	0	0	0	226	747	0	11	16
					A	701	63	0	0	138	231	202	315	36	15	0
9702	MIXED USE 67% STREETFRONT	0	862	23	P	299	0	0	0	0	0	226	747	0	11	16
					A	701	63	0	0	138	231	202	315	36	15	0
9703	MIXED USE 25% STREETFRONT	0	320	8.5	P	299	0	0	0	0	0	226	747	0	11	16
					A	701	63	0	0	138	231	202	315	36	15	0