APPENDIX A

Comment Letter C-5b Attachments

ATTACHMENT 1

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RESUME

EDUCATION

M.P.H., Epidemiology, University of California, Los Angeles, 1982
B.S., Biological Science, University of Southern California, 1979
Hazardous Materials Management Certificate Program, University California, Davis and Irvine

REGISTRATION

Registered Environmental Assessor, California, No. 729

CERTIFICATION

Certified Permitting Professional, South Coast Air Quality Management District No. B4315
CARB Accredited Lead Verifier, GHG Emissions Reporting

AREAS OF EXPERTISE

Health Risk Assessments
Environmental Impact Reports/Statements
Air Quality
Environmental Auditing
Regulatory Compliance

EXPERIENCE

1986 to present:

Senior Vice President, Environmental Audit, Inc. (EAI). Responsibilities include supervision and preparation of environmental impact reports/statements, health risk assessments, feasibility studies, environmental audits and regulatory activities. Major management activities include supervision of project development, basic planning and design, compliance with local, state, regional, federal and international rules and regulations, and development of approach and materials for public presentations. Responsible for the design of air quality monitoring studies to determine indoor/outdoor impacts of various industrial activities; solid waste disposal facilities; hazardous waste treatment, storage and disposal facilities; and wastewater treatment facilities.

1987 to 1997:

Guest Lecturer, University California, Irvine; Hazardous Materials Management Certificate Program for Social Ecology X498, Principles of Hazardous Materials Management and Engineering X468.2, Technologies for Management of Hazardous Waste. Responsible for presentation of class materials on toxicology and risk assessment issues associated with the management of hazardous materials and wastes. Also responsible for presentation of class materials on the use of incineration as an alternative for hazardous waste management.

1982 to 1986:

Public Health Specialist, Bright & Associates. Responsibilities included preparation of health risk assessments; evaluation of the potential impacts associated with processing various hazardous materials such as landfill disposal, transportation, spills, incineration, waste minimization and recycling; research for environmental impact reports/statements; interfacing with regulatory agencies; and preparation of environmental compliance manuals for various industries.

1981 to 1982:

Research Assistant, Department of Epidemiology, University of California, Los Angeles. Responsible for a portion of an EPA contract to study the health effects associated with the consumption of reused water in the Los Angeles area. Research involved statistical analyses of the cancer rates in various portions of Los Angeles County.

1979 to 1980:

Research Assistant, Department of Microbiology, University of California, Los Angeles. Responsible for various laboratory analyses conducted for research on the Murine Leukemia Virus.

Research Assistant, Alpha Therapeutics. Completed studies and laboratory analyses and techniques for the purification of blood clotting Factor IX.

1977 to 1979:

Environmental Technician, Department of Harbors Project, University of Southern California. Conducted research, field studies and laboratory analyses for a variety of studies on water quality, oil spills, cannery effluent, etc., in the Ports of Los Angeles, Long Beach and Marina Del Rey.

REPRESENTATIVE PROJECTS

The following is illustrative of representative projects managed by Ms. Stevens based on designated areas of expertise. Additional project references are available upon request.

CEQA Documents

Industrial Projects

Reviewed the Draft EIR for the Comprehensive Groundwater Cleanup Strategy for Historical Chromium Discharges from PG&E's Hinkley Compressor Station, San Bernardino County, on behalf of the Hinkley Community Advisory Committee. The EIR evaluated complicated environmental impacts associated with the cleanup of chromium contamination in groundwater.

Prepared the Draft EIR for the Chevron El Segundo Refinery PRO Project. The proposed project included refinery modifications to optimize operations, comply with regulations, and improve operating efficiency. Major issues included air quality, greenhouse gas emissions, hazards, hydrology/water quality, noise, solid/hazardous waste, and transportation/traffic. Also completed an HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the Chevron Refinery.

Prepared an EIR for the Chevron El Segundo Refinery Coke Drum Replacement Project. The proposed project included replacement of the existing coke drums with new coke drums. Major issues include construction (including LST analysis) and operational air quality impacts, GHG emissions impacts and mitigation measures, construction noise, and construction traffic impacts.

Prepared the EIR for the BP Safety, Compliance and Optimization Project at the BP Carson Refinery. The proposed project included modifications to a number of refinery units, including calculation of emissions from mobile sources. Included an inventory of both the criteria and TAC emission changes associated with the proposed project. EAI also completed an HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the BP Refinery. Major issues included air quality, hazards, noise, and traffic.

Prepared the EIR for the Ultramar Inc., Valero Wilmington Refinery Alkylation Improvement Project. The proposed project included modifications to terminate the storage, use, and transport of concentrated hydrofluoric acid at the Refinery. Major issues included air quality, hazards, hydrology/water quality, noise, and transportation/traffic. Also completed an HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the Ultramar Refinery.

Provided consulting services to the Alon Bakersfield Refinery for the preparation of an EIR for a Crude Rail Project. Responsibilities included drafting portions of the EIR including biological resources, cultural resources, geological resources, hydrology and water quality, hazards/hazardous materials, and transportation/traffic. Detailed analyses were provided on the transportation hazards associated with the transportation of crude by rail.

Prepared the Final EIR for the Tesoro Reliability Improvement and Regulatory Compliance Project. The lead agency for the EIR was the SCAQMD. The proposed project included refinery modifications to modernize equipment including replacing Cogeneration Units and Boilers, comply with regulations, and improve operating efficiency. Major issues included construction (including LST analysis) and operational air quality impacts, GHG emissions impacts and mitigation measures, hazards, and transportation/traffic. Assisted in the preparation of an inventory of criteria, TAC, and greenhouse gas emission changes associated with the proposed project, modeled the project emissions using the ISC model and completed a health risk assessment using the HARP HRA model to determine the potential for significant impacts.

Prepared the EIR for the issuance of a RCRA Part B Hazardous Waste Facility Operating Permit for the Industrial Services Oil Company facility, Los Angeles, California. Industrial Services is a hazardous waste transfer facility and a used oil recycler. The lead agency for this project was the DTSC. Major issues included air quality, earth resources, water quality, risk of upset, land use, traffic/circulation, and human health. Also prepared a health risk assessment to address the health impacts of toxic air contaminants.

Prepared an EIR for the ConocoPhillips PM10 and NOx Reduction Project. The proposed project included modifications to comply with SCAQMD Rule 1105.1 - PM10 and Ammonia Emissions from Fluid Catalytic Cracking, SCAQMD Regulation XX – RECLAIM, and further reduce emissions of ammonia and sulfur oxides at the ConocoPhillips Los Angeles Refinery.

Provided consulting services to Alt Air for the preparation of a Negative Declaration and air quality permitting for modifications to existing refinery structures to produce renewable jet fuel and renewable diesel fuel from non-edible vegetable oil and high-quality technical beef tallow. Responsibilities included drafting the Negative Declaration, evaluation of the impacts from criteria pollutant emissions, toxic air contaminant emissions and GHG emissions, as well as preparation of a health risk assessment and evaluation of other CEQA topics.

Prepared a Negative Declaration for Phillips 66 Los Angeles Refinery Carson Plant – Crude Storage Capacity Project. The project included the installation of a crude storage tank and increasing the throughput of two existing tanks to streamline the delivery of crude by ships. The environment resources that required more extensive analysis included air quality, GHG emissions, toxic air contaminants/health risks, and hazards.

Prepared a Negative Declaration, addendum, and Subsequent Negative Declaration, for the ConocoPhillips Ultra Low Sulfur Diesel Project at its Wilmington Plant, in Los Angeles, California. The proposed project included modifications to several refinery units. An HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the ConocoPhillips Refinery.

Prepared an EIR for the Paramount Clean Fuels Project which included refinery modifications to produce cleaner-burning gasoline and ultra low sulfur diesel (ULSD) fuels. The proposed project included modifications to a number of refinery units. An HRA was also prepared for the proposed project.

Prepared the EIR and Subsequent EIR for the Ultramar Reformulated Fuels Program at the Wilmington Refinery. This project included new units and refinery modifications to produce fuels in compliance with state and federal Clean Air Act requirements. The project included modifications to the Ultramar Refinery, Olympic Tank Farm, and pipelines connecting the two facilities, as well as to the larger California oil and petroleum products distribution system. The lead agency for this project was the SCAQMD. Major issues included earth resources, air quality, water, noise, traffic/circulation, risk of upset, aesthetics, and human health. Also prepared a health risk assessment to address the health impacts of toxic air contaminants.

Prepared an addendum to the Negative Declaration for the Air Liquide Hydrogen Plant at the Chevron Refinery. EAI prepared a health risk assessment in compliance with SCAQMD Rule 1401 analysis for a new flare related to the Hydrogen Plant. The project was completed by the agreed upon deadlines.

Prepared the Draft EIR for the OXY Dominguez Oil Field Project in Carson, California. The project involved the creation of a consolidated oil well and separations facility, which was comprised of up to 202 oil and gas production and injection wells, separation equipment to produce up to 6,000 barrels per day of oil and three million cubic feet of natural gas. Key environmental resources analyzed in the EIR included project criteria, toxic and GHG emissions from wells, separations equipment, fugitive components, and mobile sources; hazards/hazardous materials; hydrology and water quality; noise; and transportation and traffic.

Prepared the Negative Declaration for the Polychemie Facility in Los Angeles, California. The proposed project included modifications to add new storage tanks and vessels at the facility. An HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the Polychemie facility.

Prepared a Negative Declaration for the Ultramar Inc. Cogeneration Unit at the Wilmington Refinery. The project included the installation of a Cogeneration Unit to minimize the potential for power outages at the Refinery. The environmental resources that required more extensive analysis included air quality, GHG emissions, and health risk assessment.

Prepared the EIR for the issuance of a RCRA Part B Hazardous Waste Facility Operation Permit for the Exide Technologies facility, Vernon, California. Exide is a secondary lead smelter where used batteries and other lead products are recycled into lead ingots. The lead agency for this project was the DTSC. Major issues included air quality, earth resources, water quality, risk of upset, noise, traffic/circulation, and human health. Also prepared a health risk assessment to address the health impacts of toxic air contaminants.

Worked as part of the project team assisting the Joint Powers Authority with the preparation of Union Pacific's Intermodal Container Terminal Facility (ICTF) EIR, which included preparing the setting, impact analyses, and mitigation measures for the following resources: aesthetics, construction emissions inventory and impact analysis, cultural resources, hydrology/water quality, hazards, land use, utilities and service systems, cumulative impacts, and alternatives.

Prepared a Mitigated Negative Declaration for the Hixson Metal Finishing Risk Reduction Project, in Newport Beach, California. The proposed project consisted of on-site tank, spray booth, and oven relocation; installation of additional air pollution control systems; construction of permanent total enclosures; installation of covers on wastewater treatment tanks, preparation and implementation of an improved housekeeping and dust minimization plan, and improvements to the Facility's electrical system. The overall focus of the project was to reduce the Facility's emissions associated with anodizing, testing, plating, and coating operations for aerospace and defense industries.

Prepared a Subsequent Negative Declaration for the proposed re-start of mining operations for the Molycorp Mountain Pass mining facility. The proposed project included modifications to mining operations to improve the efficiency of the operation and extraction of rare earth elements, as well as a 49.9 MW Cogeneration facility to increase operational efficiency. Prepared an inventory of criteria, TAC, and greenhouse gas emission changes associated with the proposed project for stationary and mobile sources, modeled the project emissions, and completed a health risk assessment to determine the potential for significant impacts. GHG emission impacts and mitigation measures were developed. Major issues included aesthetics, air quality, greenhouse gas emissions, biological resources, hazards, noise, and transportation/traffic.

Prepared a Negative Declaration for the BP Carson Refinery, Maintenance Shop Project. The project consisted of the construction of a new maintenance shop for the BP Refinery, on about 15 acres of land located within the City of Carson, to replace an existing maintenance building and various refinery support functions adjacent to other office buildings. The lead agency for this project was the City of Carson. Major issues included air quality, hazards/hazardous materials, noise, and transportation/traffic.

Air Agencies/Control Districts

Prepared the EIR for the SCAQMD 2003, 2007, 2012, and 2016 Air Quality Management Plans (AQMPs). The AQMPs provide control measures and strategies to reduce air emissions and allow the South Coast Air Basin to comply with state and federal ambient air quality standards. The lead agency for these projects was the SCAQMD. Major issues included air quality, energy, hazards and hazardous materials, hydrology and water quality, and solid and hazardous wastes.

Prepared the EIR for the BAAQMD 2010 and 2017 Clean Air Plans (CAPs). The 2010 and 2017 CAPs provided control measures and strategies to reduce air emissions and allow the BAAQMD to develop a control strategy to reduce ozone, particulate matter, air toxics and greenhouse gas emissions in an integrated plan. The lead agency for these projects was the BAAQMD. Major issues included air quality, energy, hazards and hazardous materials, hydrology and water quality, transportation and traffic, and utilities and services systems

Prepared various CEQA documents for BAAQMD 2005 Ozone Strategy and various rules and regulations. The 2005 Ozone Strategy identified control measures needed to reduce emissions and comply with ozone ambient air quality standards. Major issues included air quality, hazards and hazardous materials, hydrology and water quality, and utilities. Also assisted in the preparation of various CEQA documents for proposed new and modified BAAQMD rules and regulations.

Prepared the EIR for the BAAQMD's Proposed Regulation 12, Rule 12 - Flares at Petroleum Refineries and Regulation 8 - Organic Compounds, Rule 2 -

Miscellaneous Operations. The proposed project evaluated the impacts associated with implementing measures to control emissions from flaring events. EAI prepared the environmental setting, impacts and mitigation measures for potentially significant air quality and hazard impacts identified for the proposed rule.

Prepared the EIR for the proposed changes to the BAAQMD's Air Toxics New Source Review Program. The proposed changes in the program resulted in the adoption of a new District Regulation 2, Rule 5 - New Source Review of Toxic Air Contaminants, and amendments to several existing District rules and the Manual of Procedures (MOP). EAI prepared the environmental, setting, impacts and mitigation measures for the emission control measures that could be imposed as part of the new rules and procedures. The EIR was completed within agreed upon deadlines.

Prepared a Negative Declaration for the BAAQMD's proposed amendments to Regulation 8, Rule 44 - Marine Vessel Loading Terminals, and Rule 46 - Marine Tank Vessel to Marine Tank Vessel Loading. The proposed project evaluated the impacts associated with implementing measures to control VOC emissions associated with the transfer of organic materials. The Negative Declaration was completed within agreed upon deadlines.

Prepared the EIR for the Proposed Amendments to the BAAQMD's NSR and Title V Permitting Regulations. The BAAQMD proposed amendments to update its NSR and Title V regulations to include new U.S. EPA requirements for PM2.5, GHG emissions, as well as other regulations. Prepared the NOP/IS as well as the Draft EIR. The environmental resources evaluated in the Draft EIR included air quality and GHG impacts.

Prepared the EIR for the 8-Hour Ozone Rate of Progress Plan for the Sacramento Federal Nonattainment Area. EAI used the appropriate motor vehicle emission factors and vehicle planning assumptions in the SACMET model, as developed by Sacramento Area Council of Governments for the purpose of developing travel demand forecasts for the Sacramento region. The data were used to determine the potential for significant impacts associated with implementation of the 8-Hour Ozone Rate of Progress Plan and alternatives. EAI prepared the environmental setting, impacts and mitigation measures for potentially significant air quality and transportation and traffic impacts.

Prepared the Negative Declaration for the proposed adoption of BAAQMD's Regulation 12, Rule 13: Metal Melting and Processing Operations, and Draft Regulation 12, Rule 14: Metal Recycling and Shredding Operations. The proposed amendments further reduced emissions of PM, VOCs, and toxic air contaminants from metal melting and process operations and metal recycling and shredding operations. Prepared the Negative Declaration which emphasized impacts on air quality and GHG impacts.

Prepared a Negative Declaration for proposed amendments to BAAQMD's Regulation 9, Rule 10 – Nitrogen Oxides and Carbon Monoxide from Boilers, Steam Generators, and Process Heaters in Petroleum Refineries. The proposed amendments would implement Further Study Measure 14 (FS-14) from the Bay Area 2005 Ozone Strategy and would tighten emissions limits from boilers, steam, generators, and process heaters at petroleum refineries. The environmental analyses included detailed review of air quality impacts, GHG emissions, TAC emissions, and hazards.

Prepared a Negative Declaration for the BAAQMD's proposed amendments to drycleaning regulations including Regulation 11, Rule 16 – Perchloroethylene (Perc) and Synthetic Solvent Dry Cleaning Operations, Regulation 8, Rule 17 – Non-halogenated Solvent Dry Cleaning Operations, Regulation 2, Rule 1 – Permits, General Requirements, and Regulation 8, Rule 27 – Synthetic Solvent Dry Cleaning Operations. The lead agency for this Negative Declaration was the BAAQMD. The Negative Declaration evaluated impacts associated with prohibiting new installations and relocations of dry cleaning equipment using Perc and phasing out the use of Perc as a solvent in existing dry cleaning equipment. The environmental analyses included detailed review of air quality impacts, TAC emissions, hazards, and hydrology/water quality

School Districts

Worked with the Beverly Hills Unified School District (BHUSD) on the proposed modernization of the Horace Mann K-8 School, i.e., obtaining a DTSC NFA letter and Class 14 Exemption. March 2013.

Prepared the proposed modernization of the Beverly Hills High School (BHHS), Hawthorne K-8 School, and El Rodeo K-8 School, i.e., obtaining DTSC NFA letters and completed the EIR. Prepared an EIR for the modernization of the three schools due to concerns and impacts associated with the removal of contaminated soil at BHHS and El Rodeo and related air quality and hazard concerns, the presence of historic buildings at all three schools, and traffic impacts. Project began in January 2015 and was completed in December 2015.

Completed Negative Declarations and Mitigated Negative Declarations for proposed schools for the Menifee Union School District. EAI completed CEQA documents required for proposed schools. CEQA documents were prepared from 2005 through 2016.

Prepared a Mitigated Negative Declaration for new Pacific Palms Elementary School No. 7 in the Menifee Union School District. Work was completed from February 2004 through June 2004.

Prepared a Mitigated Negative Declaration for the Menifee Union School District school bus yard. Work was completed from May 2004 through September 2004.

Prepared the Mitigated Negative Declaration for new Menifee Elementary School No. 9 in the Cottonwood Hills Specific Plan Area within the City of Lake Elsinore. Work was completed from November 2008 through March 2009.

Prepared the Mitigated Negative Declaration for the Menifee Union School District new Menifee East Development Elementary School No. 11. Work was completed from August 2006 through December 2006.

Prepared the Mitigated Negative Declaration for Menifee Union School District new Canyon Heights Elementary School No. 8. Work was completed from May 2006 through July 2006.

Prepared the Mitigated Negative Declaration for the Menifee Union School District new Elementary School No. 15, located within the Four Seasons at Menifee Valley Specific Plan area of the City of Menifee. Work was completed from June 2009 through September 2009.

Completed the Negative Declaration for Menifee Elementary School #14 in Audie Murphy Ranch. Work was completed from third quarter 2015 through March 2016.

Completed a Negative Declaration associated with the consolidation and repurposing of five elementary schools, one middle school, one high school, and one continuation high school for the Rim of the World Unified School District. This project was completed on an expedited basis (April 2010 - June 2010) pursuant to CEQA Guidelines Section 15205(d) to accommodate implementation for the 2010/2011 school year.

Completed a Negative Declaration for the Colton Joint Unified School District for the modernization of athletic fields at Bloomington High School. April 2015 through May 2016.

Completed a Negative Declaration associated with the Ocean View High School Expansion project for the Huntington Beach Union High School District. February 2009 through June 2009.

Prepared a Negative Declaration for a new elementary school No. 7 in the Desert Sands Unified School District. July 2015 through July 2016.

Prepared NOEs for the modernization of La Quinta Middle School and Hoover Elementary school in the Desert Sands Unified School District. Completed in September 2015.

Developed a CEQA strategy for a slope stabilization project at La Quinta High School for the Desert Sands Unified School District. The work was completed from January 2013 through March 2014.

Assisted in the preparation of NOEs for the modernization of Pasadena High School, Norma Coombs Alternative School, and Blair High School for the Pasadena Unified School District. September 2016.

Prepared the EIR for a new high school in the Perris Union High School District. August 2009 through July 2019.

Assisted Pepperdine University in various environmental/planning activities including the preparation of a Specific Plan for development which included expansion of the campus, the preparation of an EIR for the implementation of the Specific Plan, preparation of an EIR for the expansion of a wastewater treatment plant servicing the University, and preparation of negative declarations for minor campus alterations, and assistance in receiving permits from the County of Los Angeles and California Coastal Commission.

Prepared a negative declaration for the Environmental Science Education and Conference Center at the California State University at Fullerton's Arboretum.

Prepared a negative declaration for the Cal Poly Pomona Business Incubator.

Prepared a negative declaration for the California Academy of Science and Mathematics at the California State University at Dominguez Hills campus.

Health Risk Assessments

Prepared the HRA for a film reproduction company with laboratories in various locations to determine if emissions of toxic air contaminants would require Proposition 65 notification.

Conducted source testing for an automobile manufacturer to determine if paint products would require Proposition 65 notification.

Prepared the AB2588 HRAs for a number of refineries in the SCAQMD. These HRAs followed the California Air Pollution Control Officers Association (CAPCOA) guidelines. The HRAs included calculation of carcinogenic risk and evaluation of non-carcinogenic impacts via multipathways. The HRAs were performed using CAPCOA guidelines to determine compliance with SCAQMD rules, determine the level of impacts under the California Environmental Quality Act (CEQA) and were approved by the SCAQMD.

Prepared the HRA to determine appropriate soil clean up levels for residual lead concentrations at a former paint manufacturing plant located in Los Angeles, California. The risk assessment estimated exposure via multipathways to lead and determined the blood lead concentration following site clean up. The HRA was approved by the lead agency and used as the basis for establishing clean up levels for lead.

Prepared the AB2588 HRA for the Petro-Diamond Marine Terminal located in the Port of Long Beach, California. This HRA included emissions associated with the storage of petroleum products and combustion emissions from heaters. The HRA included calculation of carcinogenic risk and evaluation of non-carcinogenic impacts via multipathways.

Air Quality

Work completed includes the preparation of air quality analyses, air quality permit applications for facilities that include petroleum refineries, paint and coating manufacturers, hazardous waste treatment facilities, defense contractors, cement terminals, marine terminals, and vehicle manufacturing and import facilities.

Environmental Auditing

Work completed has included environmental due diligence audits, regulatory compliance audits, and Phase I property transfer audits.

Regulatory Compliance

Work completed has included the preparation and submittal of conditional use and zone change permit applications, air quality permit to construct applications, sanitation district permit applications, and working with local agencies to modify existing operations.

GRANTS AND TRAINEESHIPS

Public Health Service Grant, 1981-1982, UCLA
Public Health Service Traineeship, 1980-1982, UCLA

PUBLICATIONS

Cancer Incidence in Recycled Water Areas of Los Angeles County, 1972-78. Regents of the University of California, Los Angeles, California, (1982).

Acid Rain. Journal, People to People Environmental Control Delegation to People's Republic of China, 100 pp. (with Donald B. Bright), (1985).

ADVISORY POSITIONS

Member, Advisory Council, California State University, Fullerton, School of Natural Sciences and Mathematics.

Environmental Quality Affairs Citizens Advisory Committee, City of Newport Beach, 2009 through 2012. Chairperson 2011-2012

Environmental Quality Affairs Committee, City of Newport Beach since January 2013.

RESUME

MARCIA R. BAVERMAN
Project Manager, Environmental Audit, Inc.

EDUCATION

B.S., Chemical Engineering with Mathematics Minor, San Jose State University, 1984

REGISTRATION

Registered Chemical Engineer, California, No. 5089

CERTIFICATION

CARB Accredited Lead Verifier, Oil and Gas Specialist, Process Emissions Specialist, Greenhouse Gas Reporting, No. H-15-010
Former Certified OSHA 501Trainer

AREAS OF EXPERTISE

Air Quality
Environmental Document Preparation
Hazardous Waste Management
Policy Manual Preparation
Environmental and Safety and Health Auditing
Regulatory Compliance

EXPERIENCE

present:
Project Manager/Senior Engineer, Environmental Audit, Inc. (EAI). Responsibilities include project management, air dispersion modeling, health risk assessment preparation, CEQA document preparation, emission inventories development for industrial facilities, air and wastewater permit application preparation, conducting compliance audits for industrial facilities, environmental report preparation to provide support to environmental litigation, expert testimony, and addressing RCRA compliance issues.

1993 to 1999
Loss Control Specialist, Staff Engineer, Environmental Specialist, Unocal Corporation. Responsibilities included air emission inventory audit resolution, agency negotiations to minimize level-of-effort in underground storage tank remediation, regulation interpretation, hazardous waste management compliance, training, site safety officer, policy manual preparation, project management, contractor management, compliance and management systems auditing, participation in Western States Petroleum Association regulatory reform task forces, and environmental issues resolution.

1992 to 1993
Partner, Environment. Responsibilities included compliance auditing, environmental Phase I and Phase II assessments, third-party document review, and agency liaison for clients. Responsibilities also included all aspects of managing small firm including marketing, accounting, clerical, purchasing, and subcontractor management.

1986 to 1992
Staff, Project, and Senior Engineer: Safety Officer; Project Manager; Corporate Board Member, M.B. Gilbert Associates. Responsibilities included environmental compliance auditing, environmental Phase I and Phase II assessments, technical consultation to attorneys, safety training provider, OSHA program requirements implementation, and environmental document preparation including Spill Prevention, Control and Countermeasure Plans; Part B Hazardous Waste Storage Facility Permit Applications; Contingency Plans; Waste Minimization Plans, and Emergency Preparedness Plans. Responsibilities also included researching, writing, and publishing award-winning environmental education booklet for the California Department of Real Estate.

1985 to 1986
Industrial Hygienist, Project Manager, Med-Tox Associates. Responsibilities included indoor air monitoring, contractor oversight, building inspections, industrial hygiene monitoring for air contaminants and noise, and training.

1980 to 1982
Internships in Environmental Quality and Safety Engineering, Qualifications and Standards Engineering, and Facilities Engineering, General Electric. Responsibilities included preparation of Environmental Protection Agency required documents, Material Safety Data Sheet management, revision and preparation of updated safety operating procedure manual for chemical cleaning operations, training on noise pollution and hearing conservation. Additional responsibilities included operating a data acquisition computer during seismic qualification of nuclear control room safety-related parts, and collecting and analyzing data obtained from ambient conditions monitoring in a metallurgical stress laboratory.

REPRESENTATIVE PROJECTS

The following is illustrative of representative projects managed by Ms. Baverman based on designated areas of expertise. Additional project references are available upon request.

Air Quality

Work completed includes the calculation and preparation of emission inventories for criteria pollutants, toxic air contaminants, and greenhouse gases; preparation of air permit applications; analysis of emission inventories for conformity to emission budgets and

CEQA significance determinations; preparation of health risk assessments of facility and project emissions; preparation of air quality assessments; and, justification of reported air emissions for emission fees for facilities that include petroleum refineries, electroplating facilities, hazardous waste treatment facilities, defense contractors, military installations, marine terminals, engine manufacturers, paper products manufacturers, pesticide manufacturers, religious facilities, housing developments, and federal facilities. Performed air quality impacts analysis using multiple versions of the EMFAC emissions model for mobile sources, multiple versions of the URBEMIS emissions model for new development projects, emissions modeling using the U.S. EPA ISCST3 and AERMOD dispersion modeling software and CALINE for mobile sources, health risk assessment modeling software including ACE2588, HARP, and IRAPView.

CEQA Documents

Industrial Projects

Prepared the Draft EIR for the Chevron El Segundo Refinery PRO Project. The proposed project included refinery modifications to optimize operations, comply with regulations, and improve operating efficiency. Major issues included air quality, greenhouse gas emissions, hazards, hydrology/water quality, noise, solid/hazardous waste, and transportation/traffic. Also completed an HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the Chevron Refinery.

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Provided consulting services to the Alon Bakersfield Refinery for the preparation of an EIR for a Crude Rail Project. Responsibilities included drafting portions of the EIR including biological resources, cultural resources, geological resources, hydrology and water quality, hazards/hazardous materials, and transportation/traffic. Detailed analyses were provided on the transportation hazards associated with the transportation of crude by rail.

Provided consulting services to the Mitsubishi Cement Corporations Facility in Long Beach for the preparation of an EIR for the MCC Cement FacilityModification Project. Responsibilities included drafting portions of the EIR including air quality. Detailed analyses were provided on air quality associated with the proposed project.

Prepared the Final EIR for the Tesoro Reliability Improvement and Regulatory Compliance Project. The lead agency for the EIR was the SCAQMD. The proposed project included refinery modifications to modernize equipment including replacing Cogeneration Units and Boilers, comply with regulations, and improve operating efficiency. Major issues included construction (including LST analysis) and operational air quality impacts, GHG emissions impacts and mitigation measures, hazards, and transportation/traffic. Assisted in the preparation of an inventory of criteria, TAC, and greenhouse gas emission changes associated with the proposed project, modeled the project emissions using the ISC model and completed a health risk assessment using the HARP HRA model to determine the potential for significant impacts.

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Prepared an EIR for the Paramount Clean Fuels Project which included refinery modifications to produce cleaner-burning gasoline and ultra low sulfur diesel (ULSD) fuels. The proposed project included modifications to a number of refinery units. An HRA was also prepared for the proposed project.

Prepared the EIR and Subsequent EIR for the Ultramar Reformulated Fuels Program at the Wilmington Refinery. This project included new units and refinery modifications to produce fuels in compliance with state and federal Clean Air Act requirements. The project included modifications to the Ultramar Refinery, Olympic Tank Farm, and pipelines connecting the two facilities, as well as to the larger California oil and petroleum products distribution system. The lead agency for this project was the SCAQMD. Major issues included earth resources, air quality, water, noise, traffic/circulation, risk of upset, aesthetics, and human health. Also prepared a health risk assessment to address the health impacts of toxic air contaminants.

Prepared an addendum to the Negative Declaration for the Air Liquide Hydrogen Plant at the Chevron Refinery. EAI prepared a health risk assessment in compliance with SCAQMD Rule 1401 analysis for a new flare related to the Hydrogen Plant. The project was completed by the agreed upon deadlines.

Prepared the Draft EIR for the OXY Dominguez Oil Field Project in Carson, California. The project involved the creation of a consolidated oil well and separations facility, which was comprised of up to 202 oil and gas production and injection wells, separation equipment to produce up to 6,000 barrels per day of oil and three million cubic feet of natural gas. Key environmental resources analyzed in the EIR included project criteria, toxic and GHG emissions from wells, separations equipment, fugitive components, and mobile sources; hazards/hazardous materials; hydrology and water quality; noise; and transportation and traffic.

Prepared the Negative Declaration for the Polychemie Facility in Los Angeles, California. The proposed project included modifications to add new storage tanks and vessels at the facility. An HRA under the SCAQMD Rule 1401 requirements for the modifications to stationary sources at the Polychemie facility.

Prepared a Negative Declaration for the Ultramar Inc. Cogeneration Unit at the Wilmington Refinery. The project included the installation of a Cogeneration Unit to minimize the potential for power outages at the Refinery. The environmental resources that required more extensive analysis included air quality, GHG emissions, and health risk assessment.

Prepared the EIR for the issuance of a RCRA Part B Hazardous Waste Facility Operation Permit for the Exide Technologies facility, Vernon, California. Exide is a secondary lead smelter where used batteries and other lead products are recycled into lead ingots. The lead agency for this project was the DTSC. Major issues included air quality, earth resources, water quality, risk of upset, noise, traffic/circulation, and human health. Also prepared a health risk assessment to address the health impacts of toxic air contaminants.

Prepared a Mitigated Negative Declaration for the Hixson Metal Finishing Risk Reduction Project, in Newport Beach, California. The proposed project consisted of on-site tank, spray booth, and oven relocation; installation of additional air pollution control systems; construction of permanent total enclosures; installation of covers on wastewater treatment tanks, preparation and implementation of an improved housekeeping and dust minimization plan, and improvements to the Facility's electrical system. The overall focus of the project was to reduce the Facility's emissions associated with anodizing, testing, plating, and coating operations for aerospace and defense industries.

Prepared a Subsequent Negative Declaration for the proposed re-start of mining operations for the Molycorp Mountain Pass mining facility. The proposed project included modifications to mining operations to improve the efficiency of the operation and extraction of rare earth elements, as well as a 49.9 MW Cogeneration facility to increase operational efficiency. Prepared an inventory of criteria, TAC, and greenhouse gas emission changes associated with the proposed project for stationary and mobile sources, modeled the project emissions, and completed a health risk assessment to determine the potential for significant impacts. GHG emission impacts and mitigation measures were developed. Major issues included aesthetics, air quality, greenhouse gas emissions, biological resources, hazards, noise, and transportation/traffic.

Prepared a Negative Declaration for the BP Carson Refinery, Maintenance Shop Project. The project consisted of the construction of a new maintenance shop for the BP Refinery, on about 15 acres of land located within the City of Carson, to replace an existing maintenance building and various refinery support functions adjacent to other office buildings. The lead agency for this project was the City of Carson. Major issues included air quality, hazards/hazardous materials, noise, and transportation/traffic.

Air Agencies/Control Districts

Prepared the EIR for the SCAQMD 2003, 2007, 2012, and 2016 Air Quality Management Plans (AQMPs). The AQMPs provide control measures and strategies to reduce air emissions and allow the South Coast Air Basin to comply with state and federal ambient air quality standards. The lead agency for these projects was the SCAQMD. Major issues included air quality, energy, hazards and hazardous materials, hydrology and water quality, and solid and hazardous wastes.

Prepared the EIR for the BAAQMD 2010 and 2017 Clean Air Plans (CAPs). The 2010 and 2017 CAPs provided control measures and strategies to reduce air emissions and allow the BAAQMD to develop a control strategy to reduce ozone, particulate matter, air toxics and greenhouse gas emissions in an integrated plan. The lead agency for these projects was the BAAQMD. Major issues included air quality, energy, hazards and hazardous materials, hydrology and water quality, transportation and traffic, and utilities and services systems

Prepared various CEQA documents for BAAQMD 2005 Ozone Strategy and various rules and regulations. The 2005 Ozone Strategy identified control measures needed to reduce emissions and comply with ozone ambient air quality standards. Major issues included air quality, hazards and hazardous materials, hydrology and water quality, and utilities. Also assisted in the preparation of various CEQA documents for proposed new and modified BAAQMD rules and regulations.

Prepared a Negative Declaration for the BAAQMD's proposed amendments to Regulation 8, Rule 44 - Marine Vessel Loading Terminals, and Rule 46 - Marine Tank Vessel to Marine Tank Vessel Loading. The proposed project evaluated the impacts associated with implementing measures to control VOC emissions associated with the transfer of organic materials. The Negative Declaration was completed within agreed upon deadlines.

School Districts

Prepared CEQA documents including EIRs, Negative Declarations and CEQA exemptions for a number of schools in the Menifee Union School District, Beverly Hills

School District, Desert Sands Unified School District, Pasadena Unified School District, Colton Joint Unified School District, Perris Union High School District, and the Huntington Beach Unified High School District. EIRs included school modernization projects (where contamination and historical buildings were involved) as well as the development of proposed new schools. The Negative Declarations evaluated the impacts of a new school site and related health impacts, traffic impacts, land use impacts on adjacent residents, biological impacts, cultural impacts, among other environmental impacts.

Other Environmental Document Preparation

- **Naval Facilities in California and Nevada**

  Prepared the Spill Prevention Control and Countermeasure Plans for 7 Naval facilities in California and Nevada. Prepared a Part B permit application for hazardous waste treatment and storage facility at a Naval Air Station in California.

- **Purified Water Products Facility, Los Angeles, California**

  Evaluated wastewater treatment plant at a purified water resin regeneration facility in Los Angeles, California. Recommended plant modifications, prepared operations manual, negotiated alternative wastewater disposal during 180-day disconnection from the industrial sewer, and managed 24-hour per day operation of plant during the disconnection.

- **Industrial Lighting Manufacturer, Wilmington, California**

  Review design of wastewater treatment system for an industrial lighting manufacturer in Wilmington, California. Additional responsibilities included writing operations manual, training personnel on operation and monitoring procedures, and performing startup activities for washing system connected to wastewater treatment system.

- **Toyota Motor Sales, U.S.A., Inc. Facilities**

  Prepared operations manuals for wastewater treatment facilities, stormwater management plans, and Spill Prevention Control and Countermeasure Plans at automobile import, engine design, and manufacturing facilities.

Hazardous Waste Management

- **Unocal Corporation, Brea, California**

  Provided in-house consulting to approximately 100 field personnel on hazardous waste regulations in 45 states. Prepared and presented Resource Conservation and Recovery Act required hazardous waste management training. Coordinated and prepared submittals required for hazardous waste generation in California.

- **Furniture Manufacturing Facility, Vernon, California**

  Provided technical expertise to attorneys on hazardous waste characterization and management regulations during preliminary hearing for alleged hazardous waste management violations related to activities at a furniture manufacturing facility in Vernon, California. Managed remediation activities associated with electroplating operations.

Site Remediation Management

- **Champion Oil, Dominguez Oil Field, Dominguez Hills, CA**

  Delineated drilling mud sump contamination, oversaw landfarming remediation of excavated material.

- **Various Active and Former Service Stations, Orange County, CA**

  Managed remediation activities including quarterly groundwater sampling, soil excavation, vapor extraction, groundwater treatment, and underground storage tank removal at 40 service stations throughout Orange County. Interfaced with agency representatives from the Santa Ana Regional Water Quality Control Board, Orange County Health Care Agency, and Fire Departments in Fullerton, Santa Ana, Orange, Garden Grove, and Buena Park.

- **Unocal Redevelopment of Imperial Golf Course, Brea, Fullerton, and Placentia, CA**

  Provided technical and regulatory support during the closure and redevelopment of the Imperial Golf Course into a 700+ housing development. Activities included site safety officer, routine environmental audits of contractors, and technical support for oil well abandonment contaminant issues.

Policy Manual Preparation

- **Unocal Corporation, Brea, California**

  Prepared Loss Control Policy manual for environmental and real estate group of Unocal. Revised and produced Contractor Loss Control Policy Handbook issued to the group's contractors.

- **Jet Propulsion Laboratory, Fort Irwin, California**

  Prepared Environmental Protection Policy and Procedures Manual for Goldstone Deep Space Communications Complex, For Irwin, California.

Environmental and Safety and Health Auditing

Work completed has included environmental due diligence audits, regulatory compliance audits, and Phase 1 property transfer audits. Conducted audits for NASA, military installations, circuit board manufacturers, banks, geothermal energy production facilities, property redevelopment projects.

Regulatory Compliance

Work completed has included preparing city permit applications to construct remediation facilities; sanitation district permit applications; working with local agencies to modify existing operations; and, developing and presenting training to comply with the Toxic Substances Control Act, asbestos management and abatement activities, and Hazardous Waste Operations and Emergency Response regulations.

DBS:WORD:PROPOSAL:Resumes:Marcia Baverman 2017.doc

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ATTACHMENT 2

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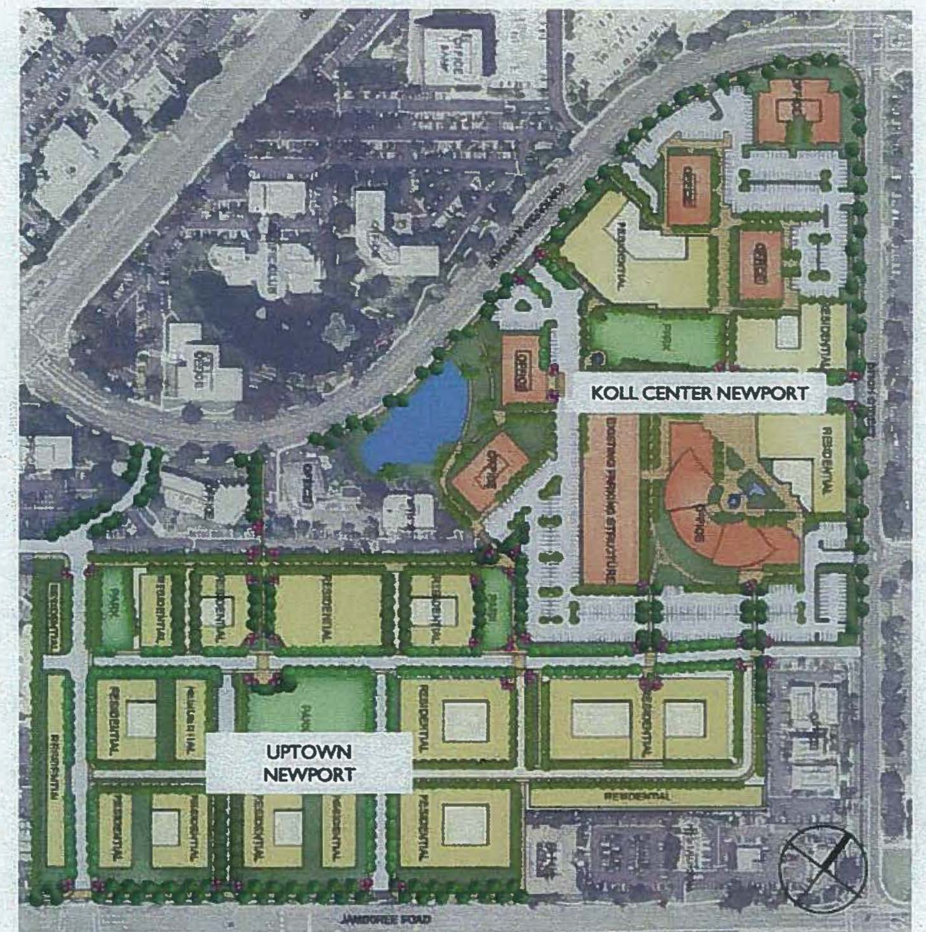


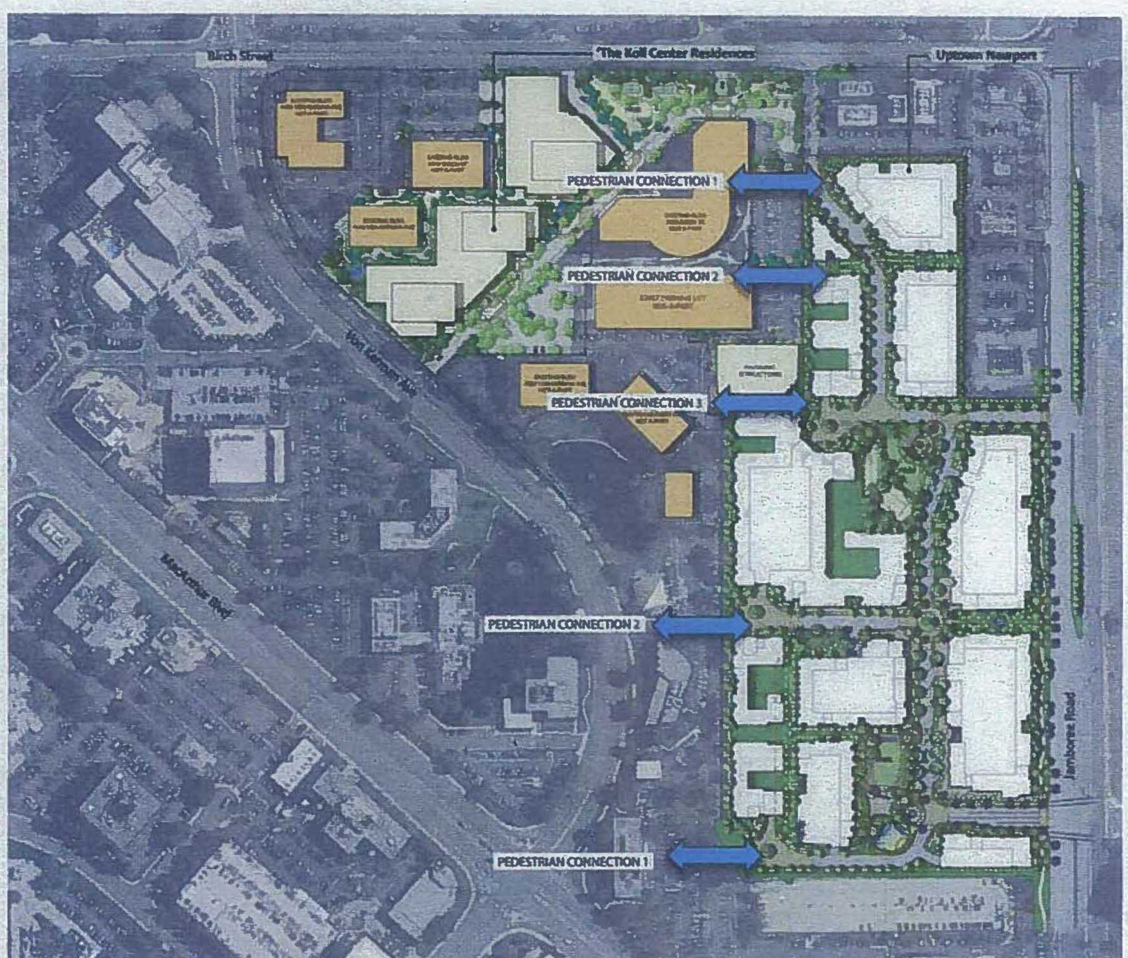
ICDP

Integrated Conceptual Development Plan (ICDP) adopted September, 2010

ICDP UNIT ALLOCATION SUMMARY

	Additive	Replacement	Density Bonus	Total
Koll Site	260			260
Conexant Site*	290	632	322	1,244
Totals	550	632	322	1,504

THE KOLL CENTER RESIDENCES



PEDSTRIAN CONNECTIVITY

THE KOLL CENTER
RESIDENCES

ATTACHMENT 3

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From: Jack Cheng <jcheng@aqmd.gov
To: Michael Choi
Cc:
Subject: RE: CalEEMod High Rise Parking

Michael,
For 10+ Floor condo, parking should be a separate land use.

The additional construction required for an aboveground or below ground parking should be included as a separate land use.

Let me know if you have any additional questions.

Jack Cheng
South Coast Air Quality Management District
CEQA IGR
(909) 396-2448
jcheng@aqmd.gov

From: Michael Choi [mailto:mchoi@envaudit.com]
Sent: Wednesday, October 18, 2017 4:26 PM
To: Jack Cheng <jcheng@aqmd.gov>
Subject: CalEEMod High Rise Parking

Jack,

The CalEEMod guidance manual says that parking is already included when modeling residential land uses, but does that apply to all residential land uses types? For instance, is it acceptable to exclude an underground/aboveground parking structure in the land use tab for a high rise (10+ floors) condo?

Any clarity in this matter is appreciated.

Thanks,

Michael Choi
Air Quality Specialist | Environmental Audit, Inc.
714.632.8521 x 227 | mchoi@envaudit.com

Comment Letter C-7c Attachments

CRMRA 5/18/2017

Attachment 1

Newport Beach General Plan Update Program
May 2017

Background

The City last comprehensively updated its General Plan in 2006 which was a multi-year effort that included a very extensive community engagement and visioning process. Due to the extent of building intensity and residential changes that were proposed at various locations throughout the community, voter approval of the new General Plan was also required pursuant to the City's charter, and that occurred in November 2006.

The City's General Plan serves as the overarching framework for development and includes the following ten elements:

- Land Use Element*
- Harbor and Bay Element
- Housing Element*
- Historical Resources Element
- Circulation Element*
- Recreation Element
- Arts and Cultural Element
- Natural Resources Element*
- Safety Element*
- Noise Element*

will look at all elements

** State Law mandated elements*

The General Plan also includes a Vision Statement and Implementation Program.

Since 2006, there have been numerous amendments to the Land Use Element, primarily to a specific property's designation on the Land Use Map, as well as comprehensive amendments to the Housing Element as mandated by State law. The Housing Element was most recently amended (5th Cycle 2013-2021) and found in compliance with State law in October 2013. The next mandated update to the Housing Element will occur in 2021.

Proposed Program

State law encourages cities and counties to comprehensively review the various elements of their general plans every ten years to ensure that elements are both current and reflect the community's vision and goals. Furthermore there have been changes in State law in respect to the mandated Circulation and Safety Elements which Newport Beach needs to address, and new "environmental justice" provisions that are required.

Staff also recommends reviewing the General Plan Vision Statement which establishes the City's ultimate development goals and what is hoped to be accomplished over the next 20 years. While the visioning process may be lengthy and intense, over ten years has lapsed since the current vision was created. Revisiting the community's desire for the future will be an important starting point for the update process.

The Program may include the following:

1. Appoint a ***General Plan Update Advisory Committee*** to advise staff and the consultant team in the review and update process.
2. ***Land Use Element*** Policy Review and Update: As part of the 2013/2014 effort to amend the Land Use Element, all of the policies were comprehensively reviewed with many revisions proposed to reflect current community conditions; these policy revisions should be reviewed for potential inclusion in this update. Un-built development potential should also be evaluated to ensure it reflects the community's current vision.
3. ***Circulation Element*** Update: Review the Master Plan of Arterial Highways (e.g., deletion of the 19th Street bridge), Master Plan of Bikeways, and consistency with the new "Complete Streets" requirements of the Government Code.
4. ***Sustainability Policies***: The community has expressed interest in adding a Sustainability Element to the General Plan or it could be incorporated into other General Plan elements.
5. ***Safety Element*** Update: Required by State Law in conjunction with Round 6 for the Housing Element (in 2021).
6. ***Harbor and Bay, Historical Resources, Recreation, Arts and Cultural, Natural Resources, Noise Elements***, and the Implementation Program: Review policies and programs and update as appropriate to reflect existing efforts and consistency among policies.
7. Address ***Environmental Justice***: Under SB 1000, local governments must either adopt an environmental justice element or include environmental justice goals, policies, and objectives in appropriate General Plan elements.
8. **Evaluate vision** for focused areas within the city: Community comments related to recent development applications indicate the need to review the City's vision for the Airport area and Newport Center. This may include a market and fiscal analysis.

Preliminary Timeframe

- **July – November 2017 (6 months):** Request for Proposals for Consultant Services; City Council appointment of Advisory Committee, and Professional Services Agreement award.
- **January 2018 – September 2019 (21 months):** Committee meetings; community outreach; visioning process; draft General Plan Amendments preparation; draft Environmental Impact Report preparation.
- **October – December 2019 (3 months):** draft Environmental Impact Report public review
- **January – February 2020 (2 months):** Planning Commission public hearings
- **March – April 2020 (2 months):** City Council public hearings and plan adoption

PLANNED COMMUNITY DEVELOPMENT STANDARDS
For Koll Center Newport

Ordinance No. 1449, adopted by the City of Newport Beach August 14, 1972
(Amendment No. 313)

Original draft	May 5, 1972

Amendment (1)	August 14, 1972
Amendment (2)	August 14, 1972
Amendment (3)	August 2, 1973
Amendment (4)	February 7, 1974
Amendment (5)	June 10, 1974
Amendment (6)	May 15, 1975
Amendment (7)	September 8, 1975
Amendment (8)	June 28, 1976
Amendment (9)	January 10, 1977
Amendment (10)	July 11, 1978
Amendment (11)	August 28, 1978
Amendment (12)	October 19, 1978
Amendment (13)	November 10, 1980
Amendment (14)	March 23, 1981
Amendment (15)	October 24, 1984
Amendment (16)	May 14, 1984
Amendment (17)	December 9, 1985
Amendment (18)	July 14, 1986
Amendment (19)	March 23, 1987
Amendment (20)	July 27, 1987
Amendment (21)	June 12, 1989
Amendment (22)	April 25, 1994
Amendment (23)	October 9, 1995
Amendment (24)	February 23, 1998
Amendment (25)	August 10, 1998
Amendment (26)	January 11, 2000
Amendment (27)	January 25, 2000
Amendment (28)	August 9, 2005
Ordinance No. 2006-19(29)	July 25, 2006
Ordinance No. 2006-21(30)	October 24, 2006
Ordinance No. 2011-3(31)	January 25, 2011
Ordinance No. 2011-8(32)	March 8, 2011
Ordinance No. 2013-5(33)	March 12, 2013

NOTE: See Footnotes beginning on Page 47 for description of amendments.

CONTENTS

PART VII. <u>ATTACHED EXHIBITS</u>

Composite.. For Information Only
Exhibit A .... Land Use

Exhibit B... Grading and Roads
Exhibit C... Storm Drain
Exhibit D .... Water & Sewer
Exhibit E... Boundary and Topography

PREFACE

It is the intent of this Planned Community Development to provide comprehensive zoning for what is now the Collins Radio property. Planned within this development are a hotel with banquet and convention facilities, a small retail and service center, service stations, restaurants, bars and theater/nightclubs, a site for the proposed Orange County Courthouse with the balance of the acreage developed as a business and professional office park emphasizing open space.

DEVELOPMENT CONSIDERATIONS (1)

This Planned Community Development is a project of The Koll Company. This area is most appropriate for commercial and light industrial uses, and therefore we submit the enclosed air traffic analysis, vehicular analysis, land use analysis and market analysis to substantiate this document. Attached drawings indicate land use, grading and roads, storm drains, water and sewer, topography and traffic analysis.

The site is comprised of approximately 154.0 acres and is generally bounded on the northeast by Campus Drive, on the southeast by Jamboree Road and on the west by MacArthur Boulevard. (10) (33)

In order to insure development consistent with the master plan concept, a review shall be required. Prior to the issuance of any building permits, a precise development plan shall be submitted by the developer to the Planning Director for review. This precise plan shall conform to the requirements of this Planned Community text and all other applicable codes and regulations and shall be approved prior to submission by The Koll Company. Included in the plan review material shall be:

1. <u>Building Criteria</u>

   a. size
   b. location
   c. height
   d. materials

2. <u>Parking Criteria</u>

   a. areas, including drives and accesses
   b. quantity
   c. size

3. <u>Landscaped Areas</u>

   a. setbacks
   b. walls
   c. plazas
   d. pools, fountains and/or other amenities

4. <u>Signing Criteria</u>

   a. location
   b. size
   c. quantity

5. All other site improvements as directed by the Planning Director and as recommended below. Items 5a through 5e inclusive.

a. Sewage System Criteria

The sewer system in the vicinity of the lake should be revised to conform to the following criteria:

1. All sewer lines should be located such that they will not be under water even when the lake is at its maximum level.

2. Sewer lines shall be located in 15-foot wide (minimum) easements and must be accessible to maintenance vehicles at all times.

3. The depth of sewer lines should not exceed 15 feet, with the possible exception of joining the existing system at MacArthur Boulevard.

b. Pedestrian Circulation

A pedestrian sidewalk system along the public streets shall be constructed throughout the development. The adequacy of such system shall be analyzed independently of any on-site pedestrian walkway system proposed for a particular portion of the development.

c. Bicycle Circulation

A system of bicycle paths coordinated with the City's Master Plan of Bicycle Trails and meeting the approval of the Planning Director and the Director of Parks, Beaches and Recreation shall be developed and maintained within the planned community.

d. Erosion Control

Landscaping plans shall incorporate provisions for Erosion Control on all graded sites which will remain vacant for a considerable period of time prior to commencement of building construction.

e. Traffic Considerations

i. Both MacArthur Boulevard and Jamboree Road shall be widened to provide for 6 through lanes, double left turn lanes at all intersections, and free right turning lanes at all intersections.

ii. Von Karman shall be widened at the intersection with MacArthur Boulevard to provide 6 lanes.

iii. All streets on the site except for Von Karman shall be flared to provide at least 5 lanes at intersections with peripheral streets.

iv. Birch Street shall be flared to 5 lanes at the intersection with Von Karman.

v. Campus Drive shall be widened to provide dual left turn lanes at Von Karman.

vi. Von Karman shall be improved for its full length from MacArthur Boulevard to Campus Drive in conjunction with initial development of areas which do not take primary access from Campus Drive or Jamboree Road.

vii. Access rights to MacArthur Boulevard shall be dedicated to the City except for the Birch Street and Von Karman Avenue intersections. Consideration may be given to providing additional access points at a later date if more detailed traffic studies demonstrate the desirability of such additional access points. Consideration shall be limited to right turn egress and right and left turn ingress. (11)

viii. Traffic signals shall be constructed at the intersections of MacArthur Boulevard with Birch Street and with Von Karman Avenue when the latter two streets are opened. The developer shall be responsible for 50% of the cost of the signal at Von Karman and 50% of the cost of the signal at Birch Street.

ix. A traffic signal shall be constructed at the intersection of Campus Drive and Jamboree Road in conjunction with the initial stages of development. The developer shall be responsible for 25% of the cost of the signal.

x. A traffic signal shall be installed at the intersection of Von Karman and Birch Street, with the developer to be responsible for 100% of the cost. Construction shall be scheduled so that the signal will be completed not later than June 30, 1977. (8)

xi. A traffic signal shall be installed at the intersection of Von Karman and Campus Drive, with the developer to be responsible for 50% of the cost. Construction shall be scheduled so that the signal will be completed not later than December 30, 1976. (8)

A traffic signal shall be installed at the intersection of Jamboree Boulevard and Birch Street, with the developer to be responsible for 50% of the cost. Construction shall be scheduled so that the signal will be completed not later than June 30, 1977. (8)

In order to accomplish the schedule for construction of these two signals, a cooperative agreement may be entered into between the developer and the City. The agreement shall provide for the developer to advance the nondeveloper share of the funding, if necessary; with provisions for reimbursement by the City. The agreement may also provide for a credit to the developer for funds advanced for the City's share of construction costs for signals constructed elsewhere in the project. (8)

xii. Provision for other traffic signals shall be investigated in conjunction with the process of development at a later date.

xiii. Phasing of Development. 1,651,757 sq. ft. of development was existing or under construction as of October 1, 1978. The additional allowable development in the total approved development plan is 1,058,863 sq.ft. Any further development subsequent to October 1, 1978, in excess of 30% of the additional allowable development, being 317,658 sq. ft., shall be approved only after it can be demonstrated that adequate traffic facilities will be available to handle that traffic generated by the project at the time of occupancy of the buildings involved. Such demonstration may be made by the presentation of a phasing plan consistent with the Circulation Element of the Newport Beach General Plan. (12)

f. <u>Airport</u> (2)

The following disclosure statement of the City of Newport Beach's policy regarding the Orange County Airport shall be included in all leases or subleases for space in the Planned Community Development and shall be included in the Covenants, Conditions and Restrictions recorded against the property.

<u>Disclosure Statement</u> (2)

The Lessee herein, his heirs, successors and assigns acknowledge that:

i. The Orange County Airport may not be able to provide adequate air service for business establishments which rely on such service;

ii. When an alternate air facility is available, a complete phase out of jet service may occur at the Orange County Airport;

iii. The City of Newport Beach may continue to oppose additional commercial air service expansion at the Orange County Airport;

iv. Lessee, his heirs, successors and assigns will not actively oppose any action taken by the City of Newport Beach to phase out or limit jet air service at the Orange County Airport.

GENERAL NOTES

Water within the planned community area will be furnished by the Irvine Ranch Water District.

Prior to or coincidental with the filing of any tentative map or use permit, the developer shall submit a master plan of drainage to the Director of Public Works.

The height of all buildings and structures shall comply with Federal Aviation Authority criteria.

Except as otherwise stated in this ordinance, the requirements of the zoning code, City of Newport Beach, shall apply.

The contents of this supplemental text notwithstanding, no construction shall be proposed within the boundaries of this planned community district except that which shall comply with all provisions of the Building Code and the various mechanical and electrical codes related thereto.

DEFINITIONS

Advertising Surface:

The total area of the face of the structure, excluding supports.

Area of Elevation:

Total height and length of a building as projected to a vertical plane.

Building Line:

An imaginary line parallel to the street right-of-way line specifying the closest point from this street right-of-way that a building structure may be located (except for overhangs, stairs and sunscreens).

Right-of-Way Line:

When reference is made to right-of-way line it shall mean the line which is then established on either the adopted Master Plan of Streets and Highways or the filed Tract Map for Minor Roads as the ultimate right-of-way line for roads or streets.

Side and Front of Corner Lots:

For the purpose of this ordinance, the narrowest frontage of a lot facing the street is the front, and the longest frontage facing the intersecting street is the side, irrespective of the direction in which the structures face.

Sign:

Any structure, device or contrivance, electric or non-electric and all parts thereof which are erected or used for advertising purposes upon or within which any poster, bill, bulletin, printing, lettering, painting, device or other advertising of any kind whatsoever is used, placed, posted, tacked, nailed, pasted or otherwise fastened or affixed.

Commerce:

All those permitted uses as specified in Section II, Group I through VII, inclusive, in this text.

Commercial Land:

The site area upon which any or all commercial permitted uses would exist.

Site Area: (3)

The total land area of the land described in the use or other permit, including footprint lots.

Special Landscaped Street:

Special landscaped streets are designated as MacArthur Boulevard, Jamboree Boulevard and Campus Drive. The landscaping requirements for special landscaped streets and for the remaining streets are described in the following text.

Streets - Dedicated and Private:

Reference to all streets or rights-of-way within this ordinance shall mean dedicated vehicular rights-of-way. In the case of private or non-dedicated streets, a minimum setback from the right-of-way line of said streets of ten (10) feet shall be required for all structures. Except for sidewalks or access drives, this area shall be landscaped according to the setback area standards from dedicated streets contained herein.

Driveway:

Vehicular access ways onto or within private property exclusive of streets, dedicated or private. A minimum separation of five (5) feet shall be maintained between all driveways and buildings.

Footprint Lot: (3)

The area of land required for the building pad, encompassing the peripheral area of the building. Appurtenant and contiguous to the footprint lot shall be all parking, landscape, setbacks and other areas as described and required by this text.

Landscape Area: (4)

The landscape area shall include walks, plazas, water and all other areas not devoted to building footprints or vehicular parking and drive surfaces. In calculating area of required landscaping any off-site landscaping such as landscaped medians or parkways in street rights-of-way shall not be included.

PART I. INDUSTRIAL – Deleted. (33)

PART II COMMERCIAL

Section I. Site Area and Building Area

Group I PROFESSIONAL & BUSINESS OFFICES

Acreages shown are net buildable land area including landscape setbacks with property lines. (4)

A. Building Sites (4)

	Total Acreage	Office Acreage
Site A	30.939 acres * (29)	30.939 acres *(29)
Site B	43.703 acres (11)	43.703 acres (11)
Site C	18.806 acres (10)	18.806 acres (10)
Site D	19.673 acres	19.673 acres
Site E	2.371 acres	2.371 acres
Site F	1.765 acres	1.765 acres
Site G	5.317 acres (8)	5.317 acres (8)
	122.574 acres (8)(10)(11)	122.574 acres(8)(10)(11)

B. Allowable Building Area

Site A	366,147 square feet (16)(26)(29)(30)
Site B	977,720 square feet (13)(16)(28)(30)(32)
Site C	674,800 square feet (10)(15)
Site D	240,149 square feet (8)(13)
Site E	32,500 square feet (4)
Site F	42,646 square feet (4)(31)
Site G	45,000 square feet (8)
	2,378,962 square feet (15)(*)(31)

C. Statistical Analysis (4)

The following statistics are for information only.
Development may include but shall not be limited to the following:

Story heights shown are average heights for possible development. The buildings within each parcel may vary.

Assumed Parking Criteria:

a. One (1) space per 225 square feet of net building area @ 120 cars per acre for Sites C, D, E, F and G.

*(3)(4) In addition to 19.399 acres of office use, there is 9.54 acres for hotel and motel and 2.0 acres of lake within Office Site A. Therefore, there are 30.939 acres net within Office Site A. (3)(4)(16)

b. One (1) space per 300 square feet of net building area @ 120 cars per acre for Sites A, B and C. (11)

1. <u>Site A</u>

Allowable Building Area .... 366,147 square feet (16)(26)(29)(30)
Site Area ...... 19.399 acres *(3)(4)(16)

a. <u>Building Height</u> — <u>Land Coverage</u> (16)(29)(30)

Two story development	.... 4.20 acres
Three story development	.... 2.80 acres
Four story development	.... 2.10 acres
Five story development	.... 1.68 acres
Six story development	.... 1.40 acres
Seven story development	.... 1.20 acres
Eight story development	.... 1.05 acres
Nine story development	.... 0.93 acres
Ten story development	.... 0.84 acres
Eleven story development	.... 0.76 acres
Twelve story development	.... 0.70 acres

b. <u>Parking</u> — <u>Land Coverage</u>

1,221 cars .... 10.18 acres (11,16,29,30)

c. <u>Landscaped Open Space</u> (4, 11,16) — <u>Land Coverage</u> (29,30)

Two story development	.... 5.02 acres
Three story development	.... 6.42 acres
Four story development	.... 7.12 acres
Five story development	.... 7.54 acres
Six story development	.... 7.80 acres
Seven story development	.... 8.02 acres
Eight story development	.... 8.17 acres
Nine story development	.... 8.29 acres
Ten story development	.... 8.38 acres
Eleven story development	.... 8.46 acres
Twelve story development	.... 8.52 acres

2. <u>Site B</u>

Allowable Building Area .... 977,720 square feet (13,16,28,30)
Site Area .... 43.703 acres (4) (11)

a.	Building Height	Land Coverage (16,28,30,32))
	Two story development	.... 11.22 acres
	Three story development	.... 7.48 acres
	Four story development	.... 5.61 acres
	Five story development	.... 4.49 acres
	Six story development	.... 3.74 acres
	Seven story development	.... 3.21 acres
	Eight story development	.... 2.81 acres
	Nine story development	.... 2.49 acres
	Ten story development	.... 2.24 acres
	Eleven story development	.... 2.04 acres
	Twelve story development	.... 1.87 acres

b.	Parking	Land Coverage (11,13,16,28,30,32)
	3,259 cars	.... 27.16 acres

c.	Landscaped Open Space (11)	Land Coverage (11,13,16,28,30,32))
	Two story development	.... 5.32 acres
	Three story development	.... 9.06 acres
	Four story development	.... 10.93 acres
	Five story development	.... 12.05 acres
	Six story development	.... 12.80 acres
	Seven story development	.... 13.33 acres
	Eight story development	.... 13.73 acres
	Nine story development	.... 14.05 acres
	Ten story development	.... 14.30 acres
	Eleven story development	.... 14.50 acres
	Twelve story development	.... 14.67 acres

3. Site C (10)

Allowable Building Area	.... 674,800 square feet (15) (17)*
Site Area	.... 18.806 acres (4)

a.	Building Height	Land Coverage (15)
	Two story development	.... 7.75 acres
	Three story development	.... 5.16 acres
	Four story development	.... 3.87 acres
	Five story development	.... 3.10 acres
	Six story development	.... 2.58 acres
	Seven story development	.... 2.21 acres
	Eight story development	.... 1.94 acres
	Nine story development	.... 1.72 acres
	Ten story development	.... 1.55 acres
	Eleven story development	.... 1.41 acres
	Twelve story development	.... 1.29 acres

b. Parking — Land Coverage (15)

2,249 cars	.... 18.74 acres

* The square footage includes a maximum of 3,250 square feet for up to two (2) restaurants, bars, or theater/nightclubs. Any portion or all of the floor area not utilized for the purpose shall revert to professional and business office use. (17)

c. Landscaped Open Space — Land Coverage (4)(15)

Two story development	.... -7.68 acres
Three story development	.... -5.09 acres
Four story development	.... -3.80 acres
Five story development	.... -3.03 acres
Six story development	.... -2.51 acres
Seven story development	.... -2.14 acres
Eight story development	.... -1.87 acres
Nine story development	.... -1.65 acres
Ten story development	.... -1.48 acres
Eleven story development	.... -1.34 acres
Twelve story development	.... -1.24 acres

4. Site D

Allowable Building Area	.... 240,149 square feet (8)(13)
Site Area	.... 19.673 acres (4)

a. Building Height — Land Coverage(8) (13)

Two story development	.... 2.75 acres
Three story development	.... 1.84 acres
Four story development	.... 1.38 acres
Five story development	.... 1.10 acres
Six story development	.... 0.92 acres
Seven story development	.... 0.79 acres
Eight story development	.... 0.69 acres
Nine story development	.... 0.61 acres
Ten story development	.... 0.55 acres
Eleven story development	.... 0.50 acres
Twelve story development	.... 0.46 acres

b. Parking — Land Coverage (8) (13)

1,067 cars	.... 8.89 acres

c.	Landscaped Open Space	Land Coverage (4) (8) (13)
	Two story development	.... 8.03 acres
	Three story development	.... 8.94 acres
	Four story development	.... 9.40 acres
	Five story development	.... 9.68 acres
	Six story development	.... 9.86 acres
	Seven story development	.... 9.99 acres
	Eight story development	.... 10.09 acres
	Nine story development	.... 10.17 acres
	Ten story development	.... 10.23 acres
	Eleven story development	.... 10.28 acres
	Twelve story development	.... 10.32 acres

5. Site E

Allowable Building Area .... 32,500 square feet (4)
Site Area .... 2.371 acres (4)

a.	Building Height	Land Coverage (4)
	Two story development	.... 0.37 acres
	Three story development	.... 0.25 acres
	Four story development	.... 0.19 acres
	Five story development	.... 0.15 acres
	Six story development	.... 0.12 acres
	Seven story development	.... 0.11 acres
	Eight story development	.... 0.10 acres
	Nine story development	.... 0.09 acres
	Ten story development	.... 0.08 acres
	Eleven story development	.... 0.07 acres
	Twelve story development	.... 0.06 acres

b.	Parking	Land Coverage (4)
	144 cars	.... 1.20 acres

c.	Landscaped Open Space (4)	Land Coverage
	Two story development	.... 0.80 acres
	Three story development	.... 0.92 acres
	Four story development	.... 0.98 acres
	Five story development	.... 1.02 acres
	Six story development	.... 1.05 acres
	Seven story development	.... 1.06 acres
	Eight story development	.... 1.07 acres
	Nine story development	.... 1.08 acres
	Ten story development	.... 1.09 acres
	Eleven story development	.... 1.10 acres
	Twelve story development	.... 1.11 acres

6. Site F (4)(31)

Allowable Building Area	.... 42,646 square feet
Site Area	.... 1.765 acres

a.

Building Height	Land Coverage
One story development	.... 0.98 acres
Two story development	.... 0.49 acres
Three story development	.... 0.33 acres
Four story development	.... 0.24 acres
Five story development	………..0.20 acres
Six story development	…………0.16 acres

b.

Parking	Land Coverage
190 cars	.... 1.58 acres

c.

Landscaped Open Space	Land Coverage
One story development	.... <0.80> acres
Two story development	.... <0.31> acres
Three story development	.... <0.15> acres
Four story development	.... <0.06> acres
Five story development	.................<0.02> acres
Six story development	.... <0.03> acres

7. Site G (8)

Allowable Building Area	.... 45,000 square feet
Site Area	.... 5.317 acres

a.

Building Height	Land Coverage
One story development	.... 1.03 acres
Two story development	.... 0.52 acres
Three story development	.... 0.34 acres
Four story development	.... 0.26 acres

b.

Parking	Land Coverage
200 cars	.... 1.67 acres

c.

Landscaped Open Space	Land Coverage
One story development	.... 2.62 acres
Two story development	.... 3.13 acres
Three story development	.... 3.31 acres
Four story development	.... 3.39 acres

Building Height

Maximum building height shall not exceed twelve (12) stories above ground level, and shall in no way exceed the height limits set by the Federal Aviation Authority for Orange County Airport.

Conclusions

The preceding figures indicate that within a fixed maximum density as the height of the building increases the resulting open landscaped area also increases.

Group II. HOTEL & MOTEL (1)

A. Building Sites

For the purposes of this statistical analysis, 9.54 acres have been allotted for hotel and motel development. This acreage is for statistical purposes only. It is necessary to allot a specific acreage within this analysis to secure office building densities within their specific parcels. Development may include but shall not be limited to this acreage. The hotel and motel site size shall be determined at the time a use permit is secured.

B. Building Height

Maximum building height shall not exceed height limits set by the Federal Aviation Authority for Orange County Airport.

Group III. COURT HOUSE

A. Building Site

Site 1: 7.80 acres .... 7.80 acres

B. Building Area

Site 1: 90,000 square feet .... 90,000 square feet

The following statistics are for information only. Development may include but shall not be limited to the following.

C. Parking
400 Cars .... 3.33 acres

D. Landscaped Open Space — Land Coverage

Two story development .... 3.44 acres
Three story development .... 3.78 acres
Four story development .... 3.95 acres
Five story development .... 4.06 acres
Six story development .... 4.13 acres

E. Building Height

Maximum building height shall not exceed height limits set by the Federal Aviation Authority for Orange County Airport.

Group IV. SERVICE STATIONS

A. Building Sites (4) (5) (11)

Site 3: 1.765 acres .... 1.765 acres

Service station site 3 shall be located within Office Site F and shall not exceed 1.765 acres in size. Any portion or all of Site 3 not utilized for service station use shall revert to either professional and business office use or restaurant use. (4)

Group V. RESTAURANTS (1) (4)

A. Building Sites

Maximum acreages for Site 2 shall not exceed 1.25 (18) acres. Maximum acreage for Site 3: 1.765 acres. Maximum acreages for Sites 4 and 5 shall not exceed 3.0 acres. Maximum acreage for Sites 6 and 7 shall not exceed 2.2 acres. (8)

(The following acreages are for information only.)

Site 1 Deleted see Group VII.	.... (18)	
Site 2	1.25 acres	
Site 3	1.765 acres	
Site 4 Deleted..	(30)	
Site 5 Deleted...	(30)	
Site 6	1.50 acres (8)	
Site 7	0.70 acres (8)	
	5.215 acres	5.215 acres (30)

Site 1 Deleted see Group VII Private Club (18)
Site 2 (4101 Jamboree – Taco Bell) located within Office Site "B" (4)(16)(30)
Site 3 located within Office Site "F". (4)
Site 4 (4300 Von Karman Avenue – Koto Restaurant) deleted and reverted to Site B Professional and Business Office Allowable Building Area. (30)
Site 5 deleted from Office Site "B" and transferred to Office Site "A" as Professional and Business Office Allowable Building Area (30)
Sites 6 and 7 located within Office Site "G". (8)

Any portion or all of the restaurant, bar, theater/nightclub acreage for Sites 2, 4, 5, 6 or 7 not utilized for that purpose shall revert to professional and business office use. Any portion or all of the restaurant acreage for Site 3 not utilized for that purpose shall revert to either professional and business office use or service station use. (4) (8) (18)

The following statistics are for information only. Development may include but shall not be limited to the following.

B. Building Area (4)(8) (30)

Site 2	2,397sq. ft.	...... 0.06 acres (30)	
Site 3	10,000 sq. ft.	...... 0.22 acres	
Site 4	Deleted		
Site 5	Deleted		
Site 6 (8)	7,000 sq. ft.	...... 0.16 acres	
Site 7 (8)	3,000 sq. ft.	...... 0.07 acres	
	22,397 sq. ft.	...... 0.51 acres	.......0.51 acres (8, 18, 30)

C. Parking

Criteria: 300 occupants/10,000 sq. ft.
1 space/3 occupants and 120 cars per acre.

Site 2	24 cars	.... 0.20 acres (30)	
Site 3	100 cars	.... 0.84 acres	
Site 4	Deleted		
Site 5	Deleted		
Site 6 (8) ...	70 cars	.... 0.58 acres	
Site 7 (8) ...	30 cars	.... 0.25 acres	
	224 cars	.... 1.87 acres	.... 1.87 acres (8) (18)(30)

D. Landscaped Open Space (4) (30)

Site 2	0.99 acres (30)	
Site 3	0.70 acres	
Site 4	Deleted	
Site 5	Deleted	
Site 6 (8)	0.76 acres	
Site 7 (8)	0.38 acres	
	2.83 acres	.... 2.83 acres (8) (18)(30)

E. Building Height

Building height of structures shall be limited to a height of thirty-five (35) feet.

Group VI. RETAIL & SERVICE CENTER

A. Building Site (4) (5)

Site 1 .... 5.026 acres
Site 2 Deleted (30)
5.026 acres .... 5.026 acres (30)

Site 2 shall be located within Office Site "B." Any portion or all of the retail and service Site 2 acreage not utilized for that purpose shall revert to professional and business office use. (4) (16)
Site 2 deleted from Office Site "B" and transferred to Office Site "A" as Professional and Business Office Allowable Building Area. (30)

B. Allowable Building Area (5)

* Retail Site No. 1 .... 120,000 sq. ft. (14)(27)
Retail Site No. 2 Deleted (30)

* Retail Site No. 1 (sq. Ft.)

Parcel	Existing	Total
Parcel 1, R/S 588	(H)	(H) 70,630
Parcel 3, R/S 506	(R)	(R) 0
	(O)	(O) 22,000
Parcel 4, R/S 506	(R) 4,115	(R) 21,896
	(O) 0	(O) 5,474
Subtotal	(R) 12,315	(R) 21,896
	(O) 0	(O) 27,474
		(H) 70,630
Total		120,000 (14)(27)

(R) = Retail (O) = Office (H) = Hotel

C. Landscape Area (5)

Twenty-five (25) percent of the 5.026 acres constituting retail and service center Site No. 1 shall be developed as landscape area.

If twenty-five (25) percent of the 5.026 acres constituting retail and service center Site No. 1 is not developed as landscape area, a specific site plan shall be submitted to the City of Newport Beach Planning Commission for approval prior to the issuing of a building permit.

D. Statistical Analysis (5)

The following statistics are for information only. Development may include but shall not be limited to the following.

Assumed parking criteria: One (1) space per 200 square feet of net building area at 120 cars per acre.

1. Site 1

Allowable Building Area .... 120,000 sq. ft. (14)(27)
Site Area .... 5.026 acres

a. Building Height (14)

Two story development .... 1.17 acres
Three story development .... 0.78 acres
Four story development .... 0.59 acres
Five story development .... 0.47 acres

b. Parking (14)

460 cars .... 3.83 acres

c. Landscaped Open Space (14)

Two story development .... 0.03 acres
Three story development .... 0.87 acres
Four story development .... 0.61 acres
Five story development .... 0.73 acres

2. Site 2 Deleted (30)

E. Building Height

Building height of structures shall be limited to a height of thirty-five (35) feet above mean existing grade as shown on Exhibit "B." (5) Building height of structures for Service Site 1 shall be limited to a height of sixty feet (27)

Group VII. PRIVATE CLUB (18)

A. Building Site

Site 1 .... 2.0 acres .... 2.0 acres

Site 1 shall be located within Office Site "A." Any portion or all of the private club acreage not utilized for that purpose shall revert to professional and business office use.

1. Site 1

Allowable Building Area ....45,000 square feet (26)

B. Building Height

Building height of structures shall be limited to a height of fifty (50) feet.

Section II. Permitted Uses

Group I. PROFESSIONAL AND BUSINESS OFFICES

To allow the location of commercial activities engaged in the sale of products or services relating to and supporting the Development Plan, provided that such activities are confined within a building or buildings.

A. Professional Offices similar in nature to but not limited to the following: (6)

1. Accountants
2. Attorneys
3. Doctors, dentists, optometrists, oculists, chiropractors and others licensed by the State of California to practice the healing arts.
4. Engineers, architects, surveyors and planners.

B. Business Offices similar in nature to but not limited to the following: (6)

1. Advertising agencies
2. Banks
3. Economic consultants
4. Employment agencies
5. Escrow offices
6. Insurance agencies
7. Laboratories
    a. Dental
    b. Medical
    c. X-Ray
    d. Bio-chemical

e. Film, wholesale only
f. Optometrical

8. Stockbrokers
9. Studios for interior decorators, photographers, artists and draftsmen.
10. Telephone answering services
11. Tourist information and travel agencies

C. <u>Hotel and Motel</u> (1)

To allow for the location within Office Site “A” of a hotel or motel development, subject to a use permit.

D. <u>Restaurants, bars and theater/nightclubs</u> subject to the procedures, regulations and guidelines set forth in Title 20 of the Newport Beach Municipal Code, in each case. (1) (3) (4) (7) (25)

1. Deleted (18)

* 2. To allow within the 43.703 acres of Office Site “B” three (3) restaurant, bar or theater/nightclub sites. (16)

3. To allow within the 18.806 acres of Office Site “C” up to two (2) restaurant, bar or theater/nightclub sites with a total area not to exceed 3,250 square feet. Specific location of these restaurants, bars or theater/nightclubs to be determined at a later date. The permitted professional and business offices’ allowable building area for the site will be reduced accordingly. (17)

4. To allow within the 1.765 acres of Office Site “F” two (2) restaurant, bar or theater/nightclub sites. Specific location of these sites to be determined at a later date. All other acreage shall be adjusted and shall not increase or decrease the professional and business offices allowable building area for the site.

5. To allow within the 5.317 acres of Office Site “G” three (3) restaurant, bar or theater/nightclub sites. Specific location of these sites to be determined at a later date. All other acreage shall not increase or decrease the professional and business offices’ allowable building area for the site. (8) (25)

* E. <u>Private Club</u> (4) (18) (26)

To allow within Office Site “A” one (1) private club site at 4110 MacArthur Boulevard.

F. <u>Service Station</u> (4)

To allow within Office Site “F” one (1) service station site. Specific location to be determined at a later date. All other acreages shall be adjusted and shall not increase or decrease the professional and business office allowable building area for the site.

* (4) If restaurant, bar or theater/nightclub, or private club uses are developed, the allowable building area for Office Site “B” shall be restricted by one of the following conditions:

1. The 963,849 square feet of allowable building area shall not increase or decrease so long as twenty-five (25) percent of the 41.969 acres constituting Office Site “B” is developed as landscaped area. (16)

2. If twenty-five (25) percent of the 42.709 acres constituting Office Site “B” is not developed as landscape area, the 963,849 square feet of allowable building area shall be reduced by the gross building area of the restaurants, bars or theater/nightclubs and/or private club. The allowable building area shall be further reduced by the number of additional parking spaces required to support a restaurant, bar or theater/nightclub, or a private club beyond what would be required for an equivalent area of office use. The reduction shall be 225 square feet per additional space. (16)

G. <u>Support Commercial</u> (20)

The uses permitted under this section are of a convenience nature ancillary to the operation and use of office facilities. These uses shall be in addition to those sites permitted under Part II. Section II. Group V (Restaurants). These uses shall not increase the allowable building area for Professional and Business Office.

1. Retail sales and services including tobacco stores, card shops, confectionery and newspaper stands, and other uses which, in the opinion of the Planning Director, are of a similar nature. Retail uses shall be located in the basement or on the first floor of a building. Storage for such uses shall be within a building.

2. Restaurants, including outdoor restaurants and take-out restaurants, bars or theater/nightclubs shall be permitted subject to the procedures, regulations and guidelines set forth in Title 20 of the Newport Beach Municipal Code, in each case. (25)

Group II. <u>HOTEL & MOTEL</u> (1)

Subject to a use permit.

Group III. <u>COURT HOUSE</u>

State, County and/or City Facilities.

Group IV. <u>SERVICE STATIONS & MECHANICAL CAR WASH</u> (4)

A. Service stations subject to the City of Newport Beach service station standards.

B. Mechanical car wash, subject to a use permit. Mechanical car wash shall only be allowed in conjunction with or in lieu of a permitted service station use.

Group V. RESTAURANTS (7)

A. Restaurants, including outdoor, drive-in or take-out restaurants, bars and theater/nightclubs, shall be subject to the procedures, regulations and guidelines set forth in Title 20 of the Newport Beach Municipal Code, in each case. Facilities other than indoor dining establishments or those that qualify as outdoor, drive-in or take-out establishments shall be subject to the City of Newport Beach regulations covering drive-in and outdoor establishments. (25)

Group VI. RETAIL & SERVICE CENTER (1)

A. Permitted Uses

1. Restaurants, including outdoor, drive-in or take-out restaurants, bars and theater/nightclubs, shall be permitted subject to the procedures, regulations and guidelines set forth in Title 20 of the Newport Beach Municipal Code, in each case, except as noted under "a" and "b" below. (7) (25)

   a. Restaurants, other than outdoor, drive-in or take-out restaurants, shall be permitted subject to the procedures, regulations and guidelines set forth in Title 20 of the Newport Beach Municipal Code, in each case. (25)

   b. Outdoor, drive-in or take-out restaurants shall be subject to the procedures, regulations and guidelines set forth in Title 20 of the Newport Beach Municipal Code, in each case. (25)

2. Barber shop and beauty parlor

3. Book and stationery store

4. Blueprinting and photostatics

5. Camera Shop

6. Delicatessen store

7. Florist

8. Shoe store or repair shop

9. Tailor

10. Tobacco store

11. Office equipment rentable and repair

12. Pharmacies

13. Tourist information, travel agencies, and ticket reservation services, but not to include any airline terminal services or facilities for the transport of passengers, baggage, or freight. (1)

14. Athletic club or health clubs (5)

* 15. Professional and Business Offices (5)

16. Other uses similar to the above listed

17. Hotel subject to approval of a Use Permit (27)

Group VII. LODGE HALLS, PRIVATE CLUBS, ATHLETIC CLUBS, UNION HEADUARTERS (1) (4) (18)

Subject to use permit.

Group VIII. AUTO DETAILING (19)

A. All drainage shall be into the sanitary sewer system.

B. That all car wash and auto detailing operations shall be conducted within a covered area.

C. This service shall be designed to serve building tenants and their patrons and guests, and shall be ancillary to the primary use.

Section III. <u>General Development Standards for Commercial Land</u>

A. <u>Site Area</u>

Minimum site area shall not be less than thirty thousand (30,000) square feet. Footprint lots shall have all required appurtenant areas contiguous thereto and the sum of these areas shall not be less than thirty thousand (30,000) square feet. (3)

* To allow, in addition to the 2,320,600 square feet of professional and business office use permitted elsewhere in the text, a maximum of 38,022 net square feet of professional and business office use within Retail and Service Center Site 1. (5) (14)

Exception: (9)

The Planning Commission may authorize an exception to the minimum site area. Application for any such exception shall be made at the time of the filing of a tentative map by the applicant. In order for an exception to be granted, the Planning Commission shall find the following facts with respect thereto:

1. That the granting of the exception will not be detrimental to the public welfare or injurious to other property in the vicinity.

2. That the Development Considerations and intent of this planned Community Development Standards are substantially met.

B. Building Area

Maximum building area for professional and business offices shall be as noted in Site Area and Building Area, Part II, Section I, Group 1.B. Parking basements or parking structures shall not be calculated as building area; however, said structures shall be used only for the parking of company vehicles, employee vehicles, or vehicles belonging to persons visiting the subject firm. (4)

C. Setbacks

All setbacks shall be measured from the property line. For the purpose of this ordinance, a street side property line is that line created by the ultimate right-of-way of the frontage street.

1. Front Yard Setback (10)

Thirty (30) feet minimum; except that unsupported roofs or sunscreens may project six (6) feet into the setback area. The setback for Site C from MacArthur Boulevard would be at least thirty-six (36) feet except that unsupported roofs or sun-screens any project six (6) feet into the setback.

2. Side Yard

Side yard setbacks will be required only when any one of the following conditions exist:

a. Corner Lot: Thirty (30) feet (street side setback only), except that unsupported roofs and sunscreens may project three (3) feet into setback area.

b. Where property abuts other than commercially zoned property, a ten (10) foot setback is required. Unsupported roofs and sunscreens may project three (3) feet into the setback area.

3. Rear Yard

None required except on a through-lot in which case the required front yard setback shall be observed.

4. Footprint Lots (6)

Except as required by the Uniform Building Code, there shall be no additional setback requirements for buildings within footprint lots. Provided, however, that buildings within footprint lots shall be so located as to observe the setbacks from streets and existing lot lines required under Part II, Section III, C.1, 2 and 3.

D. Loading Areas

1. Street side loading on other than special landscaped streets shall be allowed providing the loading dock is set back a minimum of seventy (70) feet from the street right-of-way line, or one hundred ten (110) feet from the street center line, whichever is greater. Said loading area must be screened from view from adjacent streets.

E. Storage Areas

1. All outdoor storage shall be visually screened from access streets, freeways and adjacent property. Said screening shall form a complete opaque screen up to a point eight (8) feet in vertical height, but need not be opaque above that point.

2. Outdoor storage shall be meant to include all company owned and operated motor vehicles, with the exception of passenger vehicles.

3. No storage shall be permitted between a frontage street and the building line.

F. Refuse Collection Areas

1. All outdoor refuse collection areas shall be visually screened from access streets, freeways and adjacent property. Said screening shall form a complete opaque screen.

2. No refuse collection area shall be permitted between a frontage street and the building line.

G. Telephone and Electrical Service

All "on-site" electrical lines (excluding lines in excess of 12KV) and telephone lines shall be placed underground. Transformer or terminal equipment shall be visually screened from view from streets and adjacent properties.

H. Pedestrian Access (1)

It is required of all developments in the commercial areas to submit a plan of pedestrian access to the Planning Department prior to the issuance of building permits. Said plan will detail consideration for pedestrian access to the subject property and to adjacent properties and shall be binding on subsequent development of the property. The plan shall show all interior walkways and all walkways in the public right-of-way, if such walkways are proposed or necessary.

I. Parking

All parking shall be as specified in the General Parking Requirements, Part III.

J. Signs

All signing shall be as specified in the General Sign Requirements, Part IV.

K. Landscape

All landscaping shall be as specified in the General Landscape Requirements, Part V.

PART III. GENERAL PARKING REQUIREMENTS

Section I

A. Adequate off-street parking shall be provided to accommodate all parking needs for the site. The intent is to eliminate the need for any on-street parking.

Required off-street parking shall be provided on the site of the use served, or on a contiguous site, or within three hundred (300) feet of the subject site. Where parking is provided on other than the site concerned, a recorded document shall be approved by the City Attorney and filed with the Building and Planning Departments and signed by the owners of the alternate site stipulating to the permanent reservation of use of the site for said parking.

B. Parking requirements for specific sites shall be based upon the following parking criteria. All parking shall be determined based upon building type and the area within allotted to the following functions:

1. Business & Professional Offices

One (1) space for each 225 square feet of net floor area. The parking requirement may be lowered to one (1) space for each 250 square feet of net floor area upon review and approval of the modification committee.

Company parking stalls shall not exceed twenty-five (25) percent of the total number of required parking spaces. The number and design of compact parking stalls shall be reviewed and approved by the Planning Director. (11)

Exception: (11)

Parking Requirement for Business and Professional Office Buildings based on Parking Pool. The parking requirements for office buildings within a contiguous office site may be modified in accordance with the following schedule when the net building area or areas served exceeds 100,000 square feet.

a. For the first 125,000 square feet, parking shall be provided at one space per 250 square feet of net floor area.

b. For the next 300,000 square feet, parking shall be provided at one space per 300 square feet of net floor area.

c. Any additional floor area, parking shall be provided at one space per 350 square feet of net floor area.

d. For pools based on more than 425,000 square feet of net floor area, the Planning Commission may modify the parking formula by use permit, based on a demonstrated formula.

2. Medical & Dental Offices

Five (5) spaces for each doctor or one (1) space for each 200 square feet of gross floor area, whichever is greater.

3. Manufacture, Research and Assembly - Deleted. (33)

4. Warehouse - Deleted. (33)

5. Lodge Halls, Private Clubs, Athletic Clubs, Union Headquarters (1) (4) (5)

   a. One (1) space for each 75 square feet of gross floor area plus one (1) space for each 250 square feet of gross office floor area.

   b. Specific parking requirements shall be developed for private clubs or athletic clubs based upon functions and occupancies within this use. Parking shall be in conformance to existing City of Newport Beach requirements for said occupancies or at a demonstrated formula agreeable to the Planning Director. (4) In the event that private clubs or athletic clubs are converted to another use, parking requirements for the new use shall be subject to review by the Planning Director. (5)

6. Restaurants, Bars or Theater/Nightclubs, Outdoor, Drive-In and Take-Out Restaurants (7)

   a. Restaurant, bar or theater/nightclub parking shall be in accordance with Title 20 of the Newport Beach Municipal Code, except as noted under "b" and "c" below.

* b. Restaurants, other than outdoor, drive-in or take-out restaurants, within retail and service centers shall provide one (1) space for each 200 square feet of net floor area and one (1) loading space for each 10,000 square feet of gross floor area, to the extent that the net floor area of all restaurants does not exceed twenty (20) percent of the net floor area of the retail and service center. In the event that any restaurant causes the total of all restaurant uses in the retail and service center to exceed the twenty (20) percent limitation noted above, that entire restaurant and any subsequent restaurants shall provide parking as noted under "a" above.

   c. Parking for outdoor, drive-in and take-out restaurants shall be provided in accordance with Section 20.53.060 of the Newport Beach Municipal Code.

7. Commercial Retail and Service Center (5)

One (1) space for each 200 square feet of net floor area. One (1) loading space for each 10,000 square feet of gross floor area. Professional and business office parking shall be provided per Part III, Section I.B.1. Athletic or health club parking shall be provided per Part III, Section 1.B.5b.

8. Hotels and Motels

One (1) space for each guest unit plus employees' parking on a demonstrated formula. Parking for restaurants, bars, banquet rooms, retail shops or service stores shall be as specified in the above applicable section or on a demonstrated formula acceptable to the Planning Director.

* Professional and business office net floor area shall be included in this provision. Athletic and health club net floor area shall be excluded from this provision. (5)

9. Court House

Specific parking requirements shall be developed based upon functions and occupancies within this zone. Parking shall be in conformance to existing City of Newport Beach requirements for said occupancies, or at a demonstrated formula agreeable to the Planning Director.

PART IV. GENERAL SIGN REQUIREMENTS

Section I. Sign Standards

A. Signs visible from the exterior of any building may be lighted, but no signs or any other contrivance shall be devised or constructed so as to rotate, gyrate, blink or move in any animated fashion.

B. Signs shall be restricted to advertising only the person, firm, company or corporation operating the use conducted on the site or the products sold thereon.

C. A wall sign with the individual letters applied directly shall be measured by a rectangle around the outside of the lettering and/or the pictorial symbol and calculating the area enclosed by such line.

D. All signs attached to the building shall be surface mounted.

Group I. PERMANENT IDENTIFICATION SIGNS

A. Ground Signs

Ground signs shall not exceed four (4) feet above grade in vertical height. Also, ground signs in excess of one hundred and fifty (150) square feet in area (double face) shall not be erected in the first twenty (20) feet, as measured from the property line, of any street side setback. Said sign shall not exceed a maximum area of two hundred (200) square feet.

B. Wall Signs

In no event shall an identification sign placed on a wall comprise more than ten (10) percent of the area of the elevation upon which the sign is located. Said signs shall be fixture signs. Signs painted directly on the surface of the wall shall not be permitted.

1. The following exceptions apply to industrial zoning only. In the instance of a multiple tenancy building, each individual industry may have a wall sign over the entrance to identify the tenant. Said sign shall give only the name of the company and shall be limited to six (6) inch high letters. Said signs must be oriented toward the parking or pedestrian area for that building and shall not exceed a maximum area of five (5) square feet.

2. Fascia mounted identification signs limited to two (2) facades for each building and structure.

No sign shall exceed an area equal to one and one-half (1 1/2) square feet of sign for each one (1) foot of lineal frontage of the building or store. However, no sign shall exceed two hundred (200) square feet in area per face.

3. The following exceptions apply to Professional and Business Offices and Retail and Service Center uses only. In the instance of a multiple tenancy building, each individual ground floor business may have signing in addition to permitted Building Identification signs. (6)

Each individual ground floor business shall be limited to one (1) sign per frontage not to exceed two (2) signs per business. Said signs shall not be located above the ground floor fascia. No sign shall exceed an area equal to ten (10) percent of the business face upon which it is located. However, no sign shall exceed thirty-five (35) square feet in area. (6).

In no event shall there be more than three (3) permitted ground floor wall signs per building for Professional and Business Offices. (6)

C. <u>Pole Signs</u>

One (1) identification pole sign per site will be allowed for the following commercial businesses only:

a. Restaurant
b. Cocktail lounge and/or bar
c. Hotel

If a pole sign is utilized, it shall be in lieu of other identification signs allowed by ordinance. Pole signs shall be limited to a maximum height of twenty (20) feet and a maximum area of fifty (50) square feet per face, double faced.

Group II. <u>TEMPORARY IDENTIFICATION SIGNS</u>

A. The following signs shall conform to all requirements for "Ground Signs," Section I, Group I, Item A with General Sign standards above unless specifically limited below.

1. Sale or Lease Sign

A sign, advertising the sale, lease or hire of the site shall be permitted in addition to the other signs listed in this section. Said sign shall not exceed a maximum area of forty (40) square feet.

2. Construction Sign

One (1) construction sign denoting the architects, engineers, contractor, and other related subjects, shall be permitted upon the commencement of construction. Said sign shall be permitted until such time as a final inspection of the building(s) designates said structure(s) fit for occupancy, or the tenant is occupying said building(s), whichever occurs first. Said sign shall not exceed a maximum area of forty (40) square feet.

3. Future Tenant Identification Sign

A sign listing the name of future tenant, responsible agent or realtor, and identification of the industrial complex shall be permitted. Said sign will be permitted until such time as a final inspection of the building(s) designates said structure(s) fit for occupancy or tenant is occupying said building(s), whichever occurs first. Said sign shall not exceed a maximum area of forty (40) square feet.

4. Directional Signs

Signs used to give directions to traffic or pedestrians or give instructions as to special conditions shall not exceed a total of six (6) square feet (double face) in area and shall be permitted in addition to the other signs in this section.

5. Exceptions

Group II.A.1, 2 and 3: this information may be grouped on a single sign when the aggregate surface area does exceed the summation of the individual areas for each use. This area may be distributed on all surfaces of the sign. This sign may not exceed four (4) feet above grade.

Group III. SPECIAL PURPOSE SIGNS

A. The following permanent signs shall be permitted.

1. Permanent Directional Sign

Signs used to give directions to traffic or pedestrians as to special conditions shall not exceed a total of six (6) square feet in area per face, double faced and shall be permitted in addition to other signs permitted in these standards.

2. Community Directional and/or Identification Sign

Permanent directional and identification signs, not exceeding two hundred fifty (250) square feet (per face), shall be permitted but subject to use permit.

Section II. Sign Area

A. Industrial - Deleted. (33)

B. Industrial Support Facilities and – Deleted. (33) Business and Professional Offices (33)

The following shall apply to Permitted Uses, Part I, Section III.

No sign shall exceed an area equal to one and one-half (1 1/2) square feet of sign for each one (1) foot of lineal frontage of the building. However, no sign shall exceed two hundred (200) square feet in area per face.

C. Commercial

The following shall apply to Permitted Uses, Part II, Section II, Groups II, III, V and VI.

Building identification shall be limited to a single entity. Building identification signs shall have an area not to exceed one and one-half (1 1/2) square feet of surface for each one (1) foot of lineal frontage of building. However, no sign shall exceed two hundred (200) square feet per face. Building identification signs shall be limited to two (2) facades.

D. Business and Professional Offices

The following shall apply to Permitted Uses, Part II, Section II, Group I.

Building identification shall be limited to a single entity. Building identification signs shall have an area not to exceed one and one-half (1 1/2) square feet of surface for each one (1) foot of lineal frontage of building. However, no sign shall exceed two hundred (200) square feet per face. Building identification signs shall be limited to two (2) facades.

Section III. Maintenance

All signs indicated in this section shall be maintained in a neat and orderly fashion. Periodic inspection shall be made as directed by the Planning Director, City of Newport Beach or his designated agent.

PART V. GENERAL LANDSCAPE STANDARDS

Section I. General Statement (1)

Detailed landscape and irrigation plans, prepared by a registered Architect or under the direction of a Landscape Architect, shall be submitted to and approved by the Planning Director and the Director of Parks, Beaches and Recreation prior to issuance of a building permit and installed prior to issuance of Certificate of Use and Occupancy. Landscape in the public right-of-way shall be installed per plans and specifications approved by the Parks, Beaches and Recreation Director and in accordance with Parks, Beaches and Recreation Standards.

All landscaping in this section shall be maintained in a neat and orderly fashion. Periodic inspections will be made as directed by the Planning Director and reports submitted with regard to the condition of maintenance. If suggestions of improvement are made, and are in the realm of the Maintenance Standards, the work shall be corrected within thirty (30) days of receipt of the report.

A. Maintenance

1. All planting areas to be kept free of weeds and debris.
2. Lawn and ground covers to be kept trimmed and/or mowed regularly.
3. All plantings to be kept in a healthy and growing condition. Fertilization, cultivation and tree pruning are to be carried out as part of regular maintenance.
4. Irrigation systems are to be kept in working condition. Adjustment and cleaning of system should be a part of regular maintenance.
5. Stakes, guys and ties on trees should be checked regularly for correct function; ties to be adjusted to avoid creating abrasions or girdling to the stems.
6. Damage to plantings created by vandalism, automobile or acts of nature shall be corrected within thirty (30) days.

B. Front Yard Setback Area

1. General Statement

Landscaping in these areas shall consist of an effective combination of street trees, trees, ground cover and shrubbery. All unpaved areas not utilized for parking shall be landscaped in a similar manner. Full coverage of ground cover to be expected in a minimum of three (3) months.

2. Special Landscaped Street

The entire area between the curb and the building setback line shall be landscaped, except for any driveway in said area. Tree size to be no less than 24-inch box.

3. Other Streets

The entire area between the curb and a point ten (10) feet back in the front property line shall be landscaped except for any driveway in said area. Tree size to be no less than 24 inch box.

C. Side Yard and Rear Yard

1. General Statement

All unpaved areas not utilized for parking and storage, shall be landscaped utilizing ground cover and/or shrub and tree materials.

2. Undeveloped Areas

Undeveloped areas proposed for future expansion shall be maintained in a weed free condition, but need not be landscaped.

3. Screening

Areas used for parking shall be screened from view or have the view interrupted by landscaping and/or fencing from access streets, freeways and adjacent properties. Plant materials used for screening purposes shall consist of lineal or grouped masses of shrubs and/or trees of a sufficient size and height to meet this requirement when initially installed.

4. Boundary Areas

Boundary landscaping is required on all interior property lines. Said areas shall be placed along the entire length of these property lines or be of sufficient length to accommodate the number of required trees. Trees, equal in number to one (1) tree per twenty-five (25) lineal feet of each property line, shall be planted in the above defined areas in addition to required ground cover and shrub material. Minimum width of property line landscaping shall be three (3) feet.

5. All landscaped areas shall be separated from adjacent vehicular areas by a wall or curb, at least six (6) inches higher than the adjacent vehicular area.

D. Parking Areas

Trees, equal in number to one (1) per each five (5) parking stalls, shall be provided in the parking area. Planting area around building shall not be included in parking area. Planting of trees may be in groups and need not necessarily be in regular spacing.

E. Sloped Banks

All sloped banks greater than 5 to 1, or six (6) feet in vertical height and adjacent to public right-of-way shall be stabilized, planted and irrigated with full coverage in accordance with plans submitted and approved by Planning Director.

F. Loading Areas

1. Street side loading on other than special landscaped streets, shall be allowed providing the loading dock is set back a minimum of seventy (70) feet from the street right-of-way line or one hundred ten (110) feet from the street center line, whichever is greater. Said loading area must be screened from view from adjacent streets.

G. Storage Areas

1. All outdoor storage shall be visually screened from access streets, freeways and adjacent property. Said screening shall form a complete opaque screen up to a point eight (8) feet in vertical height but need not be opaque above that point.

2. Outdoor storage shall be meant to include all company owned and operated motor vehicles, with the exception of passenger vehicles.

3. No storage shall be permitted between a frontage street and the building line.

H. Refuse Collection Areas

1. All outdoor refuse collection areas shall be visually screened from access streets, freeways and adjacent property. Said screening shall form a complete opaque screen.

2. No refuse collection area shall be permitted between a frontage street and the building line.

3. Minimum width for landscaping shall be three (3) feet around refuse collection areas.

I. Telephone and Electrical Service

All "on-site" electrical lines (excluding lines in excess of 12 KV) and telephone lines shall be placed underground. Transformer or terminal equipment shall be visually screened from view from streets and adjacent properties, or an approved method of display.

J. Pedestrian Access (1)

It is required of all developments in the commercial areas to submit a plan of pedestrian access to the Community Development Department prior to the issuance of building permits. Said plan will detail consideration for pedestrian access to the subject property and to adjacent properties, and shall be binding on subsequent development of the property. The plan shall show all interior walkways and all walkways in the public right-of-way, if such walkways are proposed or necessary.

K. Landscape Plant Vocabulary (1)

It is the intent of this standard to provide flexibility and diversity in plant selection yet maintain a limited variety to give greater unity to the development. At the direction of the Director of Community Development and the Director of Parks, Beaches and Recreation, material lists and a street tree master plan shall be developed to aid in this development.

All trees occurring in the ten (10) foot setback shall be no less than 24 inch box. The parking lot trees shall be no less than fifteen (15) gallon size.

Shrubs to be planted in containers shall not be less than one (1) gallon size. Ground covers will be planted from one (1) gallon containers or from root cuttings.

Every effort should be made to avoid using plants with invasive and shallow root systems with fruit that would stain paving or automobiles.

L. Earth berms shall be rounded and natural in character, designed to obscure automobiles and to add interest to the site. In cases where the ratio of width and height of berm creates a bank greater than 3 to 1, shrubs or walls can be used as shown in illustration (b) (c). Wheel stops shall be so placed that damage to trees, irrigation units and shrubs is avoided.

M. Trees in parking lots should be limited in variety. Selection should be repeated to give continuity. Regular spacing is not required and irregular groupings may add interest. Care should be exercised to allow plants to grow and maintain their ultimate size without restriction.

N. Storage areas are to be provided with an opaque screen up to a point of eight (8) feet in vertical height. Combination of plantings can be used to further soften hard materials and give continuity to planting.

PART VI. FOOTNOTES

(1) Planned Community text revision incorporating Planning Commission revisions and conditions of approval.

(2) Planned Community Text revision incorporating City Council conditions of approval as adopted by the city of Newport Beach. (Amendment No. 313, adopted August 14, 1972).

(3) Planned Community Text revision July 6, 1973 incorporating the addition of footprint lots and the addition of two (2) restaurant sites within Office Site "A". (Amendment No. 381, adopted August 2, 1973).

(4) Planned Community Text revision (Amendment No. 420, adopted February 7, 1974) incorporating the following changes:

a. Revised Planned Community Text site acreage figures to conform to the recorded tract map.
b. Revised Exhibit "A" (land use map) to conform to recorded tract map.
c. Changed the size of Office Site "E" and created one parcel of land comprised of Restaurant Site No. 3, Service Station Site No. 3 and the residual of Office Site "C". This new site is designated as Office Site "F".
d. Revised Retail and Service Site No. 2 from a specific location to a floating location within Office Site "A".
e. Added mechanical car wash subject to a use permit as a permitted use on the service station sites.
f. Added private clubs or athletic clubs as a permitted use on Office Site "B".
g. Made provisions for three (3) additional restaurant sites, two sites within Office Site "B: and one site within Office Site "F".

(5) Planned Community Text revision (Amendment No. 430, adopted June 10, 1974) incorporating the following changes:

a. Eliminated Service Station Site No. 2.
b. Added health or athletic club as a permitted use within the Retail and Service Center sites.
c. Added Professional and Business Office as a permitted use within the Retail and Service Center sites.
d. Added a minimum twenty-five (25) percent landscape requirements or site plan approval by the Planning commission to the development requirements of retail Site No. 1.

(6) Planned Community Text revision (Amendment No. 444, adopted May 15, 1975) incorporating the following changes:

a. Clarified the setback requirements for buildings within footprint lots.
b. Clarified Professional and Business Office permitted uses.

c. Added signing provision for ground floor businesses in multi-tenant building.

(7) Planned Community Text revision (Amendment No. 451, adopted September 8, 1975) incorporating the following changes:

a. Added the requirement that all restaurants shall be subject to the securing of a use permit with the exception of certain restaurant uses within Retail and Service Centers.

(8) Planned Community Text revision (Amendment No. 466, adopted June 28, 1976) incorporating the following changes:

a. Changed the size of Light Industrial Site No. 2.
b. Created Professional and Business Office Site "G".
c. Made provisions for two (2) restaurant sites within Office Site "G".
d. Reduced the allowable building area of Office Site "D".
e. Amended the construction timetable for traffic signals.

(9) Planned community Text revision (Amendment No. 475, adopted January 10, 1977) incorporating the following changes:

a. Established guidelines for an exception to the minimum site area.

(10) Planned Community Text revision (Amendment No. 505, adopted July 11, 1978) incorporating the following changes:

a. Increased the site area of Professional and Business Office Site "C".
b. Increased the allowable building area of Professional and Business Office Site "C".

(11) Planned Community Text revision (Amendment No. 508, adopted August 28, 1978) incorporating the following changes:

a. Made provision for consideration of additional left turn ingress from MacArthur Boulevard.
b. Eliminated Service Station Site No. 1 and added the land area to Professional and Business Office Site "B".
c. Reviewed the parking requirement for office buildings within Professional and Business Office sites.

(12) Planned Community Text revision (Amendment No. 514, adopted October 19, 1978) incorporating the following changes:

a. Established existing and additional allowable development as of October 1, 1978.

b. Established the requirement and criteria for phasing plan approval of development beyond thirty (30) percent of the additional

(13) Planned Community text revision incorporating the transfer to allowable building area from Professional and business Office Site “D: to Professional and Business Office Site “B”. (Amendment No. 550, adopted November 10, 1980).

(14) Planned Community Text revision for Retail and Service Site No. 1, which allocates existing and permitted development. (Amendment No. 558 adopted March 23, 1981).

(15) Planned community Text revision increasing the allowable building area in Site C (MacArthur Court). (Amendment No. 593, adopted October 24, 1983).

(16) Planned Community Text revision incorporating the transfer of allowable office, restaurant and retail building area from Professional and Business Office Site “A” to Professional and Business Office Site “B”. (Amendment No. 606, adopted May 14, 1984).

(17) Planned Community Text revision to allow up to two restaurants with a total floor area not to exceed 3,250 square feet within “Office Site C”. (Amendment No. 626, adopted December 9, 1985).

(18) Planned Community Text revision deleting restaurant Site 1 and substituting a private club with a total floor area not to exceed 30,000 square feet within Office Site “A”. (Amendment No. 635, adopted July 14, 1986).

(19) Planned Community Text revision to allow auto detailing as a permitted use. (Amendment No. 647, adopted March 23, 1987).

(20) Planned Community Text revision adding support commercial uses to the permitted uses under Professional and Business Office permitted uses. (Amendment No. 649, adopted July 27, 1987).

(21) Planned Community text revision combining Light Industrial Sites 1 and 2 into Light Industrial Site 1, increasing the allowable building area for the combined site by 39,000 square feet, and increasing the permitted building height from 35 feet to 55 feet. (Amendment No. 677, adopted June 12, 1989).

(22) Planned Community Text revision increasing the permitted building height in Light Industrial Site 1 from 55 feet to 75 feet. (Amendment No. 799, adopted April 25, 1994).

(23) Title 20 amendment to reinstate notice and appeal procedures for specialty food service applications. (Amendment No. 829, adopted September 11, 1995, Ordinance 95-39)

(24) Planned Community Text revision to increase the permitted height within "Light Industrial Site 1" from 75 feet to 90 feet for a single vertical column. (Amendment No. 867, adopted February 23, 1998, Ordinance 98-3).

(25) Planned Community Text revisions (Amendment No. 876, adopted August 10, 1998, Ordinance 98-20) to allow the following changes:

a. Additional restaurant uses in Office Site "G" (the current limited of two restaurants will be increased to three restaurant sites), and;
b. Permit eating and drinking establishments throughout the Koll Center Planned Community as per Title 20 of the Municipal Code.

(26) Planned Community Text revisions (Amendment No. 890, adopted 01/11/2000, Ordinance 99-28) to allow the following changes:

a. Increase the permitted level of development for Office Site A by 15,000 square feet (4110 MacArthur Boulevard) and;
b. Establish the permitted level of development for Koll Center Newport Office Site A at 418,346 gross square feet.

(27) Planned Community Text revisions (Amendment No. 897, adopted January 25, 2000, Ordinance 2000-3) to allow the following changes:

a. Designate Parcel 1 of Koll Center Newport Retail and Service Site 1 for Hotel Use, and;
b. Establish the permitted Gross Floor Area for Koll Center Newport Retail and Service Site 1 at 120,000 square feet, and
c. Establish the permitted height for the site at 60 feet.

(28) Planned Community Text revisions (Ordinance No. 2005-014, adopted August 9, 2005) to allow the following changes:

a. Office expansion of 1,367 net square feet in the Koll Center Office Site B at 4200 Von Karman Avenue.

(29) Planned Community Text revisions (Ordinance No. 2006-19), adopted July 25, 2006 to allow the following changes:

a. To increase the development allocation for Professional and Business Offices of Site A by 2,129 net square feet. (PA2005-293)

(30) Planned Community Text revisions (Ordinance No. 2006-21), adopted October 24, 2006 to allow the following changes:

a. To allow the transfer of 24,016 gross square feet of unused retail, restaurant and office square footage from Office Site B to Office Site A resulting in the elimination of the entire Retail Site #1, an undeveloped portion of Restaurant Site #2 and the entire Restaurant Site #5.

(31) Planned Community Text revisions (Ordinance No. 2011-3), adopted January 25, 2011 to allow the following changes:

a. To allow building area for Professional & Business Site F to increase by 18, 346 net square feet.

(32) Planned Community Text revisions (Ordinance No. 2011-8), adopted March 8, 2011 to allow the following changes:

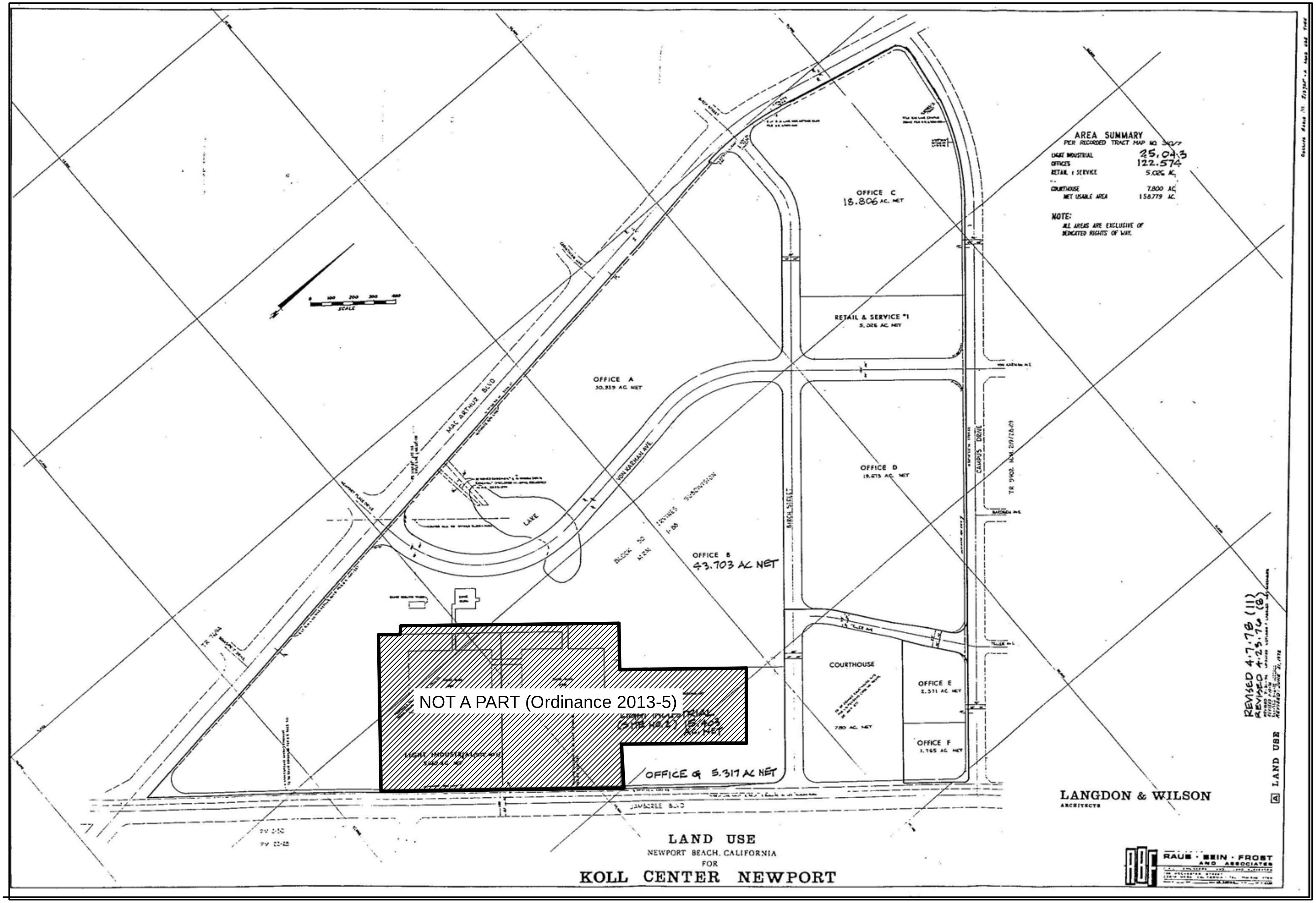
a. To allow an increase to the Allowable Building Area for Professional & Business Site B by 9,917 net square feet

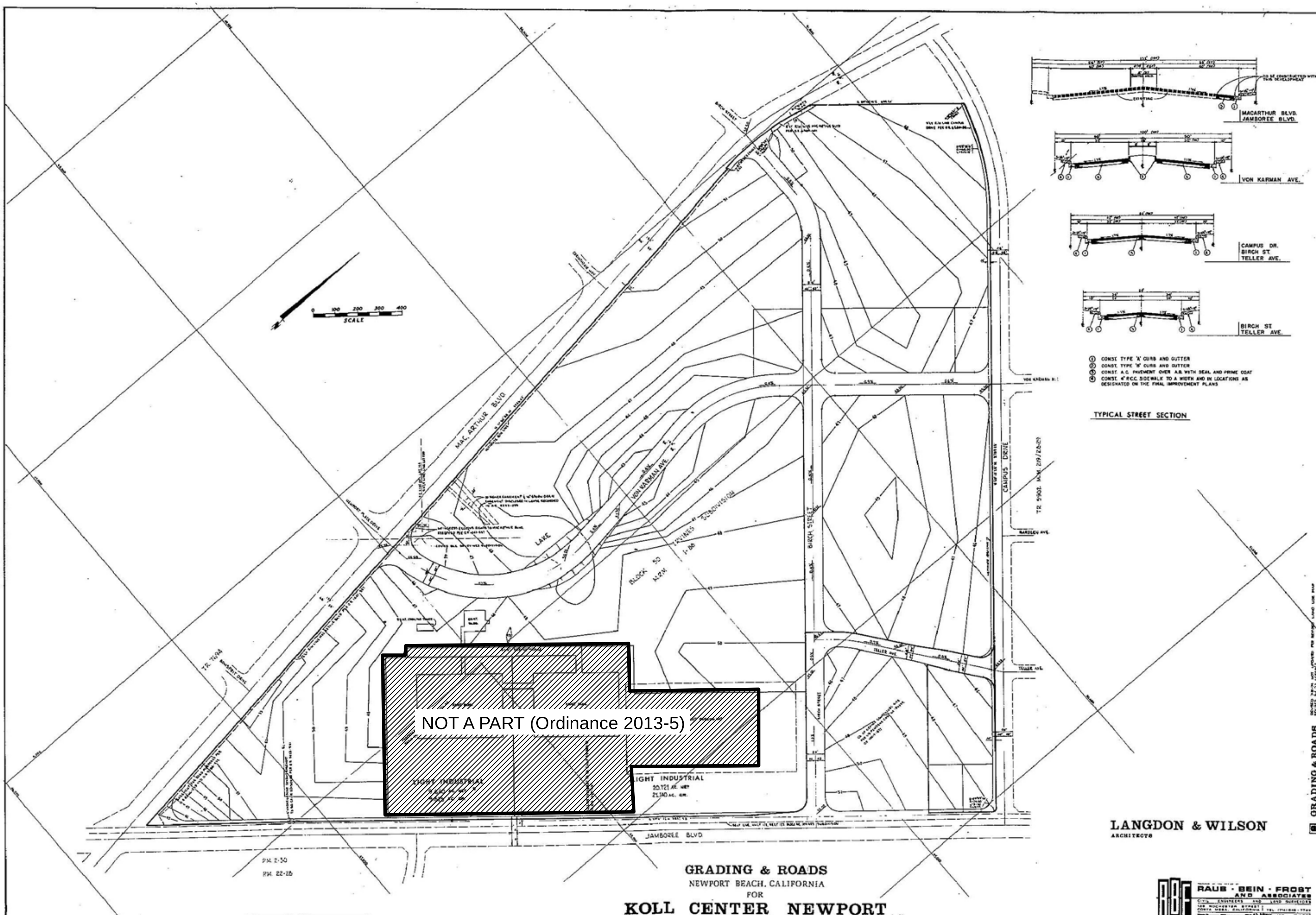
(33) Planned Community Text revisions (Ordinance No. 2013-5), adopted March 12, 2013 to allow the following changes:

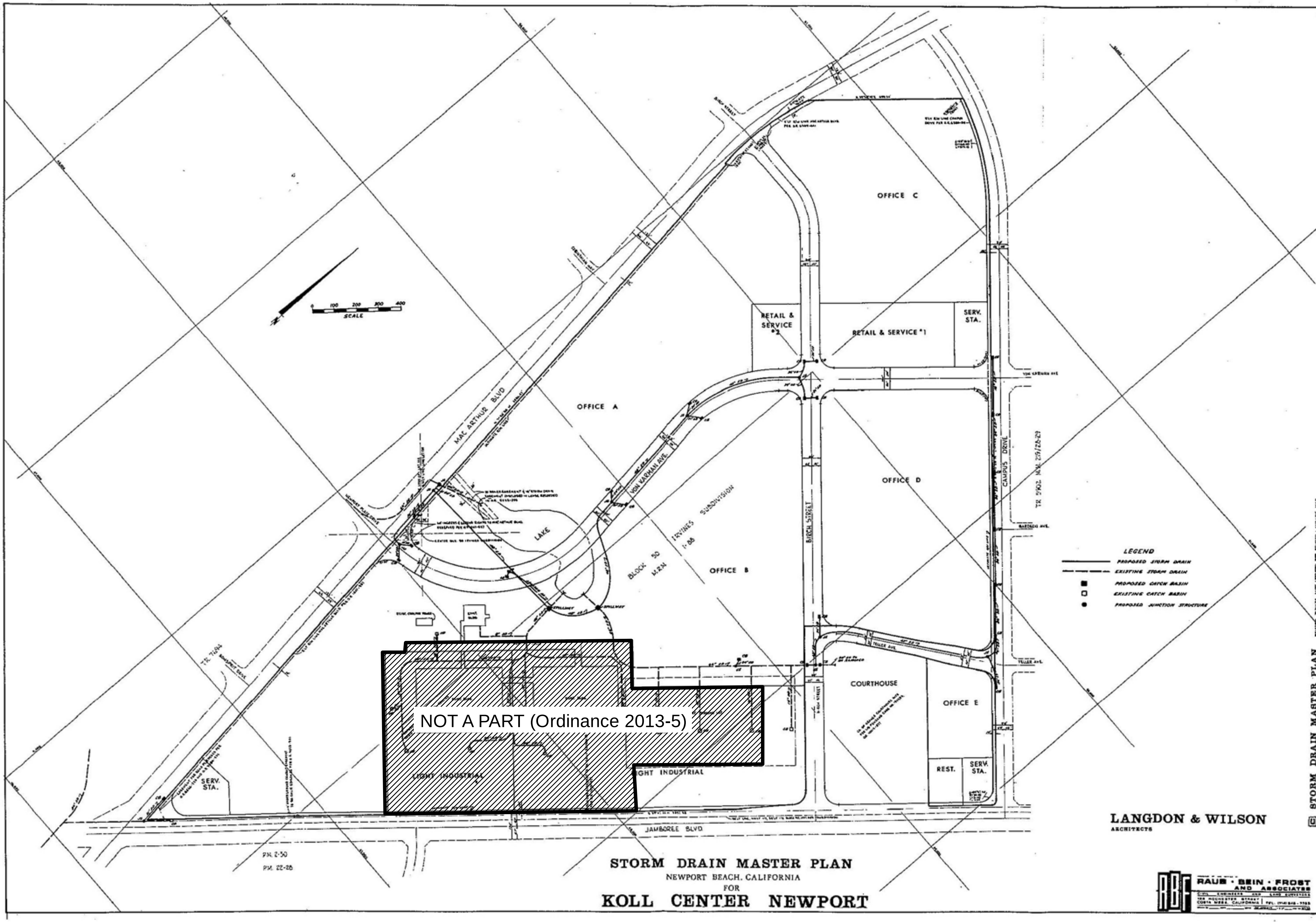
a. To delete Light Industrial Sites 1 and 2 from PC-15.
b. To delete Part I. Industrial uses in its entirety as an allowed use.
c. To revise the total acreage within PC-15 to 154.0 acres to reflect the deletion of Light Industrial Sites 1 and 2 from PC-15.
d. To update the Composite exhibit and Exhibits A through E to reflect the deletion of Light Industrial Sites 1 and 2 from PC-15.

Insert exhibits:

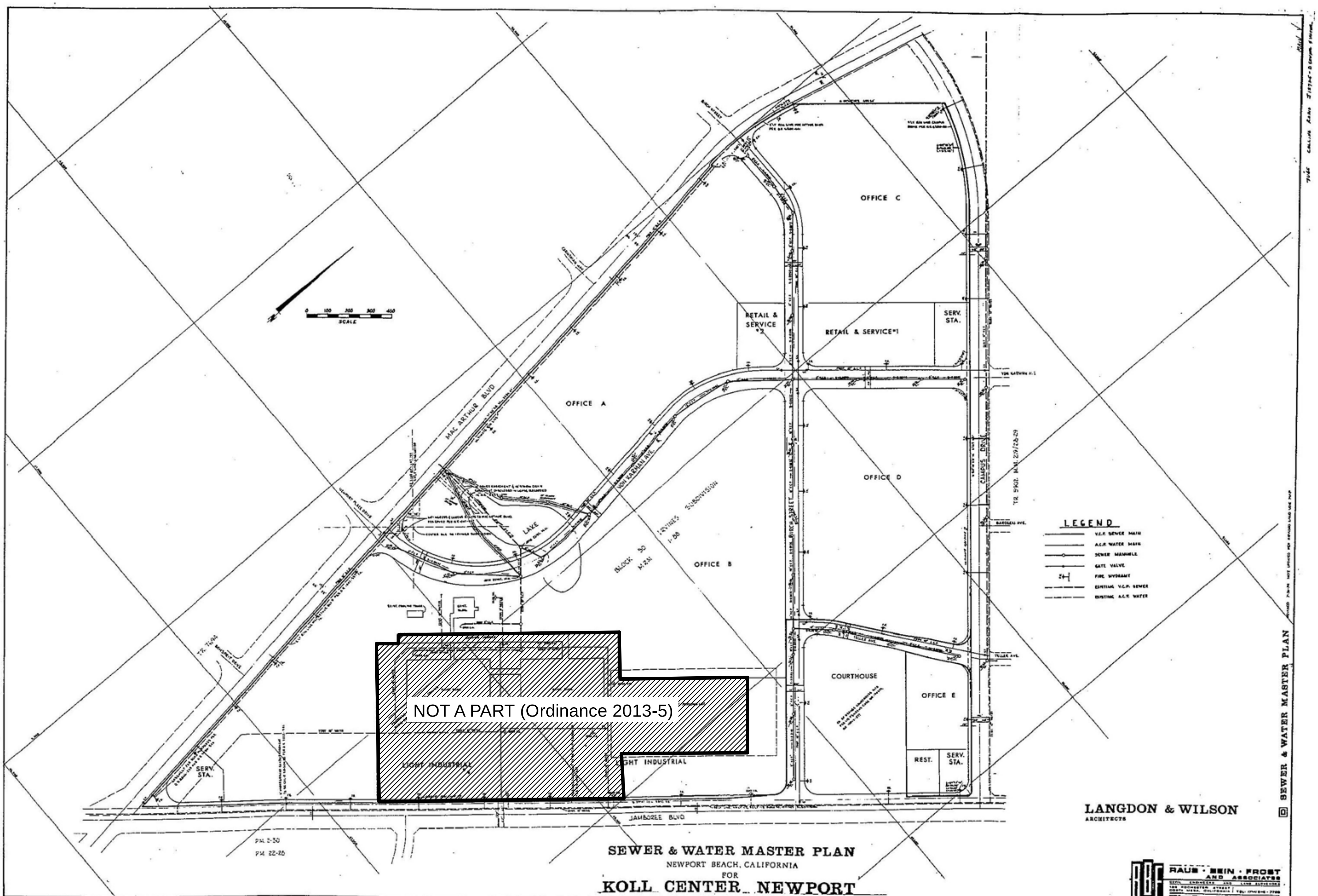
Composite.. For Information Only (33)
Exhibit A .... Land Use (33)
Exhibit B.. Grading and Roads (33)
Exhibit C.. Storm Drain (33)
Exhibit D .... Water & Sewer (33)
Exhibit E.. Boundary and Topography (33)

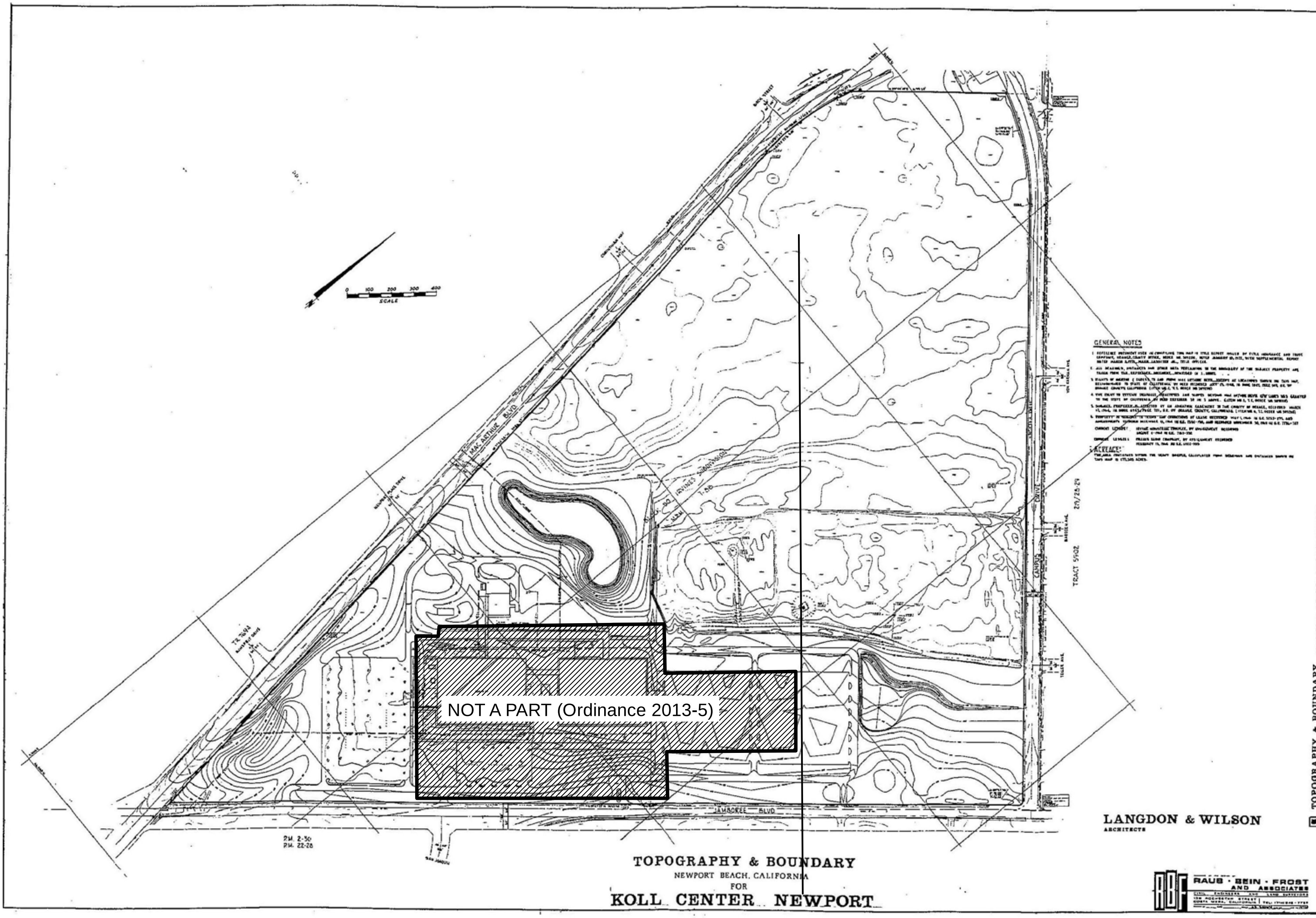

AREA SUMMARY
PER RECORDED TRACT MAP NO.
LIGHT INDUSTRIAL 25,043
OFFICES 122.574
RETAIL & SERVICE 5.026 AC.
COURTHOUSE 7.800 AC.
NET USABLE AREA 158.779 AC.
NOTE:
ALL AREAS ARE EXCLUSIVE OF DEDICATED RIGHTS OF WAY.
SCALE
OFFICE C
18.806 AC. NET
RETAIL & SERVICE #1
5.026 AC. NET
OFFICE A
30.339 AC. NET
MAC ARTHUR BLVD
VON KARMAN AVE.
BIRCH STREET
CAMPUS DRIVE
OFFICE D
19.673 AC. NET
LAKE
IRVINES SUBDIVISION
OFFICE B
43.703 AC NET
COURTHOUSE
OFFICE E
2.371 AC. NET
7.80 AC. NET
OFFICE F
1.765 AC. NET
NOT A PART (Ordinance 2013-5)
OFFICE G 5.317 AC NET
JAMBOREE BLVD
REVISED 4.7.78 (11)
REVISED 4.25.76 (8)
LAND USE
LANGDON & WILSON
ARCHITECTS
LAND USE
NEWPORT BEACH, CALIFORNIA
FOR
KOLL CENTER NEWPORT
RAUB · BEIN · FROST AND ASSOCIATES


MACARTHUR BLVD.
JAMBOREE BLVD.
VON KARMAN AVE.
CAMPUS DR.
BIRCH ST.
TELLER AVE.
BIRCH ST.
TELLER AVE.
① CONST. TYPE 'A' CURB AND GUTTER
② CONST. TYPE 'B' CURB AND GUTTER
③ CONST. A.C. PAVEMENT OVER A.B. WITH SEAL AND PRIME COAT
④ CONST. 4" P.C.C. SIDEWALK TO A WIDTH AND IN LOCATIONS AS DESIGNATED ON THE FINAL IMPROVEMENT PLANS
TYPICAL STREET SECTION
0 100 200 300 400
SCALE
MAC ARTHUR BLVD
VON KARMAN AVE
LAKE
BLOCK 50
IRVINES SUBDIVISION
BIRCH STREET
CAMPUS DRIVE
TELLER AVE
NOT A PART (Ordinance 2013-5)
LIGHT INDUSTRIAL
LIGHT INDUSTRIAL
JAMBOREE BLVD
P.M. 2-30
P.M. 22-26
GRADING & ROADS
NEWPORT BEACH, CALIFORNIA
FOR
KOLL CENTER NEWPORT
LANGDON & WILSON
ARCHITECTS
RAUB · BEIN · FROST AND ASSOCIATES
GRADING & ROADS



NOT A PART (Ordinance 2013-5)
MAC ARTHUR BLVD
OFFICE A
OFFICE B
OFFICE C
OFFICE D
OFFICE E
RETAIL & SERVICE #2
RETAIL & SERVICE #1
SERV. STA.
COURTHOUSE
REST.
LIGHT INDUSTRIAL
LAKE
VON KARMAN AVE.
BIRCH STREET
CAMPUS DRIVE
JAMBOREE BLVD
BLOCK 50 M.2.N
IRVINES SUBDIVISION 1-88
TR. 5902 M.M. 219/28-29
SCALE
0 100 200 300 400
LEGEND
PROPOSED STORM DRAIN
EXISTING STORM DRAIN
PROPOSED CATCH BASIN
EXISTING CATCH BASIN
PROPOSED JUNCTION STRUCTURE
P.M. 2-50
P.M. 22-26
STORM DRAIN MASTER PLAN
NEWPORT BEACH, CALIFORNIA
FOR
KOLL CENTER NEWPORT
LANGDON & WILSON
ARCHITECTS
RAUB · BEIN · FROST AND ASSOCIATES
STORM DRAIN MASTER PLAN


NOT A PART (Ordinance 2013-5)
OFFICE A
OFFICE B
OFFICE C
OFFICE D
OFFICE E
RETAIL & SERVICE #2
RETAIL & SERVICE #1
SERV. STA.
COURTHOUSE
REST.
LIGHT INDUSTRIAL
LAKE
MAC ARTHUR BLVD
JAMBOREE BLVD
CAMPUS DRIVE
VON KARMAN AVE.
BIRCH STREET
TELLER AVE.
SCALE
LEGEND
V.C.P. SEWER MAIN
A.C.P. WATER MAIN
SEWER MANHOLE
GATE VALVE
FIRE HYDRANT
EXISTING V.C.P. SEWER
EXISTING A.C.P. WATER
LANGDON & WILSON
ARCHITECTS
SEWER & WATER MASTER PLAN
NEWPORT BEACH, CALIFORNIA
FOR
KOLL CENTER NEWPORT
RAUB · BEIN · FROST AND ASSOCIATES
SEWER & WATER MASTER PLAN



NOT A PART (Ordinance 2013-5)
SCALE
0 100 200 300 400
MAC ARTHUR BLVD
JAMBOREE BLVD
TRACT 5902
GENERAL NOTES
ACREAGE
P.M. 2-30
P.M. 22-26
TOPOGRAPHY & BOUNDARY
NEWPORT BEACH, CALIFORNIA
FOR
KOLL CENTER NEWPORT
LANGDON & WILSON
ARCHITECTS
RAUB · BEIN · FROST AND ASSOCIATES
TOPOGRAPHY & BOUNDARY

Attachment 3
22073

T 7953

RECORDING REQUESTED BY AND
WHEN RECORDED MAIL TO:

O'Melveny & Myers
611 West 6th Street
Los Angeles, California 90017

Attention: Jerold L. Miles

MAIL TAX STATEMENTS TO:

Koll Center Newport
1901 Dove Street
Newport Beach, California 90210

GRANT DEED

AND

DECLARATION OF COVENANTS, CONDITIONS AND RESTRICTIONS

FOR A VALUABLE CONSIDERATION, the receipt and sufficiency of which is hereby acknowledged, KOLL CENTER NEWPORT, a Limited Partnership formed under the Uniform Limited Partnership Act of California ("Grantor"), hereby grants to ________________________________ ("Grantee") an undivided __/____ interest in Lot ___ (the "Lot") of Tract No. 7953 in the City of Newport Beach, California, as shown on a Tract Map recorded in Book 310, Pages 7 through 11 of Miscellaneous Maps, Official Records of Orange County, California;

Together with:

1. The exclusive right of occupancy of the Building Site described and set forth in Section 2.01 hereof;

2. The right to use all Common Facilities as set forth in Section 2.04 hereof;

Subject, however, to:

1. Non-delinquent real property taxes and assessments;

MAIL TAX STATEMENTS AS INDICATED ABOVE

2. That certain Declaration of Covenants, Conditions and Restrictions dated November 2, 1972 and recorded November 6, 1972 in Book 10413, Page 594, Official Records of Orange County (the "CC&R's");

3. Easements, rights, covenants, conditions and restrictions and other matters of record;

4. The exclusive rights to occupy portions of the Lot heretofore granted by Grantor to other parties by deeds recorded in the Official Records of Orange County or hereafter to be granted by Grantor pursuant to the provisions of Section 3.03 hereof;

5. The rights of other owners of interests in the Lot to use the Common Facilities as set forth in Section 3.01 hereof;

6. All other rights and restrictions herein set forth.

This conveyance is made subject to the covenants, conditions and restrictions set forth herein by and between Grantor and Grantee.

ARTICLE I

DEVELOPMENT OF THE LOT

1.01. Development Standards. The development of the Lot and each portion thereof is governed by and subject to the provisions of (i) the CC&R's; (ii) the Planned Community Development Standards (the "Development Standards") mentioned therein; and (iii) Ordinance No. 1449 adopted by the City of Newport Beach, California on August 14, 1972, a copy of which Ordinance is attached to the CC&R's as Exhibit 1, which CC&R's, Development Standards and Ordinance are by this reference incorporated herein to the extent applicable to the Lot. The Development Standards provide for the construction on the Lot of office buildings and other structures, the aggregate floor area and ground area of which are limited to maximums set forth therein (said maximums being respectively called the "Allowable Floor Area" and "Allowable Site Area") together with public and private streets, driveways, walkways, bike ways, lighting, landscaping, utilities, parking and other such facilities. All such facilities may hereinafter be called the "Common Facilities".

1.02. Manner of Development. It is the intention of Grantor that the Lot shall be developed in an orderly manner in accordance with the Development Standards and the CC&R's. The provisions of this Grant Deed set forth certain provisions for such development which, together with the CC&R's and the Development Standards, constitute a general plan for the protection, maintenance, development and improvement of the Lot. In furtherance of such plan of development, it is the intention and practice of Grantor to convey undivided interests in the fee estate of the Lot to various persons or entities, together with (i) the exclusive right to develop and occupy portions of the Lot in accordance with the Development Standards and (ii) the non-exclusive right to use the Common Facilities in common with Grantor and other Owners of portions of the Lot, each of such conveyances to be made subject to covenants and conditions of the nature set forth herein. In addition, Grantor has undertaken the installation of certain of the Common Facilities such as streets, walkways, bikeways, driveways and utilities and has imposed and shall impose upon various Grantees the obligation to install such

Common Facilities as parking and landscaping. The cost of maintaining the Common Facilities shall be prorated among the various Owners of the Lot.

1.03. Certain Definitions. As used herein:

(a) the term "Owners" shall refer to any person or entity holding record fee title to all or any portion of or any interest in the Lot. In the event that the ownership of any building or other improvements on any portion of the Lot shall ever be severed from the land, whether by lease or by deed, only the owner of the interest in the land shall be deemed an Owner hereunder;

(b) the term "Development Area" shall mean a portion of the surface of the Lot designated by Grantor for development by an Owner;

(c) the term "Building Site" shall mean a portion of a Development Area upon which a building and appurtenant improvements may be built and occupied by a designated Owner and as to which said designated Owner shall have the exclusive right to use and occupy;

(d) the term "Site Area Allocation" shall mean, with respect to any Development Area, the size, in square feet, of the Building Site designated thereon. The aggregate of all Site Area Allocations shall not exceed the Allowable Site Area;

(e) the term "Floor Area Allocation" shall mean, with respect to any Building Site, the maximum gross floor area of any building which may be constructed thereon. The aggregate of all Floor Area Allocations shall not exceed the Allowable Floor Area.

ARTICLE II

GRANTEE'S DEVELOPMENT AREA

2.01. Development Area and Building Site. Grantor hereby irrevocably delegates to Grantee the exclusive right to develop the surface of that portion of the Lot described in Exhibit A attached hereto and by this reference incorporated herein ("Grantee's Development Area"), together with the right to construct on a portion thereof, described in Exhibit B attached hereto and by this reference incorporated herein ("Grantee's Building Site") consisting of _____ square feet ("Grantee's Site Area Allocation") and thereafter to occupy, lease and maintain a ____-story office building containing a total of no more than _______ square feet of floor area ("Grantee's Floor Area Allocation"). Nothing contained herein shall be deemed to constitute a conveyance to Grantee of a fee ownership in Grantee's Development Area greater than Grantee's percentage interest in the entire Lot. The right to construct on the Building Site shall include the right of lateral support from adjacent land together with the right to encroach onto adjacent land for foundations, eaves and overhangs. The right to construct a building on Grantee's Building Site shall include the right to remodel, repair, demolish and rebuild said building, so long as the gross floor area of said building does not exceed Grantee's Floor Area Allocation.

2.02. Construction of Common Facilities - By Grantor. Grantor hereby covenants, for the benefit of Grantee, to provide access to Grantee's Development Area by roads to be constructed and dedicated by Grantor in accordance with the Development Standards, to grade and pave such roads and install such curbs, gutters, lighting and other roadway improvements as may be required by the Development Standards and to install and bring to the edge of Grantee's Development Area, sewers, gas, water, electricity and other utilities necessary to service the building to be constructed by Grantee. Grantee shall be responsible for all utility hook-up fees and expenses.

2.03. Construction of Common Facilities - By Grantee. By acceptance hereof, Grantee hereby covenants, for the benefit of Grantor and each other Owner of any interest in the Lot, to construct and install or to cause the construction and installation of parking facilities and landscaping on Grantee's Development Area of the nature, area and type necessary to satisfy the Development Standards, due regard being given to the nature of the building to be constructed on Grantee's Building Site.

2.04. Occupancy Rights. Grantor hereby confirms to Grantee the non-exclusive right to use the Common Facilities heretofore or hereafter constructed on the Lot and to use and occupy those areas of the Lot upon which the Common Facilities have been constructed in common with all other Owners, occupants, guests and invitees of the Lot or portions thereof or of any of the buildings constructed thereon. Grantor and Grantee hereby acknowledge that Grantee's right to use the Common Facilities is appurtenant to and an incident of Grantee's ownership of an undivided interest in the fee estate of the Lot. Grantee hereby agrees that its right and the right of its successors, assigns, guests and invitees to use the Common Facilities and occupy the surface of the Lot shall be limited to that reasonably necessary or incidental to the construction, use, occupancy and maintenance of the building and related improvements to be installed on Grantee's Development Area. In consideration of the exclusive right herein granted to Grantee to use and occupy Grantee's Building Site, Grantee hereby waives, quitclaims and relinquishes any right to use or occupy any other Building Site heretofore or hereafter designated by Grantor in accordance with the plan of development described herein or the right to develop or improve any portion of the Lot other than Grantee's Development Area, except as otherwise set forth herein. The exclusive right to use and occupy any Building Site shall include the exclusive right to the rents and profits thereof.

ARTICLE III

RESERVATIONS

3.01. Common Facilities. Grantor hereby reserves unto itself, so long as it owns any portion of or any interest in the Lot, the non-exclusive use, and the right to grant to others the non-exclusive use, of all parking facilities, driveways, walkways and other Common Facilities constructed within or upon Grantee's Development Area or upon any other portion of the Lot, together with the right to install, maintain, improve, repair and replace driveways, walkways, bikeways and other Common Facilities across the surface of all portions of the Lot except designated Building Sites; provided, however, that all use by Grantor or others of the Common Facilities shall be incidental to the construction, development, use and occupancy of buildings now or hereafter constructed on the various Building Sites heretofore or hereafter designated within the Lot.

3.02. Easements. Grantor hereby reserves unto itself, so long as it owns any portion of or any interest in the Lot, the right to establish and to grant to others non-exclusive easements for the construction, installation, maintenance, removal, replacement, operation and use of utilities, including but not limited to sewers, water and gas pipes and systems, drainage lines and systems, electric power and conduit lines and wiring, telephone conduits, lines and wires, and other utilities, public or private, beneath the ground surface (except vaults, vents, access structures and other facilities required to be above ground surface by good engineering practice) of all portions of the Lot except designated Building Sites at such location or locations as Grantor shall determine advisable. including the right to dedicate, grant or otherwise convey easements or rights of way to any public utility or governmental entity for such purposes. In the performance of any work in connection with such utilities, Grantor or its designees shall make adequate provision for the safety and convenience of all persons using the surface of said area, shall not unreasonably interfere with or disrupt the use of the Common Facilities and shall replace and restore the areas and facilities as nearly as possible to the condition in which they were prior to the performance of such work.

3.03. Right to Create Development Areas. Grantor hereby reserves unto itself, so long as it owns any portion of or any interest in the Lot, the right to grant to others undivided interests in the ownership of the Lot (such interests to be conveyed out of the interest then owned by Grantor) and concurrently therewith and as an incident thereto to designate portions of the Lot as Development Areas and to allocate to the grantees thereof Floor Area

Allocations, provided, however, that (i) no hereafter designated Development Area shall overlap any previously designated Development Area; (ii) each such grant and conveyance shall be made expressly subject to the rights and conditions contained herein and to the CC&R's and the Development Standards; (iii) the aggregate of all Floor Area Allocations shall not exceed the total Allowable Floor Area allocated to the Lot pursuant to the Development Standards; and (iv) the aggregate area of all Building Sites shall not exceed the total Allowable Site Area allocated to the Lot pursuant to the Development Standards.

ARTICLE IV

MAINTENANCE OF COMMON FACILITIES

4.01. Maintenance. So long as Grantor owns any interest in the Lot, Grantor agrees and covenants, for the benefit of Grantee and every other Owner to supervise the maintenance and repair of the Common Facilities. Such maintenance shall include, without limitation:

(a) Maintenance of the surface of all parking areas, private driveways, walkways and bikeways in a smooth and clean condition, including (i) the paving and repairing or surfacing and resurfacing of such areas when necessary with the type of material originally installed therein, or such substitute thereof as shall in all respects be equal thereto in quality, appearance and durability; (ii) the removal of debris and waste material and the washing or sweeping of paved areas as required: (iii) the painting and repainting of striping, markers and directional signs as needed;

(b) The cleaning, maintenance and relamping of any lighting fixtures except such fixtures as may be the property of any utility or governmental body;

(c) Performance of necessary maintenance of landscaping as needed, including the trimming, watering and fertilization of all grass, ground cover, shrubs and trees; the removal of dead or waste material and the replacement of any dead grass, ground cover, shrubs or trees.

(d) Maintenance of general public liability insurance for the benefit of all Owners against claims for bodily injury, death or property damage occurring on, in or about the Common Facilities and the adjoining streets, sidewalks and passageways, but not within any Building Sites or the buildings thereon, such insurance to afford protection of not less than $1,000,000 with respect to bodily injury or death to any one person, not less than $5,000,000 with respect to any one accident, and not less than $1,000,000 with respect to property damage.

Each Owner shall be responsible for the maintenance of its designated Building Site and the improvements constructed thereon, including the removal of trash generated therefrom and the maintenance or repair of any utility lines which service said Owner's Building Site and improvements. At such time as Grantor no longer owns any interest in the Lot, Grantor shall assign and delegate the aforesaid maintenance obligation to the Architectural Committee described in the CC&R's. Should the Architectural Committee be unwilling or unable to assume such obligation, or after initially assuming such obligation shall thereafter be unable or unwilling to continue such obligation, then the obligation to maintain the Common Facilities shall be assigned and delegated to the Owners pro rata in accordance with their ownership interests.

In such event, 51% in interest of the Owners shall have the right to designate a maintenance operator, and from time to time to replace such operator, to perform all of the maintenance obligations described in this Section. The designation by 51% of the Owners of such an operator shall be binding upon all other Owners. In the event that the Owners shall fail to designate a maintenance operator, then until such time as the Owners shall designate such an operator, each Owner shall be responsible to maintain, at his expense, all Common Facilities located on his designated Development Area. Any portions of the Lot not included within a Development Area shall be maintained by the holder of the adjoining Development Area, but the cost of such maintenance shall be borne by all Owners pro rata.

4.02. Allocation of Maintenance Costs. The cost of maintaining the Common Facilities shall be borne by the Owners to whom Development Areas have been designated in the proportion that each Owner's designated Floor Area Allowance bears to the total of all of the Floor Area Allowances from time to time allocated to Owners by Grantor (which total may be less than the Allowable Floor Area). Each Owner's pro rata maintenance obligation ("Maintenance Share") shall commence as of the date of the conveyance to such Owner of an interest in the Lot and the designation of a Floor Area Allowance. However, so long as Grantor shall own any interest in the Lot, Grantor shall be solely responsible for the cost of maintaining any Common Facilities which are not located within a Development Area. To illustrate the foregoing: it is assumed that during calendar 1974 Development Areas have been assigned to three Owners (designated "Owners A, B and C"). It is further assumed, for purposes of illustration, that the Allowable Building Area for the Lot is 800,000 square feet. It is further assumed that the several Owners have the following interests:

	Undivided Interest	Floor Area Allocation	Maintenance Share
Owner A	10/100	80,000	25%
Owner B	10/100	80,000	25%
Owner C	20/100	160,000	50%
Grantor	60/100	--	--

If, at the end of 1974, an additional undivided 10/100 interest is conveyed to a fourth Owner, the maintenance cost allocation for calendar 1975 would be:

	Undivided Interest	Floor Area Allocation	Maintenance Share
Owner A	10/100	80,000	20%
Owner B	10/100	80,000	20%
Owner C	20/100	160,000	40%
Owner D	10/100	80,000	20%
Grantor	50/100	--	--

4.03. <u>Computation of Maintenance Costs</u>. Common Facility maintenance costs shall include the sum of (i) all expenses in connection with the maintenance of the Common Facilities in the manner set forth in Section 4.01 hereof, determined in accordance with generally accepted accounting principles consistently applied; (ii) real property taxes assessed against all Development Areas, not including, however, any real property taxes assessed against the buildings constructed thereon by the several Owners thereof; (iii) premiums payable for the general liability insurance described in Section 4.01(d) hereof; and (iv) the costs incurred by Grantor or any subsequent maintenance operator for accounting for the computation and collection of maintenance costs.

All costs and expenses of Common Facility maintenance except that attributable to real property taxes shall be assessed by Grantor or any subsequent maintenance operator and billed to each Owner quarterly. Such assessments shall be paid by each Owner promptly upon receipt thereof. Assessments for real property taxes for each tax fiscal year shall be billed by Grantor or any subsequent maintenance operator within ten days after receipt of the tax bills from the taxing agency. Each Owner shall remit one half of his pro rata share of such taxes prior to December 1 of each year and the balance prior to April 1 of each year.

4.04. Lien for Maintenance Assessments. In the event that any Owner shall fail to pay its share of the costs and expenses of the Common Facilities within 15 days after such costs and expenses have been assessed by the maintenance operator, or in the case of real property taxes, prior to delinquency, Grantor, the other Owners or any of them, may advance such costs and expenses thus unpaid (including any penalties or interest imposed for delinquent payment of taxes and assessments), and upon the making of such advance and the giving of written notice of the nature and amount thereof to the delinquent Owner, shall be entitled to immediate reimbursement for the amount thereof, together with interest at 10% per annum on such advance. If the delinquent Owner shall fail to reimburse the Owner making such advance for the amount of the advance and interest thereon within thirty days after notice of such advance is given, the Owner making such advance may, at any time within two years after the expiration of said thirty-day period, file for record in the Office of the County Recorder of Orange County, California, a claim of lien signed by the Owner making such advance for the amount thereof, together with interest thereon, which claim shall contain (i) a statement of the unpaid amount of such advance and interest thereon; (ii) a description of the ownership interest in the Lot of the delinquent Owner, together with a description sufficient for identification of any buildings on the Lot which are owned by such delinquent Owner; and (iii) the name of the delinquent Owner. Such claim of lien shall be effective to establish a lien against the interest of the delinquent Owner in the Lot, which interest shall include such Owner's exclusive right to occupy its designated Building Site, together with any buildings constructed thereon, in the amount specified therein, together with interest at 10% per annum from the date of the advance, recording fees, costs of title search obtained in connection with such lien or the foreclosure thereof and court costs and reasonable attorneys' fees which may be incurred in the enforcement of such a lien. Such a lien, when so established against the real property described in said claim, shall be prior or superior to any right, title, interest, lien or claim which may be or may have been acquired in or attached to the real property interests subject to the lien subsequent to the time of filing such claim for record. Such lien shall be for the benefit of the Owner making such advance and may be enforced and foreclosed in a suit or action brought by such Owner in any court of competent jurisdiction, if brought within one year of the filing of such claim.

ARTICLE V

CONDEMNATION

5.01. Allocation of Award. In the event that any portion of the Lot is taken by any public or quasi-public authority under power of eminent domain, the following rules shall govern the allocation of the award for such taking:

(a) any amounts paid in connection with the taking of any buildings shall belong to the Owners thereof;

(b) any amounts paid in connection with any Building Site shall belong to the designated holder thereof;

(c) any amounts paid in connection with any Common Facilities (excluding any amounts paid in connection with the underlying land) shall be paid to the Owners in the same proportion as their Maintenance Share;

(d) the balance of any award shall be paid to the several Owners, including Grantor, in proportion to their ownership interests.

So long as Grantor owns any interest in the Lot, Grantor shall have the sole and exclusive right to negotiate and settle, on behalf of all Owners, any condemnation action relating to any portion of or any interest in the Lot not included within a designated Development Area, and by acceptance hereof, Grantee hereby irrevocably designates Grantor its agent and attorney in fact for the purpose of such negotiation and settlement. The exclusive right to negotiate and settle any condemnation action relating to any Development Area shall be exercised jointly by the designated Owner thereof and by Grantor on behalf of all Owners. The exclusive right to negotiate and settle any condemnation action relating to any building or Building Site shall be exercised by the Owner and holder thereof.

ARTICLE VI

GRANTOR'S REPURCHASE OPTION

6.01. Grant of Option. It is contemplated that Grantor may desire to sell a portion of the Lot in fee simple to a developer for purposes other than commercial office development which may be permitted by the CC&R's and the Development Standards. In such event, it would not be in the best interests of the Owners to include such use and such portion of the Lot within the Plan of Development for the Lot. Therefore, in the event that Grantor desires to make such a sale, Grantee hereby gives Grantor an option to repurchase Grantee's interest in any portion of the Lot which is not, at the time of the exercise of such option, included within any Development Area. Such option may be exercised at any time and from time to time within ten years from the date hereof by the conveyance to Grantee of an additional undivided interest in the Lot (except (i) that portion of the Lot then being repurchased and (ii) any portions of the Lot previously repurchased), such additional interest to be computed as follows: $X = \frac{A}{100-B} - A$ where:

X equals the additional interest to be conveyed to Grantee

A equals Grantee's present ownership interest in the Lot, expressed as a decimal fraction

B equals the area of the portion of the Lot to be repurchased, expressed as a percentage of the area of the entire Lot.

Thus: If Grantee's present undivided interest is 9%; and the portion of the Lot to be repurchased is 10%, then:

$$X = \frac{.09}{1.00-.10} - .09 = \frac{.09}{.90} - .09 = .10 - .09 = 1\%$$

Upon such conveyance of such additional undivided interest in the balance of the Lot, Grantee shall quitclaim to Grantor all of Grantee's rights, title and interest in the Lot to be repurchased. Thereafter, the repurchased portion of the Lot shall no longer be considered part of the Lot and the owner of such portion shall thereafter have no right or interest in the Common Facilities or in the obligation to maintain such facilities.

ARTICLE VII

MISCELLANEOUS COVENANTS AND AGREEMENTS

7.01. Conveyance of Additional Interests. At such time as Grantor shall have conveyed so many undivided interests in the Lot and, in connection with such conveyances, designated substantially all of the Lot as Development Areas, so that the undivided interest in the Lot not theretofore conveyed by Grantor and the portions of the Lot not theretofore designated as Development Areas are so small as not, in Grantor's opinion, to constitute a useful economic unit, Grantor shall quitclaim to all Owners then holding undivided interests in the Lot the balance of the undivided interest then retained by Grantor, such conveyance to be made pro rata in proportion to each Owner's Maintenance Share. Thereafter, Grantor shall have no further interest in the Lot or in the rights or obligations created by this Deed.

7.02. Right of Partition. Grantee hereby acknowledges that the common design for development of the Lot is of mutual benefit to each Owner of any interest in the Lot and that any partition of the Lot prior to the complete development thereof would work to the great prejudice of each Owner. Therefore, so long as Grantor retains any interest in the Lot, Grantee shall not have, and hereby waives, any right or power to partition the Lot or any interest therein.

7.03. Covenants Running with the Land. The agreements and covenants contained in this Grant Deed are hereby declared to be covenants running with the Land for the benefit of all of the Lot. Said covenants shall benefit and be binding upon each portion of the Lot and upon each person having any interest therein. The re-purchase option contained in Article VI hereof is declared to be personal to Grantor and may not be assigned or delegated.

7.04. Rights of Mortgagee. Breach of any of the terms, conditions, covenants and restrictions of this Grant Deed shall not defeat or render invalid the lien of any mortgage or deed of trust made in good faith and for value, but the terms, conditions, covenants and restrictions set forth herein shall be binding upon and effective against any person or entity who may hereafter acquire title to the property hereby conveyed by foreclosure, trustee's sale or otherwise.

7.05. Nature of Improvements. Any building or other improvement heretofore or hereafter constructed on Grantee's Building Site shall remain the sole property of Grantee and may be sold or conveyed by Grantee, together with or separate from Grantee's interest in the Lot, provided that such transfer is subject to these CC&R's. Notwithstanding any such separate conveyance, any such building or improvement shall at all times be deemed to be real property.

7.06. Partial Invalidity. If any portion of the terms, conditions, covenants and restrictions set forth herein is determined to be invalid for any reason, the remaining portion shall remain in full force and effect as if such portion had not been included herein.

7.07. Article Headings. Headings at the beginning of each numbered article of this Grant Deed are solely for the convenience of the parties and are not a part of this document.

IN WITNESS WHEREOF, this Grant Deed has been executed as of the date first above written.

KOLL CENTER NEWPORT
By REI of Arlington, Inc.

By________________________

By________________________

By________________________
Donald M. Koll

Grantee ________________________ hereby accepts this conveyance on the terms and conditions contained herein. By execution and acceptance of this Grant Deed, Grantee hereby affirms and agrees to be bound by all covenants and conditions contained herein.

____

By___________________________

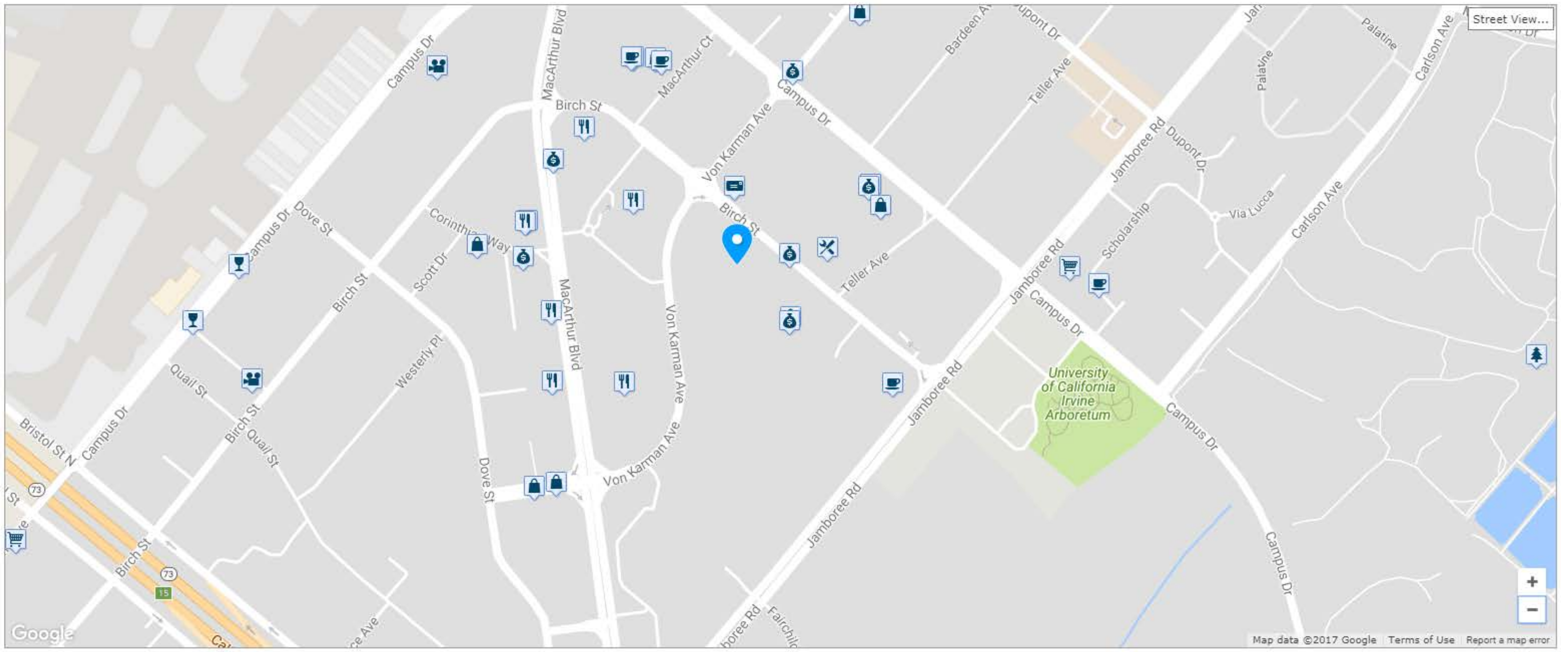
By___________________________

Koll Center Residences Walk Score (WalkScore.com)

What's Nearby

×

Restaurants: Citrus	.1mi	>
Coffee: Peet's Coffee & Tea	.3mi	>
Bars: Pub District Inc	.6mi	>
Groceries: Village Market	.4mi	>
Parks: San Joaquin Freshwater Marsh...	.8mi	>
Schools: Newport Montessori School	1mi	>
Shopping: Hanging With Mr Cooper	.1mi	>
Entertainment: Bar Coding Professionals, ZBA,...	.2mi	>
Errands: Alliance Bank	.1mi	>
Search Nearby:		>



Something missing? Add a place

Walk Score® Get Scores Find Apartments My Favorites Add to Your Site

Type an address, neighborhood or city **Go**

4910 Birch Street

Add scores to your site

Newport Beach, California, 92660

Commute to **Downtown Costa Mesa**

18 min 44 min 29 min 60+ min View Routes

Favorite **Map** **Nearby Apartments**

Looking for a home for sale in Newport Beach?

Walk Score **43**

Car-Dependent

Most errands require a car.

About this Location

No street view available

4910 Birch Street has a Walk Score of 43 out of 100. This location is a Car-Dependent neighborhood so most errands require a car.

This location is in Newport Beach. Nearby parks include San Joaquin Freshwater Marsh Reserve, San Joaquin Wildlife Sanctuary and Stanford Park.

Attachment 5

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

50 YEARS

2016–2040 RTPSCS

THE **2016-2040** REGIONAL TRANSPORTATION PLAN/ SUSTAINABLE COMMUNITIES STRATEGY

A Plan for Mobility, Accessibility, Sustainability and a High Quality of Life

ADOPTED

APRIL 2016

ADOPTED
APRIL 2016

SOUTHERN CALIFORNIA
ASSOCIATION OF GOVERNMENTS

2016–2040 RTPSCS

U.S. Department of Transportation

Federal Highway Administration

U.S. Department of Transportation

Federal Transit Administration

Caltrans

CALIFORNIA DEPARTMENT OF TRANSPORTATION

Funding: The preparation of this document was financed in part through funds from the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA). Additional financial assistance was provided by the California Department of Transportation (Caltrans). The contents do not necessarily reflect the official views or policies of FHWA, FTA or Caltrans.

MISSION STATEMENT

LEADERSHIP | VISION | PROGRESS

Leadership, vision and progress which promote economic growth, personal well-being and livable communities for all Southern Californians.

SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS WILL ACCOMPLISH THIS MISSION BY:

- Developing long-range regional plans and strategies that provide for efficient movement of people, goods and information; enhance economic growth and international trade; and improve the environment and quality of life
- Providing quality information services and analysis for the region
- Using an inclusive decision-making process that resolves conflicts and encourages trust
- Creating an educational and work environment that cultivates creativity, initiative and opportunity

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Hon. Michele Martinez, Santa Ana

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Hon. Margaret E. Finlay, Duarte

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RESOLUTION NO. 16-578-2

A RESOLUTION OF THE SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS APPROVING THE 2016-2040 REGIONAL TRANSPORTATION PLAN/ SUSTAINABLE COMMUNITIES STRATEGY (2016 RTP/SCS); RELATED CONFORMITY DETERMINATION; AND RELATED CONSISTENCY AMENDMENT #15-12 TO THE 2015 FEDERAL TRANSPORTATION IMPROVEMENT PROGRAM (FTIP)

WHEREAS, the Southern California Association of Governments (SCAG) is a Joint Powers Agency established pursuant to California Government Code Section 6502 et seq.; and

WHEREAS, SCAG is the designated Metropolitan Planning Organization (MPO) for the counties of Los Angeles, Riverside, San Bernardino, Ventura, Orange, and Imperial, pursuant to Title 23, United States Code Section 134(d); and

WHEREAS, SCAG is responsible for maintaining a continuing, cooperative, and comprehensive transportation planning process which involves the preparation and update every four years of a Regional Transportation Plan (RTP) pursuant to Title 23, United States Code Section 134 et seq., Title 49, United States Code Section 5303 et seq., and Title 23, Code of Federal Regulations Section 450 et seq.; and

WHEREAS, SCAG is the multi-county designated transportation planning agency under state law, and as such, is responsible for preparing and adopting the FTIP (regional transportation improvement program, under state law) every two years pursuant to Government Code §§ 14527 and 65082, and Public Utilities Code §130301 et seq.; and

WHEREAS, pursuant to Senate Bill (SB) 375 (Steinberg, 2008) as codified in Government Code §65080(b) et seq., SCAG must also prepare a Sustainable Communities Strategy (SCS) that will be incorporated into the RTP and demonstrates how the region will meet its greenhouse gas (GHG) reduction targets as set forth by the California Air Resources Board (ARB); and

WHEREAS, ARB set the per capita GHG emission reduction targets from automobiles and light trucks for the SCAG region at 8% below 2005 per capita emissions levels by 2020 and 13% below 2005 per capita emissions levels by 2035; and

WHEREAS, pursuant to Government Code §65080(b)(2)(B), the SCS must: (1) identify the general location of uses, residential densities, and building intensities within the region; (2) identify areas within the region sufficient to house all the population of the region, including all economic segments of the population, over the course of the planning period of the regional transportation plan taking into account net migration into the region, population growth, household formation and employment growth; (3) identify areas within the region sufficient to house an eight-year projection of the regional housing need for the region pursuant to Government Code Section 65584; (4) identify a transportation network to service the transportation needs of the region; (5) gather and consider the best practically available scientific information regarding resource areas and farmland in the region as defined in subdivisions (1) and (b) of the Government Code Sections 65080 and 65581; and (6) consider the statutory housing goals specified in Sections 65580 and 65581, (7) set forth a forecasted development pattern for the region which when integrated with the transportation network, and other transportation measures and policies, will reduce the GHG emissions from automobiles and light trucks to achieve the GHG reduction targets, and (8) allow the RTP to comply with air quality conformity requirements under the federal Clean Air Act; and

WHEREAS, through the conduct of a continuing, comprehensive and coordinated transportation planning process in conformance with all applicable federal and state requirement, SCAG developed and prepared its latest RTP/SCS, the Final 2016-2040 RTP/SCS ("2016 RTP/SCS"); and

WHEREAS, the 2016 RTP/SCS sets forth the long-range regional plan, policies and strategies for transportation improvements and regional growth throughout the SCAG region through the horizon year of 2040; and

WHEREAS, the 2016 RTP/SCS includes a regional growth forecast that was developed by working with local jurisdictions using the most recent land use plans and policies and planning assumptions; and

WHEREAS, the 2016 RTP/SCS includes a financially constrained plan and a strategic plan. The constrained plan includes transportation projects that have committed, available or reasonably available revenue sources, and thus are probable for implementation. The strategic plan is an illustrative list of additional transportation investments that the region would pursue if additional funding and regional commitment were secured; and such investments are potential candidates for inclusion in the constrained RTP/SCS through future amendments or updates. The strategic plan is provided for information purposes only and is not part of the financially constrained and conforming Final 2016 RTP/SCS; and

WHEREAS, the 2016 RTP/SCS includes a financial plan identifying the revenues committed, available or reasonably available to support the SCAG region's surface transportation investments. The financial plan was developed following basic principles including incorporation of county and local financial planning documents in the region where available, and utilization of published data sources to evaluate historical trends and augment local forecasts as needed; and

WHEREAS, the 2016 RTP/SCS includes a sustainable communities strategy which sets forth a forecasted development pattern for the region, which, when integrated with the transportation network, and other transportations measures and policies, if implemented, will reduce the GHG emissions from automobiles and light trucks to achieve the regional GHG targets set by ARB for the SCAG region; and

WHEREAS, the 2016 RTP/SCS must be consistent with all applicable provisions of federal and state law including:

(1) The Moving Ahead for Progress in the 21st Century Act (MAP-21, PL 112-141) and the metropolitan planning regulations at 23 U.S.C. §134 et seq., as was amended by the Fixing America's Surface Transportation Act (P.L. 114-94, December 4, 2015);

(2) The metropolitan planning regulations at 23 C.F.R. Part 450, Subpart C;

(3) California Government Code §65080 et seq.; Public Utilities Code §130058 and 130059; and Public Utilities Code §44243.5;

(4) §§174 and 176(c) and (d) of the federal Clean Air Act [(42 U.S.C. §§7504 and 7506(c) and (d)] and Environmental Protection Agency (EPA) Transportation Conformity Rule, 40 C.F.R. Parts 51 and 93;

(5) Title VI of the 1964 Civil Rights Act and the Title VI assurance executed by the State pursuant to 23 U.S.C. §324;

(6) The Department of Transportation's Final Environmental Justice Strategy (60 Fed. Reg. 33896; June 29, 1995) enacted pursuant to Executive Order 12898, which seeks to avoid disproportionately high and adverse impacts on minority and low-income populations with respect to human health and the environment;

(7) Title II of the 1990 Americans with Disabilities Act (42 U.S.C. §§12101 et seq.) and accompanying regulations at 49 C.F.R. §27, 37, and 38; and

(8) SB 375 (Steinberg, 2008) as codified in California Government Code §65080(b) et seq.;

WHEREAS, SCAG is further required to comply with the California Environmental Quality Act (CEQA) (Cal. Pub. Res. Code § 21000 et seq.) in preparing the 2016 RTP/SCS; and

WHEREAS, SCAG prepared a program environmental impact report (PEIR) for the 2016 RTP/SCS. The PEIR serves as a programmatic document that conducts a region-wide assessment of potential significant environmental effects of the 2016 RTP/SCS; and

WHEREAS, in non-attainment and maintenance areas for transportation-related criteria pollutants, the MPO, as well as the Federal Highways Administration (FHWA) and Federal Transit Administration (FTA), must make a conformity determination on any updated or amended RTP in accordance with the federal Clean Air Act to ensure that federally supported highway and transit project activities conform to the purpose of the State Implementation Plan (SIP); and

WHEREAS, transportation conformity is based upon a positive conformity finding with respect to the following tests: (1) regional emissions analysis, (2) timely implementation of Transportation Control Measures, (3) financial constraint, and (4) interagency consultation and public involvement; and

WHEREAS, on April 4, 2012, the SCAG Regional Council found the 2012 RTP/SCS to be in conformity with the State Implementation Plans for air quality, pursuant to the federal Clean Air Act and the EPA Transportation Conformity Rule. Thereafter, FHWA and FTA made a conformity determination on the 2012 RTP/SCS with said determination to expire on June 4, 2016; and

WHEREAS, on September 11, 2014, in accordance with federal and state requirements, the SCAG Regional Council approved the 2015/16 – 2020/21 Federal Transportation Improvement Program (2015 FTIP), which was federally approved on December 15, 2014. The 2015 FTIP represents a staged, multi-year, intermodal program of transportation projects which covers six fiscal years and includes a priority list of projects to be carried out in the first four fiscal years; and

WHEREAS, pursuant to Government Code §65080(b)(2)(F) and federal public participation requirements, including 23 C.F.R. §450.316(b)(1)(iv), SCAG must prepare the RTP/SCS by providing adequate public notice of public involvement activities and time for public review. On April 3, 2014, SCAG approved and adopted a Public Participation Plan, to serve as a guide for SCAG's public involvement process, including the public involvement process to be used for the 2016 RTP/SCS, and included an enhanced outreach program that incorporates the public participation requirements of SB 375 and adds strategies to better serve the underrepresented segments of the region; and

WHEREAS, pursuant to Government Code §65080(b)(2)(F)(iii), during the summer 2015, SCAG held a series of RTP/SCS public workshops throughout the region, including residents, elected officials, representatives of public agencies, community organizations, and environmental, housing and business stakeholders; and

WHEREAS, in accordance with the interagency consultation requirements, 40 C.F.R. 93.105, SCAG consulted with the respective transportation and air quality planning agencies, including but not limited to, extensive discussion of the Draft Conformity Report before the Transportation Conformity Working Group (a forum for implementing the interagency consultation requirements) throughout the 2016 update process; and

WHEREAS, the Transportation Conformity Report contained in the Final 2016 RTP/SCS makes a positive transportation conformity determination. Using the final motor vehicle emission budgets released by ARB and found to be adequate by the EPA, this conformity determination is based upon staff's analysis of the applicable transportation conformity tests; and

WHEREAS, each project or project phase included in the FTIP must be consistent with the approved RTP, pursuant to 23 C.F.R. §450.324(g). Amendment #15-12 to the 2015 FTIP has been prepared to ensure consistency with the Final 2016 RTP/SCS; and

WHEREAS, conformity of Amendment #15-12 to the 2015 FTIP has been determined simultaneously with the Final 2016 RTP/SCS in order to address the consistency requirement of federal law; and

WHEREAS, on November 5, 2015, SCAG Policy Committees (comprising the Community, Economic and Human Development Committee; the Energy and Environment Committee; and the Transportation Committee) recommended that the Regional Council at its December 4, 2015 meeting authorize release of the Draft 2016 RTP/SCS PEIR for a public review and comment period concurrent with the public review and comment period for the Draft 2016 RTP/SCS; and

WHEREAS, on December 3, 2015, the Regional Council approved release of the Draft 2016 RTP/SCS PEIR concurrent with release of the Draft 2016 RTP/SCS for a 60-day public review and comment period; and

WHEREAS, SCAG released the Draft 2016 RTP/SCS and the associated Draft Amendment #15-12 to the 2015 FTIP for a 60-day public review and comment period that began on December 4, 2015 and ended on February 1, 2016; and

WHEREAS, the SCAG also released the Draft 2016 RTP/SCS PEIR concurrently with the release of the Draft 2016 RTP/SCS, and issued a Notice of Availability for the same 60-day public review and comment period of December 4, 2015 to February 1, 2016; and

WHEREAS, SCAG followed the provisions of its adopted Public Participation Plan regarding public involvement activities for the Draft 2016 RTP/SCS and Draft 2016 RTP/SCS PEIR. Public outreach efforts included publication of the Draft 2016 RTP/SCS and Draft 2016 RTP/SCS PEIR on SCAG's website, distribution of public information materials, held four (4) duly-noticed public hearings (three public hearings were video-conferenced to four regional offices in different counties), and 14 elected official briefings within the SCAG region to allow stakeholders, elected officials and the public to comment on the Draft 2016 RTP/SCS and the Draft 2016 RTP/SCS PEIR; and

WHEREAS, during the public review and comment period, SCAG received 162 verbal and written comment submissions on the Draft 2016 RTP/SCS and 81 comment submissions on the Draft 2016 RTP/SCS PEIR; and

WHEREAS, SCAG staff presented an overview of the comments received on the Draft 2016 RTP/SCS and Draft 2016 RTP/SCS PEIR, and a proposed approach to the responses, to the Policy Committees and Regional Council at a joint meeting on March 3, 2016; and

WHEREAS, comment letters and SCAG staff responses on the Draft 2016 RTP/SCS and Draft 2016 RTP/SCS PEIR were posted on the SCAG web page on March 14, 2016, and included as part of the Final 2016 RTP/SCS, Public Participation and Consultation Appendix. SCAG also notified all commenters of the availability of the comments and responses; and

WHEREAS, on March 18, 2016, SCAG posted the proposed Final 2016 RTP/SCS and proposed Final 2016 RTP/SCS PEIR on its website; and

WHEREAS, on March 24, 2016, SCAG's three Policy Committees held a public, special joint meeting to consider a recommendation to the Regional Council to approve and adopt the proposed Final 2016 RTP/SCS and certify the proposed Final 2016 RTP/SCS PEIR at the April 7, 2016 Regional Council meeting; and

WHEREAS, prior to the adoption of this resolution, the Regional Council certified the Final 2016 RTP/SCS PEIR prepared for the 2016 RTP/SCS to be in compliance with CEQA; and

WHEREAS, the Regional Council has had the opportunity to review the Final 2016 RTP/SCS and its related appendices as well as the staff report related to the Final 2016 RTP/SCS, and consideration of the Final 2016 RTP/SCS was made by the Regional Council as part of a public meeting held on April 7, 2016.

NOW, THEREFORE BE IT RESOLVED, the Regional Council hereby approves and adopts the Final 2016 RTP/SCS.

BE IT FURTHER RESOLVED by the Regional Council that:

1. In adopting this Final 2016 RTP/SCS, the Regional Council finds as follows:

a. The Final 2016 RTP/SCS complies with all applicable federal and state requirements, including the metropolitan planning provisions as identified in the Code of Federal Regulations Title 23 Part 450 and Title 49, Part 613, and the SCS and other State RTP requirements as identified in California Government Code Section 65080. Specifically, the Final 2016 RTP/SCS fully addresses the requirements relating to the development and content of metropolitan transportation plans as set forth in 23 C.F.R.§450.322 et seq., including issues relating to: identification of transportation facilities that function as an integrated metropolitan transportation system; operational and management strategies; safety and security; performance measures; environmental mitigation; the need for a financially constrained plan; consultation and public participation; and transportation conformity;

b. The Final 2016 RTP/SCS complies with the emission reduction targets established by the California ARB and meets the requirements of SB 375 (Steinberg, 2008) as codified in Government Code §65080(b) et seq. by achieving per capita GHG emission reductions relative to 2005 of 8% by 2020 and 18% by 2035; and

c. The Final 2016 RTP/SCS's preferred land use scenario and corresponding forecast of population, household and employment growth is adopted at the jurisdictional level, and any corresponding sub-jurisdictional level data and/or maps is advisory only.

2. The Regional Council hereby makes a positive transportation conformity determination of the Final 2016 RTP/SCS and Amendment #15-12 to the 2015 FTIP. In making this determination, the Regional Council finds as follows:

a. The Final 2016 RTP/SCS and Amendment #15-12 to the 2015 FTIP passes the four tests and analyses required for conformity, namely: regional emissions analysis; timely implementation of Transportation Control Measures; financial constraint analysis; and interagency consultation and public involvement;

3. In approving the Final 2016 RTP/SCS, the Regional Council also approves and adopts Amendment #15-12 to the 2015 FTIP, in compliance with the federal requirement of consistency with the RTP;

4. That the foregoing recitals are true and correct and incorporated herein by this reference; and

5. SCAG's Executive Director or his designee is authorized to transmit the Final 2016 RTP/SCS and its conformity findings to the FTA and the FHWA to make the final conformity determination in accordance with the Federal Clean Air Act and EPA Transportation Conformity Rule, 40 C.F.R. Parts 51 and 93.

TO BE PASSED, APPROVED AND ADOPTED by the Regional Council of the Southern California Association of Governments at its regular meeting on the 7th day of April, 2016.

Cheryl Viegas-Walker
President
Council Member, City of El Centro

Attest:

Hasan Ikhrata
Executive Director

Approved as to Form:

Joann Africa
Chief Counsel

EXECUTIVE SUMMARY

Image courtesy of Samer Momani

EXECUTIVE SUMMARY HIGHLIGHTS

ENVISIONING OUR REGION IN 2040

Transport yourself 25 years into the future. What kind of Southern California do you envision? SCAG envisions a region that has grown by nearly four million people—sustainably. In communities across Southern California, people enjoy increased mobility, greater economic opportunity and a higher quality of life.

OUR VISION

In our vision for the region in 2040, many communities are more compact and connected seamlessly by numerous public transit options, including expanded bus and rail service. People live closer to work, school, shopping and other destinations. Their neighborhoods are more walkable and safe for bicyclists. They have more options available besides driving alone, reducing the load on roads and highways. People live more active and healthy lifestyles as they bike, walk or take transit for short trips. Goods flow freely along roadways, highways, rail lines and by sea and air into and out of the region—fueling economic growth.

Southern California's vast transportation network is preserved and maintained in a state of good repair, so that public tax dollars are not expended on costly repairs and extensive rehabilitation. The region's roads and highways are well-managed so that they operate safely and efficiently, while demands on the regional network are managed effectively by offering people numerous alternatives for transportation.

Housing across the region is sufficient to meet the demands of a growing population with shifting priorities and desires, and there are more affordable homes for all segments of society. With more connected communities, more choices for travel and robust commerce, people enjoy more opportunities to advance educationally and economically. As growth and opportunity are distributed widely, people from diverse neighborhoods across the region share in the benefits of an enhanced quality of life.

With more alternatives to driving alone available, air quality is improved and the greenhouse gas emissions that contribute to global climate change are reduced. Communities throughout Southern California are more prepared to confront and cope with the inevitable consequences of climate change, including droughts and wildfires, heat waves, rising seas and extreme weather. Meanwhile, natural lands and recreational areas that offer people a respite from the busier parts of the region are preserved and protected.

At mid-century, technology has transformed how we get around. Automated cars have emerged as a viable option for people and are being integrated into the overall transportation system. Shared mobility options that rely on instantaneous communication and paperless transactions have matured, and new markets for mobility are created and strengthened.

Above all, people across the region possess more choices for getting around and with those choices come opportunities to live healthier, more economically secure and higher quality lives.

This vision for mid-century, which is built on input received from thousands of people across Southern California, is embodied in the 2016 Regional Transportation Plan/Sustainable Communities Strategy (2016 RTP/SCS, or Plan), a major planning document for our regional transportation and land use network. It balances the region's future mobility and housing needs with economic, environmental and public health goals. This long-range Plan, required by the State of California and the federal government, is updated by SCAG every four years as demographic, economic and policy circumstances change. The 2016 RTP/SCS is a living, evolving blueprint for our region's future.

OUR OVERARCHING STRATEGY

It is clear that the path toward realizing our vision will require a single unified strategy, one that integrates planning for how we use our land with planning for how we get around.

Here is what we mean: we can choose to build new sprawling communities that pave over undeveloped natural lands, necessitating the construction of new roads and highways—which will undoubtedly become quickly overcrowded and contribute to regional air pollution and ever-increasing greenhouse gas emissions that affect climate change.

Or, we can grow in more compact communities in existing urban areas, providing neighborhoods with efficient and plentiful public transit, abundant and safe opportunities to walk, bike and pursue other forms of active transportation, and preserving more of the region's remaining natural lands for people to enjoy. This second vision captures the essence of what people have said they want during SCAG outreach to communities across the region.

SCAG acknowledges that more compact communities are not for everyone, and that many residents of our region prefer to live in established suburban neighborhoods. The agency supports local control for local land use decisions, while striving for a regional vision of more sustainable growth.

Within the 2016 RTP/SCS, you will read about plans for "High Quality Transit Areas," "Livable Corridors" and "Neighborhood Mobility Areas." These are a few of the key features of a thoughtfully planned, maturing region in which people benefit from increased mobility, more active lifestyles, increased economic opportunity and an overall higher quality of life. These features embody the idea of integrating planning for how we use land with planning for transportation.

As we pursue this unified strategy, it will be vital that we ensure that the benefits of our initiatives are widely distributed and that the burdens of development are not carried by any one group disproportionately. Social equity and environmental justice are key considerations of our overall Plan.

CHALLENGES WE FACE

We are living at a time of great change in Southern California. Our region must confront several challenges as we pursue the goals outlined in the 2016 RTP/SCS:

- **We are growing slower:** But our region is projected to grow to 22 million people by 2040—an increase of nearly four million people.
- **Our overall population will be older:** The median age of our region's overall population is expected to rise, with an increasing share of senior citizens. This demographic shift will have major impacts on transportation needs and on our transportation plans. A key challenge for the region will be to provide seniors with more transportation options for maintaining their independence as they age.
- **A smaller percentage of us will be working:** The share of younger people of working age is expected to fall. The ratio of people over the age of 65 to people of working age (15 to 64) is expected to increase. This means that our region could face a labor shortage and a subsequent reduction in tax revenues.
- **A large number of us want more urban lifestyles:** Today's Millennials, born between 1980 and 2000, are expected to demand more compact communities and more access to transit—shifting regional priorities for the overall transportation system and the types of housing that are constructed. Baby Boomers are also expected to increasingly desire these kinds of communities.
- **Many of us will continue to live in the suburbs and drive alone:** Despite the emerging trends discussed above, many people in the region will continue to live in suburban neighborhoods and drive alone to work, school, shopping and other destinations—rather than use public transit and other transportation alternatives. The 2016 RTP/SCS will not change how everyone chooses to get around, but the Plan is designed to offer residents more choices so that we can experience regionwide benefits.
- **Housing prices are increasing:** Housing prices are rising steadily and affordability is declining. As communities are redeveloped to be more compact with new transit options and revitalized urban amenities, existing residents may risk displacement.
- **Our transportation system requires rehabilitation and maintenance:** Southern California's transportation system is becoming increasingly compromised by decades of underinvestment in maintaining and preserving our infrastructure. These investments have not kept pace with the demands placed on the system and the quality of many of our roads, highways, bridges, transit and bicycle and pedestrian facilities is continuing to deteriorate. If we continue on our current path of seriously underfunding system preservation, the cost of bringing our system back to a reasonable state of good repair will grow exponentially.
- **Transportation funding is scarce and insufficient:** Full funding for transportation improvements is currently not sustainable, given the projected needs. Projected revenues from the gas tax, the historic source of transportation funding, will not meet transportation investment needs—and gas tax revenues, in real terms, are actually in decline as tax rates (both state and federal) have not been adjusted in more than two decades while the number of more fuel efficient and alternative powered vehicles continues to grow.
- **Moving goods through the region faces growing pains:** The movement of goods will face numerous challenges as consumer demand for products increases and the region continues to grow as a major exchange point for global trade. Infrastructure for freight traffic will be strained, current efforts to reduce air pollution from goods movement sources will not be sufficient to meet national air quality standards, capacity at international ports will be over-burdened and warehouse space could fall short of demands.
- **Technology is transforming transportation:** Mobility innovations including electric cars, the availability of real-time traveler information, the expansion of car sharing and ridesourcing due to smart phones and other technological advances will require updated planning to smoothly integrate these new travel options into the overall transportation system.
- **Millions suffer from chronic diseases:** Many people in our region suffer from chronic diseases related to poor air quality and physical inactivity. Heart disease, stroke, cancer, chronic lower respiratory disease and diabetes are responsible for 72 percent of all deaths in our region. Nine percent of residents have been diagnosed with diabetes, 27 percent with hypertension and 13 percent with asthma, and more

than 60 percent are overweight or obese, according to the California Health Interview Survey.

- **Climate change demands that we adapt:** The consequences of climate change will continue to impact everyday life for millions of people. The region is expected to experience more droughts and wildfires, water shortages because of drought but also because of declining snowpack in our mountains, rising seas, extreme weather events, and other impacts. Communities will need to make their neighborhoods more resilient to these changes.

OUR PROGRESS SINCE 2012

Although our challenges are great, the region has made significant progress over the past few years.

TRANSIT

Transit service continues to expand throughout the region and the level of service has exceeded pre-recessionary levels—mainly due to a growth in rail service. Significant progress has been made toward completing capital projects for transit, including the Los Angeles County Metropolitan Transportation Authority (Metro) Orange Line Extension and the Metro Expo Line. Meanwhile, five major Metro Rail projects are now under construction in Los Angeles County.

PASSENGER RAIL

Passenger rail is expanding and improving service on several fronts. The Amtrak Pacific Surfliner is now being managed locally by the Los Angeles-San Diego-San Luis Obispo (LOSSAN) Rail Corridor Agency; Riverside County Transportation Commission (RCTC) completed the Perris Valley Line in early 2016; Metrolink became the first commuter railroad in the nation to implement Positive Train Control and purchase fuel-efficient, low-emission Tier IV locomotives; and the California High-Speed Train is under construction in the Central Valley, and planning and environmental work is underway in our region to the Los Angeles/Anaheim Phase One terminus. Several other capital projects are underway or have been completed, including the Anaheim Regional Intermodal Transportation Center (ARTIC) and the Burbank Bob Hope Airport Regional Intermodal Transportation Center, among others.

HIGHWAYS

The expansion of highways has slowed considerably over the last decade because of land, financial and environmental constraints. Still, several projects have been completed since 2012 to improve access and close critical gaps and congestion chokepoints in the regional network. These include the Interstate 10 westbound widening in Redlands and Yucaipa, the Interstate 215 Bi-County HOV Project in Riverside and San Bernardino Counties, and a portion of the Interstate 5 South Corridor Project in Los Angeles County (between North Fork Coyote Creek to Marquardt Avenue), among others.

REGIONAL HIGH-OCCUPANCY VEHICLE (HOV) AND EXPRESS LANE NETWORK

The demands on our region's highways continue to exceed available capacity during peak periods, but several projects to close HOV gaps have been completed. The result has been 39 more lane miles of regional HOV lanes on Interstates 5, 405, 10, 215 and 605, on State Routes 57 and 91, and on the West County Connector Project (direct HOV connection between Interstate 405, Interstate 605 and State Route 22) within Orange County. The region is also developing a regional express lane network. Among the milestones: a one-year demonstration of express lanes in Los Angeles County along Interstate 10 and Interstate 110 was made permanent in 2014; and construction has begun on express lanes on State Route 91 extending eastward to Interstate 15 in Riverside County.

ACTIVE TRANSPORTATION

Our region is making steady progress in encouraging more people to embrace active transportation and more than $650 million in Active Transportation Program investments are underway. Nearly 38 percent of all trips are less than three miles, which is convenient for walking and biking. As a percentage share of all trips, bicycling has increased more than 70 percent since 2007 to 1.12 percent. More than 500 miles of new bikeways have been constructed in the region, and safety and encouragement programs are helping people choose walking and biking.

GOODS MOVEMENT

The region continues to make substantial progress toward completing several major capital initiatives to support freight transportation and reducing harmful emissions generated by goods movement sources. Progress since 2012 has included implementation of the San Pedro Bay Ports Clean Air Action Program (CAAP), which is reducing diesel particulate matter dropping by 82 percent, nitrogen oxides by 54 percent and sulfur oxides by 90 percent; and the San Pedro Bay Ports Clean Truck Program, which has led to an 80 percent reduction in port truck emissions. The region has also shown progress in advanced technology for goods movement, including a one-mile Overhead Catenary System (OCS) in the City of Carson. Construction of the Gerald Desmond Bridge has begun. Seventeen out of 71 planned grade separation projects throughout the region have been completed, and another 21 are expected to be complete in 2016. Double tracking of the Union Pacific (UP) Alhambra Subdivision has been initiated. The Colton Crossing, which physically separated two Class I railroads with an elevated 1.4-mile-long overpass that lifts UP trains traveling east-west, was completed in August 2013.

SUSTAINABILITY IMPLEMENTATION

Since 2012, SCAG's Sustainability Planning Grant Program has funded 70 planning projects (totaling $10 million) to help local jurisdictions link local land use plans with 2012 RTP/SCS goals. Local jurisdictions have updated outmoded General Plans and zoning codes; completed specific plans for town centers and Transit Oriented Development (TOD); implemented sustainability policies; and adopted municipal climate action plans. Thirty of the 191 cities and two of the six counties in the SCAG region report having updated their General Plans since 2012, and another 42 cities have General Plan updates pending. Fifty-four percent of the cities reporting adopted or pending General Plan updates include planning for TOD, 55 percent plan to concentrate key destinations, and 76 percent include policies encouraging infill development. Of the counties reporting updates or pending updates to their General Plans, 75 percent include TOD elements, 100 percent encourage infill development, 75 percent promote concentrated destinations, and 75 percent feature policies to address complete communities. To protect water quality, 91 percent of cities have adopted water-related policies and 85 percent have adopted measures to address water quality. To conserve energy, 86 percent of cities have implemented community energy efficiency policies, with 80 percent of those cities implementing municipal energy efficiency policies and 76 percent implementing renewable energy policies. Of the region's 191 cities, 189 have completed sustainability components, with 184 cities implementing at least ten or more policies or programs and ten cities implementing 20 or more policies or programs. This last group includes Pasadena, Pomona and Santa Monica.

AFFORDABLE HOUSING

The state is offering new opportunities to help regions promote affordable housing. In spring 2015, California's Affordable Housing Sustainable Communities (AHSC) program awarded its first round of funding to applicants after a competitive grant process. Of $122 million available statewide, $27.5 million was awarded to ten projects in the SCAG region. Eight-hundred forty-two affordable units, including 294 units designated for households with an income of 30 percent or less of the area median income, will be produced with this funding. Meanwhile, Senate Bill 628 (Beall) and Assembly Bill 2 (Alejo) provide jurisdictions with an opportunity to establish a funding source to develop affordable housing and supportive infrastructure and amenities.

PUBLIC HEALTH

The SCAG region has several ongoing efforts to promote public health. The Los Angeles County Departments of Public Health and City of Los Angeles Planning Department are developing a Health Atlas that highlights health disparities among neighborhoods. In Riverside County, the Healthy Riverside County Initiative has formed a Healthy City Network to continue to successfully work with the county's 28 cities to enact Healthy City Resolutions and Health Elements into their General Plans. The County of San Bernardino has recently completed the Community Vital Signs Initiative, which envisions a "county where a commitment to optimizing health and wellness is embedded in all decisions by residents, organizations and government."

ENVIRONMENTAL JUSTICE

Since the adoption of the 2012 RTP/SCS, social equity and environmental justice have become increasingly significant priorities in regional plans. For example, plans to promote active transportation, improve public health, increase access to transit, preserve open space, cut air pollution and more are all evaluated for how well the benefits of these efforts are distributed among all demographic groups. The State of California's Environmental Protection Agency (Cal/EPA) developed a new tool, CalEnviroScreen, which helps to identify areas in the state that have higher levels of environmental vulnerability due to historical rates of toxic exposure and certain social factors. Based on this tool, much of the region can stand to benefit from Cap-and-Trade grants that give priority to communities that are disproportionately impacted.

SETTING THE STAGE FOR OUR PLAN

SCAG began developing the 2016 RTP/SCS by first reaching out to the local jurisdictions to hear directly from them about their growth plans. The next step was to develop scenarios of growth, each one representing a different vision for land use and transportation in 2040. More specifically, each scenario was designed to explore and convey the impact of where the region would grow, to what extent the growth would be focused within existing cities and towns and how it would grow—the shape and style of the neighborhoods and transportation systems that would shape growth over the period. The refinement of these scenarios, through extensive public outreach and surveys, led to a "preferred scenario" that helped guide the strategies, programs and projects detailed in the Plan.

MAJOR INITIATIVES

With the preferred scenario selected, the 2016 RTP/SCS, which includes $556.5 billion in transportation investments, has proposed several major initiatives to strive toward our vision for 2040.

PRESERVING THE TRANSPORTATION SYSTEM WE ALREADY HAVE (FIX-IT-FIRST)

The 2016 RTP/SCS calls for the investment of $275.5 billion toward preserving our existing system. The allocation of these expenditures includes the transit and passenger rail systems, the State Highway System, and regionally significant local streets and roads.

EXPANDING OUR REGIONAL TRANSIT SYSTEM TO GIVE PEOPLE MORE ALTERNATIVES TO DRIVING ALONE

The 2016 RTP/SCS includes $56.1 billion for capital transit projects and $156.7 billion for operations and maintenance. This includes significant expansions of the Metro subway and Light Rail Transit (LRT) system in Los Angeles County. Meanwhile, new Bus Rapid Transit (BRT) routes will expand higher-speed bus service regionally; new streetcar services will link major destinations in Orange County; and new Metrolink extensions will further connect communities in the Inland Empire. Other extensive improvements are planned for local bus, rapid bus, BRT and express service throughout the region. To make transit a more attractive and viable option, the 2016 RTP/SCS also supports implementing and expanding transit signal priority; regional and inter-county fare agreements and media; increased bicycle carrying capacity on transit and rail vehicles; real-time passenger information systems to allow travelers to make more informed decisions; and implementing first/last mile strategies to extend the effective reach of transit.

EXPANDING PASSENGER RAIL

The 2016 RTP/SCS calls for an investment in passenger rail of $38.6 billion for capital projects and $15.7 billion for operations and maintenance. The Plan calls for maintaining the commitments in the 2012 RTP/SCS, including Phase 1 of the California High-Speed Train and the Southern California High-Speed Rail Memorandum of Understanding (MOU), which identifies a candidate project list to improve the Metrolink system and the LOSSAN rail corridor, thereby providing immediate, near-term benefits to the region while laying the groundwork for future integration with California's High-Speed Train project. These capital projects will bring segments of the regional rail network up to the federally defined speed of 110 miles per hour or greater and help lead to a blended system of rail services.

IMPROVING HIGHWAY AND ARTERIAL CAPACITY

The 2016 RTP/SCS calls for investing $54.2 billion in capital improvements and $103.0 billion in operations and maintenance of the State Highway System and regionally significant local streets and roads throughout the region. This includes focusing on achieving maximum productivity by adding capacity, primarily by closing gaps in the system and improving access and other measures including the deployment of new technology. The Plan also continues to support a regional network of express lanes, building on the success of the State Route 91 Express Lanes in Orange County, as well as Interstate 10 and Interstate 110 Express Lanes in Los Angeles County.

MANAGING DEMANDS ON THE TRANSPORTATION SYSTEM

The 2016 RTP/SCS calls for investing $6.9 billion toward Transportation Demand Management (TDM) strategies throughout the region. These strategies focus on reducing the number of drive-alone trips and overall vehicle miles traveled (VMT) through ridesharing, which includes carpooling, vanpooling and supportive policies for ridesourcing services such as Uber and Lyft; redistributing or eliminating vehicle trips from peak demand periods through incentives for telecommuting and alternative work schedules; and reducing the number of drive-alone trips through increased use of transit, rail, bicycling, walking and other alternative modes of travel.

OPTIMIZING THE PERFORMANCE OF THE TRANSPORTATION SYSTEM

The 2016 RTP/SCS earmarks $9.2 billion for Transportation System Management (TSM) improvements. These include extensive advanced ramp metering, enhanced incident management, bottleneck removal to improve flow (e.g., auxiliary lanes), expansion and integration of the traffic signal synchronization network, data collection to monitor system performance, integrated and dynamic corridor congestion management, and other Intelligent Transportation System (ITS) improvements. Recent related initiatives include the Caltrans Advanced Traffic Management (ATM) study for Interstate 105 and the Regional Integration of ITS Projects (RIITS) and Information Exchange Network (IEN) data exchange efforts at Los Angeles Metro.

PROMOTING WALKING, BIKING AND OTHER FORMS OF ACTIVE TRANSPORTATION

The 2016 RTP/SCS plans for continued progress in developing our regional bikeway network, assumes all local active transportation plans will be implemented, and dedicates resources to maintain and repair thousands of miles of dilapidated sidewalks. The Plan invests $12.9 billion in active transportation strategies. The Plan also considers new strategies and approaches beyond those proposed in 2012. To promote short trips, these include improving sidewalk quality, local bike networks and neighborhood mobility areas. To promote longer regional trips, these strategies include developing a regional greenway network and continuing investments in the regional bikeway network and access to the California Coastal Trail. Active transportation will also be promoted by integrating it with the region's transit system; increasing access to 224 rail, light rail and fixed guideway bus stations; promoting 16 regional corridors that support biking and walking; supporting bike share programs; educating people about the benefits of active transportation for students; and promoting safety campaigns.

STRENGTHENING THE REGIONAL TRANSPORTATION NETWORK FOR GOODS MOVEMENT

The 2016 RTP/SCS includes $70.7 billion in goods movement strategies. Among these are establishing a system of truck-only lanes extending from the San Pedro Bay Ports to downtown Los Angeles along Interstate 710; connecting to the State Route 60 east-west segment and finally reaching Interstate 15 in San Bernardino County; working to relieve the top 50 regional truck bottlenecks; adding mainline tracks for the Burlington Northern Santa Fe (BNSF) San Bernardino and Cajon Subdivisions and the Union Pacific Railroad (UPRR) Alhambra and Mojave Subdivisions; expanding/modernizing intermodal facilities; building highway-rail grade separations; improving port area rail infrastructure; reducing environmental impacts by supporting the deployment of commercially available low-emission trucks and locomotives; and, in the longer term, advancing technologies to implement a zero- and near zero-emission freight system.

LEVERAGING TECHNOLOGY

Advances in communications, computing and engineering—from shared mobility innovations to zero-emission vehicles—can lead to a more efficient transportation system with more mobility options for everyone. Technological innovations also can reduce the environmental impact of existing modes of transportation. For example, alternative fuel vehicles continue to become more accessible for retail consumers and for freight and fleet applications—and as they are increasingly used, air pollution can be reduced. Communications technology, meanwhile, can improve the movement of passenger vehicles and connected transit vehicles. As part of the 2016 RTP/SCS, SCAG has focused location-based strategies specifically on increasing the efficiency of Plug-in Hybrid Electric Vehicles (PHEV) in the region. These are electric vehicles that are powered by a gasoline engine when their battery is depleted. The 2016 RTP/SCS proposes a regional charging network that will increase the number of PHEV miles driven on electric power, in addition to supporting the growth of the PEV market generally. In many instances, the additional chargers will create the opportunity to increase the electric range of PHEVs, reducing vehicle miles traveled that produce tail-pipe emissions.

IMPROVING AIRPORT ACCESS

Recognizing that the SCAG region is one of the busiest and most diverse commercial aviation regions in the world and that air travel is an important contributor to the region's economic activity, the 2016 RTP/SCS includes strategies for reducing the impact of air passenger trips on ground transportation congestion. Such strategies include supporting the regionalization of air travel demand; continuing to support regional and inter-regional projects that facilitate airport ground access (e.g., High-Speed Train); supporting ongoing local planning efforts by airport operators, county transportation commissions and local jurisdictions; encouraging the development and use of transit access to the region's airports; encouraging the use of modes with high average vehicle occupancy; and discouraging the use of modes that require "deadhead" trips to/from airports (e.g., passengers being dropped off at the airport via personal vehicle).

FOCUSING NEW GROWTH AROUND TRANSIT

The 2016 RTP/SCS plans for focusing new growth around transit, which is supported by the following policies: identifying regional strategic areas for infill and investment; structuring the Plan on centers development; developing "Complete Communities"; developing nodes on a corridor; planning for additional housing and jobs near transit; planning for changing demand in types of housing; continuing to protect stable, existing single-family areas; ensuring adequate access to open space and preservation of habitat; and incorporating local input and feedback on future growth. These policies support the development of:

- **High Quality Transit Areas (HQTAs):** areas within one-half mile of a fixed guideway transit stop or a bus transit corridor where buses pick up passengers at a frequency of every 15 minutes or less during peak commuting hours. While HQTAs account for only three percent of total land area in SCAG region, they are planned and projected to accommodate 46 percent of the region's future household growth and 55 percent of the future employment growth.
- **Livable Corridors:** arterial roadways where jurisdictions may plan for a combination of the following elements: high-quality bus frequency; higher density residential and employment at key intersections; and increased active transportation through dedicated bikeways.
- **Neighborhood Mobility Areas (NMAs):** strategies are intended to provide sustainable transportation options for residents of the region who lack convenient access to high-frequency transit but make many short trips within their urban neighborhoods. NMAs are conducive to active transportation and include a "Complete Streets" approach to roadway improvements to encourage replacing single- and multi-occupant automobile use with biking, walking, skateboarding, neighborhood electric vehicles and senior mobility devices.

IMPROVING AIR QUALITY AND REDUCING GREENHOUSE GASES

It is through integrated planning for land use and transportation that the SCAG region, through the initiatives discussed in this section, will strive toward a more sustainable region. The SCAG region must achieve specific federal air quality standards. It also is required by state law to lower regional greenhouse gas emissions. California law requires the region to reduce per capita greenhouse gas emissions in the SCAG region by eight percent by 2020—compared with 2005 levels—and by 13 percent by 2035. The strategies, programs and projects outlined in the 2016 RTP/SCS are projected to result in greenhouse gas emissions reductions in the SCAG region that meet or exceed these targets.

PRESERVING NATURAL LANDS

Many natural land areas near the edge of existing urbanized areas do not have plans for conservation and are vulnerable to development pressure. The 2016 RTP/SCS recommends redirecting growth from high value habitat areas to existing urbanized areas. This strategy avoids growth in sensitive habitat areas, builds upon the conservation framework and complements an infill-based approach.

FINANCING OUR FUTURE

To accomplish the ambitious goals of the 2016 RTP/SCS through 2040, SCAG forecasts expenditures of $556.5 billion—of which $275.5 billion is budgeted for operations and maintenance of the regional transportation system and another $246.6 billion is reserved for transportation capital improvements.

Forecasted revenues comprise both existing and several new funding sources that are reasonably expected to be available for the 2016 RTP/SCS, which together total $556.5 billion. Reasonably available revenues include short-term adjustments to state and federal gas excise tax rates and the long-term replacement of gas taxes with mileage-based user fees (or equivalent fuel tax adjustment). These and other categories of funding sources were identified as reasonably available on the basis of their potential for revenue generation, historical precedence and the likelihood of their implementation within the time frame of the Plan.

WHAT WE WILL ACCOMPLISH

Overall, the transportation investments in the 2016 RTP/SCS will provide a return of $2.00 for every dollar invested. Compared with an alternative of not adopting the Plan, the 2016 RTP/SCS would accomplish the following:

- The Plan would result in an eight percent reduction in greenhouse gas emissions per capita by 2020, an 18 percent reduction by 2035 and a 21 percent reduction by 2040—compared with 2005 levels. This meets or exceeds the state's mandated reductions, which are eight percent by 2020 and 13 percent by 2035.
- Regional air quality would improve under the Plan, as cleaner fuels and new vehicle technologies help to significantly reduce many of the pollutants that contribute to smog and other airborne contaminants that impact public health in the region.
- The combined percentage of work trips made by carpooling, active transportation and public transit would increase by about four percent,

with a commensurate reduction in the share of commuters traveling by single occupant vehicle.

- The number of Vehicle Miles Traveled (VMT) per capita would be reduced by more than seven percent and Vehicle Hours Traveled (VHT) per capita by 17 percent (for automobiles and light/medium duty trucks) as a result of more location efficient land use patterns and improved transit service.
- Daily travel by transit would increase by nearly one-third, as a result of improved transit service and more transit-oriented development patterns.
- The Plan would reduce delay per capita by 39 percent and heavy-duty truck delay on highways by more than 37 percent. This means we would spend less time sitting in traffic and our goods would move more efficiently.
- More than 351,000 additional new jobs annually would be created, due to the region's increased competitiveness and improved economic performance that would result from congestion reduction and improvements in regional amenities as a result of implementing the Plan.
- The Plan would reduce the amount of previously undeveloped (greenfield) lands converted to more urbanized uses by 23 percent. By conserving open space and other rural lands, the Plan provides a solid foundation for more sustainable development in the SCAG region.
- The Plan would result in a reduction in our regional obesity rate from 26.3 percent to 25.6 percent in areas experiencing land use changes, and a reduction in the share of our population that suffers with high blood pressure from 21.5 percent to 20.8 percent.

HOW WE WILL ENSURE SUCCESS

Our Plan includes several performance outcomes and measures that are used to gauge our progress toward meeting our goals. These include:

- Location Efficiency, which reflects the degree to which improved land use and transportation coordination strategies impact the movement of people and goods.
- Mobility and Accessibility, which reflects our ability to reach desired destinations with relative ease and within a reasonable time, using reasonably available transportation choices.
- Safety and Health, which recognize that the 2016 RTP/SCS has impacts beyond those that are exclusively transportation-related (e.g., pollution-related disease).
- Environmental Quality, which is measured in terms of criteria pollutants and greenhouse gas emissions.
- Economic Opportunity, which is measured in terms of additional jobs created as a result of the transportation investments provided through the 2016 RTP/SCS.
- Investment Effectiveness, which indicates the degree to which the Plan's expenditures generate benefits that transportation users can experience directly.
- Transportation System Sustainability, which reflects how well our transportation system is able to maintain its overall performance over time in an equitable manner with minimum damage to the environment and without compromising the ability of future generations to address their transportation needs.

The 2016 RTP/SCS is designed to ensure that the regional transportation system serves all segments of society. The Plan is subject to numerous performance measures to monitor its progress toward achieving social equity and environmental justice. These measures include accessibility to parks and natural lands, roadway noise impacts, air quality impacts and public health impacts, among many others.

LOOKING BEYOND 2040

The 2016 RTP/SCS is based on a projected budget constrained by the local, state and federal revenues that SCAG anticipates the region receiving between now and 2040. The Strategic Plan discusses projects and strategies that SCAG would pursue if new funding were to become available. The Strategic Plan discussion includes long-term emission reduction strategies for rail and trucks; expanding the region's high-speed and commuter rail systems; expanding active transportation; leveraging technological advances for transportation; addressing further regional reductions in greenhouse gas emissions; and making the region more resilient to climate change—among other topics. We anticipate that these projects and strategies may inform the development of the next Plan, the 2020 RTP/SCS.

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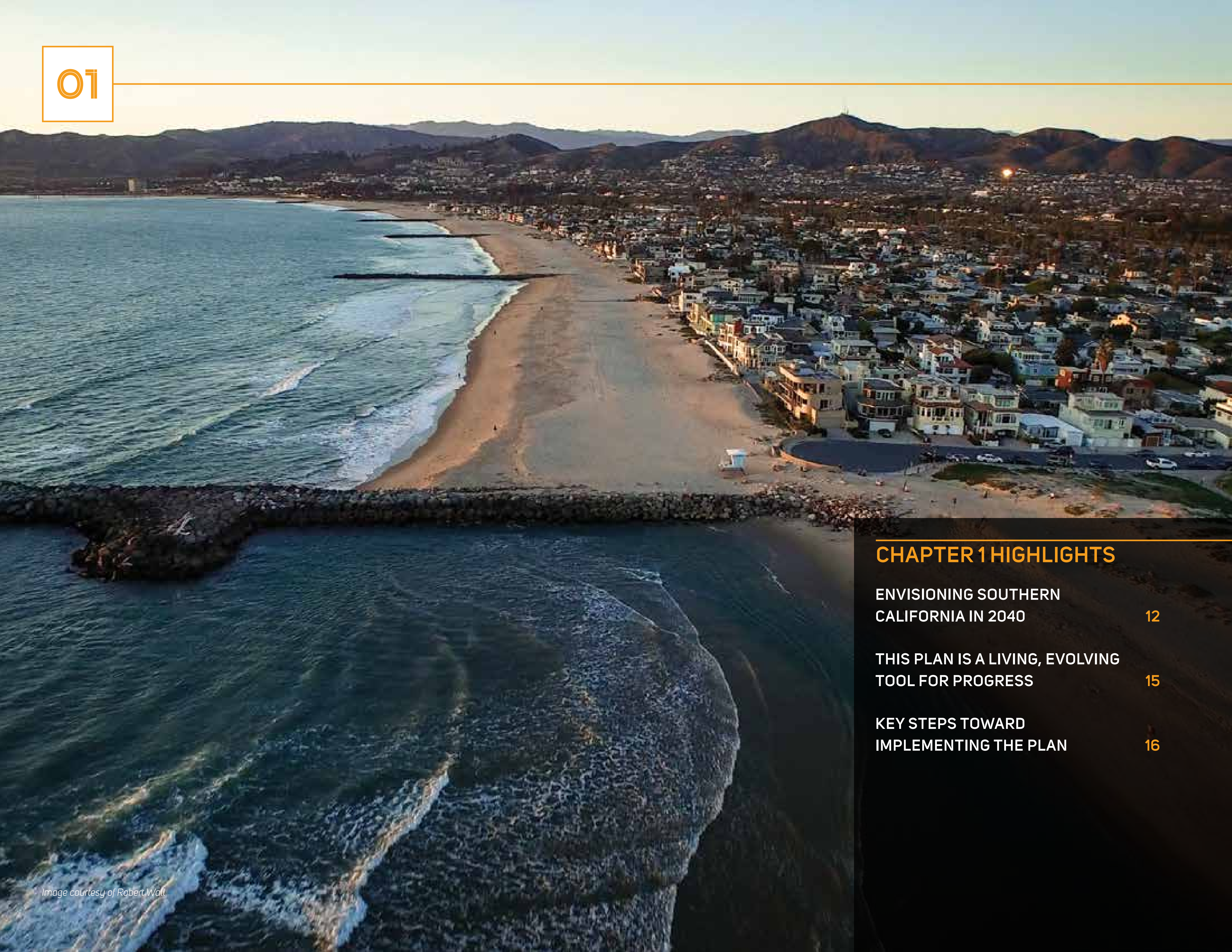


Image courtesy of Robert Wall

CHAPTER 1 HIGHLIGHTS

INTRODUCTION

Southern California is one of the most dynamic and beautiful places on the planet. A global center for entertainment and culture, commerce, tourism and international trade, our region is graced by a temperate climate, a spectacular coastline, rolling hills and inland valleys, towering mountain ranges, and expansive deserts. It is no wonder Southern California has become home to more than 18 million people.

ENVISIONING SOUTHERN CALIFORNIA IN 2040

OUR CHANGING REGION

Today, our region is in the midst of great changes. Our population continues to increase and demographics are shifting. In the coming years, Baby Boomers, born between 1946 and 1964, and Millennials, born between 1980 and 2000, will have an increasingly greater impact on how and where we live and how we travel. Overall, our region will continue to grow more racially and ethnically diverse in the coming decades. These and other changes will transform the character of Southern California over the next 25 years as people choose different places to live and more efficient ways to get around. People will have new expectations for the health and vibrancy of their communities. They will want a greater degree of mobility with transportation options that are more accessible and flexible. People will also expect to have more options for recreational space. They will want cleaner air. How our region responds to growth and the evolving priorities and desires of the people who live here will significantly shape our overall quality of life.

This 2016 RTP/SCS charts a course for closely integrating land use and transportation in certain areas of the region—so that we as a whole can grow smartly and sustainably. It outlines $556.5 billion in transportation system investments through 2040. The Plan was prepared through a collaborative, continuous and comprehensive (3 Cs) process by SCAG, the largest Metropolitan Planning Organization (MPO) in the nation. It serves as an update to SCAG's 2012 RTP/SCS.

It might seem obvious that as a region we should coordinate decisions about where people live, work, go to school, shop and spend their free time with decisions about the transportation system that serves them. But in a region as large and complex as ours, closely integrating strategies for land use and transportation is a huge undertaking. This Plan, more than just a list of projects and initiatives, tells an important story about our future. It is a story about how we will meet complex and daunting challenges in one of the biggest and most influential metropolitan regions in the world, and ultimately how working together we can integrate decisions about transportation and using land to realize a regional transportation system that promotes economic growth and sustainability.

CHALLENGES WE FACE

As we look to the future, we will confront many challenges, some of which we already face today and others that will emerge as we continue to grow. We are living now with the consequences of growth: more people, more houses, more jobs, more freight traffic and more cars. The six counties that encompass our region—Imperial, Los Angeles, Orange, Riverside, San Bernardino and Ventura—have all experienced the consequences of that growth. In our urban and suburban areas, roads and highways have grown increasingly congested. As a result, regional air pollution has worsened and greenhouse gas emissions that contribute to climate change have increased. Everyday trips to work, school, shopping and more have become more time consuming and in some cases more costly.

Neighborhoods that many people once considered affordable are now priced out of reach—particularly in established urban communities that have seen major public and private investments such as new transit access and new developments that mix upscale housing with popular stores and restaurants.

As our region's demographics change, there will be a greater desire for housing situated closer to jobs, healthcare, shopping and other amenities, and more public transportation options. The region will have to find ways to meet these demands.

Maintaining and enhancing a transportation system that can tackle these challenges will require adequate funding, and securing that funding for a better transportation system will be perhaps the region's biggest challenge. Our overall transportation system is aging rapidly and deteriorating. Deferring maintenance because of a lack of funding will continue to strain the system.

As our economy grows, freight traffic will increase on our roadways, along rail lines, and at our airports and seaports. This will place new demands on general transportation infrastructure such as highways and surface streets, as well as infrastructure specific to international trade and domestic commerce. This growth in goods movement also will contribute to air pollution, making it harder for the region to attain federal standards for air quality and comply with new state rules for lowering greenhouse gas emissions.

Meanwhile, our region faces huge public health challenges, as people suffer from chronic diseases associated with poor air quality and a lack of physical activity. This is why it is so critical to integrate decisions about where we live and work with decisions about how we travel. It matters how neighborhoods

SUSTAINABILITY

The practice of analyzing the impacts of decisions, policies, strategies and development projects on the Environment, the Economy and Social Equity

are laid out and linked to bus lines, bike and walking paths, and other transportation options.

Finally, our region faces the huge challenge of confronting and coping with the consequences of climate change. Making communities more resilient to heat waves, wildfires, rising seas, extreme rainstorms and other projected impacts will depend on smart planning. We'll review these challenges in more depth in Chapter 3.

REALIZING OUR VISION FOR A BETTER FUTURE

The 2016 RTP/SCS outlines concrete steps for meeting these challenges, and creating the conditions and infrastructure that result in increased mobility, easier access to destinations, and more transportation options. The Plan also analyzes the impacts of its decisions, policies, strategies and development projects on the environment, the economy and social equity. By doing this, the 2016 RTP/SCS promotes a sustainable future in which the environment is protected, economic growth is supported and the Plan's benefits are widely distributed.

The 2016 RTP/SCS envisions vibrant, livable communities that are healthy and safe with transportation options that provide easy access to schools, jobs, services, health care and other basic needs. These communities will be conducive to walking and bicycling and will offer residents improved access to amenities such as parks and natural lands. Collectively, these communities will support opportunities for business, investment and employment and fuel for a more prosperous economy. This vision recognizes the region's tremendous diversity, and that no single solution will work everywhere.

SCAG worked closely with local jurisdictions to develop the Plan, which incorporates local growth forecasts, projects and programs and includes complementary regional policies and initiatives. Because SCAG encompasses six counties, it is important that the 2016 RTP/SCS reflect the region's diverse needs and priorities. Every effort was made to ensure that this happened.

Since 2009, every MPO in California has been required to develop a Sustainable Communities Strategy as part of its Regional Transportation Plan—therefore the name "RTP/SCS." This SCS is a vital part of the overall Plan. It charts a course for how the SCAG region will reach state-mandated reductions in greenhouse gas emissions from cars and light trucks, which contribute to climate change. This SCS will be discussed extensively in the coming pages. The SCS is a driving force of this Plan, although not the only one. Once implemented along with the rest of the Plan, it will improve the overall quality of life for all residents of the region.

While our region faces great challenges, we are living at a time of technological and economic innovation that will help us meet those challenges. New mobility innovations can help the region meet the challenges of growth and increasing demands on our transportation system. Automated vehicles, drivers available on demand, data-driven infrastructure, and vehicles that respond to both their passengers and the environment are among the new mobility innovations that will reshape how we travel throughout the region. Many people, particularly Millennials, are already embracing some of these mobility innovations and are likely to be early adopters as new ones emerge. But these advances in mobility also have the potential to help all generations maintain their independence as they age.

The Plan considers new patterns of development as the regional economy continues to recover and grow, the composition of our population changes, the housing market responds to evolving needs, and demands and mobility innovations emerge. The Plan also includes a long-term strategic vision for the region that will help guide decisions for transportation and how we use land, as well as the public investments in both, through 2040.

MAJOR THEMES IN THE 2016 RTP/SCS

Throughout this Plan you will read about important themes that resonate throughout the document and help define its focus. A few have already been introduced. These themes include:

Integrating strategies for land use and transportation. The Plan recognizes that transportation investments and future land use patterns are inextricably linked, and continued recognition of this close relationship will help the region make choices that sustain our existing resources and expand efficiency, mobility and accessibility for people across the region. In particular, the Plan draws a closer connection between where we live and work, and it offers a blueprint for how Southern California can grow more sustainably.

Striving for sustainability. Creating a more sustainable region means growing and living in ways that use our resources efficiently to survive and prosper—from the water we drink, to the air we breathe, to the energy we consume. It is essential that we strive for regional environmental sustainability as we also confront the potential impacts of continued climate change on our transportation infrastructure and communities. In Southern California, striving for sustainability includes achieving state-mandated targets for reducing greenhouse gas emissions from cars and light trucks and federal air quality conformity requirements, and also adapting wisely to a changing environment and climate.

Protecting and preserving our existing transportation infrastructure. The Plan places a priority on investing in the transportation system we already have, to maintain and extend its life and utility. It recognizes that deferring maintenance of infrastructure leads to costlier repairs in the future.

Increasing capacity through improved systems management. Pouring new concrete is not the only way to add capacity to our roadways. Transportation Systems Management, or TSM, is a powerful strategy that aims to improve the capacity and efficiency of the existing transportation system without resorting to large-scale and expensive capital improvements. Examples of TSM projects include coordinating traffic signals along a corridor; deploying changeable message signs that display real-time road information; and ramp meters that control the timing of vehicles driving onto highways.

Giving people more transportation choices. The Plan will provide people with more options for transportation and mobility, offering them various alternatives to driving alone. This will be accomplished by enhancing public transit capacity and increasing its viability by making it more accessible; completing critical road connections; providing greater opportunities for biking and walking, particularly for short trips; exploring how people might use alternative fuel vehicles within their neighborhoods and beyond; increasing telecommuting and flexible work schedules; encouraging new mobility innovations; and improving safety. These Transportation Demand Management, or TDM, strategies will help us better manage the demand we place on the roadway network by reducing the number of people who drive alone and encouraging them to use alternative modes of travel.

Leveraging technology. Advances in communications, computing and engineering—from shared mobility innovations to zero-emissions vehicles—can lead to a more efficient transportation system with more mobility options for everyone. Technological innovations also can reduce the environmental impact of existing modes of transportation. For example, alternative fuel vehicles continue to become more accessible for retail consumers and for freight and fleet applications—and as they are increasingly used, air pollution can be reduced. Communications technology, meanwhile, can improve the movement of passenger vehicles and connected transit vehicles. Moreover, the way urban and suburban areas are shaped can support and encourage shared mobility and other new forms of transportation.

Responding to demographic and housing market changes. The region's demographics and housing market are fluid and dynamic. The housing market has rebounded since the 2012 RTP/SCS was adopted, and the number of Millennials and empty nesters has continued to increase with many seeking smaller housing and a more walkable lifestyle. For many households in the region, minimizing transportation and housing costs remains a priority. The Plan includes strategies focused on compact infill development, superior placemaking (the process of creating public spaces that are appealing), and expanded housing and transportation choices. The goal is to create a region that can respond to changing demographics and markets.

Supporting commerce, economic growth and opportunity. The Plan supports economic growth by building the infrastructure the region needs to promote the smooth flow of goods and easier access to jobs, services, educational facilities, healthcare and more. The Plan also preserves natural lands, improves air quality and creates vibrant urban centers—all of which are critical for attracting and retaining the people and jobs Southern California needs to thrive.

Promoting the links among public health, environmental protection and economic opportunity. The Plan places a priority on implementing the integration of transportation and land use strategies to improve our overall health. The Plan will result in improved air quality, provide more opportunities for people to be physically active, and protect natural lands and habitats. The result: communities will become healthier places to live, allowing people and businesses to thrive.

Building a Plan based on the principles of social equity and environmental justice. The Plan is designed to create regionwide benefits that are distributed equitably, while avoiding having any one group carrying the burdens of development disproportionately. It is particularly important that the Plan consider the consequences of transportation projects on low-income and minority communities and minimize negative impacts. In striving for environmental justice, the Plan provides specific measures to lessen the negative environmental impacts of transportation projects on these communities, as well as metrics to monitor how successful these measures are throughout the communities.

THIS PLAN IS A LIVING, EVOLVING TOOL FOR PROGRESS

WHY SCAG UPDATES THIS PLAN

The State of California and the federal government require that SCAG and other regional planning agencies update their respective Regional Transportation Plan/Sustainable Communities Strategy every four years. Key laws and requirements drive our work. Two primary mandates include:

- SCAG is required by federal law to prepare and update a long-range (minimum of 20 years) RTP (23 U.S.C.A. §134 et seq). Most areas within the SCAG region have been designated as nonattainment or maintenance areas for one or more transportation-related criteria pollutants. Pursuant to the federal Clean Air Act, SCAG's 2016 RTP/SCS is required to meet all federal transportation conformity requirements, including: regional emissions analysis, financial constraint, timely implementation of transportation control measures, and interagency consultation and public involvement (42 U.S.C. §7401 et seq).
- California Senate Bill 375 (SB 375) requires that the RTP also include an SCS, which outlines growth strategies that better integrate land use and transportation planning and help reduce the state's greenhouse gas emissions from cars and light trucks (California Government Code §65080 (b)(2)(B). The RTP is combined with the SCS to form the RTP/SCS, which is further detailed in Chapter 5. For the SCAG region, the California Air Resources Board (ARB) has set greenhouse gas reduction targets at eight percent below 2005 per capita emissions levels by 2020, and 13 percent below 2005 per capita emissions levels by 2035. As we will discuss in this Plan, the region will meet or exceed these targets, lowering greenhouse gas emissions (below 2005 levels) by eight percent by 2020; 18 percent by 2035; and 21 percent by 2040.

While SCAG is required to meet these statutory requirements, all good long-term plans are routinely re-evaluated and updated. SCAG is committed to ensuring that the RTP/SCS is a living document that evolves as the region's demographics, priorities, desires and economy change.

MOBILITY AND ACCESSIBILITY

MOBILITY refers to how quickly and efficiently people can travel from one location to another. ACCESSIBILITY refers to how connected people's destinations are to transportation options.

Direct improvements to the transportation system can increase mobility. Two examples are speeding up train service and relieving congestion on highways. Improving accessibility requires better coordinating our investments for how we use land with our investments for transportation. Developing housing, businesses and other "Transit Oriented Development" around train stations, for example, improves accessibility.

BENEFITS BEYOND CLEANER AIR

This Plan, of course, is about much more than cleaner air and reduced greenhouse gas emissions, although those are primary goals. SCAG must plan for accommodating another 3.8 million residents in its region. The region also expects to add another 2.4 million jobs and 1.5 million new households by the Plan horizon of 2040. The strategies contained in the 2016 RTP/SCS are expected to produce numerous benefits. Among them are:

GREENHOUSE GASES

Components of the atmosphere (carbon dioxide, methane, nitrous oxide and fluorinated gases) that contribute to the greenhouse effect

- **Better Placemaking:** The Plan will promote the development of better places to live and work through measures that encourage more compact development in certain areas of the region, varied housing options, bicycle and pedestrian improvements, and efficient transportation infrastructure.
- **Improved Access and Mobility:** The Plan will encourage strategic transportation investments that add appropriate capacity and improve critical road conditions in the region, increase transit capacity and expand mobility options. Meanwhile, the Plan outlines strategies for developing land in coming decades that will place destinations closer together, thereby decreasing the time and cost of traveling between them.
- **Households save more money:** The Plan is expected to result in less energy and water consumption across the region, as well as lower transportation costs for households.
- **Improved Public Health and a Healthier Environment:** Improved placemaking and strategic transportation investments will help improve air quality; improve health as people have more opportunities to bicycle, walk and pursue other active alternatives to driving; and better protect natural lands as new growth is concentrated in existing urban and suburban areas.

These benefits add up to a simple and powerful idea: a more efficient transportation network and more livable and sustainable communities throughout our region.

KEY STEPS TOWARD IMPLEMENTING THE PLAN

To move forward on the Plan, SCAG needs to take some critical steps. Here are a few of them:

1. **Funding the Plan**

   The 2016 RTP/SCS includes a $556.5 billion financial plan, discussed in Chapter 6 and detailed further in the Transportation Finance Appendix, that identifies how much money will be available to support the region's capital, operating, maintenance and transportation system preservation needs over the life of the Plan. It includes a core revenue forecast of existing local, state and federal funding sources, along with new funding sources that are reasonably expected to be available through 2040.

   These new sources of funding include anticipated adjustments to state and federal gas tax rates based on historical trends and recommendations from two national commissions created by Congress; efforts to further leverage existing local sales tax measures; value capture strategies (e.g., tax increment financing); potential national freight program/freight fees; and passenger and commercial vehicle tolls for specific facilities. Other reasonably expected revenues in the future will come from innovative financing strategies, such as private equity participation. The Plan includes strategies to ensure that these sources of revenue are available, in accordance with federal guidelines.

   There is also a need to identify and secure funding to support deployment and implementation of the land use policies and strategies contained in the Plan to fully realize a sustainable regional vision. It will be essential to secure resources from the California Greenhouse Gas Reduction Fund, also know as Cap-and-Trade, in order to support the Plan's objectives. Additionally, innovative and emerging financing options such as Enhanced Infrastructure Finance Districts will need to be explored and implemented by local jurisdictions.

2. **Collaborating with Local Jurisdictions and Stakeholders**

   Implementing the Plan will require SCAG to continue working closely with all jurisdictions, just as it did during its development. In particular, SCAG will need to work with the six county transportation commissions responsible for managing and prioritizing the portfolio of transportation investments in their respective counties. SCAG also must work with the California Department of Transportation (Caltrans), transit operators, port and airport authorities, and other implementing agencies. In addition, the agency will have to work with the local jurisdictions and counties responsible for land use and transportation planning, and the air quality management districts in charge of monitoring conditions throughout the region. The agency will also have to work with key stakeholders including local public health departments to ensure that the Plan benefits the economy and promotes social equity. To ensure that the region makes progress on its goals, SCAG will monitor its own progress toward achieving its targets and will share this information with its partners and the public.

3. **Looking Ahead Beyond 2040**

To fully address our region's long-term needs, SCAG must consider strategies and investments beyond what is contained in the financially constrained portion of the 2016 RTP/SCS—that is, the investment plan built on revenues that are reasonably expected over the life of the Plan. Chapter 9 provides an overview of potential programs and policies that may be implemented if additional funding becomes available in the future. These include:

- Long-term emission-reduction investments for trucks and rail
- Unfunded operational improvements
- Unfunded capital improvements
- Expansion of our region's high-speed rail and commuter rail systems
- Increased use of active transportation
- Technology and new mobility innovations
- Expansion of the regional network of express lanes

SCAG expects that the 2016 RTP/SCS Strategic Plan will influence the next update to the RTP/SCS in 2020, and the strategies detailed above will eventually be incorporated into future investment plans.

Chapter 2 discusses the current transportation system in the region, how we use land today and also a graphic overview of progress achieved since the 2012 RTP/SCS was adopted. It will be followed in Chapter 3 with a review of challenges we face as a region. The first three chapters of the 2016 RTP/SCS set the stage for a discussion of the Plan's development in Chapter 4 and a comprehensive review of the Plan's strategies, programs and projects in Chapter 5.

THE RTP/SCS

WHAT'S REQUIRED

- Long-term vision of how the region will address regional transportation and land use challenges and opportunities
- Investment framework

FEDERAL

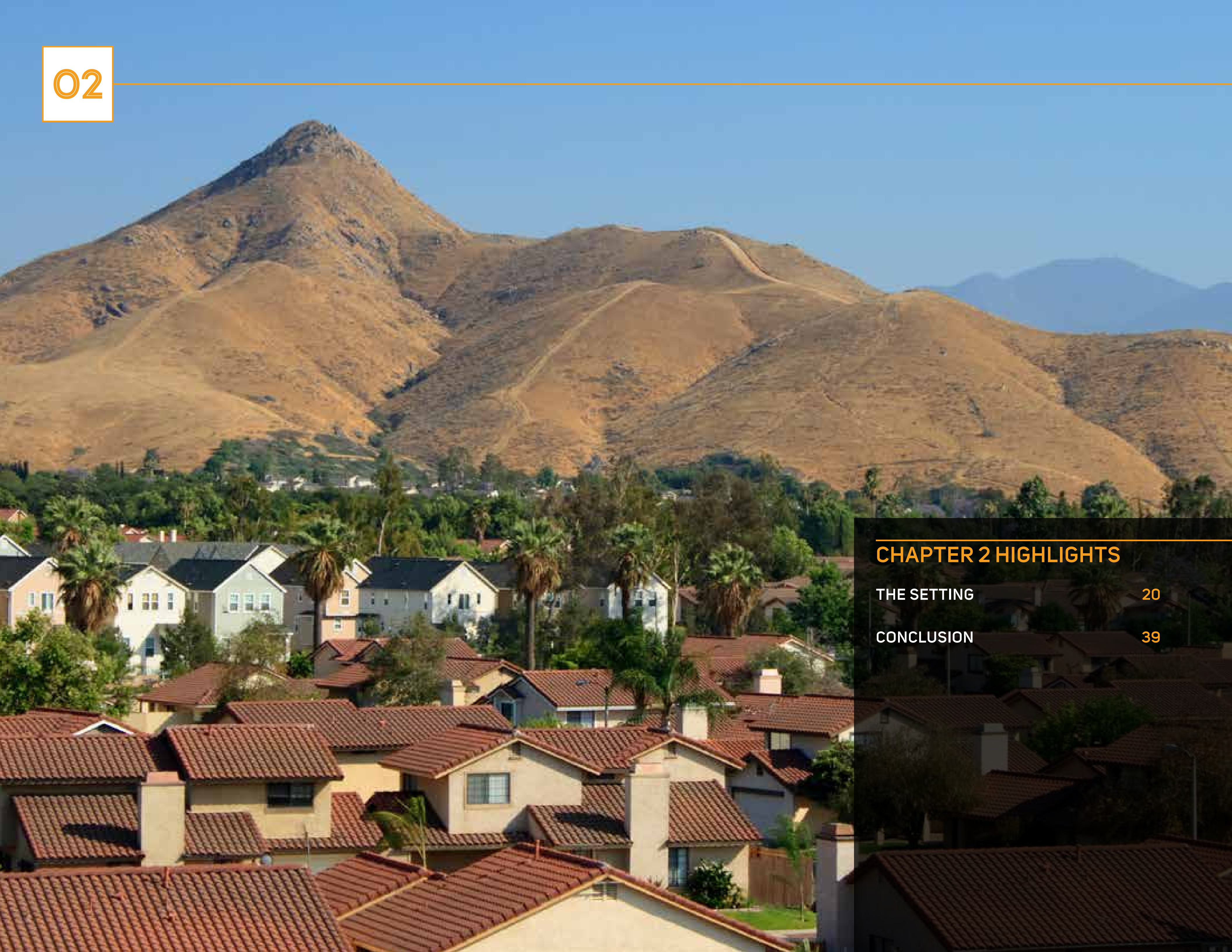
- Updated every four years to maintain eligibility for federal funding
- Long-range: 20+ years into the future
- Demonstrate transportation conformity
  - Regional emissions analysis
  - Financially-constrained (revenues = costs)
  - Timely implementation of transportation control measures
  - Interagency consultation and public involvement
- Must be developed in consultation/coordination with key stakeholders

STATE

- Achieve SB 375 requirements (reduce greenhouse gas emissions from cars and light trucks)

WHAT'S INCLUDED

- Vision, policies and performance measures
- Forecasts (e.g., population, households, employment, land use and housing needs)
- Financial plan
- List of projects (to be initiated and/ or completed by 2040)
- Analysis of priority focus areas (e.g., goods movement and active transportation)



02

CHAPTER 2 HIGHLIGHTS

WHERE WE ARE TODAY

To plan effectively for the future, it is important to understand the current conditions of land use and transportation throughout our large and complex region. This chapter reviews those current conditions.

THE SETTING

HOW WE USE LAND TODAY

SCAG recognizes that decisions by local jurisdictions about how land is used can impact the regional transportation system, and decisions about regional transportation investments can impact land use. The agency also understands that most land use planning is typically conducted by local jurisdictions, while regional and state agencies often make major decisions about transportation investments.

This is why it is critical for the region to integrate strategies for our transportation system with strategies for how we use land. Only by doing this can we achieve sustainable growth and a high quality of life for our region. This first section of Chapter 2 offers an overview of how we use land in the SCAG region, and its relevance to improving our regional transportation system as we head toward 2040.

CATEGORIZING LAND USE

Of the 38,000 square miles of total land in the SCAG region, only 21 percent is suitable for development. Of this limited developable land, more than half has already been fully developed. However, of the remaining developable land, only a small portion of it can be developed as sustainable transit-ready infill—meaning it can be reached via planned transit service and that it can readily access existing infrastructure (water resources, sewer facilities, etc.). According to regional land use data, only two percent of the total developable land in the region is located in High Quality Transit Areas (HQTAs), defined as areas within one-half mile of a well-serviced fixed guideway transit stop, and including bus transit corridors where buses pick up passengers every 15 minutes or less during peak commute hours. A more compact land development strategy is needed, which will be discussed in Chapter 5. Please note that this limited remaining land for future development does not account for potential reductions of developable acreage resulting from conservation efforts currently underway.

As the agency prepared the 2016 RTP/SCS, it needed to organize the many different types and classifications of land uses in the region for required technical analyses. The SCAG region is diverse and large, and the types and classifications of land use used by one jurisdiction often differ from those used by another. The result is that there are many different land use types and classifications that SCAG must organize for its own analyses.

To accurately represent land uses throughout the region, SCAG aggregated information from jurisdictions and simplified the types and classifications of land use into a consolidated set of land use types. The agency then converted these consolidated land uses into 35 "Place Types" to reflect the diversity of land use planning. Descriptions, standards and graphic examples of each Place Type can be found in the Reference Documents section of the SCS Background Documentation Appendix. These Place Types were used in an urban setting design tool known as the Urban Footprint Scenario Planning Model (SPM), to demonstrate urban development in the Plan in terms of form, scale and function in the built environment.

SCAG then classified the Place Types into three Land Development Categories (LDCs). A table of how the 35 Place Types were categorized into the three LDCs can be found in the Reference Documents section of the SCS Background Documentation Appendix. The agency used these categories to describe the general conditions that exist and/or are likely to exist within a specific area. They reflect the varied conditions of buildings and roadways, transportation options, and the mix of housing and employment throughout the region. The three Land Development Categories that SCAG used are:

1. **Urban:** These areas are often found within and directly adjacent to moderate and high density urban centers. Nearly all urban growth in these areas would be considered infill or redevelopment. The majority of housing is multifamily and attached single-family (townhome), which tend to consume less water and energy than the larger types found in greater proportion in less urban locations. These areas are supported by high levels of regional and local transit service. They have well-connected street networks, and the mix and intensity of uses result in a highly walkable environment. These areas offer enhanced access and connectivity for people who choose not to drive or do not have access to a vehicle.
2. **Compact:** These areas are less dense than those in the Urban Land Development Category, but they are highly walkable with a rich mix of retail, commercial, residential and civic uses. These areas are most likely to occur as new growth on the urban edge, or as large-scale redevelopment. They have a rich mix of housing, from multifamily and attached single-family (townhome) to small- and medium-lot single-family homes. These areas are well served by regional

and local transit service, but they may not benefit from as much service as urban growth areas and are less likely to occur around major multimodal hubs. Streets in these areas are well connected and walkable, and destinations such as schools, shopping and entertainment areas can typically be reached by walking, biking, taking transit, or with a short auto trip.

3. **Standard:** These areas comprise the majority of separate-use, auto-oriented developments that have characterized the American suburban landscape for decades. Densities in these areas tend to be lower than those in the Compact Land Development Category, and they are generally not highly mixed. Medium- and larger-lot single-family homes comprise the majority of this development form. Standard areas are not typically well served by regional transit service, and most trips are made by automobile.

NATURAL LANDS AND FARM LAND

Southern California is one of the most biodiverse areas on the planet, with an enormous wealth of natural habitats, and flora and fauna that include species that only exist in Southern California. Our iconic mountain ranges, chaparrals, numerous rivers and expansive deserts make up our regional identity. Additionally, Southern California has a rich agricultural history and continues to be a food producer for the rest of the country. However, issues such as infrastructure needs, continuing development pressure, climate change and limited financial resources present significant challenges in protecting and maintaining the quality and quantity our natural lands and farm lands.

A considerable amount of the region's natural lands, including some key habitat areas, are already protected.[1] Some areas, especially near the edge of existing urbanized areas, do not have plans for conservation and are susceptible to development. These include lands that are important and unique habitats and have high per-acre habitat values, such as riparian habitat (i.e., areas adjacent to bodies of water such as streams or rivers). These habitat types tend to have high per-acre habitat values—meaning these areas are home to a high number of species and serve as highly functional habitats. Some key habitat types are underrepresented within areas of the region already under protection.

Local land use decisions play a pivotal role in the future of some of the region's most valuable habitat and farm lands. Many local governments have taken steps toward planning comprehensively for conserving natural lands and farm lands, while also meeting demands for growth. Across the region, transportation agencies and local governments have used tools, such as habitat conservation plans, to link land use decisions with comprehensive conservation plans in order to streamline development.

To support those and other comprehensive conservation planning efforts and to inform the local land use decision making process, SCAG has studied regional-scale habitat values (see EXHIBIT 2.1), developed a conservation framework and assembled a natural resource database.[2] Over the past several years, SCAG and regional partners such as county transportation commissions (CTCs), environmental organizations and local governments have supported natural land restoration, conservation and acquisition in ways that could contribute to reducing greenhouse gas emissions, streamlining projects and addressing climate change impacts to natural habitats. Please see the Natural & Farm Lands Appendix for additional details.

SHIFTING HOUSING TYPES

In the postwar era that shaped the physical landscape and popular image of Southern California, most households consisted of parents with children—often residing on large suburban lots with single-family houses. But in the 21st century, the region is witnessing demographic shifts that are influencing housing choices. Today, a smaller percentage of households have younger children at home, and the number of households without children is dramatically increasing. The housing market is expected to reflect these trends with an increased demand for smaller-lot single-family houses, as well as multifamily housing close to shopping, transit services and other amenities. Currently, 55 percent of the region's homes are detached single-family houses. Over the next 20 years, the region is projected to add another 1.5 million homes, and much of this increase will be homes on smaller lots and multifamily housing (33 percent single-family housing to 67 percent multifamily housing). Though new housing will tend to be multifamily housing, the region's overall housing stock will remain similar to the existing housing stock, with a breakdown of 49 percent single-family housing and 51 percent multifamily housing (see FIGURE 2.1).

OUR HOUSING NEEDS

As a Council of Governments, SCAG is required by California housing law to

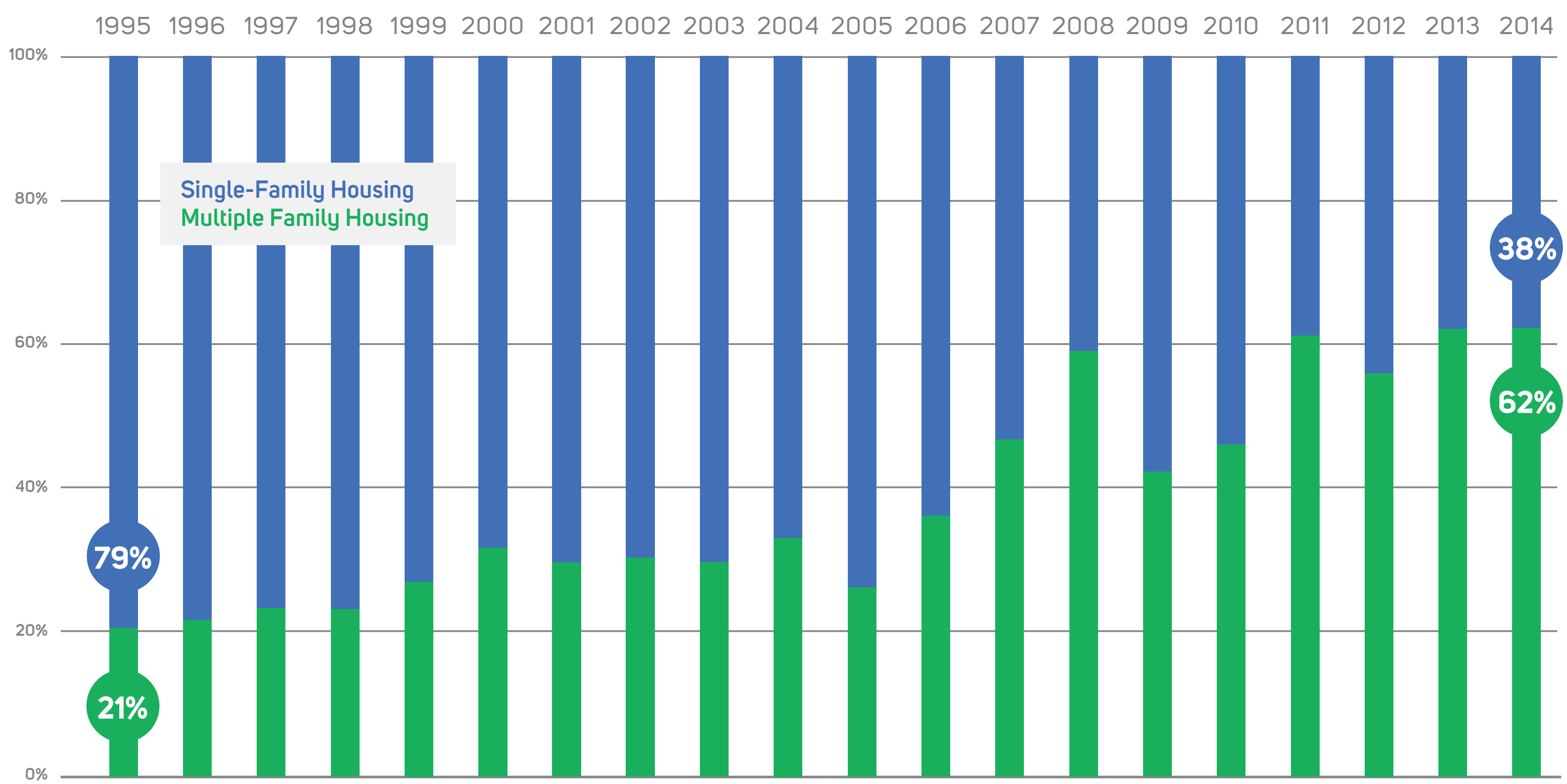
[1] O'Neill, T., & Bohannon, J. (2015). Conservation Framework and Assessment. SCAG.

[2] These documents can be found at: http://sustain.scag.ca.gov/Pages/LinksResources.aspx.

conduct a Regional Housing Needs Assessment (RHNA) every eight years. This assessment determines future housing needs for every jurisdiction in a given region for a specific time period. This determination is referred to as the RHNA allocation, which represents projected housing needs for an eight-year period, as required by state law. For our region, the most recent RHNA allocation, also known as the fifth RHNA cycle, was adopted by the SCAG's Regional Council in October 2012 and it covers a projection period between January 2014 and October 2021. The RHNA allocation breaks down housing needs into four income categories: very low (less than 50 percent of the county's median income); low (50 to 80 percent of the median); moderate (80 to 120 percent); and above moderate (more than 120 percent). For the fifth RHNA cycle, the regional RHNA allocation was 412,137 units, broken down as follows: 100,632 very low; 64,947 low; 72,053 moderate; and 174,505 above moderate.

However, although these housing units are planned and zoned for, available data sources indicate that the supply of affordable housing has not met needs, despite strong building activity for market rate housing. For example, during the last RHNA cycle (2006–2014), nearly 22,000 units were constructed using Low Income Housing Tax Credits (LIHTC), a rough benchmark in affordable housing building activity for households with very low income. This building activity represents about 12 percent of the 165,457 units in this category regionally. In contrast, more than 150,000 single-family homes, most likely

FIGURE 2.1 SCAG REGION SHARE OF MULTIPLE/SINGLE BUILDING PERMITS ISSUED



Source: U.S. Census Bureau, Security Pacific National Bank (Prior to 1987) and Construction Industry Research Board (1988 to present)
Single-family housing units include detached, semi-detached, row house and town house units. Multifamily housing includes duplexes, 3-4 unit structures, and apartment type structures with five units or more.

EXHIBIT 2.1 HABITAT VALUE

Per-Acre Habitat Value

Urban/Agricultural (2.39 to 8.75) | Low (8.76 to 14.20) | Medium (14.21 to 17.48) | High (17.49 to 20.28) | Very High (20.29 to 24.43) | Basin | County Boundaries

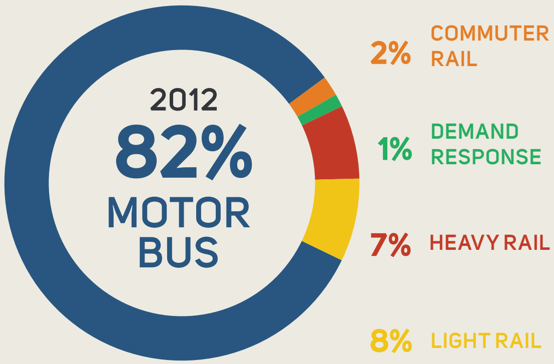
Habitat value refers to the numeric value of a site or area based on an assessment that takes into account species, habitat and functional relationship. The assessment tool aims to spatially capture biodiversity and complexity based on peer-reviewed informational data sets. Please see the Natural & Farm Lands Appendix for a more detailed description of the assessment used to develop the Habitat Value map.

(Source: SCAG)

FOCUS TRANSIT

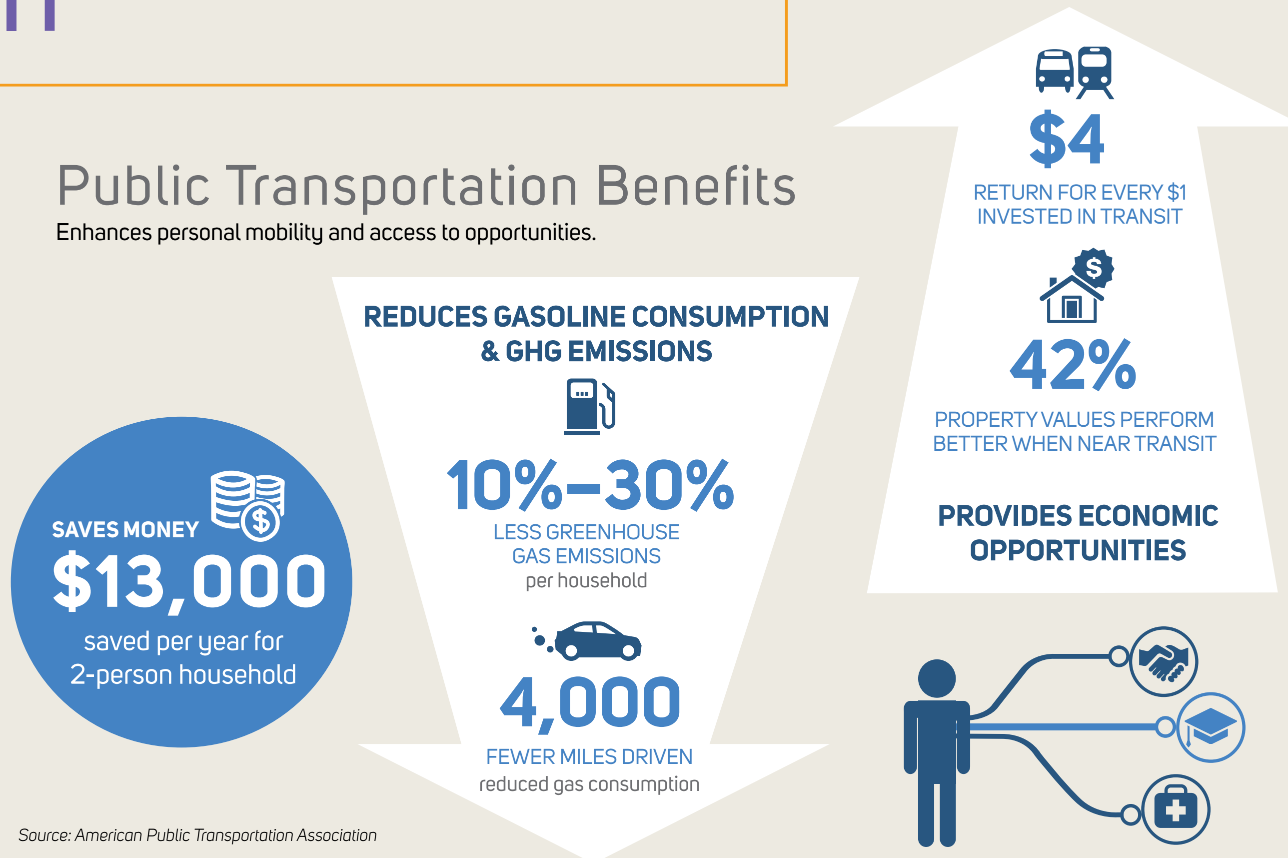
Transit Trips by Mode

The share of bus trips in the region has decreased over time but buses still represent the majority of all transit modes.



Public Transportation Benefits

Enhances personal mobility and access to opportunities.

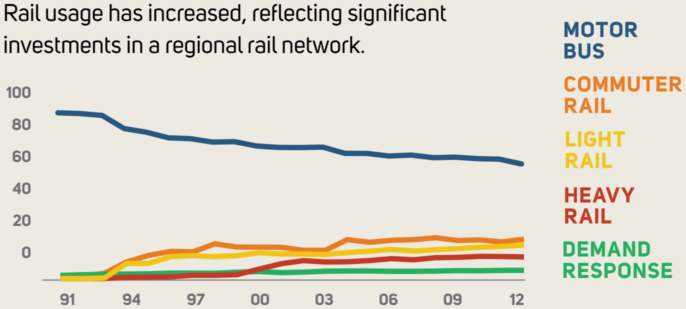


Source: American Public Transportation Association

Passenger Miles by Mode

(percent)

Rail usage has increased, reflecting significant investments in a regional rail network.



Transit Passenger Miles

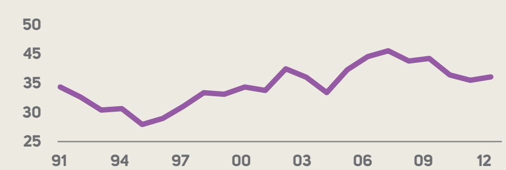
(millions)

Transit use has increased over the last 20 years. In 2012, transit riders took 711 million trips, traveling more than 3.6 billion miles. Growth in passenger miles was driven by a 15% increase in average transit trip length.

Transit Trips

(per capita)

Growth in transit use has not always kept up with population. The number of transit trips per person is about the same as it was 20 years ago.



suitable for the above moderate income category, representing more than 52 percent of the 293,547 above moderate units needed, were built over the same period. A similar trend can be seen in the first two years after the adoption of the fifth cycle RHNA (2013 and 2014), with barely 2,000 units of new construction reporting use of LIHTC while nearly 30,000 single-family units have been built during this time. No new construction using LIHTC was reported in 2014. Although LIHTC has historically been used in about one out of five new multifamily construction, this data suggests that market rate building activity is far stronger than building activity for very low income housholds and that the need for affordable housing continues to increase.

Within the housing elements of their General Plans, each jurisdiction in our region is required to show how it would accommodate its RHNA allocation for the designated period. This is accomplished through a sites and inventory analysis that evaluates zoning and land use policies. SCAG is tasked with providing the regional RHNA allocation, but housing elements are reviewed and approved by the California Department of Housing and Community Development. Since the fifth cycle adoption due date of October 2013, 84 percent of the region's jurisdictions have housing elements in compliance with state housing law. The next RHNA allocation for our region is anticipated to be adopted by SCAG in October 2020, with housing elements due by October 2021.

TABLE 2.1 2012 HQTA

COUNTY	WITHIN HQTA			
	HOUSEHOLDS	%	EMPLOYMENT	%
Imperial	0	-	0	-
Los Angeles	1,552,900	48%	2,357,400	56%
Orange	173,500	17%	392,900	26%
Riverside	3,200	0.50%	24,500	4%
San Bernardino	17,200	3%	39,600	6%
Ventura	6,800	3%	22,400	7%
SCAG	1,753,600	30%	2,836,800	38%

HIGH QUALITY TRANSIT AREAS (HQTAs) AND TRANSIT PRIORITY AREAS (TPAs)

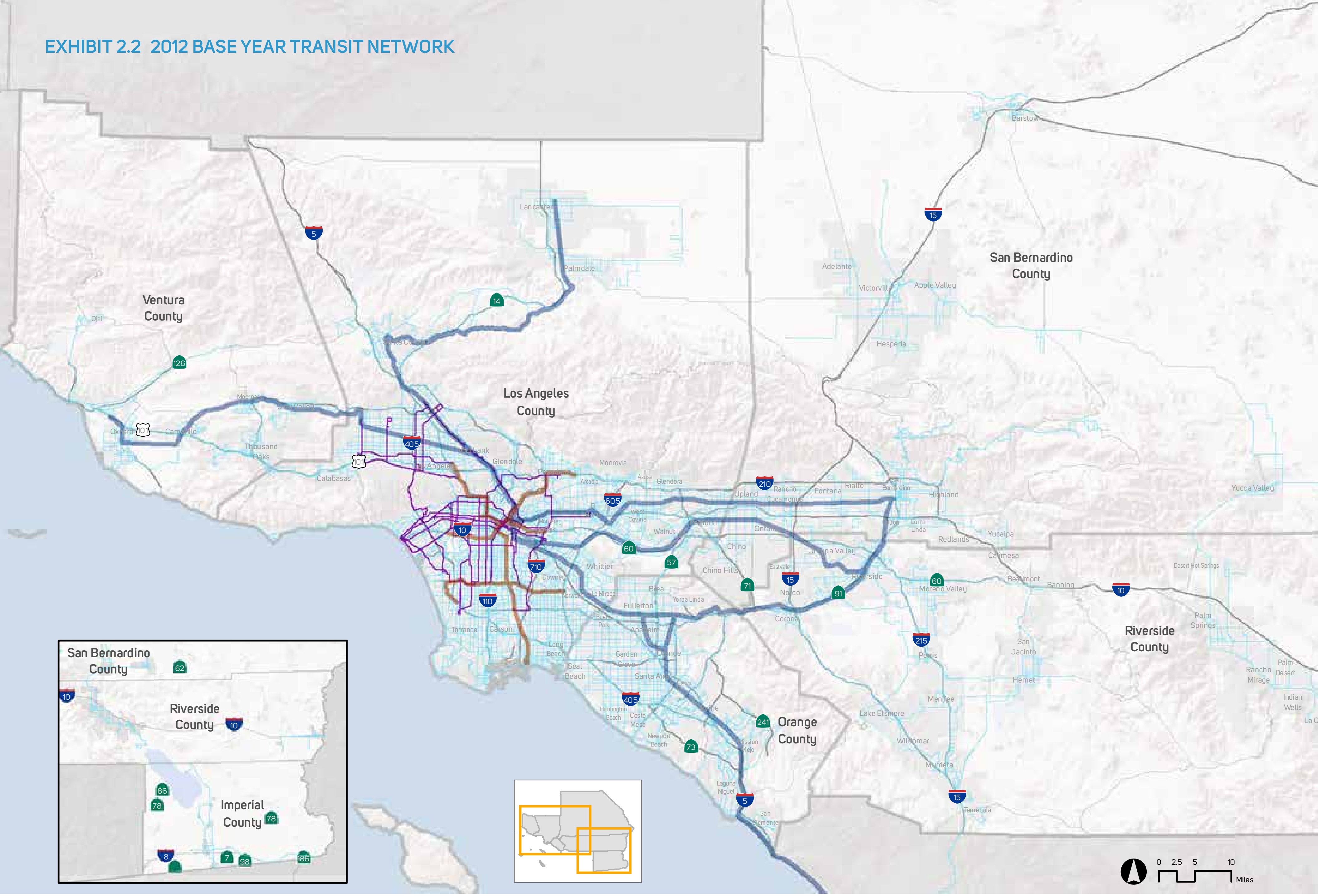
The overall land use pattern detailed in the 2012 RTP/SCS reinforced the idea of focusing new housing and employment within the region's HQTAs. For planning purposes, an HQTA, as we have mentioned, is defined as an area within one-half mile of a well-serviced fixed guideway transit stop, and it includes bus transit corridors where buses pick up passengers every 15 minutes or less during peak commute hours. The 2012 RTP/SCS also identified Transit Priority Areas (TPAs), which are defined as locations where two or more high-frequency transit routes intersect. Currently, more than five million residents in the region live within HQTAs. These HQTAs currently accommodate 2.8 million jobs (see TABLE 2.1).

High density development could also produce high quality housing with consideration of urban design, construction and durability, and result in increased ridership on important public transit investments. Local jurisdictions throughout the region are applying more sophisticated planning practices in the specific plans and zoning codes that govern these areas in order to promote this kind of development. As housing density increases in cities and HQTAs, local governments are investing in pedestrian and bike infrastructure and reducing parking requirements to support people who choose not to have a car or cannot afford one. Local jurisdictions are also creating and retaining affordable housing near transit, helping to increase connectivity to employment opportunities and reducing reliance on automobile ownership.

The positive effects on real estate values, retail sales and property taxes, as well as the social benefits of developing within HQTAs are also well documented.[3] For example, less automobile-dependent settings, like HQTAs, spur volunteerism, social interaction and community engagement with more opportunities for face-to-face contact. Creating active places that are busy throughout the day and evening also improves safety and reduces crime rates within the surrounding neighborhood. Increased retail sales and easy transit accessibility translate into higher business profits, rent, commercial real estate values and government property taxes. Similarly, housing value premiums associated with being near a transit station (usually expressed as being within one-quarter to one-half mile of a station) average 17 percent to 30 percent higher than comparable properties located elsewhere.

[3] Center for Neighborhood Technology. (2013). The New Real Estate Mantra: Location Near Public Transportation. Washington, D.C.

EXHIBIT 2.2 2012 BASE YEAR TRANSIT NETWORK



Bus Rapid Bus and Bus Rapid Transit Urban Rail Commuter Rail

(Source: SCAG)

HQTAs and TPAs are powerful examples of how integrating strategies for land use and transportation can help us achieve our long-term goals for greater mobility, a strong economy and sustainable growth. In the next section of this chapter, we will discuss the state of our overall transportation system today. That will help us set the stage for Chapter 5, where we will review our strategies, programs and projects for our transportation system and explain how we will integrate them with how we use land. Efficient use of our land is the basis for an efficient transportation system.

HOW WE TRAVEL TODAY

TRANSIT

Our regional transit system today is comprised of an extensive network of services provided by dozens of operators. This network includes fixed-route local bus lines, community circulators, express and rapid buses, Bus Rapid Transit (BRT), demand response,[4] light rail transit, heavy rail transit (subway) and commuter rail.[5] The region's providers of transit offer the second largest amount of service in the country, after that of the New York City metropolitan area (see EXHIBIT 2.2).

Transit plays an important role in Southern California's integrated transportation system. It provides an alternative to driving for many and provides mobility to people who do not have cars. The transit network is the region's largest non-automotive passenger transportation mode by trip volume, by a huge degree. Riders of transit took more than eight times as many trips as air travelers in FY2011-12 and nearly 267 times as many trips as passenger rail travelers.

Transit use provides external benefits to the region's transportation system, through investment, reduced traffic congestion and air pollution emissions reductions. The American Public Transportation Association (APTA) estimates that for every billion dollars invested in transit (as of 2007) about 36,000 jobs are created. This includes the direct purchasing power of transit agencies and also the spending power of the employees of transit agencies.[6] Were this rate to have held constant into FY2011-12, transit spending in the SCAG region would have resulted in the creation or maintenance of roughly 150,000 jobs.

The Texas Transportation Institute (TII), in its annual Urban Mobility Report, estimates traffic congestion delay averted due to the use of the region's public transportation system. In 2011, using transit helped residents of the SCAG region avoid 10 hours of delay per person, and saved the region more than $250 million in averted traffic delay costs.

Each of the region's residents take an average of 39 transit trips each year, at an operating and maintenance cost of $3.46 per trip (this amount increases to roughly $5.05 when both operations and capital expenditures are accounted for). Transit users typically pay 25 percent of the operating and maintenance cost of their travel, with the remaining 75 percent paid for by state and local public subsidies. Most capital expenditures are also funded with public subsidies, including a larger share of federal grants. Despite recent service cuts, the region's total combined capital and operations spending exceeded $3.59 billion in FY2011-12.

The past eight years have been tough economically for Southern California's transit agencies. Although bus service accounted for 82 percent of the region's transit trips in FY2011-12, the agencies that provide it have been hit particularly hard. Many have had to cut service. Total bus service provided by the Los Angeles County Metropolitan Transportation Authority (Metro) has declined by 10 percent, Orange County providers have cut bus service by 11 percent, and Los Angeles County Municipal Operators bus service has fallen by three percent.

These declines in service are tied to the Great Recession, as total ridership and per-capita ridership have stagnated. In FY2011-12, ridership of just under 711 million trips was up 1.7 percent compared with the prior year, but it represented a six percent decline from a pre-recession high of more than 750 million trips. The per-capita trip total of nearly 39 for FY2011-12 represents a loss of seven percent from the pre-recession high of more than 42 per-capita trips. Preliminary data for FY2014-15 show that total ridership and per capita ridership have continued to decline. Total transit trips are expected to fall below 700 million for the first time since FY2003-04.

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4 "Demand response" is defined as a transit mode comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations.

5 Commuter rail is discussed separately in more detail, along with intercity passenger rail such as Amtrak and CA High-Speed Train, as part of "Passenger Rail."

6 American Public Transportation Association, 2009, "Job Impacts of Spending on Public Transportation: An Update." White Paper.

Since 1991, transit agencies in the region have provided about 13.22 billion transit trips. In that time, urban rail and commuter rail have grown from 1.3 percent of transit trips to 16.1 percent of trips in 2012. Bus trips have declined from 98.6 percent of trips to about 83 percent. Urban and commuter rail together supply 11.6 percent of all Vehicle Revenue Miles because the per vehicle capacity is much higher than that of buses. Urban and commuter rail services are 20.9 percent of all transit operating expenses in our region.

PASSENGER RAIL

Southern California is served by an ever expanding passenger rail network, including intercity, commuter and freight services, and this network is expanding and improving in terms of capacity, efficiency and safety. Many capital, operational and safety improvements are underway and planned throughout this existing network, including transportation corridors currently not served by rail.

The region's passenger rail network, along with the number of passengers and service levels, has steadily grown since 1990, except for a dip during the Great Recession. In 1990, the only passenger rail service operating in the region was the Pacific Surfliner and Amtrak's long-distance trains such as the Coast Starlight and Southwest Chief. Metrolink began commuter rail service in October 1992, and it continues to expand its network and levels of service. The Pacific Surfliner, which carried 2.7 million passengers in FY2013-14, operates 11 daily round-trips between Los Angeles and San Diego, five round-trips between Los Angeles and Santa Barbara/Goleta, and two round-trips north to San Luis Obispo. The Pacific Surfliner is Amtrak's second busiest corridor, behind the Northeast Corridor between Washington, D.C. and Boston. The line's average speed is 46 miles per hour (mph).

The Southern California Regional Rail Authority (SCRRA), the operator of Metrolink, operates 165 weekday trains on seven lines and the system carried 11.7 million passengers in FY2013-14. Weekend service provides 34 trains on Saturdays and 28 on Sundays. Metrolink operates two round-trip express trains: one round-trip on the San Bernardino Line and one round-trip on the Antelope Valley Line (to Palmdale only). System-wide average speed is 37 mph.

Notable recent efforts include the first Metrolink e-ticketing program rollout in 2016. Also, the LOSSAN Rail Corridor (Los Angeles–San Diego–San Luis Obispo Rail Corridor) received a Cap-and-Trade Transit and Intercity Rail Capital Program grant in the spring of 2015 to re-establish a cooperative fare agreement with local connecting transit agencies for free transfers to and from the Pacific Surfliner. This program had never been fully developed by Caltrans Division of Rail (DOR), and recently it had been discontinued.

These cooperative fare agreements and media efforts include effective marketing across passenger rail markets and transit riders. Metrolink has been successful with its special service trains for both Dodgers' and Angels' games and other special events. These types of services introduce passenger rail to the general public and can lead to new regular customers.

In July 2015, Metrolink started a pilot fare project on the Antelope Valley Line. It included a 25-percent reduction in fares (except for the weekend day pass) and allowed station-to-station travel for just $2.00. Due to the success of this pilot program, on January 1, 2016 Metrolink implemented a $3.00 station-to-station fare system-wide. (The $2.00 station-to-station program was discontinued on the Antelope Valley Line, however the 25 percent fare reduction was extended to June 30, 2016.) Since 2012, Metrolink has offered its successful weekend pass, allowing unlimited travel throughout the entire Metrolink system on both Saturday and Sunday for just $10.00. (The fare has since increased to $10.00 per weekend day.) Monthly pass holders can take unlimited trips on the weekend.

The renaissance of rail travel in our region is exciting. However, significant challenges are keeping our commuter and intercity rail networks from realizing their full potential to help reduce highway congestion, and cut air pollution and lower greenhouse gas emissions. Among these challenges:

More than half of the commuter and intercity rail network operates on one track, some of which is owned by freight railroads that maintain priority for their own operations. Passenger trains are assigned "slots," meaning that they are allowed to move in a particular direction for a fixed time period. This results in the relatively slow average speeds noted above, reducing the incentive for commuters to use the train system (and instead prompting them to commute by car), as well as reducing the number of passenger trains that can serve our region.

One-track operations present other challenges. Even a minor delay can lead to a train losing its slot, thereby causing cascading delays throughout the network and throughout the day. Commuter and intercity rail networks in Chicago and on the East Coast have much higher service frequencies than we do in our region, mainly because they have fewer single-track segments and fewer conflicts with freight railroads. Our region has a large list of rail improvements either in the planning phases or which are ready for construction. These improvements include adding double-tracking, sidings, station improvements and grade separations to increase speed and service levels. However, there is no dedicated long-term funding for commuter and intercity rail to move these projects forward.

ACTIVE TRANSPORTATION

Our region has made steady progress in encouraging people to embrace active transportation, that is, human-powered transportation such as walking and biking. Across our region today, many people live and work in areas where trips are short enough to be completed by walking or biking. Walking and biking as a share of all trips is more than 18 percent in our most urban areas where there are abundant nearby destinations/land uses, yet still reaches 11 percent in rural areas where land uses are less diverse.[7] There is a strong relationship between land use and travel behavior. Land use characteristics play a key role in determining the conditions for and feasibility of walking and biking in a community, due to the sensitivity of these modes to trip length.

7 California Department of Transportation (2012). California Household Travel Survey.

HOW WE GET TO WORK

14% CARPOOL

76% DRIVE ALONE

5% TRANSIT *(Bus/Rail)*

5% NON-MOTORIZED *(Walk/Bike)*

Source: SCAG Regional Travel Demand Model

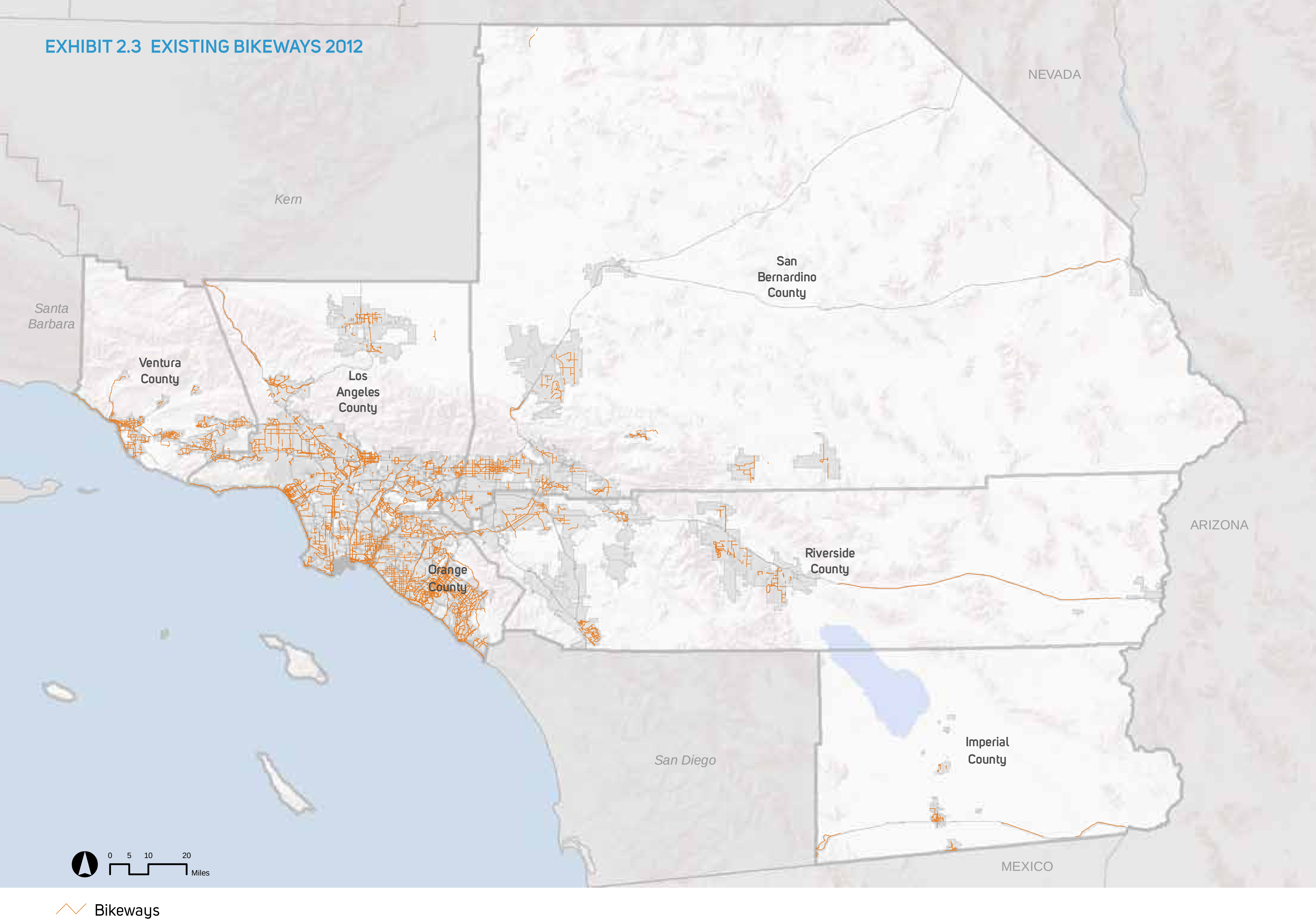
The regional bike network is expanding but remains fragmented. Nearly 500 additional miles of bikeways were built since SCAG's 2012 RTP/SCS, but only 3,919 miles of bikeways exist regionwide, of which 2,888 miles are bike paths/ lanes (see EXHIBIT 2.3).

Walking represents nearly 17 percent of all trips in the SCAG region, with the largest share in Los Angeles County. It is how most transit riders reach their station. Most walk trips (83 percent) are less than one half mile; walkers are less likely to travel further because of a lack of pedestrian friendly infrastructure. Routes to stops and stations are often circuitous and/or obstructed, increasing the time it takes to complete a trip by transit and therefore making the choice to use transit less attractive. A study in Los Angeles County found that the most common barriers to station access on foot or bicycle include: long blocks, highway over/underpasses, concerns about safety and security, sidewalk maintenance, legibility/lack of signage and right-of-way constraints leading to limited space for safe walking and biking.[8] Currently, all six counties in the SCAG region are pursuing first/last mile solutions to make transit or border crossing stations more accommodating to active transportation. Their efforts are aided by the Federal Transit Administration (FTA), which has extended the "walk-shed" (the area encircling a destination point) from transit stations from a quarter mile to a half mile, enabling transit funding to be used for larger areas around transit stations.[9] The "bike-shed," as defined through FTA guidance, extends three miles in all directions from a station.

While the number of bicyclists and pedestrians is increasing, so are injuries and fatalities—although not as fast as the growth overall in active transportation. Nevertheless, injuries among those who bike and walk are increasing at a time when the total number of traffic-related injuries and fatalities is dropping regionwide. Improving safety will likely require pursuing innovative strategies (as described in the following sections) to reduce conflicts among bicyclists, pedestrians and automobiles. In 2015, the City of Los Angeles began its Vision Zero Campaign. Vision Zero is a road safety policy that promotes smart behaviors and roadway design that anticipates mistakes, so that collisions do not result in severe injury or death.

8 Los Angeles County Metropolitan Transportation Authority (2014) First Last Mile Strategic Plan & Planning Guidelines.
9 Department of Transportation (Friday, August 19, 2011): Final Policy Statement on the Eligibility of Pedestrian and Bicycle Improvements Under Federal Transit Law. Federal Register Volume 76, Number 161 Pages 52046-52053.

EXHIBIT 2.3 EXISTING BIKEWAYS 2012



(Source: SCAG)

HIGHWAYS AND ARTERIALS

Our region's highways and arterials continue to be the backbone of our overall transportation network, and they are vital to moving people and goods throughout the region. Across the Southern California region, our highway and arterial system covers about 70,000 roadway lane miles and accommodates 66 million trips per day. Our roadways are not only used by automobiles and freight trucks, they are also used for transit and for those who choose to walk, bike and use other forms of active transportation. According to SCAG's Regional Travel Demand Model (RTDM), more than nine out of 10 trips rely either entirely or in part on the highway and arterial system. Based on currently available data, there are 3.6 million person-hours of daily delay and 11.8 minutes of daily delay per capita along our region's highways and local arterials.

Maintaining the operational efficiency of our roadways is crucial if we are to maintain the mobility of our region. Unfortunately, traffic congestion continues to adversely affect our highway and arterial system every day. Although we have made improvements, the increasing travel demands that will come with a growing population in coming years will lead to increased congestion. This traffic congestion will not only make life difficult for commuters, it will also degrade our region's air quality and our overall quality of life. To address congestion and to improve our transportation network's efficiency, the region has been investing in Transportation Systems Management and Transportation Demand Management projects as described in the following sections.

TRANSPORTATION SYSTEMS MANAGEMENT (TSM) AND TRANSPORTATION DEMAND MANAGEMENT (TDM)

For our regional transportation system to operate efficiently and smoothly, operators must manage the system effectively, as well as the demands placed on it. To do so, they implement TSM and TDM strategies.

TSM employs a series of techniques designed to maximize the capacity and efficiency of the existing transportation system and its facilities. One of these techniques deploys Intelligent Transportation Systems (ITS), which will be discussed below. TDM involves a variety of strategies to manage the demand placed on our roadway network and to reduce our dependence on driving alone. These include promoting ridesharing, value pricing,[10] telecommuting or alternative work schedules and alternative modes of travel such as transit, passenger rail and active transportation.

[10] Value pricing is a user fee applied during peak demand periods on congested roadways to improve the reliability and efficiency of the transportation system and provide travelers with greater choices.

The common goals of TSM and TDM are to improve the productivity of our transportation system, reduce traffic congestion, improve air quality and reduce or eliminate the need to construct new and expensive transportation infrastructure.

Transportation Systems Management (TSM)

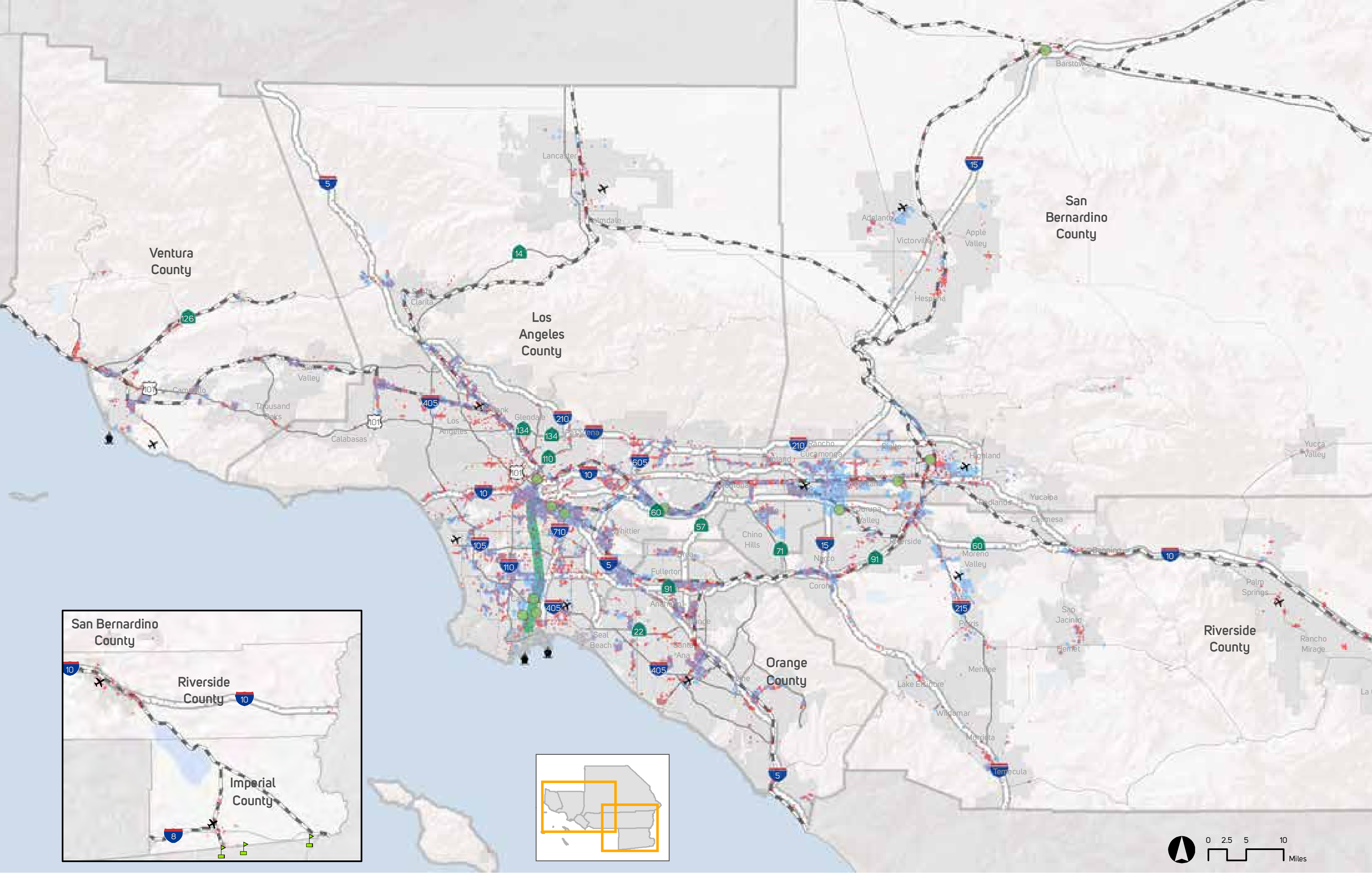
A critical TSM technique is Intelligent Transportation Systems, or ITS, which makes use of advanced detection, communications and computing technologies to improve the safety and efficiency of our surface transportation network. These systems allow system operators and users to better manage and optimize the capacity of the region's transportation system. Data is collected about the status of our highways, traffic signals, transit vehicles, freight vehicles, passenger trains and shared-ride vehicles and is integrated in ways that improve the efficiency of the overall transportation system.

SCAG has a critical role to play in the development and management of ITS in the region. As the region's Metropolitan Planning Organization, SCAG is charged with developing and maintaining the Southern California Regional ITS Architecture. This architecture is the regional planning tool for ensuring a cooperative process to prioritize and deploy ITS technologies and for identifying critical data connections between institutional stakeholders (e.g., connecting two transit operators). This architecture helps the region deploy ITS systems that are truly integrated. Stakeholders are able to share information among many agencies in consistent and compatible formats to achieve improved safety and efficiency. SCAG works closely with the CTCs, local governments and Caltrans Districts to update and maintain the regional architecture and assure the use of required systems, engineering requirements and applicable standards—which is required when federal funds are used on ITS projects.

The Southern California highway system has an extensive ITS system that covers most of the urbanized portion of our region. Loop detectors in the pavement and video cameras provide information on speed and volume, and identify congestion and incidents that are fed to Caltrans/California Highway Patrol (CHP) Transportation Management Centers (TMCs). Arterial ITS systems are in place throughout the region as well. Local arterial systems include advanced signal synchronization capabilities to increase the flow of traffic and also to detect and respond to changes in traffic volume or direction of travel and manage incidents. Like the highway network, these systems include loop and video detection and also rely on wireless data such as that provided by Google.

Most medium- to large-scale, fixed-route and Dial-a-Ride operators in our region have implemented transit ITS components. These include automatic

EXHIBIT 2.4 EXISTING REGIONAL GOODS MOVEMENT SYSTEM



Ports	Intermodal Facilities	**Routes**	**Warehouses**
Ports of Entry		Major Freight Highway Corridors / Alameda Corridor	>= 50,000 sq ft
Major Airports		Main Line Rail Network	< 50,000 sq ft

(Source: SCAG, CoStar Realty Information Inc.)

vehicle location (AVL) and transit signal priority (TSP) systems. Automatic vehicle location systems have greatly increased the effectiveness of real-time scheduling information, increasing convenience for transit passengers. TSP gives transit vehicles signal priority to improve passenger throughput and bus speed. The TSP system is an integral part of Metro's Rapid Bus program, which has 20 routes. Santa Monica's Big Blue Bus, Culver City Bus and Torrance Transit are others that employ TSP systems as well. Using a combination of hard-wired loop technology and wireless technology, they reduce travel times by up to 25 percent.

Transportation Demand Management (TDM)

Our region employs an array of TDM strategies to better manage the demand placed on our roadway network by reducing the number of people who drive alone as well as encouraging them to use alternative modes. As a consequence, these strategies have helped reduce air pollution and greenhouse gas emissions. These strategies include promoting carpooling and vanpooling; biking and walking; car sharing and bike sharing; telecommuting; flexible work schedules; and intelligent parking, among other strategies. The region has a long history of investing in a comprehensive High-Occupancy Vehicle (HOV) or carpool lane system, supported by investments in park-and-ride facilities, rideshare matching and vanpooling services. A 2014 national study of employers by the Families and Work Institute and the Society for Human Resource Management showed that employers are becoming more willing to provide employees with flexible work arrangements and more choices in managing work time, without loss of pay. As Baby Boomers continue to retire in increasing numbers and are replaced by younger, more tech-savvy workers, and as employers continue to embrace technology and remote access capabilities, we expect to see increases in the percentage of workers who telecommute or have flexible work schedules.

A significant amount of travel in the region is still by people who choose to drive alone (42 percent of all trips and nearly 76 percent of work trips). So, the challenge of getting individuals to seek alternative modes of travel remains.

GOODS MOVEMENT

Our region's transportation network for moving goods, referred to as our "goods movement" system, relies today on multiple modes of transportation and complex infrastructure. Whether carrying imported goods from the ports to regional distribution centers, supplying materials for local manufacturers, or delivering consumer goods to residents, our goods movement system sustains regional industries and consumer needs every day. This system includes deep-water marine ports, international border crossings, Class I rail lines, interstate highways, state routes and local connector roads, air cargo facilities, intermodal facilities, and distribution and warehousing centers. EXHIBIT 2.4 depicts our region's multimodal goods movement system.

Major Elements of the Goods Movement System:

- **Seaports (Ports of Los Angeles, Long Beach and Hueneme):** Serving as the largest container port complex in the U.S., the Ports of Los Angeles and Long Beach (together called the San Pedro Bay Ports) handled about 117 million metric tons of imports and exports in 2014—for a total value of about $395.7 billion.[11] The Port of Hueneme in Ventura County specializes in the import and export of automobiles, fresh fruit and produce and serves as the primary support facility for the offshore oil industry. In 2014, two-way trade activities through the Port of Hueneme were valued at nearly $9.2 billion and generated $1.1 billion in economic activities in the immediate region.[12]
- **Land Ports:** The international border crossings in Imperial County are busy commercial land ports, and they were responsible for more than $8 billion in imports and $6 billion in exports in 2014. This cross-border commerce was driven by the maquiladora trade, as well as the movement of agricultural products. [13]
- **Air Cargo Facilities:** The region is home to numerous air cargo facilities, including Los Angeles International Airport (LAX) and Ontario International Airport (ONT). Together they handled more than 99 percent of the region's air cargo, valued at more than $96 billion,[14] in 2014.
- **Highways and Local Roads:** Our region has more than 70,000 roadway lane miles.[15] Sections of Interstate 710, Interstate 605, State Route 60 and State Route 91 carry the highest volumes of truck traffic in the region and averaged more than 25,000 trucks per day in 2013. Other major components of the regional highway network also serve significant numbers of trucks. These include Interstates 5, 10, 15 and 210. More than 20,000 trucks per day travel on some sections.

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11 American Association of Port Authorities and U.S. Trade Online, U.S. Census.
12 U.S. Trade Online, U.S. Census and Port of Hueneme.
13 The term maquiladora refers to a manufacturing operation in Mexico. The majority of them are located along the US border and within the Foreign Trade Zones (FTZs) to capitalize on duty-free and tariff-free provisions for assembly and material processing.
14 U.S. Trade Online, U.S. Census.
15 Highway Performance Monitoring System, California Department of Transportation, http://www.dot.ca.gov/hq/tsip/hpms/.

FOCUS GOODS MOVEMENT

THE SCAG REGION IS THE LARGEST INTERNATIONAL GATEWAY IN THE U.S.

supported by AIRPORTS, LAND PORTS OF ENTRY, SEAPORTS, RAILWAYS, HIGHWAYS and WAREHOUSE & DISTRIBUTION CENTERS

FACTORY

STORE

REGIONAL AIRPORTS HANDLED NEARLY **$96 BILLION** IN INTERNATIONAL AIR CARGO IN 2014

#1 SOUTHERN CALIFORNIA has the **LARGEST CONTAINER PORT COMPLEX** in the UNITED STATES

#9 and has the **NINTH LARGEST CONTAINER PORT COMPLEX** in the WORLD

SOUTHERN CALIFORNIA HAS **3,747 MILES** OF HIGHWAYS (that is 41% of all the highway road miles in California)

2 CLASS 1 RAILROADS

6 INTERMODAL RAIL YARDS**

** Not including carload and automobile terminals

CLOSE TO **1.2 BILLION SQ. FT.** OF WAREHOUSING & DISTRIBUTION SPACE

CLOSE TO **750 MILLION SQ. FT.** ARE FACILITIES >50K SQ. FT. IN SIZE

(2014)

In 2014, the VALUE OF INTERNATIONAL TRADE that moved through the SCAG region was over

$515 BILLION

includes maritime and cross-border trade and air freight

In 2014, Goods Movement dependent industries generated

2.9 MILLION JOBS

HOW CAN WE GROW WITH LESS IMPACT?

$2.6 BILLION COST OF WASTED LABOR HOURS & FUEL from Truck Congestion on Highways

ANNUAL COST OF AIR POLLUTION in the SCAG region is at least **$14.6 BILLION**

371% GROWTH in VEHICLE HOURS OF DELAY per day at rail-highway grade crossings across the region by 2040

These roads carry a mix of cargo loads, including local, domestic and international. The arterial roadway system also plays a critical role in goods movement, providing first/last mile connections to regional ports, manufacturing facilities, intermodal terminals, warehousing and distribution centers, and retail outlets.

- **Class I Railroads:** Critical to the growth of the region's economy, the Burlington Northern Santa Fe Railway (BNSF) and Union Pacific (UP) carry international and domestic cargo to and from distant parts of the country. The BNSF mainline operates on the Transcontinental Line (and San Bernardino Subdivision). The UP operates on the Coast Line, Saugus Line through Santa Clarita, Alhambra and Los Angeles Subdivisions and Yuma Subdivision to El Paso. Both railroads operate on the Alameda Corridor, which connects directly to the San Pedro Bay Ports. The San Pedro Bay Ports also provide several on-dock rail terminals, along with the six major intermodal terminals operated by the BNSF and UP.
- **Warehouse and Distribution Centers:** The SCAG region is home to one of the largest clusters of logistics activity in North America. In 2014, the region had close to 1.2 billion square feet of facility space for warehousing, distribution, cold storage and truck terminals.[16] Nearly 750 million square feet of this space, in 4,900 buildings, were facilities larger than 50,000 square feet. An estimated ten percent of the occupied warehouse space served port-related uses, while the remaining 90 percent supported domestic shippers.[17] Many of these warehouses are clustered along key goods movement corridors. Port-related warehousing is concentrated in the Gateway Cities subregion, while national and regional distribution facilities tend to be located in the Inland Empire.

Key Goods Movement Functions and Markets

Our region's goods movement system serves a wide range of markets including international, domestic and local trade. Although the international trade market has a significant presence in the region, most freight activities are generated by local businesses moving goods to local customers and supporting national domestic trade. These businesses are sometimes referred to as "goods movement-dependent industries." In 2014, these industries, including manufacturing, wholesale and retail trade, construction, and warehousing, employed nearly three million people throughout the region and contributed $291 billion to the regional gross domestic product (GDP). These industries are anticipated to grow substantially, with manufacturing projected to increase its GDP contribution 130 percent by 2040 and wholesale trade growing 144 percent.[18]

Growth of E-Commerce and Goods Movement

The retail industry provided nearly $30 billion in wages and salaries for the region in 2014.[19] This industry includes a wide variety of subsectors such as motor vehicles, furniture, electronics and appliances, building materials, health and personal care products, clothing, sporting goods, and books. One of the most notable changes in the retail industry is the strong growth in e-commerce sales. E-commerce sales for U.S. retailers totaled $261 billion in 2013, an increase of 13.6 percent from 2012. Total retail sales increased by 3.8 percent in the same period. Within the e-commerce sales merchandise category, clothing and clothing accessories had the largest sales at $40 billion, followed by electronics and appliances at nearly $23 billion. E-commerce provides consumers with a broad range of shopping options, including the ability to compare product prices instantaneously from mobile devices and to opt for home delivery or store pick-up of merchandise. Simultaneously, e-commerce has changed how traditional distribution centers and retail outlets are operating to meet customer demand. Distribution centers in the past delivered bulk size goods to their customers or vendors. Because e-commerce orders tend to be smaller in size (i.e., a single item order as compared to a bulk-case order), many retailers and distribution center/warehouse operators are upgrading their facilities, or developing new facilities, to meet surging e-commerce orders. These changes are also generally characterized by the use of smaller trucks and integrator delivery vans (such as UPS, FedEx and DHL) due to overnight or two-day delivery requirements of e-commerce customers.

Same-Day Delivery Demands

Consumers are increasingly demanding quicker fulfillment of their orders. More recent developments include same-day delivery options. To meet the same-day delivery promise, distribution or fulfillment center proximity to population centers becomes critical. This is exemplified by large-scale e-commerce fulfillment center developments at the periphery of urban population centers. At the same time, small to medium size buildings that are narrow, but with ample loading doors and docks in urban cores, have also been attractive as they provide even quicker access to dense population centers than those in the outskirts. Additionally, retailers are increasingly using products available

[16] CoStar Reality Information, Inc. www.costar.com, based on November 2014 data downloads.
[17] Industrial Warehousing in the SCAG Region Study, SCAG, based on the Avison-Young methodology for port-related and non-port related warehousing needs.
[18] REMI TranSight SCAG, CA, USv3.6.5.
[19] Regional Economic Model Inc. TranSight SCAG, CA, US v3.6.5.

at their stores to fulfill e-commerce orders. Parcel hubs, delivery centers and accessibility to local streets and highways throughout the region will continue to be critical to e-commerce growth.[20 21 22]

[20] E-commerce Evolutions – Element 4: Distribution and Fulfillment Centers, NAIOP, May 2015, http://www.naiop.org/en/E-Library/Business-Trends/Distribution-and-Fulfillment-Centers.aspx.

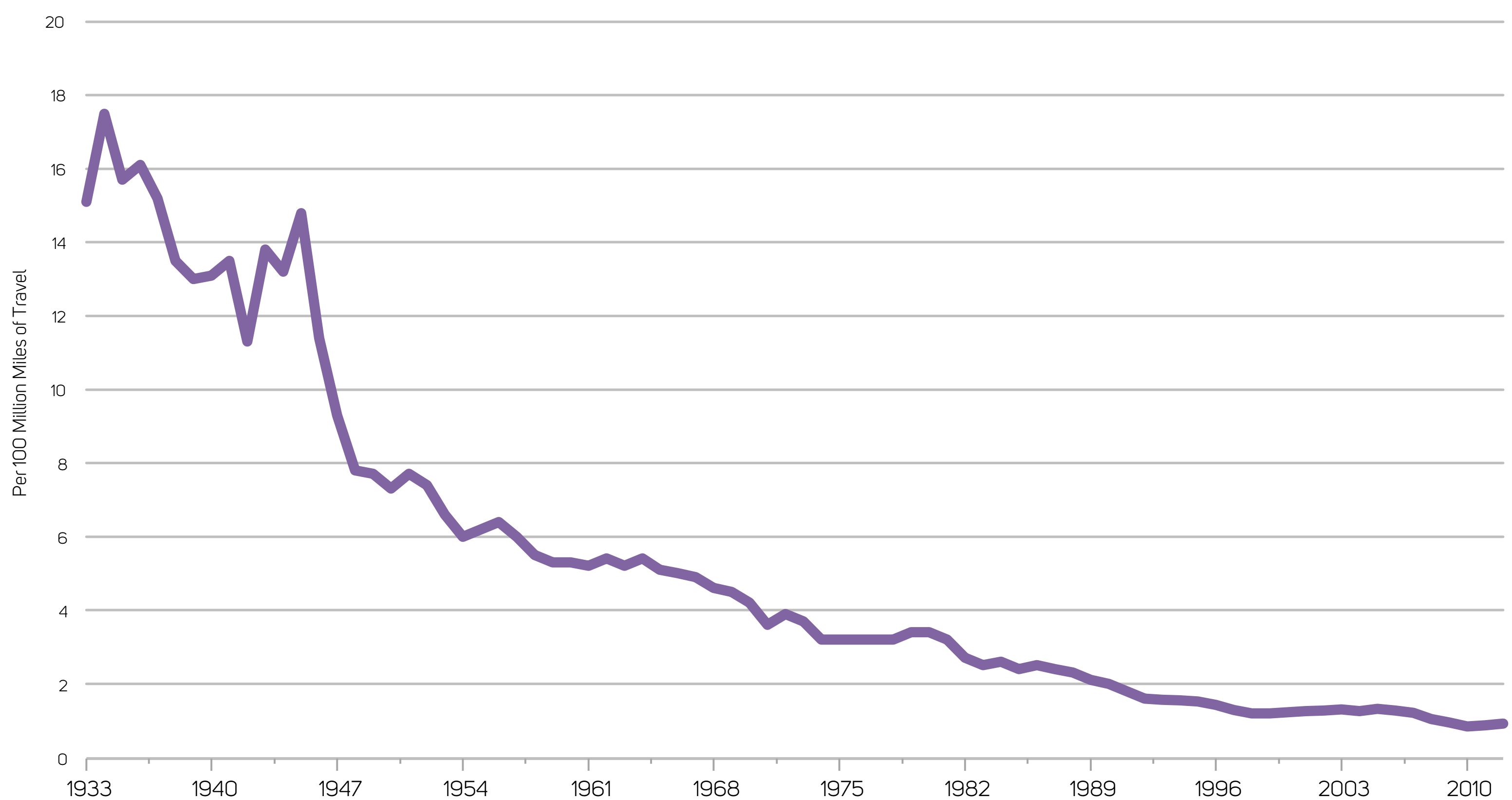
[21] Retailers must overcome logistics lag for same-day delivery, Kris Bjornson, JLL, April 2014, http://www.joneslanglasalleblog.com/investor/retailers-must-overcome-logistics-lag-for-same-day-delivery/.

[22] Same-day delivery is transforming the CRE industry, Kris Bjornson, JLL, June 2015, http://www.joneslanglasalleblog.com/investor/same-day-delivery-is-transforming-the-cre-industry/?utm_source=us-retail-ecom&utm_medium=jll-website&utm_campaign=featured-post.

STATE OF SAFETY

The safety of people and goods is one of the most important considerations in developing, maintaining and operating our diverse transportation system. Throughout California, the rate of fatal and injury collisions on highways has declined dramatically since the California Highway Patrol began keeping such data in the 1930s (see FIGURE 2.2). California has led the nation in roadway safety for many of the past 20 years. Only recently have roadways nationally become as safe as those in California. California's most recently recorded mileage death rate (MDR)—defined as fatalities per 100 million vehicle miles traveled (VMT)—was 0.91, while the MDR within the SCAG region was slightly lower at 0.83. Both MDRs for the state and SCAG region are lower than the national MDR of 1.09.

FIGURE 2.2 MAKING OUR ROADWAYS SAFER: CALIFORNIA MILEAGE DEATH RATE (1933–2012)



Source: https://www.chp.ca.gov/InformationManagementDivisionSite/Documents/2012-sec1.pdf

Our region has an extensive transportation system, with more than 70,000 lane miles of highway and arterial lanes and 3,900 miles of bikeways. As of 2014, the region had 14.9 million licensed drivers and 11.8 million registered vehicles. As of 2012 (the most recent year that data was available), more than 1,300 people died and 121,000 were injured (of which 6,800 were considered severe) in traffic collisions in the region.

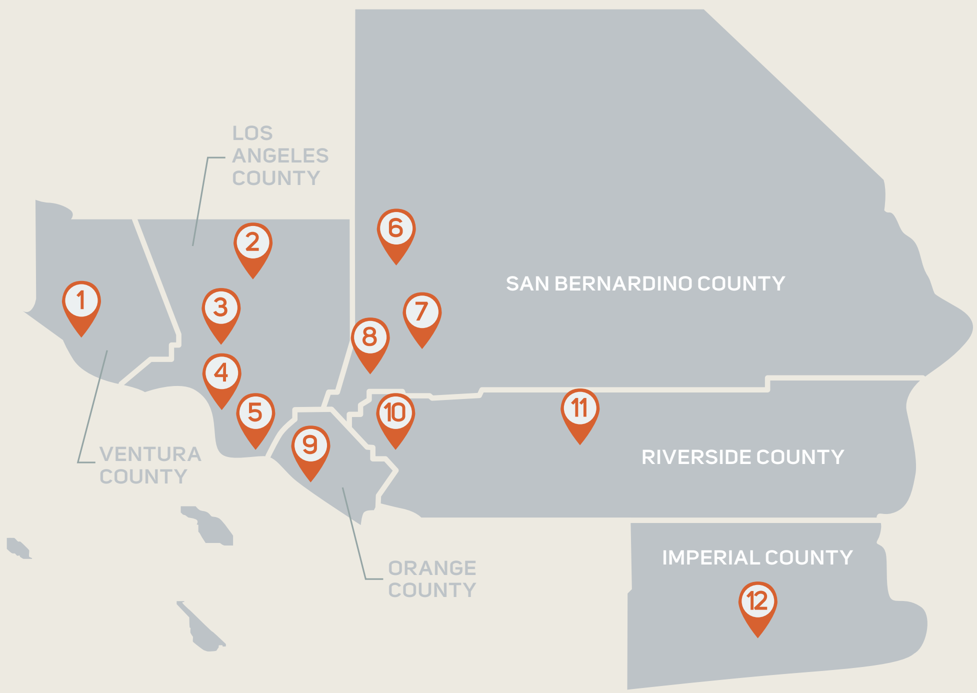
In 2012 President Obama signed into law MAP-21, the Moving Ahead for Progress in the 21st Century Act, which funded surface transportation programs and required states to develop Strategic Highway Safety Plans (SHSPs).[23] The California Department of Transportation (Caltrans) responded by developing an updated SHSP through a participatory process. Throughout 2014, Caltrans conducted an extensive outreach effort to more than 50 agencies and organizations throughout the state—including SCAG—to gather feedback on improving the overall SHSP. This effort led to the release of the final California SHSP in 2015. California's ultimate goal is to reach zero deaths on our highways—a concept known as "Toward Zero Deaths" (TZD). Specifically, California aims to achieve a three percent per year reduction for the number

[23] In December 2015, the Fixing America's Surface Transportation Act, or "FAST Act," was signed into law, which authorizes funding for surface transportation programs. SCAG expects to work with Caltrans to monitor the rulemaking process to implement FAST Act provisions.

Map of Airports

12

EXISTING & PLANNED COMMERCIAL AIRPORTS SERVING THE SCAG REGION



1. Oxnard
2. Palmdale
3. Burbank Bob Hope
4. Los Angeles International
5. Long Beach
6. Southern California Logistics
7. San Bernardino International
8. Ontario International
9. John Wayne
10. March Inland Port
11. Palm Springs International
12. Imperial County

AIRLINE PASSENGER VOLUME

71 MILLION IN 1994

91 MILLION IN 2014

and rate of fatalities and a 1.5 percent per year reduction for the number and rate of severe injuries. Although the SHSP and previous California SHSPs set various actions that state agencies can take to reduce fatalities, there are complementary strategies that local governments can pursue, such as Vision Zero initiatives. For additional details regarding strategies, please see the Safety &Security Appendix.

As we continue to work to improve safety for motorists, we also must tackle the alarming fatality rates of those who use other modes of transportation. Safety is a priority for all modes of transportation, and improving safety for people who walk and bike is critical. Based on currently available data, about 27 percent of all traffic-related fatalities in our region involved pedestrians and five percent of traffic-related fatalities involved bicyclists, according to data from the Statewide Integrated Traffic Records System (SWITRS).

AVIATION AND GROUND ACCESS

The SCAG region is one of the busiest and most diverse commercial aviation regions in the world. In 2014, more than 60 airlines offered scheduled service to one or more of our region's airports, providing more than 1,200 daily commercial departures—one every 70 seconds. These departing flights travel all over the United States and to every corner of the globe; a total of 169 destinations in 37 countries had non-stop service from our region in 2014. Our airports also play a critical role in the region's goods movement network, and they impact the operations of our ground transportation network as well. The passengers arriving at or departing from our airports generate more than 200,000 daily trips on our region's ground transportation system.

Passenger and cargo air travel in the region is supported by a multiple airport system that spans six counties. There are seven commercial airports with scheduled passenger service, five additional facilities with the infrastructure to accommodate scheduled service, seven active military air fields and more than forty general aviation airports. Worldwide, few other regions have as many commercial airports within a comparable geographic area, making Southern California one of the world's most complex aviation systems.

In 2014, the airports in our region handled more than 1.5 million aircraft operations (take-offs and landings), nearly 800,000 of which were commercial operations. In the face of this huge number of air travelers and aircraft, our airports work efficiently. Flights to our region arrive on schedule more than 80 percent of the time. Thanks to favorable weather conditions, lengthy tarmac delays that occur in other regions are virtually unheard of here. The size of the regional market for air travel and the absence of a single dominant air carrier in the region result in healthy competition among airlines, so air travelers enjoy some of the lowest average airfares in the country.

Air travel is an important contributor to the region's economic activity. Nearly half of the air travel in the region consists of visitors from other parts of the country and the world traveling here to conduct business, enjoy a vacation or visit friends and relatives. About one-third of air travel to the region is business related. Therefore, any passenger who arrives at or departs from an airport in our region is good for the region as a whole. Spending by passengers who used our airports to visit the region in 2012 contributed nearly $27.4 billion to the regional economy. The money spent by visitors on meals, lodging, entertainment, transportation and other purchases supported nearly 275,000 jobs.

As with other modes of transportation, the demand for air travel was impacted heavily by the recession that began in 2007. In 2014, the airports in our region served 91.2 million total passengers, surpassing the previous peaks of 89.4 million in 2007 and 88.7 million in 2000.

The demand for air cargo was even more sharply impacted by the recessions of 2001 and 2007. The 2.4 million metric tons of cargo transported through the airports in our region in 2014 remained ten percent below the pre-recession peak of 2.7 million metric tons in each year from 2004–2006 and five percent below year 2000 levels.

In addition to its commercial airports, the SCAG region is also home to a large general aviation (GA) system. Included in this segment are airports serving non-commercial corporate jets, single engine planes, helicopters, emergency and firefighting operations, and flight training activity. General aviation airport facilities also act as relievers to commercial airports and provide diversionary locations for commercial planes that require emergency landings.

There are more than 40 general aviation airports in the SCAG region, and they are as diverse in size and market area as the commercial facilities. Van Nuys Airport (VNY), the second busiest general aviation facility in the United States, serves several important functions for the region, including serving as the base for many corporate jets. As of May 2015, Van Nuys Airport began offering U.S. Customs and Border Protection services for international general aviation flights to benefit business travelers and reduce airspace congestion.

CONCLUSION

Today we face numerous challenges on the road toward greater mobility, a stronger economy and sustainable growth that maintains a high quality of life regionwide. In the Chapter 3, we'll review some of these challenges.

OUR PROGRESS SINCE 2012

THE 2012 RTP/SCS WAS THE FIRST REGIONAL PLAN THAT SCAG DEVELOPED WITH A SUSTAINABLE COMMUNITIES STRATEGY,

a new state requirement following the passage of SB 375, the Sustainable Communities and Climate Protection Act of 2008. The legislation required that land use and transportation planning be integrated to achieve its prescribed greenhouse gas reduction targets and air quality requirements. At its core, the 2012 RTP/SCS envisioned a future in which an abundance of safe and efficient transportation choices provide ready access to jobs, education and healthcare—and the region's economy, public health and overall quality of life are strong. Since 2012, the region has made considerable progress. Here are some highlights:

TRANSIT

Transit service continues to expand throughout the region and the level of service has exceeded pre-recessionary levels—mainly due to a growth in rail service. Significant progress has been made toward completing capital projects for transit, including the Metro Orange Line Extension and the Metro Expo Line. Meanwhile, five major Metro Rail projects are now under construction in Los Angeles County.

PASSENGER RAIL

Passenger rail is expanding and improving service on several fronts. The Amtrak Pacific Surfliner is now being managed locally by the Los Angeles-San Diego-San Luis Obispo (LOSSAN) Rail Corridor Agency; Riverside County Transportation Commission (RCTC) completed the Perris Valley Line in early 2016; Metrolink became the first commuter railroad in the nation to implement Positive Train Control and purchase fuel-efficient, low-emission Tier IV locomotives; and the California High-Speed Train is under construction in the Central Valley, and planning and environmental work is underway in our region to the Los Angeles/Anaheim Phase One terminus. Several other capital projects are underway or have been completed, including the Anaheim Regional Intermodal Transportation Center (ARTIC) and the Burbank Bob Hope Airport Regional Intermodal Transportation Center, among others.

HIGHWAYS

The expansion of highways has slowed considerably over the last decade because of land, financial and environmental constraints. Still, several projects have been completed since 2012 to improve access and close critical gaps and congestion chokepoints in the regional network. These include the Interstate 10 westbound widening in Redlands and Yucaipa, the Interstate 215 Bi-County HOV Project in Riverside and San Bernardino Counties, and a portion of the Interstate 5 South Corridor Project in Los Angeles County (between North Fork Coyote Creek to Marquardt Avenue), among others.

REGIONAL HIGH-OCCUPANCY VEHICLE (HOV) AND EXPRESS LANE NETWORK

The demands on our region's highways continue to exceed available capacity during peak periods, but several projects to close HOV gaps have been completed. The result has been 39 more lanes miles of regional HOV lanes on Interstates 5, 405, 10, 215 and 605, on State Routes 57 and 91 and on the West County Connector Project (direct HOV connection between Interstate 405, Interstate 605 and State Route 22) within Orange County. The region is also developing a regional express lane network. Among the milestones: a one-year demonstration of express lanes in Los Angeles County along Interstate 10 and Interstate 110 was made permanent in 2014; and construction has begun on express lanes on State Route 91 extending eastward to Interstate 15 in Riverside County.

ACTIVE TRANSPORTATION

Our region is making steady progress in encouraging more people to embrace active transportation and more than $650 million in Active Transportation Program investments are underway. Nearly 38 percent of all trips are less than three miles, which is convenient for walking or biking. As a percentage share of all trips, bicycling has increased more than 70 percent since 2007 to 1.12 percent. More than 500 miles of new bikeways have been constructed in the region and safety and encouragement programs are helping people choose walking and biking as options.

GOODS MOVEMENT

The region continues to make substantial progress toward completing several major capital initiatives to support freight transportation and reducing harmful emissions generated by goods movement sources. Progress since 2012 has included implementation of the San Pedro Bay Ports Clean Air Action Program (CAAP), reducing diesel particulate matter by 82 percent, nitrogen oxide by 54 percent and sulfur dioxide by 90 percent; and the San Pedro Bay Ports Clean Truck Program has led to an 80 percent reduction in port truck emissions. The region has also shown progress in advanced technology for goods movement, including a one-mile Overhead Catenary System (OCS) in the City of Carson. Construction of the Gerald Desmond Bridge has begun. Seventeen out of 71 planned grade separation projects throughout the region have been completed, and another 21 should be completed in 2016. Double tracking of the Union Pacific (UP) Alhambra Subdivision has been initiated. The Colton Crossing, which physically separated two Class I railroads with an elevated 1.4-mile-long overpass that lifts UP trains traveling east-west, was completed in August 2013.

SUSTAINABILITY IMPLEMENTATION

Since 2012, SCAG's Sustainability Planning Grant Program has funded 70 planning projects (totaling $10 million) to help local jurisdictions link local land use plans with 2012 RTP/SCS goals. Local jurisdictions have updated outmoded General Plans and zoning codes; completed specific plans for town centers and Transit Oriented Development (TOD); implemented sustainability policies; and adopted municipal climate action plans. Thirty of the 191 cities and two of the six counties in the SCAG region report having updated their General Plans since 2012, and another 42 cities have General Plan updates pending. Fifty-four percent of the cities reporting adopted or pending General Plan updates include planning for Transit Oriented Development (TOD), 55 percent plan to concentrate key destinations, and 76 percent include policies encouraging infill development. Of the counties reporting updates or pending updates to their General Plans, 75 percent include TOD elements, 100 percent encourage infill development, 75 percent promote concentrated destinations, and 75 percent feature policies to address complete communities. To protect water quality, 91 percent of cities have adopted water-related policies and 85 percent have adopted measures to address water quality. To conserve energy, 86 percent of cities have implemented community energy efficiency policies, with 80 percent of those cities implementing municipal energy efficiency policies and 76 percent implementing renewable energy policies. Of the region's 191 cities, 189 have completed sustainability components, with 184 cities implementing at least ten or more sustainability policies or programs and ten cities implementing 20 or more sustainability policies or programs. This last group includes Pasadena, Pomona and Santa Monica.

AFFORDABLE HOUSING

The state is offering new opportunities to help regions promote affordable housing. In spring 2015, California's Affordable Housing Sustainable Communities (AHSC) program awarded its first round of funding to applicants after a competitive grant process. Of $122 million available statewide, $27.5 million was awarded to ten projects in the SCAG region. Eight-hundred forty-two affordable units, including 294 units designated for households with an income of 30 percent or less of the area median income, will be produced with this funding. Meanwhile, Senate Bill 628 (Beall) and Assembly Bill 2 (Alejo), provide jurisdictions with an opportunity to establish a funding source to develop affordable housing and supportive infrastructure and amenities.

PUBLIC HEALTH

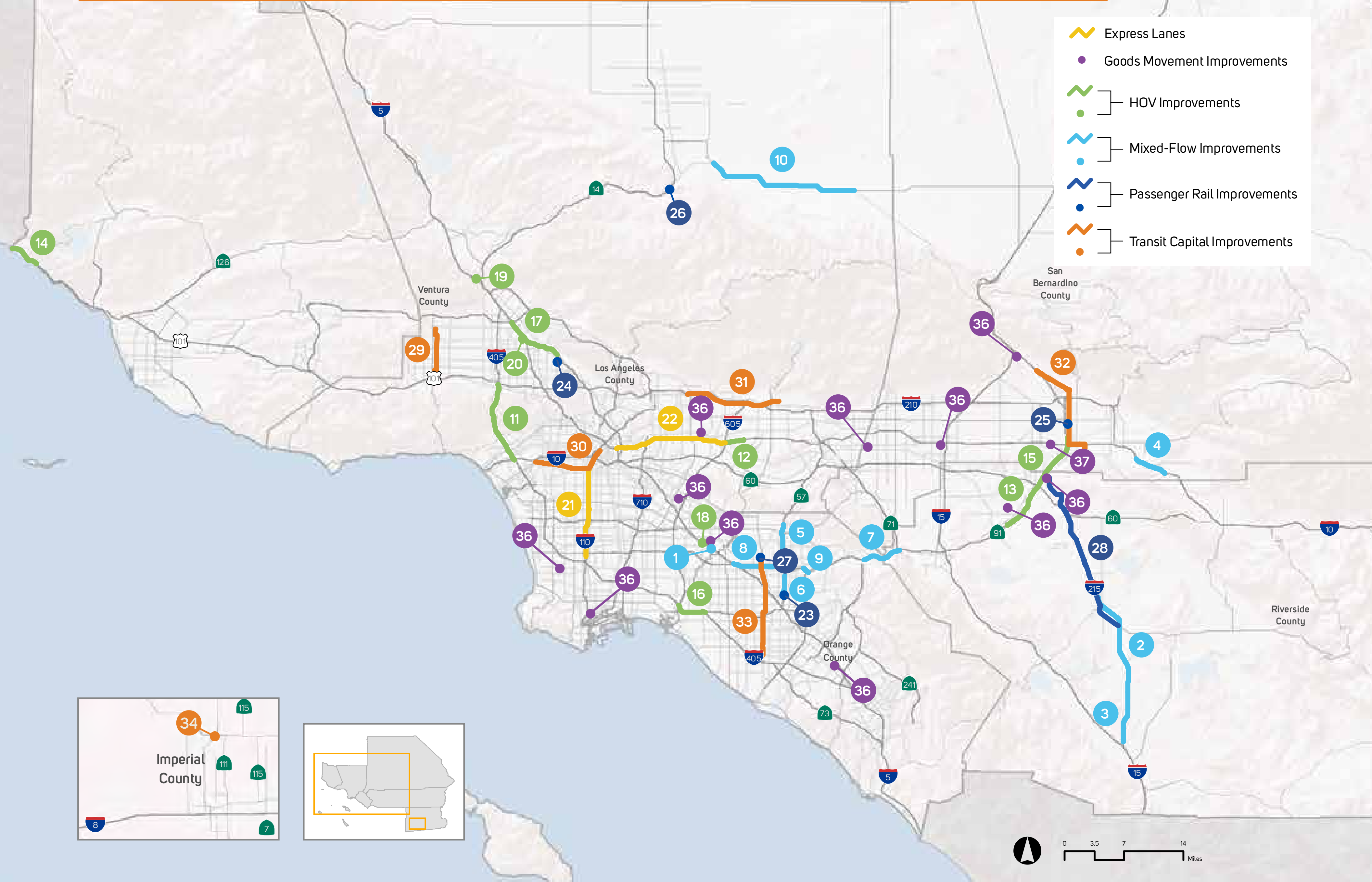
The SCAG region has several ongoing efforts to promote public health. The Los Angeles County Departments of Public Health and the City of Los Angeles Planning Department are developing a Health Atlas that highlights health disparities among neighborhoods. In Riverside County, the Healthy Riverside County Initiative has formed a Healthy City Network to continue to successfully work with the county's 28 cities to enact Healthy City Resolutions and Health Elements into their General Plans. The County of San Bernardino has recently completed the Community Vital Signs Initiative, which envisions a "county where a commitment to optimizing health and wellness is embedded in all decisions by residents, organizations and government."

ENVIRONMENTAL JUSTICE

Since the adoption of the 2012 RTP/SCS, social equity and environmental justice have become increasingly significant priorities in regional plans. For example, plans to promote active transportation, improve public health, increase access to transit, preserve open space, cut air pollution and more are all evaluated for how well the benefits of these efforts are distributed among all demographic groups. The State of California's Environmental Protection Agency (Cal/EPA) developed a new tool, CalEnviroScreen, which helps to identify areas in the state that have higher levels of environmental vulnerability due to historical rates of toxic exposure and certain social factors. Based on this tool, much of the region can stand to benefit from Cap-and-Trade grants that give priority to communities that are disproportionately impacted.

OUR PROGRESS SINCE 2012

Mobility Projects in the SCAG Region



1 **I-5 South Corridor**
One mixed-flow lane on I-5 from OC line to I-605 (currently in construction, however portion between North Fork Coyote Creek to Marquardt Avenue is complete).

2 **I-215 Central**
One mixed-flow lane in each direction between Scott Road and Nuevo Road.

3 **I-215 South**
One mixed-flow lane in each direction between Murrieta Hot Springs Road and Scott Road.

4 **I-10 Widening**
One westbound mixed flow lane on I-10 between Live Oak Canyon Road in Yucaipa and Ford Street in Redlands.

5 **State Route 57 Widening (Northern Segment)**
One northbound mixed-flow lane on SR-57 between Orangethorpe Avenue and Lambert Road.

6 **State Route 57 Widening (Southern Segment)**
One northbound mixed-flow lane on SR-57 between Katella Avenue and Lincoln Avenue.

7 **SR-91 Lane Addition (Eastern Segment)**
One mixed-flow lane on SR-91 between SR-241 and SR-71.

8 **SR-91 Lane Addition (Western Segment)**
One westbound mixed-flow lane on SR-91 between SR-57 and I-5.

9 **SR-91 Lane Extension and Reconstruction**
Addition of a Tustin Avenue exit bypass lane, reconstructing the auxiliary lane and modifying the number one and two lanes of the connector to serve as two general purpose lanes that merge into one general purpose lane just west of Tustin Avenue off- ramp.

10 **SR-138 Corridor Improvements**
Lane widening on SR-138 between Avenue T and SR-18.

11 **I-405 Sepulveda Pass Improvements**
Addition of northbound HOV lane on I-405 between I-10 and US-101.

12 **I-10 HOV Lane (Phase I)**
Addition of HOV lane on I-10 between I-605 and Puente Avenue as permanent facility.

13 **SR-91 HOV Lane**
Addition of HOV lane on SR-91 from Adams Street to SR-60/I-215 Interchange.

14 **US-101 HOV Lane**
Addition of HOV lane on US-101 from Mobil Pier Road to Casitas Pass Road.

15 **I-215 Bi-County HOV Gap Closure**
Addition of HOV lane on I-215 from Orange Show Road to SR-91/SR-60 Interchange.

16 **West County Connector**
Direct HOV connector between I-405/I-605/SR-22.

17 **I-5 HOV Lane**
Addition of HOV lane on I-5 from Hollywood Way to SR-118.

18 **I-5 South Corridor**
Addition of HOV lane on I-5 from OC line to I-605 (currently in construction, however portion between North Fork Coyote Creek to Marquardt Avenue is complete).

19 **I-5/SR-14 HOV Connector**
Addition of HOV connector between I-5 and SR-14.

20 **SR-170/I-5 HOV Connector**
Addition of HOV connector between SR-170 and I-5.

21 **I-110 Express Lanes**
Conversion of the I-110 Harbor Transitway HOV lanes (Harbor Gateway Transit Center to Adams Blvd.) to permanent Express Lanes.

22 **I-10 Express Lanes**
Conversion of the I-10 El Monte Busway HOV lanes (I-605 to Alameda St.) to permanent Express Lanes.

23 **Anaheim Regional Intermodal Transportation Center (ARTIC)**
An Intermodal transportation center in Orange County serving Orange County Transportation Authority (OCTA) buses and various intercity buses, as well as Metrolink and the Amtrak Pacific Surfliner.

24 **Burbank Bob Hope Airport Regional Intermodal Transportation Center**
A multimodal transportation center which includes a consolidated rental car center, bike storage and a bus transit center. A pedestrian bridge to the existing Amtrak and Metrolink station is in the planning stage.

25 **Downtown San Bernardino Transit Center and Metrolink Extension**
One-mile Metrolink extension to downtown San Bernardino, from the previous terminus at the Santa Fe Depot. This multimodal center serves Metrolink, sbX (bus rapid transit), the future Redlands Rail and local Omnitrans bus lines.

26 **Vincent Grade/Acton Siding and Platform**
Adds significant capacity to the northern portion of the Antelope Valley Line, which is mostly single track.

27 **Fullerton Metrolink Station Parking Structure**
Construction of a parking structure providing an additional 814 parking spaces serving Metrolink and OCTA patrons.

28 **Metrolink Perris Valley Line**
A 24-mile extension of existing Metrolink service from downtown Riverside to south Perris, with four new stations constructed at Riverside Hunter Park, Moreno Valley/March Field, Downtown Perris and South Perris.

29 **Metro Orange Line Extension**
A four-mile northward extension of the Metro Orange Line from Canoga Station to the Chatsworth Station.

30 **Metro Exposition Line**
An 8.6 mile light rail corridor connecting Downtown LA and Culver City, including ten new light rail stations.

31 **Metro Gold Line Foothill Extension Phase 2A**
An 11.5-mile light rail extension between Pasadena and Azusa serving six new stations.

32 **Omnitrans E Street sbX**
A 16-mile bus rapid transit project including 6-miles of dedicated bus lanes on E Street, providing service between California State University San Bernardino and the City of Loma Linda.

33 **OCTA Bravo! Route 543**
A new 12-mile limited-stop bus service along Harbor Boulevard, from the Fullerton Transportation Center through the cities of Anaheim, Garden Grove, Santa Ana and terminating at MacArthur Boulevard in Costa Mesa.

34 **The Brawley Transit Transfer Center**
Transit transfer station in Imperial County serving various Imperial Valley Transit routes including the new Gold Line circulator shuttle.

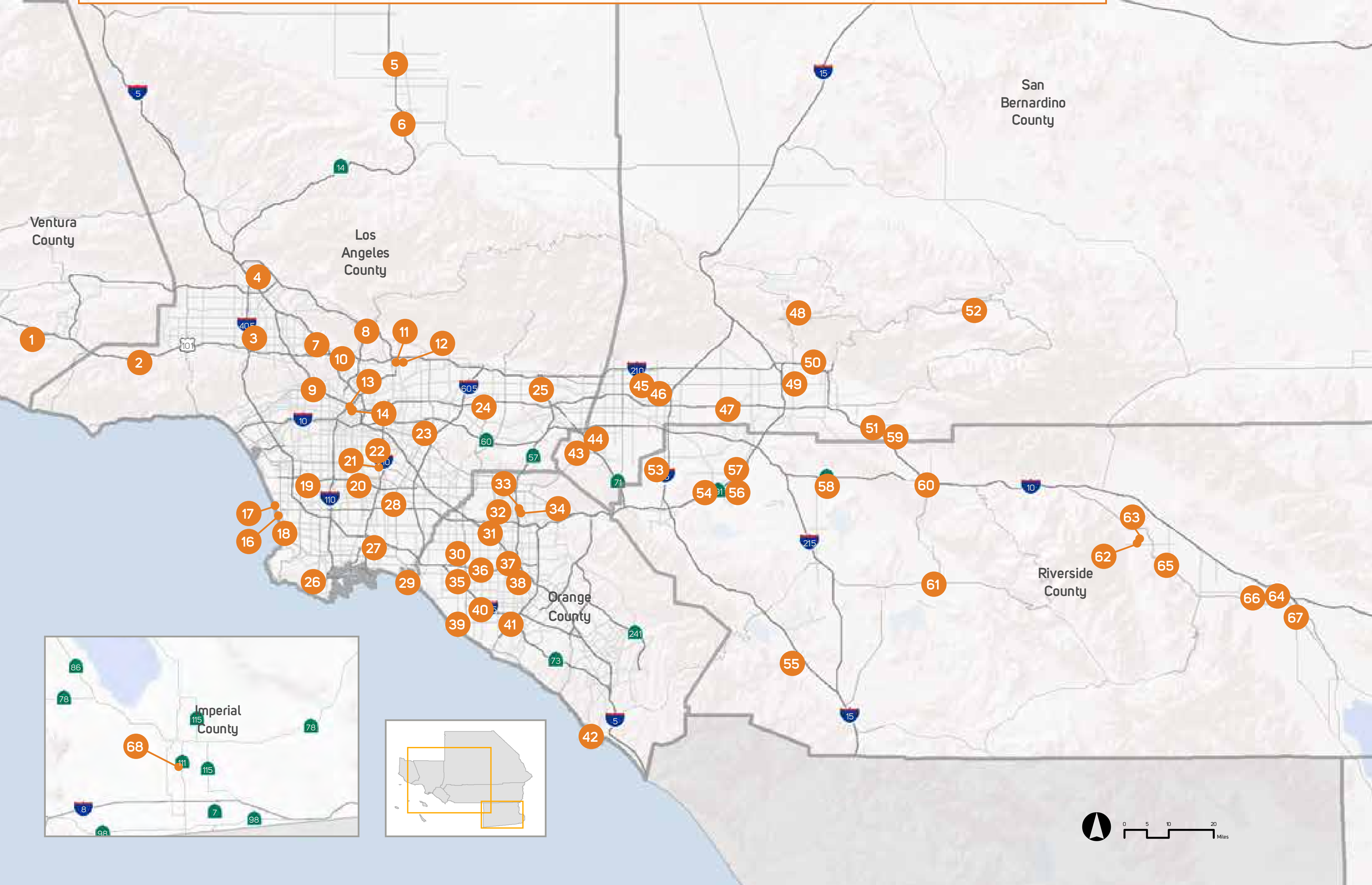
35 **SunLine Transit Administrative Facility**
New SunLine Transit administrative building in Coachella Valley.

36 **Grade Separations**
Various grade separation improvements throughout the region.

37 **Colton Crossing**
A rail to rail grade separation project that physically separated two Class I mainline rail tracks with an elevated 1.4 mile-long overpass that lifts UP trains traveling east-west. This project removed the chokepoint that existed where the Burlington Northern Santa Fe (BNSF) mainline crossed UP tracks in Colton.

OUR PROGRESS SINCE 2012

Sustainability Planning Grant Projects in the SCAG Region



VENTURA COUNTY

1. Ventura County Connecting Newbury Park Multi-Use Pathway Plan

LOS ANGELES COUNTY

2. Las Virgenes-Malibu Council of Governments Multi-Jurisdictional Regional Bicycle Plan
3. Los Angeles Van Nuys & Boyle Heights Modified Parking Requirements
4. Los Angeles Northeast San Fernando Sustainability & Prosperity Strategy
5. Lancaster Complete Streets Master Plan
6. Palmdale Avenue Q Feasibility Study
7. Burbank Mixed-Use Development Standards
8. La Cañada Flintridge Climate Action Plan
9. Los Angeles Hollywood Central Park
10. Glendale Space 134
11. Pasadena Form-Based Street Design Guidelines
12. Pasadena GHG Emission Reduction Evaluation Protocol
13. Los Angeles CEQA Streamlining Assessment
14. Los Angeles Park 101 District
15. Los Angeles Bicycle Plan Performance Evaluation
16. Hermosa Beach Carbon Neutral Plan
17. South Bay Bicycle Coalition Mini-Corral Plan
18. South Bay COG Neighborhood-Oriented Development Graphics
19. Hawthorne Crenshaw Station Area Active Transportation Plan
20. Lynwood Safe and Healthy Community Element
21. South Gate Gateway District/Eco Rapid Transit Station Specific Plan
22. Bell General Plan Update
23. Pico Rivera Kruse Rd. Open Space Study
24. West Covina Downtown Central Business District
25. San Dimas Downtown Specific Plan
26. Rancho Palos Verdes/Los Angeles Western Ave. Corridor Design Implementation Guidellines
27. Long Beach Willow Springs Wetland Habitat Creation Plan
28. Paramount/Bellflower Regional Bicycle Connectivity - West Santa Ana Branch Corridor

ORANGE COUNTY

29. Seal Beach Climate Action Plan
30. Stanton Green Planning Academy
31. Anaheim Bicycle Master Plan Update
32. Fullerton East Wilshire Avenue Bicycle Boulevard
33. Orange County Parks OC Bicycle Loop
34. Placentia General Plan/Sustainability Element & Development Code
35. Westminster General Plan Update - Circulation Element
36. Garden Grove Re:IMAGINE Pedals & Feet
37. Orange County "From Orange to Green" Zoning Code Update
38. Santa Ana Complete Streets Plan
39. Huntington Beach Neighborhood Electric Vehicle Plan
40. Fountain Valley Euclid/I-405 Overlay Zone
41. Costa Mesa Implementation Plan for Multi-Purpose Trails
42. Dana Point General Plan Update

SAN BERNARDINO COUNTY

43. Chino Hills Climate Action Plan and Implementation Strategy
44. Chino Bicycle & Pedestrian Master Plan
45. Rancho Cucamonga Healthy RC Sustainability Action Plan
46. Rancho Cucamonga Metrolink Station and TOD Feasibility Report
47. San Bernardino Bloomington Area Valley Blvd. Specific Plan Health & Wellness Element
48. SANBAG Climate Action Plan Implementation Tools
49. SANBAG Countywide Bicycle Route Mobile Application
50. SANBAG Countywide Complete Streets Strategy and Safe Routes to School Study
51. Yucaipa College Village/Greater Dunlap Neighborhood Sustainable Community
52. Big Bear Lake Rathbun Corridor Sustainability Plan

RIVERSIDE COUNTY

53. Eastvale Bicycle & Pedestrian Master Plan
54. WRCOG Public Health: Implementing the Sustainability Framework
55. WRCOG Land Use, Transportation and Water Quality Planning Framework
56. WRCOG Climate Action Plan Implementation
57. Riverside Restorative Growthprint
58. Moreno Valley Nason St. Corridor Plan
59. Calimesa Wildwood & Calimesa Creek Trail Master Plan
60. Beaumont Climate Action Plan
61. Hemet Downtown Specific Plan
62. Palm Springs Urban Forestry Initiative
63. Palm Springs Sustainablility Master Plan Update
64. Indio General Plan Sustainability & Mobility Elements
65. Cathedral City General Plan Update - Sustainability
66. CVAG CV Link Health Impact Assessment
67. Coachella La Plaza East Urban Development Plan

IMPERIAL COUNTY

68. Imperial County Transportation Commission Safe Routes to School Plan

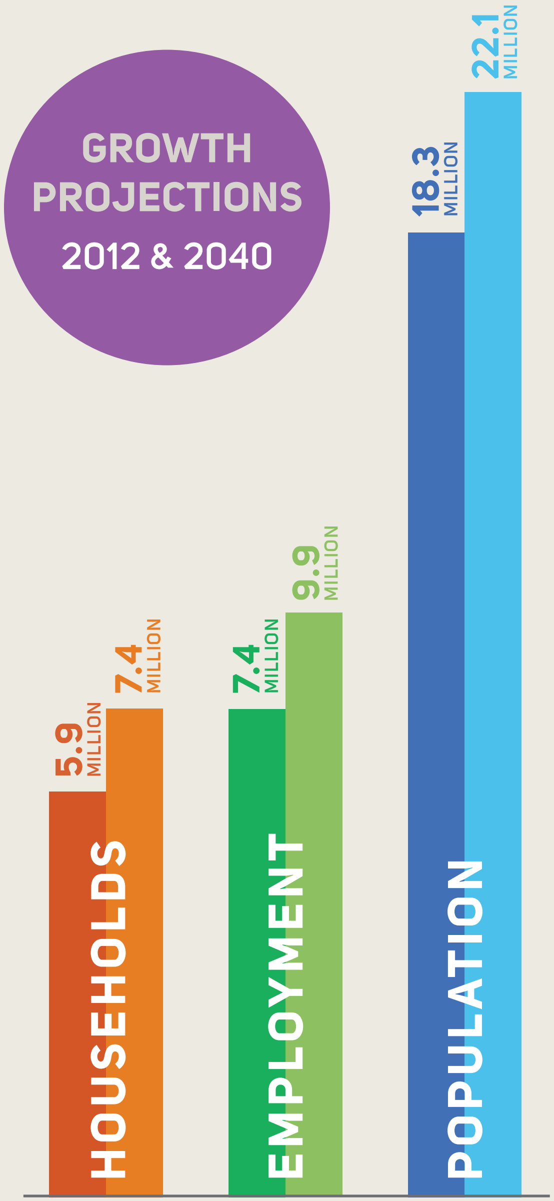
03

CHAPTER 3 HIGHLIGHTS

CHALLENGES IN A CHANGING REGION

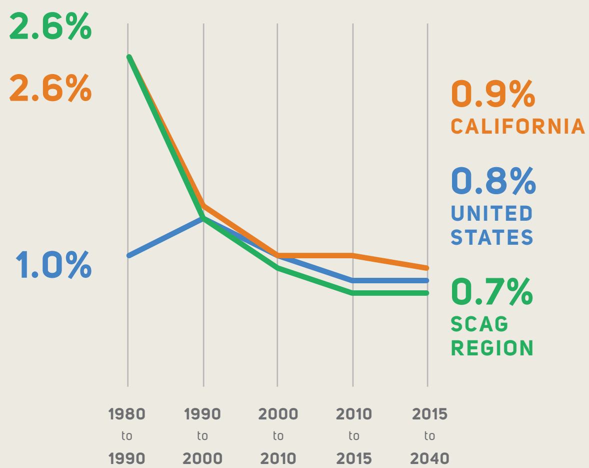
The challenges facing our region are formidable and require that we strategically plan now. This chapter explores some of our more pressing challenges as we head toward 2040.

FOCUS DEMOGRAPHICS



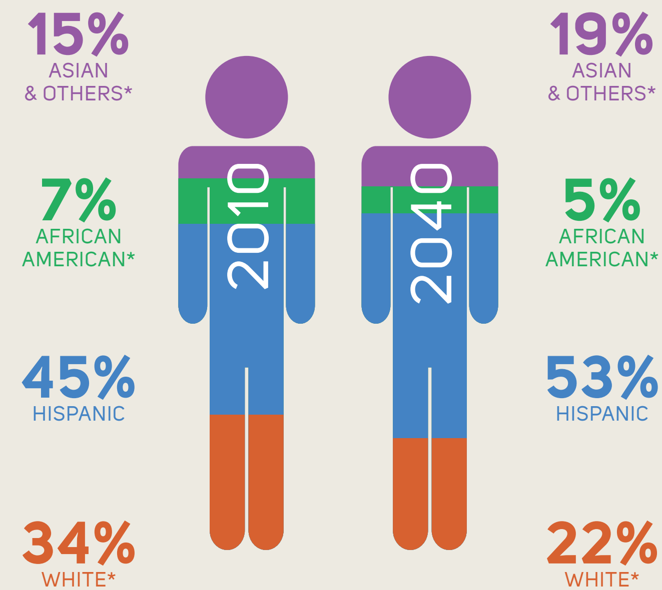
Source: CA DOF, CA EDD, SCAG

Average Annual Population Growth Rate



Source: US Census Bureau, CA DOF, SCAG

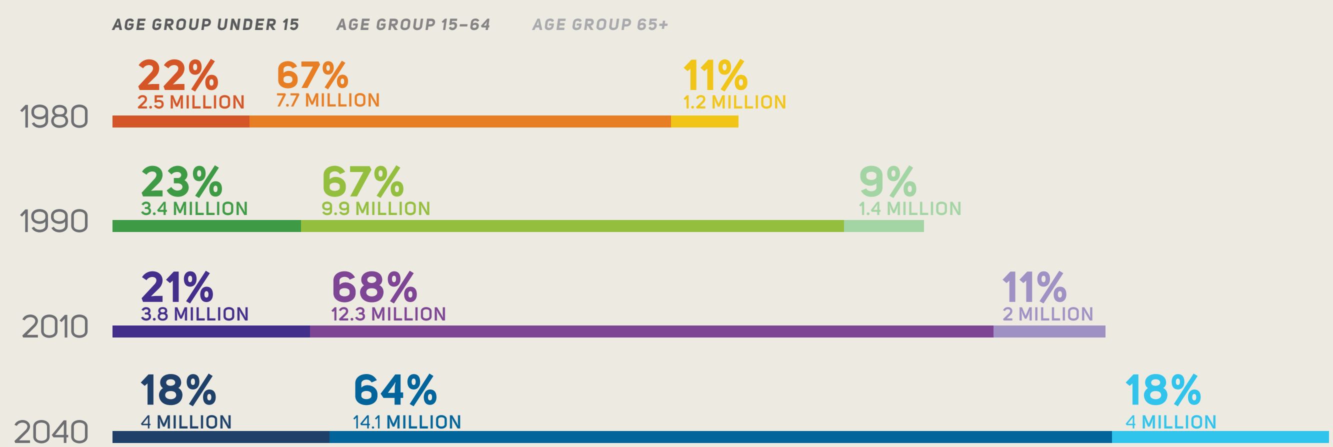
Changes in Ethnic Composition of Population



Due to rounding total may not be 100 percent

* Non-Hispanic | Source: US Census Bureau, SCAG

More Baby Boomers Will Age & Retire



Source: US Census Bureau, SCAG

RECESSION, RECOVERY AND CURRENT ECONOMIC CHALLENGES

The Great Recession, which lasted from December 2007 through June 2009, caused massive job losses and had a devastating impact on our region's economic well-being and population growth. Now that the recession is behind us and our region has experienced a decline in unemployment and housing foreclosures, challenges still remain. Though the region's employment levels are now where they were in 2007, our population continues to grow slowly. Also, the region's median household income (adjusted for inflation) has declined as wages have stagnated for a larger population base. This is because of not only the lack of high income jobs for the median household, but the inability to access higher paying jobs that are available but require higher education and/or technical skills. An increase in the number of low-paying jobs, and the resulting lower income, has contributed to more people slipping into poverty.

The health of Southern California's economy depends on the well-being of businesses and households, and a strong and efficient regional transportation system can go a long way in helping businesses and households succeed. An efficient transportation system can lead to an increase in productivity, personal income and ultimately public tax revenues. Businesses depend on a reliable transportation network to create products and services that reach their customers at a reasonable cost. Households depend on an integrated, accessible and dependable transportation network to provide reliable access to education, jobs, shopping and recreational activities. A sustainable, time-efficient and cost-effective transportation system can help neighborhood businesses compete more effectively with those in neighboring jurisdictions. Relieving congestion contributes greatly to future employment growth. For our region to remain a competitor in the global economy, SCAG must continue to invest strategically in transportation infrastructure, while ensuring that it obtains the maximum return on those investments.

CURRENT DEMOGRAPHIC TRENDS

The six counties that comprise our region have experienced significant demographic changes and they can expect even more changes over the next 25 years. The overall population will continue to grow more slowly than in the past, and it will also change in terms of its age distribution and racial and ethnic breakdown. Where people choose to live will also change. More people in our region will increase the demands on our already strained transportation system, as well as on available land for development.

According to the California Department of Finance, our region is now home to 18.9 million people, or about 5.9 percent of the U.S. population and 48.3 percent of California's population. The region is the second-largest metropolitan area in the country, after the New York metropolitan area. If it were a state, our region would rank fifth in the U.S. in terms of the size of its population, just behind New York and ahead of Illinois.

By 2040, the region's population is expected to grow by more than 20 percent to 22 million people—an increase of 3.8 million people. Importantly, we expect the region to grow differently than in the past. Before 1990, population growth was driven largely by both a natural increase and migration. That is, people moved into Southern California from other states and countries and there was additional population growth due to a net increase in the existing population (births minus deaths). Since 1990, however, any gains from immigration have been offset by domestic migration losses and Southern California's population growth has been fueled mostly by a natural increase (more births than deaths)—despite declining fertility rates. This continuing trend is expected to account for most of the Southern California's future population growth by 2040.

As we approach the middle of the century, Southern California's population will still remain racially and ethnically diverse. Currently, we are 47 percent Hispanic, 31 percent non-Hispanic White, 16 percent non-Hispanic Asian/Other and six percent non-Hispanic African American. In particular, the rapid growth of the region's Hispanic population is expected to continue; by 2040 it is projected that 53 percent of the region's residents will be Hispanic. The region's non-Hispanic Asian/Other population is also expected to increase, growing to 19 percent of the population.

Notably, the median age of our region's overall population is projected to rise, with more older people throughout Southern California as we approach the middle of the century. As the Baby Boomer generation continues to age, our region will experience a significant increase in its senior population—a trend expected nationwide. Today, people who are 65 and older represent around 12 percent of the region's total population. But by 2040, the number of seniors will increase to 18 percent (i.e., nearly one in five people in our region). This demographic shift will have major impacts on the locations and types of housing we build and our plans for transportation. This demographic group of seniors covers a wide range of needs; residents in their late sixties and early seventies will have different needs than those in their eighties and nineties. Nonetheless, a key challenge for the region will be to help seniors maintain their independence in their homes and communities.

STATE HIGHWAY SYSTEM PRESERVATION

TOTAL NEEDS =

$65.8 BILLION

EXISTING FUNDS =

$26.7 BILLION

GAP =

$39.0 BILLION

Note: Numbers may not sum to total due to rounding.

As the number and share of seniors are projected to increase, the percentage share of younger people of working age is expected to fall. The ratio of people older than 65 to people of working age (15 to 64) is expected to increase to 28 seniors per 100 working age residents by 2040—up from 16 in 2010. This means that our region could face a labor shortage and a subsequent reduction in tax revenues.

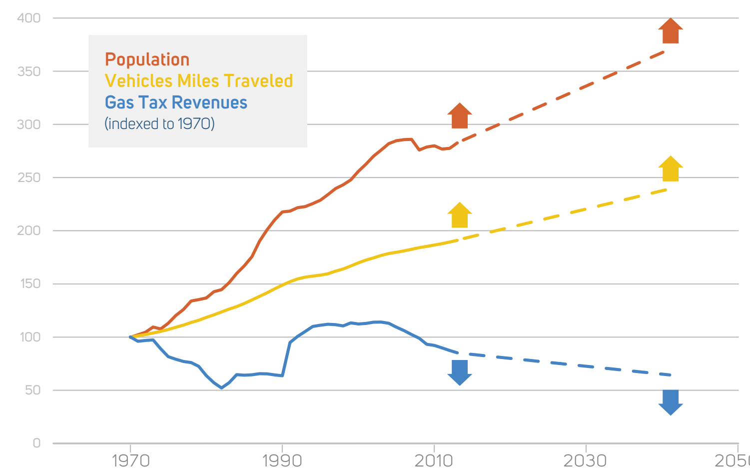
As we plan for the future and face these challenges, we also expect an interesting convergence of interests between two distinct population groups—namely Millennials, who today range in age from 20 to 35, and aging Baby Boomers, who range in age from 51 to 70. Millennials represent 22.4 percent of our region's total population and rely less on automobiles than have previous generations; they are less apt to acquire drivers licenses, drive fewer miles and conduct fewer overall trips. Research also shows that Millennials often prefer to live in denser, mixed-use urban areas well served by transit, rather than decentralized suburban areas. This trend could explain why there has been increasing demand for new multifamily housing.[1] Millennials also are more likely than other groups to embrace a range of mobility options, including shared cars, biking, transit and walking. These evolving preferences for transportation and housing are significant because Millennials will account for a large part of Southern California's overall population in 2040. In the near term, their housing and transportation preferences, when combined with the need of Baby Boomers to maintain their independence, could significantly change how Southern California develops.

FINANCING TRANSPORTATION

Perhaps our most critical challenge is securing funds for a transportation system that promotes a more sustainable future. The cost of a multimodal transportation system that will serve the region's projected growth in population, employment and demand for travel surpasses the projected revenues expected from the gas tax—our historic source of transportation funding. The purchasing power of our gas tax revenues is decreasing and will continue on a downward trajectory as tax rates (both state and federal) have not been adjusted in more than two decades while transportation costs escalate, fuel efficiency improves and the number of alternative-fuel vehicles continues to grow. FIGURE 3.1 highlights the decline in gas tax revenues, in relation to the growing population and demand for travel.

To backfill limited state and federal gas tax revenues, our region has continued to rely on local revenues to meet transportation needs. In fact, 71 percent of SCAG's core revenues are local revenues. Seven sales tax measures have been adopted throughout the region since the 1980s, so the burden of raising tax dollars has shifted significantly to local agencies. In reality, we need a stronger state and federal commitment to raising tax dollars for the Southern California transportation system—given its prominence and importance to the state and national economy, particularly when it comes to the movement of goods. Our region's transportation system should be able to rely on more consistent tax revenues raised at all levels of government.

FIGURE 3.1 CALIFORNIA POPULATION, TRAVEL AND GAS TAX REVENUE TRENDS



Source: Caltrans, California Department of Finance, California State Board of Equalization, White House Office of Management and Budget

[1] Dutzik, T., Inglis, J., & Baxandall, Ph.D., P. (2014). Millennials in Motion: Changing Travel Habits of Young Americans and the Implications for Public Policy. U.S. PIRG Education Fund.

TABLE 3.1 PROPOSED 2016–2040 RTP/SCS GROWTH FORECAST

	POPULATION				HOUSEHOLDS				EMPLOYMENT			
REGION	2012	2020	2035	2040	2012	2020	2035	2040	2012	2020	2035	2040
IMPERIAL	180,000	234,000	272,000	282,000	49,000	72,000	89,000	92,000	59,000	102,000	121,000	125,000
LOS ANGELES	9,923,000	10,326,000	11,145,000	11,514,000	3,257,000	3,494,000	3,809,000	3,946,000	4,246,000	4,662,000	5,062,000	5,226,000
ORANGE	3,072,000	3,271,000	3,431,000	3,461,000	999,000	1,075,000	1,135,000	1,152,000	1,526,000	1,730,000	1,870,000	1,899,000
RIVERSIDE	2,245,000	2,480,000	3,055,000	3,183,000	694,000	802,000	1,009,000	1,055,000	617,000	849,000	1,112,000	1,175,000
SAN BERNARDINO	2,068,000	2,197,000	2,638,000	2,731,000	615,000	687,000	825,000	854,000	659,000	789,000	998,000	1,028,000
VENTURA	835,000	886,000	945,000	966,000	269,000	285,000	306,000	312,000	332,000	375,000	409,000	420,000
SCAG	18,322,000	19,395,000	21,486,000	22,138,000	5,885,000	6,415,000	7,172,000	7,412,000	7,440,000	8,507,000	9,572,000	9,872,000

Source: SCAG
Note: All figures are rounded to the nearest 1,000. The County numbers may not sum to the region total due to rounding.

FOCUS

IMPORTANCE OF SYSTEM PRESERVATION

We Will Pay More–If We Do Not Fix-it-First

EACH $1 SPENT HERE...
Seals, Thin Overlays (Preventive Maintenance)
SURFACE DAMAGE
4–7 Years

DELAYS SPENDING $3 HERE...
Thicker Overlays
MINOR DAMAGE
6–7 Years

DELAYS SPENDING $8 HERE...
Rehabilitation/Reconstruction
MAJOR DAMAGE
10+ Years

Source: 2013 State of the Pavement Report

The State of Disrepair

17% OF HIGHWAYS ARE **DISTRESSED**

6% OF LOCAL ROADS IN **FAILED CONDITION IN 2012**

25% OF LOCAL ROADS WILL BE IN **FAILED CONDITION** IN 2022 UNDER CURRENT (2012) FUNDING

18% OF BRIDGES RATED AS **FUNCTIONALLY OBSOLETE**

10% OF BRIDGES RATED AS **STRUCTURALLY DEFICIENT**

$103 BILLION

of all **proposed expenditures** through **2040** are allocated to highway & arterial system operations & maintenance in the **2016 RTP/SCS**

Source: Federal Highway Administration National Bridge Inventory & 2014 State Highway Operation & Protection Program

A Bumpy & Costly Ride

Annual Vehicle Maintenance Costs by Metropolitan Area Due to Poor Road Conditions

LOS ANGELES/ ORANGE COUNTY	$832	$542	MISSION VIEJO
HEMET	$738	$534	VENTURA COUNTY
TEMECULA/MURRIETA	$664	$501	INDIO-CATHEDRALCITY-PALM SPRINGS
INLAND EMPIRE	$638	$421	LANCASTER-PALMDALE

Bumpy Roads Ahead Study & TRIP, A National Transportation Research Group, 2013

PRESERVING OUR TRANSPORTATION SYSTEM

Southern California's transportation system is in an unfortunate state of disrepair due to decades of underinvestment. Quite simply, investments to preserve the system have not kept pace with the demands placed on it. The inevitable consequence of this deferred maintenance is poor road pavement, which is particularly evident on our highways and local arterials. The rate of deterioration is expected to accelerate significantly as maintenance continues to be deferred. And as maintenance is deferred, the cost of bringing these assets back to a state of good repair is projected to grow exponentially. SCAG estimates that the cost to maintain our transportation system at current conditions, which is far from ideal, will be in the tens of billions of dollars beyond what is currently committed. For instance, the gap between needs and existing funding for the State Highway System through 2040 is now estimated at $39.0 billion. It should be noted that Caltrans is the owner and operator of the State Highway System and is responsible for funding the operation and maintenance of state highways, while local jurisdictions are responsible for the funding of operations and maintenance of local arterials.

Moving forward, the region needs to continue to "Fix-it-First" as a top priority—that is, focusing the necessary funds on preserving the existing transportation network while strategic investments are made in system expansions. Failing to adequately invest in the preservation of Southern California's roads, highways, bridges, railways, bicycle and pedestrian facilities, and transit infrastructure will only lead to further deterioration, which has the potential to worsen our congestion challenges. In addition, potholes and other imperfections in the roadway come with real costs to motorists, estimated by one study at more than $700 per household each year. The region's transportation system represents billions of dollars of investments that must be protected in order to serve current and future generations. The loss of even a small fraction of these assets could significantly compromise the region's overall mobility.

Preservation of the region's transit system, for example, is more important than ever as Baby Boomers, one of the fastest growing groups requiring transportation services, age. The region needs to plan for this projected increase in seniors with increased funding for transit and paratransit maintenance and preservation. Preserving infrastructure that encourages active transportation, such as walking and biking, is also important for maintaining mobility for those unable or uninterested in driving. It is also a cost-effective way to increase the number of roadway users without increasing roadway congestion.

MOVING GOODS EFFICIENTLY IN A HUGE AND COMPLEX REGION

The smooth and efficient movement of goods is critical to our regional economy, particularly as our region continues to recover from the recession. A number of key trends and drivers are expected to impact our region's goods movement system. Some of these, along with associated challenges, are highlighted below.

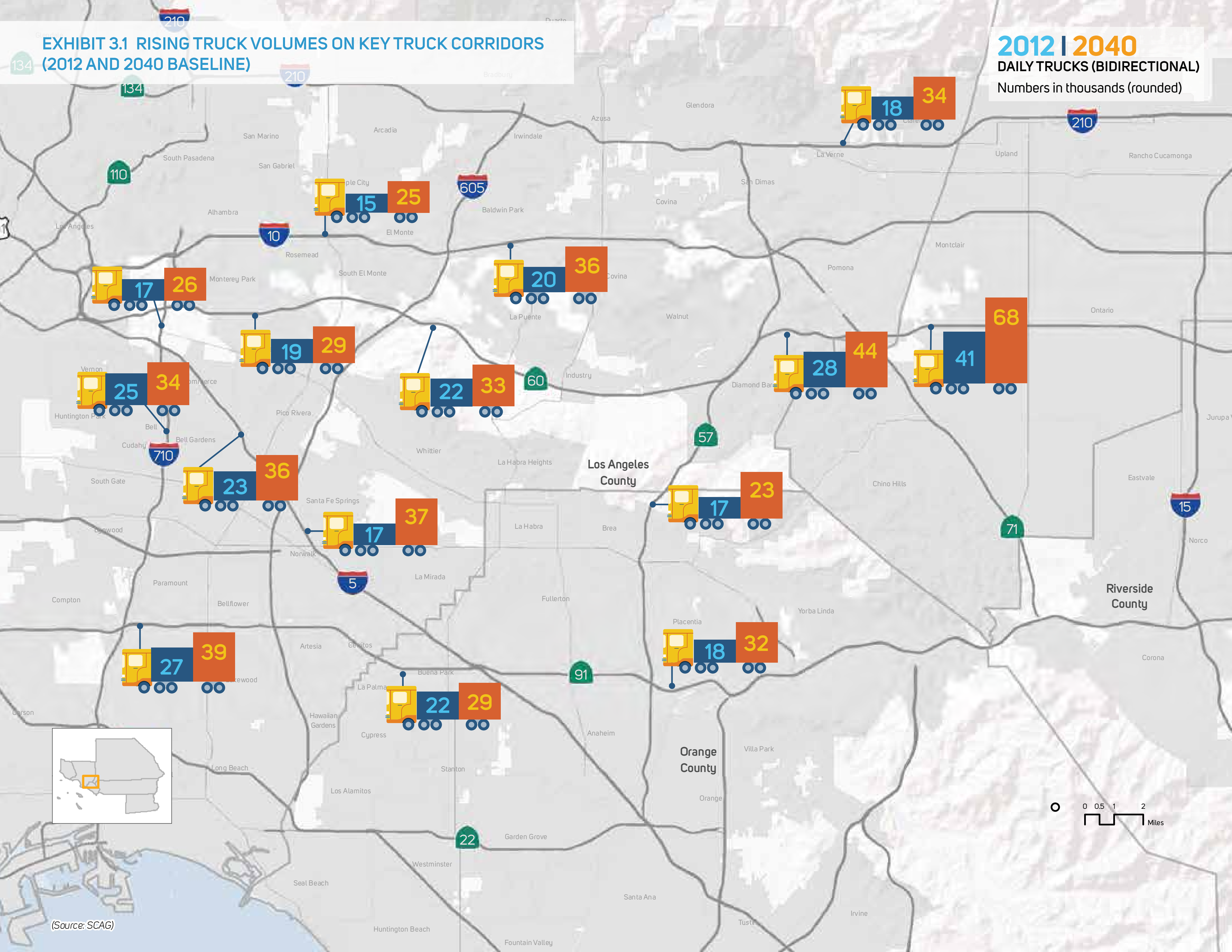
Population and Employment Growth: The regional population and rate of employment in our region are key indicators of economic health, and both are projected to grow rapidly over the next two decades. Our region's population growth is expected to fuel consumer demand for products and the goods movement services that provide them. This increased demand will drive stronger growth in freight traffic on already constrained highways and rail lines. Truck volumes on many key corridors are anticipated to grow substantially, as shown in EXHIBIT 3.1. Truck and auto delays will increase, as will truck-involved accidents. Levels of harmful emissions also will rise. The increase in rail volumes is expected to exacerbate vehicle hours of delay at rail and highway crossings.[2] Moreover, growing demand for commuter rail services on rail lines owned by the freight railroads will create additional capacity challenges.

Continued Growth in International Trade: The San Pedro Bay Ports anticipate cargo volumes to grow to 36 million containers by 2040—despite increasing competition with other North American ports, the expansion of the Panama Canal and more recent delays at port terminals due to labor negotiations. Port of Hueneme in Ventura County is also positioned to grow as a preferred port for specialized cargo such as automobiles, break bulk and military cargo. This growth will place further demands on marine terminal facilities, highway connections and rail intermodal terminals. If port-related rail traffic and commuter demands are to be met, mainline rail capacity improvements will be required as well. Meanwhile, mitigating the impacts of increased train traffic in communities will continue to be a challenge.

Logistics Epicenter: Southern California is the nation's epicenter for distribution and logistics activity, and it will continue to be a significant source of well-paying jobs in the region through 2040. The region has close to 1.2 billion square feet of facility space for warehousing, distribution, cold storage and truck terminals.[2] Nearly 1.1 billion square feet of this space is occupied. By 2040,

[2] CoStar Realty Information, Inc. www.costar.com, based on November 2014 data downloads.

EXHIBIT 3.1 RISING TRUCK VOLUMES ON KEY TRUCK CORRIDORS (2012 AND 2040 BASELINE)



(Source: SCAG)

the region may experience a shortfall of more than 527 million square feet of warehouse space, relative to demand.[3]

Air Quality Issues: Goods movement emissions contribute to regional air pollution problems (e.g., NOx and PM 2.5) and pose public health challenges. Emissions generated by the movement of goods are being reduced through efforts such as the San Pedro Bay Ports Clean Air Action Plan, as well as regulations such as the statewide Heavy Duty Truck and Bus Rule. But these reductions alone are unlikely to be sufficient to meet regional air quality goals.

Currently, much of the SCAG region does not meet federal ozone and fine particulate air quality standards as mandated by the federal Clean Air Act. The South Coast Air Basin has a deadline to reduce ozone concentrations to 80 parts per billion (ppb) by 2023 under the revoked 1997 eight-hour ozone standards, and further down to 75 ppb by 2031 under the current 2008 eight-hour ozone standards. Moreover, new federal ozone standards are expected to be finalized by the Environmental Protection Agency (EPA) in the 2015/2016 time frame, with an expected new attainment deadline of 2037. This means that NOx emissions in the South Coast Air Basin must be reduced 65 percent by 2023 and 75 percent (beyond projected 2023 emissions) by 2032 in order to attain federal ozone standards.[4] Additional attainment deadlines are in effect for PM 2.5.

Reducing greenhouse gas emissions is also a priority, as determined by the landmark California legislation Assembly Bill 32 and Senate Bill 375, and the more recent Executive Order B-30-15 signed by Governor Brown in April 2015. Several state measures have been implemented to reduce greenhouse gas emissions, with some implications for freight. These include the Low Carbon Fuel Standard and the inclusion of greenhouse gas emissions from transportation fuels under the California's Cap-and-Trade Program. Additional state programs are under development as part of the state's Sustainable Freight Strategy (SFS).

[3] Industrial Warehousing in the SCAG Region Study, Task 4 Warehousing Demand Forecast.
[4] Preliminary Draft AQMD Air Quality Management Plan White Paper, Goods Movement, June 2015.

HOUSING AFFORDABILITY, GENTRIFICATION AND DISPLACEMENT

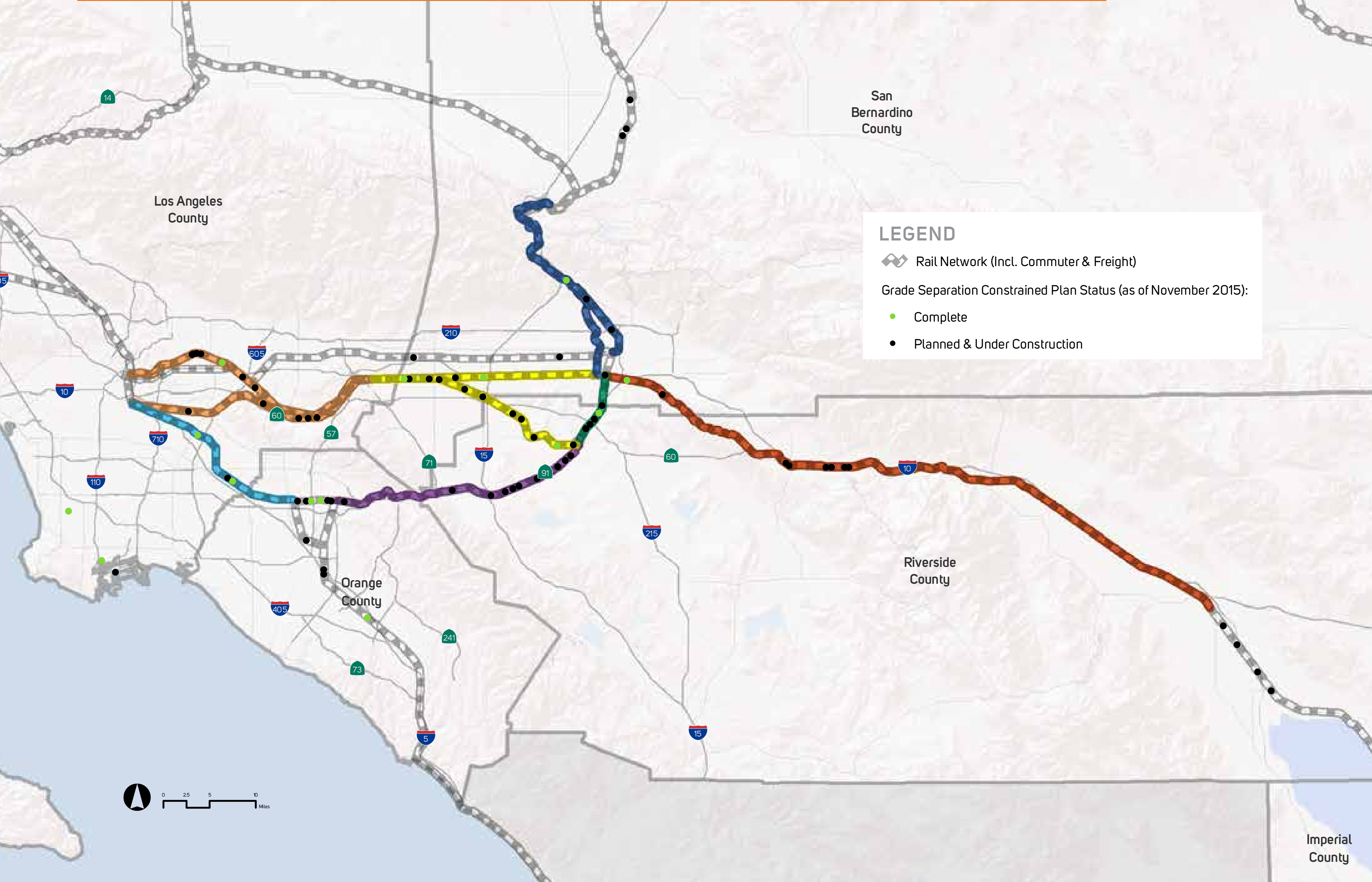
The cost of housing in Southern California is among the highest in the nation. Across our region, home prices and rents continue to rise, and the region continues to experience a shortage of affordable housing. The California Association of Realtors' (CAR) affordability index, which measures the percentage of households that can afford to purchase a median priced home in the state, remains around 35 percent for the SCAG region. Nearly 55 percent of renters and 45 percent of homeowners spend more than 30 percent of their income on rent or mortgage payments.

Affordability is becoming a significant issue in many communities, particularly in urban areas after the implementation of a new rail line, transit station or other major public investment. Housing unaffordability can undermine the overall goals of the RTP/SCS because it can contribute to suburban sprawl, longer job commutes and higher greenhouse gas emissions. As wealthier "outsiders" move into established communities, the increased demand for housing and business/retail space can lead to escalating costs for residential and commercial real estate. Many traditionally low-income, urban core communities at risk for gentrification are seeing dramatic changes in housing, retail stores, schools and other neighborhood amenities.

The region's overall affordability issues are particularly troubling because the region has a disproportionately high concentration of low-income and minority populations that are unemployed, live under the poverty line, have lower educational attainment, and live in close proximity to environmentally stressed areas. The region accounts for 67 percent of Californians who live in disadvantaged communities, as defined by Senate Bill 535, which requires investment in disadvantaged communities from California's Cap-and-Trade revenues. This represents more than 6.36 million people. Investments in transportation and other public infrastructure, affordable housing, economic development and job creation can help these communities in need.

As our region builds communities that are more compact and more transit-oriented, regional greenhouse gas emissions are anticipated to decline and residents from a variety of income levels will continue to make housing choices that allow them to use an increasing number of mobility options. The overall quality of life is expected to increase for many people. Transit investments and strategies will be most effective if coordinated with land use strategies,

PEAK DAY TRAIN VOLUME BY SEGMENT
(2012 to 2040)



RAIL SEGMENTS

BNSF Cajon Subdivision
San Bernardino-Silverwood PLUS

UPRR Mojave Subdivision
W. Colton-Silverwood

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	2	89
2040	2	167

UPRR LA Subdivision
East LA-Pomona PLUS

UP Alhambra Subdivision
Yuma Jct. - Pomona

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	54	37
2040	98	100

UP LA Subdivision
Pomona-W. Riverside PLUS

UPRR Alhambra Subdivision
Pomona-W. Colton

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	13	43
2040	48	112

UPRR Yuma Subdivision
Colton - Indio

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	1	40
2040	2	95

BNSF San Bernardino Subdivision
Atwood-W. Riverside

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	27	40
2040	62	91

BNSF San Bernardino Subdivision
Hobart-Fullerton

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	49	36
2040	110	80

BNSF San Bernardino Subdivision
W. Riverside-Colton

	PASSENGER TRAINS PER DAY	FREIGHT TRAINS PER DAY
2012	39	60
2040	108	139

GRADE SEPARATION PROJECTS

24
CURRENTLY UNDER CONSTRUCTION

+

42
PLANNED

WOULD **SAVE** AN ESTIMATED

5,500
DAILY VEHICLE HOURS OF DELAY
IN 2040

AFFORDABLE HOUSING TOOLBOX FOR LOCAL JURISDICTIONS

1. Streamline the residential project permitting process
2. Reduced fees or waivers for affordable housing development
3. Reduce parking requirements, especially in transit-rich areas
4. Adopt an affordable housing overlay zone
5. Preservation of mobile homes
6. Establish a housing trust fund
7. Add inclusionary zoning to the housing ordinance
8. Density Bonus ordinance
9. Increase density in transit-rich areas
10. Link a housing program with other policies such as active transportation and public health
11. Consider new building types and models, such accessory dwelling units or small units
12. Establish a Community Revitalization and Investment Authority (per AB 2) or Enhanced Infrastructure Financing District (per SB 628)

including transit-oriented development and providing affordable housing. However, people from low-income communities near new transit infrastructure may face displacement. Generally, displacement refers to a situation in which gentrification places pressure (through eviction or because of market forces) on people from existing communities to relocate to more affordable places. If those communities are priced out and move away from newly constructed transit facilities, those facilities lose the very people who are more likely to use them. Research suggests that lower income residents generate fewer vehicle miles traveled (VMT) and demonstrate the largest relative VMT reductions with location efficiency.[5]

This Plan's vision and goals include ensuring that regionwide benefits improve social equity—that is, the benefits of our Plan are realized by all populations in our Southern California region while its burdens are not carried disproportionately by one group over another. Providing people throughout our region with access to high quality transit and ensuring that they also have access to more affordable housing are related objectives. Currently, SCAG is partnering with the state and other regional agencies to study issues related to displacement and travel behavior near transit. Those results will inform future regional policies. Community advocates and other housing stakeholders are working to ensure that investments in traditionally low-income communities benefit existing residents and businesses instead of dividing communities. SCAG encourages municipalities to pursue strategies that avoid displacement, especially near transit stations, and ensure that existing communities retain their housing options.

The integration of affordable housing development with the goals of Senate Bill 375 has been the focus of several recently enacted state legislative bills. Bills such as Assembly Bill 2222 (Nazarian) and Assembly Bill 313 (Atkins) aim to preserve affordable housing in rapidly changing development environments, such as in projects that apply for local density bonuses and within Enhanced Infrastructure Financing Districts, respectively. Other bills, such as Assembly Bill 744 (Chau), reduce parking requirements for housing designed for low income households and seniors and meet certain thresholds for transit access, which not only lower the cost of building affordable housing but also encourages the development of affordable housing near transit—a clear goal of Senate Bill 375.

On a local level, there are a variety of tools available for jurisdictions to consider to increase the supply of affordable housing available (please see Affordable Housing Toolbox graphic). These tools are designed to reduce the cost of building affordable housing or establish a funding source for preserving or building affordable housing. While there is not a "one size fits all" approach, SCAG encourages jurisdictions to consider these strategies in order to address local housing affordability challenges.

5 Newmark, Ph.D, G., & Haas Ph.D., P. (2015). Income, Location Efficiency, and VMT: Affordable Housing as a Climate Strategy. San Francisco: California Housing Partnership.

Additionally, there are a number of statewide programs and resources to assist local jurisdictions in funding the production of affordable housing. As mentioned in earlier chapters, there are several new funding opportunities to help regions and jurisdictions promote affordable housing. California's Affordable Housing Sustainable Communities (AHSC) program, funded by the statewide Greenhouse Gas Reduction Fund created by Assembly Bill 32, provides funding to certain projects that provide affordable housing through a competitive grant process. Moreover, other programs such as the California Department of Housing and Community Development (HCD)'s Housing-related Parks Program, provides funds to local jurisdictions to maintain and rehabilitate parks and open space based on the number of affordable housing units built. Other opportunities to build housing also include Senate Bill 628 (Beall) and Assembly Bill 2 (Alejo), which allow jurisdictions to establish special reinvestment districts to develop affordable housing and supportive infrastructure and amenities. As the regional MPO, SCAG is committed to providing jurisdictions and stakeholders applying for funding opportunities with data, technical and policy support in order to further the progress of establishing more affordable housing in the region aligned with the goals of the RTP/SCS.

IMPROVING PUBLIC HEALTH

Today, many people in our region suffer from poor health due to chronic diseases related to poor air quality and physical inactivity. Chronic diseases including heart disease, stroke, cancer, chronic lower respiratory disease and diabetes are responsible for 72 percent of all deaths in our region, according to the California Department of Public Health. Furthermore, more than 60 percent of residents are overweight or obese, more than eight percent have diabetes, 27 percent suffer from hypertension and more than 12 percent suffer from asthma, according to the California Health Interview Survey. Health care costs resulting from being physically inactive, obese and overweight and from asthma cost our Southern California region billions of dollars annually in medical expenses, lost life and lost productivity, research shows.[6] For example, one study showed that health care costs resulting from physical inactivity and obesity reached an estimated $41.2 billion in 2006 in California.

A growing body of evidence shows that how a neighborhood is laid out and linked to transportation options can shape the lifestyles that people have—how physically active they are and how safe their everyday lives can be.[7] As a result, regional planning for land use and transportation across the U.S. has increasingly incorporated strategies to improve public health. MPOs such as SCAG are focusing on improving transportation safety, offering people more opportunities to walk, bike and embrace other forms of active transportation, improve first/last mile connections to transit, and improve access to natural lands. They are also pursuing strategies to make neighborhoods more walkable, improve air quality, help people cope with climate change impacts such as extreme heat events, improve accessibility to essential destinations such as hospitals and schools, and work overall toward a transportation system and land use patterns that promote regional economic strength.

One of the challenges that SCAG faces as it strives to improve public health is the sheer size and diversity of our region. Public health varies widely by geographic location, income and race. There is no one size fits all approach to meeting this complex challenge. It requires flexibility and creativity to ensure that initiatives are effective in both rural and urban areas.

To gain more insight on the connection between how we use land and public health, SCAG has identified seven focus areas for further analysis: access to essential destinations, affordable housing, air quality, climate adaptation, economic opportunity, physical activity and transportation safety. For more details, see the Plan's Public Health Appendix.

CONFRONTING A CHANGING ENVIRONMENT

The consequences of continued climate change already are impacting California and more intensified changes are expected. Ongoing drought conditions, water shortages due to less rainfall as well as declining snowpack in our mountains, and an agriculture industry in crisis have become hard realities in recent years. Climate change is transforming the state's natural habitats and overall biodiversity. Continued changes are expected to impact coastlines as sea levels rise and storm surges grow more destructive. Forests will continue to be impacted by drought and wildfire. Climate change also will impact how we use energy and the quality of public health. Our statewide transportation

6 Peck, C., Logan, J., Maizlish, N., & Van Court, J. (2013). The Burden of Chronic Disease and Injury: California. 2013. California Department of Public Health.

7 Frank, L. D., Schmid, T. L., Sallis, J. F., Chapman, J., & Saelens, B. E. (2005). "Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ." American Journal of Preventive Medicine, 28(2S2), 117-125.

system will experience new challenges as well as the global and regional climate continues to change.[8]

Researchers project that both coastal and inland Southern California will see many more days of extreme heat, with temperatures exceeding 95 degrees Fahrenheit.[9] This is expected to increase heat-related mortality, lower labor productivity and boost demands for energy. Meanwhile, changing patterns of rain and snowfall—including the amount, frequency and intensity of precipitation across the state—will have serious long-term impacts on the supply and quality of water in Southern California.

It is clear that our region needs to prepare for these projected challenges and a big part of that effort is to make individual communities and the region as a whole more resilient to the consequences of climate change. "Climate resiliency" can be defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change.[10] Without advance planning and effective action, the consequences of climate change will negatively impact our transportation system, our economy and our everyday lives.

The state's Adaptive Planning Guide encourages our region and others across California to evaluate the local impacts of climate change. These impacts include increased temperatures, reduced precipitation, rising sea levels, a fall in tourism, reduced water supplies, a heightened risk of wildfire, threats to public health related to degraded air quality and heat, stresses on endangered and threatened species, diminished snowpack and coastal erosion.[11] Our region is still facing a serious drought that began in 2012 and its length and severity has led to mandatory water restrictions for the first time in state history. At the same time, state programs designed to meet future climate challenges proactively are underway. These include initiatives such as the Safeguarding California[12] plan, as well as Governor Brown's Executive Order calling for new actions to mitigate and adapt to the impacts of climate change. These initiatives present regional agencies such as SCAG with opportunities to show leadership as the state confronts climate change challenges.

Continued climate change will impact our region in various ways and we are now getting a clearer picture of how it will impact the day-to-day lives of those of us who are most vulnerable—such as the poor, the elderly and the disabled. Responding effectively to climate change requires us to cooperate more with one another, to use limited resources more wisely, and to think more creatively to align our goals. The impacts of climate change, like other environmental challenges, are expected to hit hardest those communities that are least equipped to handle them. Particularly in Southern California, public agencies must focus on safeguarding people who are most vulnerable to extreme heat and air pollution. The elderly and children under five years old are most vulnerable to heat-related illness.[13] As our demographics change, proactive planning that ensures the health of these distinct populations will be increasingly important.

Our region certainly cannot fight climate change alone. It will be a global effort. However, it is up to us to make sure we can adapt to climate change and mitigate its impacts in our own region. We cannot expect anyone else to do this work for us. Long-range regional planning inherently recognizes the relationship between today's investments and tomorrow's outcomes. Confronting climate change and building climate resilient communities is, at its core, an exercise in smart planning. We will need to build on actions we have already taken by integrating considerations of climate and sustainability into the approaches we take to grow our economy, protect the environment and public health, and plan for the future.

8 California Resources Agency. (n.d.) Fact Sheets on California Climate Risks [Fact Sheet]. Retrieved from http://resources.ca.gov/docs/climate/Safeguarding_Handout_All.pdf.

9 Rogers, J., Barba, J., & Kinniburgh, F. (2015). From Boom to Bust? Climate Risk in the Golden State. Risky Business Project. Accessed at http://riskybusiness.org/uploads/files/California-Report-WEB-3-30-15.pdf.

10 Safeguarding California: Reducing Climate Risk. (2014). California Natural Resources Agency. Accessed at http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf.

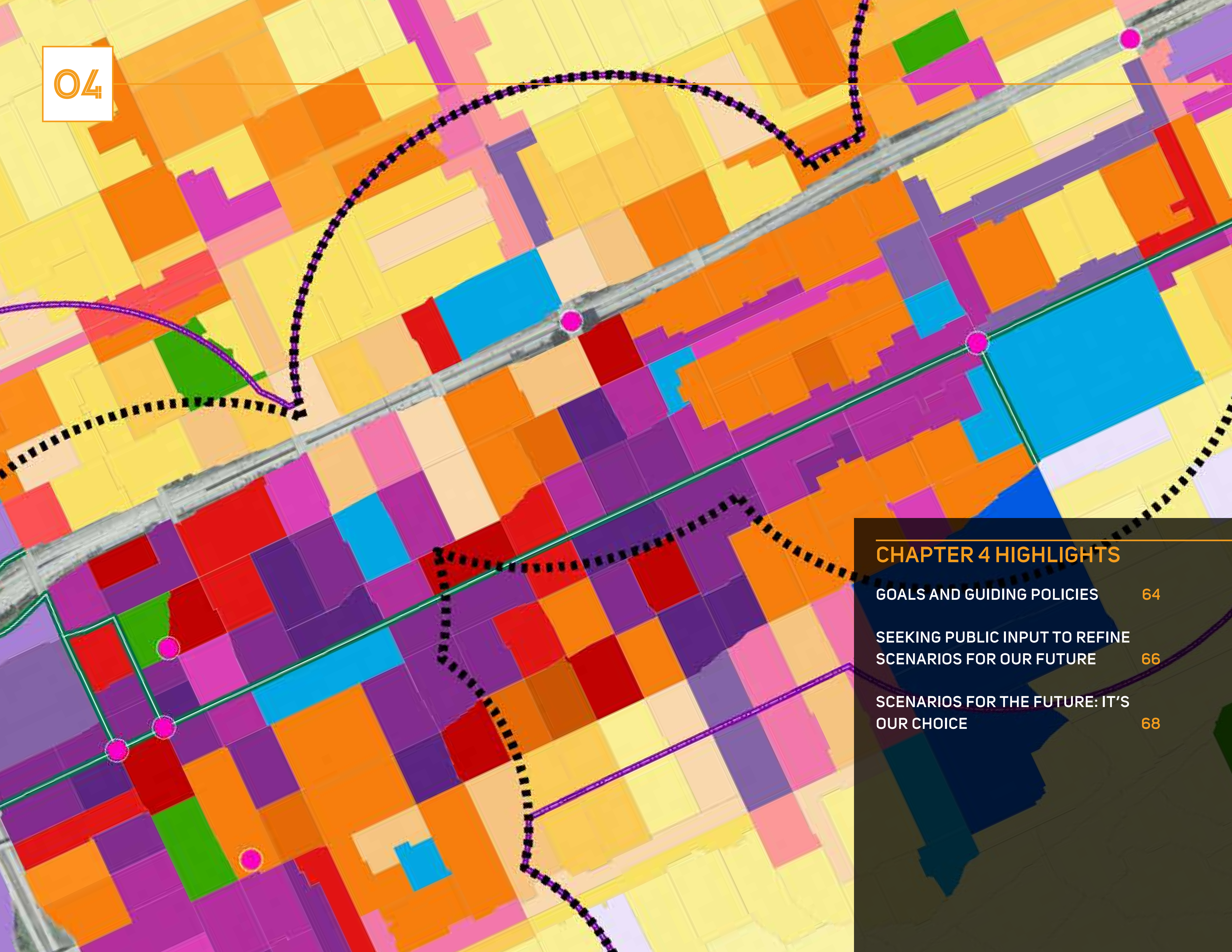
11 California Adaptation Planning Guide: Planning for Adaptive Communities. (2012). California Emergency Management Agency & California Natural Resources Agency. Accessed at http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf.

12 California Adaptation Planning Guide: Planning for Adaptive Communities. (2012). California Emergency Management Agency & California Natural Resources Agency. Accessed at http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf.

13 California Adaptation Planning Guide: Planning for Adaptive Communities. (2012). California Emergency Management Agency & California Natural Resources Agency.

CONCLUSION

We will now turn to a discussion of how SCAG developed the 2016 RTP/SCS, with a particular emphasis on the extensive public outreach that SCAG conducted to develop the best Plan possible to address our challenges. The 2016 RTP/SCS, after all, is the region's Plan for the future. By design, it reflects the region's needs, priorities and desires—as well as the statutory requirements of the State of California and the federal government.



04

CHAPTER 4 HIGHLIGHTS

CREATING A PLAN FOR OUR FUTURE

The RTP/SCS is a long-range visioning plan that balances future mobility and housing needs with goals for the environment, the regional economy, social equity and environmental justice, and public health. Ultimately, the Plan is intended to help guide transportation and land use decisions and public investments.

This update, the 2016 RTP/SCS, reflects goals and guiding policies and a vision developed through extensive outreach to the general public and numerous stakeholders across our region. SCAG values the region's tremendous diversity and acknowledges that it cannot tackle challenges in the same way everywhere. This chapter discusses how the Plan was developed, and it offers an overview of SCAG's "preferred scenario" for land use and transportation in our region in 2040. SCAG developed this preferred scenario to guide its update of the 2012 RTP/SCS and then settle on a final set of strategies, programs and projects that will place the region more firmly on the road toward achieving its goals. Those strategies, programs and projects are reviewed in Chapter 5.

GOALS AND GUIDING POLICIES

As SCAG updated the 2012 RTP/SCS, it evaluated its existing goals, guiding policies and performance measures to determine whether they should be refined. Since the adoption of the 2012 RTP/SCS, several developments have occurred that influenced the development of the 2016 RTP/SCS. These include:

- A surface transportation funding and authorization bill known as "Moving Ahead for Progress in the 21st Century Act" (MAP-21) was signed into law by President Obama on July 6, 2012. MAP-21 includes specific goals for safety; improving the condition of transportation infrastructure; reducing congestion and making the transportation system more reliable; freight movement and economic vitality; and environmental sustainability. MAP-21 now requires that Metropolitan Planning Organizations such as SCAG set performance targets for improving transportation safety and system preservation in coordination with state departments of transportation.

  At the time this document was being prepared, the federal rulemaking process to implement MAP–21 was not yet complete. SCAG will continue to monitor rulemaking to understand the implications for the Plan, and take the necessary steps to fully evaluate the final rule. Also, in December 2015, the Fixing America's Surface Transportation Act, or "FAST Act," was signed in to law. The FAST Act is a five-year transportation funding and authorization bill that maintains many of the MAP-21 provisions, but also has new provisions including a national freight program. As with MAP-21, SCAG will monitor the rulemaking process to implement FAST Act provisions.

2016 RTP/SCS GOALS

1. Align the plan investments and policies with improving regional economic development and competitiveness.
2. Maximize mobility and accessibility for all people and goods in the region.
3. Ensure travel safety and reliability for all people and goods in the region.
4. Preserve and ensure a sustainable regional transportation system.
5. Maximize the productivity of our transportation system.
6. Protect the environment and health of our residents by improving air quality and encouraging active transportation (e.g., bicycling and walking).
7. Actively encourage and create incentives for energy efficiency, where possible.
8. Encourage land use and growth patterns that facilitate transit and active transportation.
9. Maximize the security of the regional transportation system through improved system monitoring, rapid recovery planning, and coordination with other security agencies.*

**SCAG does not yet have an agreed-upon security performance measure.*

2016 RTP/SCS GUIDING POLICIES

1. Transportation investments shall be based on SCAG's adopted regional Performance Indicators.
2. Ensuring safety, adequate maintenance and efficiency of operations on the existing multimodal transportation system should be the highest RTP/SCS priorities for any incremental funding in the region.
3. RTP/SCS land use and growth strategies in the RTP/SCS will respect local input and advance smart growth initiatives.
4. Transportation demand management (TDM) and active transportation will be focus areas, subject to Policy 1.
5. HOV gap closures that significantly increase transit and rideshare usage will be supported and encouraged, subject to Policy 1.
6. The RTP/SCS will support investments and strategies to reduce non-recurrent congestion and demand for single occupancy vehicle use, by leveraging advanced technologies.
7. The RTP/SCS will encourage transportation investments that result in cleaner air, a better environment, a more efficient transportation system and sustainable outcomes in the long run.
8. Monitoring progress on all aspects of the Plan, including the timely implementation of projects, programs, and strategies, will be an important and integral component of the Plan.

- The rapid advancement of new technologies such as real-time traveler information, on-demand shared mobility services enabled by smartphone applications, car sharing and bike sharing is influencing how households travel and their choices about vehicle ownership. New technologies are encouraging more efficient transportation choices, which help public agencies manage the multimodal transportation system more efficiently.
- There is a continuing emphasis on reducing greenhouse gas emissions, even after the adoption of Senate Bill 375. On April 29, 2015, Governor Brown issued Executive Order B-30-15, which establishes a California greenhouse gas reduction target of 40 percent below 1990 levels by 2030. Because the transportation sector is the largest contributor to California's greenhouse gas emissions (more than 36 percent), SCAG anticipates updated and more stringent regional emissions reduction targets.

This Plan's goals are intended to help carry out our vision for improved mobility, a strong economy and sustainability. Based on our assessment of these developments, the goals of the 2016 RTP/SCS, which are represented graphically in this chapter, remain unchanged from those adopted in the 2012 RTP/SCS.

The guiding policies for the 2016 RTP/SCS are intended to help focus future investments on the best-performing projects and strategies to preserve, maintain and optimize the performance of the existing transportation system. Two additional guiding policies have been added since 2012. The first addition (Guiding Policy 6) addresses emerging technologies and the potential for such technologies to lower the number of collisions, improve traveler information, reduce the demand for driving alone and lessen congestion related to road incidents and other non-recurring circumstances (a car collision, for example). The second addition (Guiding Policy 7) recognizes the potential for transportation investments to improve both the efficiency of the transportation network and the environment.

SEEKING PUBLIC INPUT TO REFINE SCENARIOS FOR OUR FUTURE

To develop a preferred scenario for the region at 2040, SCAG first generated four preliminary scenarios for our region's future—each one representing a different vision for land use and transportation in 2040. More specifically, each scenario was designed to explore and convey the impact of where the region would grow, to what extent the growth would be focused within existing cities and towns, and how it would grow—in other words, the shape and style of the neighborhoods and transportation systems that would shape growth over the period. To help the agency refine these four scenarios, SCAG reached out extensively to the general public and numerous stakeholders to seek their views and input. Refining the scenarios was an important step on the road toward settling on a preferred scenario—which offers a comprehensive picture of what kind of future we want. The scenarios and the selected preferred scenario proved to be powerful planning tools to solidify our vision for our region at the middle of the century. These preliminary scenarios are not the ones modeled in the Program Environmental Impact Report (PEIR).

Public outreach was integral to the development of the entire RTP/SCS, but particularly during the refinement of scenarios. To ensure that the 2016 RTP/SCS was developed openly and inclusively, the agency implemented a comprehensive public outreach and involvement program. This was based on a Public Participation Plan adopted by SCAG's Regional Council in April 2014. Specific public engagement strategies used during the development of the Draft 2016 RTP/SCS included:

- Developing materials for public outreach in a variety of formats to reach broad audiences, including a short video, fact sheets, surveys, PowerPoint presentations and poster boards.
- Centralizing RTP/SCS information on a new easy-to-use microsite, developed to be mobile/tablet friendly and compliant with the 1990 Americans with Disabilities Act.
- Supporting multiple committees, task forces and working groups made up of SCAG partners, stakeholders and interested groups to develop the key components of the Plan.
- Holding multiple public open houses before the release of the Draft RTP/SCS, to allow direct and interactive participation with interested parties.

OUR COUNTY TRANSPORTATION COMMISSIONS

The SCAG region includes a total of six county transportation commissions (CTCs), one for each county—Imperial, Los Angeles, Orange, Riverside, San Bernardino and Ventura. Each CTC is responsible for planning and implementing countywide transportation improvements, allocating locally-generated transportation revenues, state and federal funding, and, in some cases, operating transit services. During each RTP/SCS update, the CTCs provide SCAG with extensive project lists that are then incorporated into the Plan. The projects included on these lists are regarded as regionally significant and/or anticipated to receive (or already receiving) federal and state funds. In addition, the CTCs anticipate that these projects will be initiated or completed by the Plan's horizon year (in this case, 2040). The 2016 RTP/SCS includes more than 4,000 projects—ranging from highway improvements, railroad grade separations, bicycle lanes, new transit hubs and replacement bridges. CTCs are a valuable resource for learning more about projects that are coming to your community by 2040.

ICTC Imperial County Transportation Commission

Metro

OCTA

RCTC Riverside County Transportation Commission

Governments SANBAG Working Together

VCTC Ventura County Transportation Commission

CALIFORNIA TRANSPORTATION PLAN 2040

INTEGRATING CALIFORNIA'S TRANSPORTATION FUTURE

The State of California, with direction from the California Department of Transportation (Caltrans), developed a statewide, long-range transportation plan with a 25-year planning horizon, the California Transportation Plan 2040 (CTP 2040). The Draft CTP 2040 provides a long-range policy framework to meet California's future mobility needs and reduce greenhouse gas emissions. Caltrans is required to develop this plan per Senate Bill 391 (2009). Specifically, emissions must be reduced to 1990 levels from current levels by 2020, and 80 percent below the 1990 levels by 2050 as described by Assembly Bill 32 (2006) and Executive Order S-03-05 (2015). The CTP 2040 will demonstrate how major metropolitan areas, rural areas, and state agencies can coordinate planning efforts to achieve critical statewide goals. Like the CTP 2040, the 2016 RTP/SCS aims to motivate the development of an integrated, multi-modal transportation system that is sustainable, improves mobility and enhances our quality of life. Though the CTP 2040 is not yet finalized (anticipated approval in the next year), it helped inform the goals, policies and strategies included in the 2016 RTP/SCS.

California Transportation Plan 2040
Integrating California's Transportation Future

- Announcing the schedule for the open houses through a wide variety of means, including community calendars, distributing flyers at local events and libraries, email newsletters, social media and ethnic media.
- Seeking the assistance of transit agencies, stakeholder organizations and their communication channels to maximize outreach opportunities.
- Reaching out to traditionally underrepresented and/or underserved audiences.
- Evaluating public participation activities to continually improve the outreach process.

The overall Plan was developed with input from local governments, county transportation commissions (CTCs), tribal governments, non-profit organizations, businesses and local stakeholders within Imperial, Los Angeles, Orange, Riverside, San Bernardino and Ventura counties. Outreach and coordination efforts also included work with providers of public transportation, county transportation commissions, and designated Consolidated Transportation Services Agencies (CTSAs) to ensure consistency with the plans and programs of these agencies, including short and long range plans of Coordinated Public Transit Human Services Transportation Plans. A fuller discussion of these plans can be found on pages 61–65 of the Transit Appendix.

From past plan development cycles, SCAG had heard from many participants about the need for early engagement during the development of the RTP/SCS. For members of the public, SCAG conducted public engagement activities between May and July 2015, with 23 open house events held across six counties. These events helped educate residents on the goals of the Plan, explore topics included in the Plan and gather input on priorities with an electronic survey. Participants reviewed poster boards showing projected changes in population and demographics within their county and the region, and then were asked for their input on how the region could accommodate growth in a variety of areas. These include providing transportation options, improving public health, preserving natural lands and supporting economic opportunities.

During discussion of the scenarios, major components were presented with maps, charts and figures. SCAG presented results associated with each scenario at public open houses held throughout the region to help stakeholders understand regional growth options. Participants learned about:

- The impact that different options for growth would have on transportation, land use, the economy and the environment
- The degree to which growth could be focused within the region's local jurisdictions over the next 25 years
- The potential shape and style of neighborhoods and transportation systems
- How varying combinations of land use and transportation strategies lead to different land consumption, travel, energy, water and pollutant impacts

Specific details on the scenarios can be found in the SCS Background Documentation Appendix.

Recognizing that not all members of the public could attend the open houses, SCAG provided an opportunity to participate virtually by providing workshop materials and a survey online. Hundreds of Southern Californians participated online and gave input on transit accessibility, transportation investments and other topics. A summary report from the survey was presented at a special joint meeting of SCAG's Regional Council and Policy Committees, and this report is also included in the Public Participation & Consultation Appendix.

In addition to these outreach efforts, all regular and special meetings of SCAG's Transportation Committee; Community, Economic and Human Development Committee; Energy and Environment Committee; Legislative/Communications and Membership Committee; Executive Administration Committee; and Regional Council were publicly noticed and opportunities for public comment were provided at each meeting. Federally required interagency consultation was done through the monthly meetings of the Transportation Conformity Working Group. Additional outreach strategies that were implemented are outlined in Public Participation & Consultation Appendix.

SCAG is not an implementing agency, so it is not directly involved in the construction or operation of transportation projects and other infrastructure improvements discussed in this Plan. The significance of the 2016 RTP/SCS is that the vision contained within the Plan sets the tone for policy development by other government agencies throughout the region. The public involvement discussed in this chapter helped the SCAG board and staff members understand the needs and concerns of stakeholders, leading to a more meaningful collective vision for the region's future.

SCENARIOS FOR THE FUTURE: IT'S OUR CHOICE

To refine the scenarios and ultimately develop a preferred scenario, SCAG gathered a large amount of feedback at the public meetings we have discussed. An important part of this process involved conducting comprehensive surveys.

SURVEY PARTICIPATION

Participants at public workshops were asked to complete a 37-question survey to provide input on their priorities, and open-ended feedback was encouraged. The survey was also available for completion on SCAG's website. Survey questions and a summary of responses are included in Public Participation & Consultation Appendix. Between the 2016 RTP/SCS Open Houses and the 2016 RTP/SCS website, more than 650 residents from throughout the SCAG region participated in the survey. About 75 percent of open house attendees participated in the survey, indicating that stakeholders were engaged during the workshops and wanted to participate in a meaningful way. The majority of survey participants resided in Los Angeles County, making up 51 percent of the total, followed by Orange County at 15 percent and Riverside, San Bernardino and Ventura Counties at nine percent each. Five percent of online participants did not state in which county they reside.

SURVEY RESULTS

Expanding transportation choices was clearly a priority for survey participants. Whether it is through public transportation, express lanes, bicycles or personal vehicles, our region wants as wide a range of choices as possible. When asked what our top priority should be for managing our regional highway and road system, the top two responses were almost evenly split. Most respondents wanted to protect and preserve existing transportation infrastructure—supporting a "Fix-it-First" policy—and they wanted to achieve maximum productivity through system management and demand management.

Moreover, the general open-ended comments received suggested there should be less focus on constructing new roads and lanes to build capacity. When asked about transportation budget priorities, survey respondents primarily favored creating more public transportation options, followed closely by constructing bikeways and then improving traffic flow. Regarding transit, feedback received from comment cards was particularly helpful. The most prevalent comments stated a desire for:

- More efficient posting of time schedules
- More accurate system maps
- Better integration of fare systems
- Increasing space for bicycles on public transit
- Creating a comprehensive, efficient and regional-scale bus system
- Exploring opportunities such as double-decker highways that explicitly allow transit operations on one level
- Expanding transit commuter options

Open-ended written comments provided helpful direction in the area of active transportation. Many commenters preferred enhancing non-motorized infrastructure such as bike lanes and sidewalks to improve access to transit and increasing transportation options for all. Suggested strategies included:

- Simultaneously funding road improvements and prioritizing pedestrian infrastructure
- Increasing resources for Complete Streets and protected bike lanes
- Providing public education for motorists, cyclists and pedestrians to help everyone understand how roads are to be shared

Survey participants recognized the connection between public health, active transportation and the environment. When asked about which areas of public health they were most concerned about, air quality was the top health concern among respondents. Having safe areas for walking, biking and physical activity was also a concern, as was access to healthy food.

There is no "one size fits all" type of land use or density in a region as diverse as ours. However, it is fair to say that survey participants generally favored infill development rather than expanding our urban footprint into natural areas or farmland; 80 percent of respondents preferred development in existing areas. For example, when asked where future residential development should mostly occur, the majority of participants said they preferred part mixed-use, part urban areas. Some suburban mixed-use areas were also desired, but strictly urban or suburban areas were least favored. When asked what type of housing should be built to accommodate our region's future population, multifamily attached housing was the leading response. Small-lot detached homes and townhouses were somewhat favored, and large lot detached housing was least favored. About 90 percent of survey participants found protecting natural habitat areas to be important or very important.

Collectively, the survey responses offered an invaluable guide to help finalize the Plan's investments, strategies and priorities. They reflect how regional stakeholders want us to address priority areas such as transit and roadway investments, system management, active transportation, land use and public health.

OUR PREFERRED SCENARIO

The extensive public outreach, coupled with detailed analysis of each scenario and coordination with technical and policy committees, led to our selection of a preferred scenario for the 2016 RTP/SCS based upon SCAG's "Policy Growth Forecast." This preferred scenario also incorporated inputs from local jurisdictions, including the land use and transportation strategies, investments and policies reflected in the 2012 RTP/SCS.

The preferred scenario envisions future regional growth that is well coordinated with the transportation system improvements of the approved 2012 RTP/SCS, as well as anticipated new transportation projects planned by the region's CTCs and transit providers. It also incorporates best practices for increasing transportation choices; reducing our dependence on personal automobiles; allowing future growth in walkable, mixed-use communities and in High-Quality Transit Areas (HQTAs); and further improving air quality.

Regional investments in making transit trips quicker and easier are expanded to increase transit ridership. New land use concepts such as "Livable Corridors" and "Neighborhood Mobility Areas" are also introduced. These are described in more detail later in the Plan. In the preferred scenario for the 2016 RTP/SCS, new residential growth from 2012 to 2040 is split between multifamily housing (66 percent) and detached single-family homes (34 percent). The preferred scenario is the result of an investment plan that is assumed to be financially constrained.

To help our regional partners envision how the preferred scenario fosters development on the ground, SCAG built upon its earlier outreach and solicited feedback from local jurisdictions on the distribution of new households and employment at the neighborhood level, through 2040. During the review of the draft policy growth forecast in summer 2015, jurisdictions were asked to provide input on the growth scenario, including information on specific planned development projects with entitlements, other planned projects, or recently completed developments. Accordingly, the following core principles provided the framework for the preferred scenario:

- **Principle #1:** The preferred scenario will be adopted at the jurisdictional level, thus directly reflecting the population, household and employment growth projections derived from the local input process and previously reviewed and approved by local jurisdictions. The preferred scenario maintains these projected jurisdictional growth totals, meaning future growth is not reallocated from one local jurisdiction to another.
- **Principle #2:** The preferred scenario at the Transportation Analysis Zone (TAZ) level is controlled to be within the density ranges* of local general plans or input received from local jurisdictions.
- **Principle #3:** For the purpose of determining consistency for California Environmental Quality Act (CEQA), lead agencies such as local jurisdictions have the sole discretion in determining a local project's consistency with the 2016 RTP/SCS.
- **Principle #4:** TAZ level data or any data at a geography smaller than the jurisdictional level has been utilized to conduct required modeling analyses and is therefore advisory only and non-binding given that sub-jurisdictional forecasts are not adopted as part of the 2016 RTP/SCS. TAZ level data may be used by jurisdictions in local planning as it deems appropriate. There is no obligation by a jurisdiction to change its land use policies, General Plan, or regulations to be consistent with the 2016 RTP/SCS.
- **Principle #5:** SCAG will maintain communication with agencies that use SCAG sub-jurisdictional level data to ensure that the "advisory and non-binding" nature of the data is appropriately maintained.

Consistent with the above stated principles, the preferred scenario and corresponding forecast of population, household and employment growth is adopted at the jurisdictional level as part of the 2016 RTP/SCS and sub-jurisdictional level data and/or maps associated with the 2016 RTP/SCS is advisory only. For purposes of qualifying for future funding opportunities and/or other incentive programs, sub-jurisdictional data and/or maps used to determine consistency with the Sustainable Communities Strategy shall only be used at the discretion and with the approval of the local jurisdiction. However, this does not otherwise limit the use of the sub-jurisdictional data and/or maps by SCAG, CTCs, Councils of Governments, SCAG Subregions, Caltrans and other public agencies for transportation modeling and planning purposes. Any other use of the sub-jurisdictional data and/or maps not specified herein, shall require agreement from the Regional Council, respective policy committees and local jurisdictions.

The preferred scenario improves the reduction of greenhouse gas emissions in the region and enhances public health and other co-benefits from large transportation investments and improvements in technology—particularly those that focus on transit and first/last mile strategies.

Furthermore, the preferred scenario offers a vision for how we want our region to grow over the next quarter century and it gives us a clear-eyed view of what we want to achieve. Guided by goals and policies, built through analysis and refined with extensive public input, developing the preferred scenario set the stage for the hard work of building a comprehensive plan of land use and transportation strategies, programs and projects designed to confront our many challenges and move our region toward the vision embodied in the preferred scenario.

**With the exception of the six percent of TAZs that have average density below the density range of local general plans. The TAZs showing lower densities than GP designations are consistent with existing conditions and future land use and growth projections provided by local jurisdictions. SCAG did not lower the growth.*

Chapter 5 reviews those strategies, programs and projects that collectively will move the region toward realizing the outcomes seen in the preferred scenario—including more livable, healthy and economically strong communities and a more sustainable future.

05

CHAPTER 5 HIGHLIGHTS

THE ROAD TO GREATER MOBILITY & SUSTAINABLE GROWTH

At the beginning of Chapter 1, we reviewed several themes that resonate throughout the 2016 RTP/SCS. The first of these was: "Integrating strategies for land use and transportation." This is SCAG's overarching strategy for achieving its goals of regional economic development, maximized mobility and accessibility for all people and goods in our region, safe and reliable travel, a sustainable regional transportation system, a protected natural environment, health for our residents, and more.

INTEGRATING TRANSPORTATION AND LAND USE PLANNING: THE KEY TO ACHIEVING OUR GOALS

By integrating our strategies for transportation with our strategies for using land—in other words, considering in tandem how we grow and how we get around—we can build the communities that we want. Planning that does not strive for this close integration can result in sprawling suburbs connected haphazardly to poorly managed highways and isolated communities that lack easy access to public transportation connecting people from home to work, school and other destinations. Precious resources are squandered: time, energy, money, productivity, clean air and good health, among others.

As the region's transportation planning agency, SCAG has long promoted the concept of integrating transportation planning and land use planning. Since 2002, with the Southern California Compass and Shared Growth Vision for the region and the subsequent Compass Blueprint program (now the Sustainability Planning Grant Program), SCAG has promoted integrated planning tools for local governments that want their residents to have more mobility options, make their communities more livable, increase prosperity among all people and strive for sustainability. Subsequent policies adopted at the regional level in 2004, 2008 and 2012 have supported and advanced the integration of transportation and land use planning.

With the passage of Senate Bill 375 in 2008, the State of California formalized the idea of integrating planning statewide when the California Air Resources Board (ARB) set regional targets for reducing greenhouse gas emissions and required every Metropolitan Planning Organization (MPO) in the state to develop an SCS that charted a course toward reduced emissions and a more sustainable future. A central tenet of the SCS requirement is for MPOs to integrate land use and transportation planning.

Here is one example: High Quality Transit Areas (HQTAs) are places where people live in compact communities and have ready access to a multitude of safe and convenient transportation alternatives to driving alone—including walking and biking, taking the bus, light rail, commuter rail, the subway and/or shared mobility options. Along high quality bus corridors, for instance, a bus arrives at least every 15 minutes. Residential and commercial development is integrated with plans for transit, active transportation and other alternatives to driving alone.

The integrated strategies, programs and projects reviewed in this chapter are designed to improve a region with very specific changes underway: Over the next 25 years, our region's population is projected to grow by more than 20 percent, from about 18 million people to more than 22 million people. Diverse households will reside in all types of communities, including urban centers, cities, towns, suburban neighborhoods and rural areas. Much of the region will continue to be populated by households living in detached single-family dwellings located in lower-density suburban areas. However, 67 percent of new residences will be higher density multifamily housing, built as infill development within HQTAs. Households will demand more direct and easier access to jobs, schools, shopping, healthcare and entertainment, especially as Millennials mature and seniors grow in number. Concurrently, our Southern California region will remain a vital gateway for goods and services, an international center for innovation in numerous industries and a place that offers its residents a high standard of living. We know that our future growth will add new pressures to our transportation system and to our communities. However, through long-term planning that integrates strategies for transportation and land use, we can ensure that our region grows in ways that enhance our mobility, sustainability and quality of life.

OUR STRATEGIES FOR TRANSPORTATION AND LAND USE

In the discussion that follows, transportation and land use strategies are grouped separately, but it will nevertheless become clear how closely they are related to one another. The section that follows is the heart of the 2016 RTP/SCS, and by the end of the chapter our region's course toward a more mobile and sustainable future should be evident.

Serving as an MPO, Regional Transportation Planning Agency and Council of Governments, SCAG has an essential responsibility to develop an RTP/SCS that is dedicated to detailing recommended regional transportation investments and strategies. The agency has developed these transportation strategies in the context of how we are projected to grow and live as a region in coming decades. In this chapter we will first review regional strategies for growth and land use and then move into a comprehensive review of the agency's plans for the region's multi-faceted transportation system.

LAND USE STRATEGIES

The land use strategies included in this Plan are built on a foundation of contributions from communities, cities, counties and other local agencies across our region. The land use patterns reviewed here, for example, are based on local general plans as well as input from local governments. For this Plan update, SCAG was committed to preserving the growth forecasts provided by local jurisdictions at the jurisdictional level.

At the same time, Senate Bill 375 requires that SCAG, as the region's MPO, strive to develop a vision of regional development patterns that integrate with and support planned transportation investments. As part of that mandate, an overall land use pattern has been developed that respects local control, but also incorporates best practices for achieving state-mandated reductions in greenhouse gas emissions through decreases in per capita vehicle miles traveled (VMT) regionally.

2016 RTP/SCS LAND USE POLICIES

The 2016 RTP/SCS reaffirms the 2008 Advisory Land Use Policies that were incorporated into the 2012 RTP/SCS. These foundational policies, which have guided the development of this Plan's strategies for land use, are:

- Identify regional strategic areas for infill and investment
- Structure the plan on a three-tiered system of centers development[1]
- Develop "Complete Communities"
- Develop nodes on a corridor
- Plan for additional housing and jobs near transit
- Plan for changing demand in types of housing
- Continue to protect stable, existing single-family areas
- Ensure adequate access to open space and preservation of habitat
- Incorporate local input and feedback on future growth.

2016 RTP/SCS LAND USE STRATEGIES

For this Plan, land use strategies are described in this section.

Reflect The Changing Population And Demands

The SCAG region, home to about 18.3 million people in 2012, currently features 5.9 million households and 7.4 million jobs. By 2040, the Plan projects that these figures will increase by 3.8 million people, with nearly 1.5 million more homes and 2.4 million more jobs. HQTAs will account for three percent of regional total land, but will accommodate 46 percent and 55 percent of future household and employment growth respectively between 2012 and 2040. The 2016 RTP/SCS land use pattern contains sufficient residential capacity to accommodate the region's future growth, including the eight-year regional housing need, as shown in TABLE 5.1. The land use pattern accommodates about 530,000 additional households in the SCAG region by 2020 and 1.5 million more households by 2040. The land use pattern also encourages improvement in the jobs-housing balance by accommodating 1.1 million more jobs by 2020 and about 2.4 million more jobs by 2040.

This 2016 RTP/SCS reflects a continuation of the shift in demographics and household demand since 2012. This shift is apparent in the land use development pattern, which assumes a significant increase in small-lot, single-family and multifamily housing that will mostly occur in infill locations near bus corridors and other transit infrastructure. In some cases, the land use pattern assumes that more of these housing types will be built than currently anticipated in local General Plans. This shift in housing type—especially the switch from large-lot to small-lot single-family homes—is already occurring as developers respond to new demands. In 2008, 45 percent of all housing units were multifamily homes. From 2012 through 2040, the Plan projects that 66 percent of the 1.5 million new homes expected to be built in the SCAG region will be multifamily units, reflecting demographic shifts and anticipated market demand. This will result in an increase of multifamily units in the region to 49 percent of all housing units in the region.

Combating Gentrification and Displacement

The 2012 RTP/SCS discussed strategies to combat gentrification and displacement, a continuing challenge that we discussed in Chapter 3. Jurisdictions in the SCAG region should continue to be sensitive to the possibility of gentrification and work to employ strategies to mitigate its potential negative community impacts. Generally, the SCAG region will benefit from higher-density infill development, which means that neighborhoods will be adding to the local housing stock rather than maintaining the current stock and simply changing the residential population. In addition, local jurisdictions are encouraged to pursue the production of permanent affordable housing through deed restrictions or development by non-profit developers, which will ensure that some units will remain affordable to lower-income households. SCAG will

[1] Complete language: "Identify strategic centers based on a three-tiered system of existing, planned and potential relative to transportation infrastructure. This strategy more effectively integrates land use planning and transportation investment." A more detailed description of these strategies and policies can be found on pps. 90–92 of the SCAG 2008 Regional Transportation Plan, adopted in May 2008.

work with local jurisdictions and community stakeholders to seek resources and provide assistance to address possible gentrification impacts of new development on existing communities and vulnerable populations.

Focus New Growth Around Transit

The 2016 RTP/SCS overall land use pattern reinforces the trend of focusing new housing and employment in the region's HQTAs (see EXHIBIT 5.1). While maintaining jurisdictional totals, the overall land use pattern moves new development from areas outside of HQTAs into these areas. SCAG incorporated land use plans provided by local jurisdictions into this pattern. While many residents and employees within half a mile of a transit stop or corridor can walk or bike to transit, not all of these areas are targeted for new growth and/or land use changes. The 2016 RTP/SCS assumes that 46 percent of new housing and 55 percent of new employment locations developed between 2012 and 2040 will be located within HQTAs, which comprise only three percent of the total land area in the SCAG region. Since adoption of the 2012 RTP/SCS, jurisdictions have referenced HQTAs in their planning documents and have positioned themselves to compete for California's Cap-and-Trade auction proceeds to support Transit Oriented Development (TOD) and active transportation infrastructure.

HQTAs are a cornerstone of land use planning best practice in the SCAG region because they concentrate roadway repair investments, leverage transit and active transportation investments, reduce regional life cycle infrastructure costs, improve accessibility, avoid greenfield development, create local jobs, and have the potential to improve public health and housing affordability. Here, households have expanded transportation choices with ready access to a multitude of safe and convenient transportation alternatives to driving alone—including walking and biking, taking the bus, light rail, commuter rail, the subway and/or shared mobility options. Households have more direct and easier access to jobs, schools, shopping, healthcare and entertainment, especially as Millennials form households and the senior population increases. Moreover, focusing future growth in HQTAs can provide expanded housing choices that nimbly respond to trends and market demands, encourage adaptive reuse of existing structures, revitalize main streets and increase Complete Street investments.

Additional local policies that ensure that development in HQTAs achieve the intended reductions in VMT and greenhouse gas emissions include:

TABLE 5.1 REGIONAL HOUSING NEEDS ASSESSMENT, ADOPTED 2012

Projection period 2014–2021

COUNTY	NUMBER OF VERY LOW INCOME HOUSEHOLDS	NUMBER OF LOW INCOME HOUSEHOLDS	NUMBER OF MODERATE INCOME HOUSEHOLDS	NUMBER OF ABOVE MODERATE INCOME HOUSEHOLDS	TOTAL
Imperial	4,194	2,553	2,546	7,258	16,551
Los Angeles	45,672	27,469	30,043	76,697	179,881
Orange	8,734	6,246	6,971	16,015	37,966
Riverside	24,117	16,319	18,459	42,479	101,374
San Bernardino	13,399	9,265	10,490	24,053	57,207
Ventura	4,516	3,095	3,544	8,003	19,158
SCAG	100,632	64,947	72,053	174,505	412,137

EXHIBIT 5.1 HIGH QUALITY TRANSIT AREAS IN THE SCAG REGION FOR 2040 PLAN

High Quality Transit Areas (including rail stations and qualifying bus corridors, see glossary for definition)

- 2012 Base Year
- 2040 Plan (Note: 2040 Plan Rail Station Alternatives shown as ⊙)

(Source: SCAG)

- Affordable housing requirements
- Reduced parking requirements
- Adaptive reuse of existing structures
- Density bonuses tied to family housing units such as three- and four-bedroom units
- Mixed-use development standards that include local serving retail
- Increased Complete Streets investments around HQTAs. Complete Streets are streets designed, funded and operated to enable safe access for roadway users of all ages and abilities, including pedestrians, bicyclists, motorists and transit riders.

The State of California is also trying to encourage growth around transit with the passage of Senate Bill 743 (SB 743), which seeks to facilitate transit-oriented projects in existing urbanized areas. The bill creates a new exemption from CEQA for certain projects that are residential or employment centers or mixed-used projects located within a Transit Priority Area (TPA), a part of a specific plan with a certified EIR and consistent with the SCS or APS.

Transit Oriented Development, HQTAs and Local Air Quality Impacts

The 2016 RTP/SCS recognizes guidance from the 2005 ARB air quality manual, which recommends limiting the siting of sensitive uses within 500 feet of highways and urban roads carrying more than 100,000 vehicles per day. This ARB guidance is carefully applied in areas that support Transit Oriented Development. Less than 10 percent of HQTAs planned in the 2016 RTP/SCS would fall within 500 feet of highways and highly traveled corridors, according to geographic information system (GIS) analyses. While density is increased in some areas of HQTAs, growth remains constant in areas within 500 feet of highways and urban roads to reflect local input, thereby balancing the growth distribution.

Plan for Growth Around Livable Corridors

The Livable Corridors strategy seeks to revitalize commercial strips through integrated transportation and land use planning that results in increased economic activity and improved mobility options. Since 2006, SCAG has provided technical assistance for 19 planning efforts along arterial roadway corridors. These corridor planning studies focused on providing a better understanding of how corridors function along their entire length. Subsequent research has distinguished the retail density and the specific kinds of retail needed to make these neighborhood nodes destinations for walking and biking.

From a land use perspective, Livable Corridors strategies include a special emphasis on fostering collaboration between neighboring jurisdictions to encourage better planning for various land uses, corridor branding, roadway improvements and focusing retail into attractive nodes along a corridor.

Livable Corridors Network

SCAG identified 2,980 miles of Livable Corridors along arterial roadways discussed in corridor planning studies funded through the Sustainability Planning Grant program and along enhanced bus transit corridors identified by regional partners. However, the land use strategies proposed in the 2016 RTP/SCS are not tied to a specific corridor. Livable Corridors are predominately a subset of the HQTAs, however 154 miles are not designated as HQTAs. These miles were identified in Sustainability Planning Grant projects and are proposed for active transportation improvements and the land use planning strategies described below.

Livable Corridors Strategies

The Livable Corridors concept combines three different components into a single planning concept to model the VMT and greenhouse gas emission reduction benefits:

- **Transit improvements:** The associated county transportation commissions (CTCs) have identified some of these corridors for on-street, dedicated lane Bus Rapid Transit (BRT) or semi-dedicated BRT-light. The remaining corridors have the potential to support other features that improve bus performance. These other features include enhanced bus shelters, real-time travel information, off-bus ticketing, all door boarding and longer distances between stops to improve speed and reliability.
- **Active transportation improvements:** Livable Corridors should include increased investments in Complete Streets to make these corridors and the intersecting arterials safe for biking and walking.
- **Land use policies:** Livable Corridor strategies include the development of mixed-use retail centers at key nodes along the corridors, increasing neighborhood-oriented retail at more intersections and zoning that allows for the replacement of under-performing auto-oriented strip retail between nodes with higher density residential and employment. These strategies will allow more context sensitive density, improve retail performance, combat blight and improve fiscal outcomes for local communities.

Provide More Options For Short Trips

Thirty-eight percent of all trips in the SCAG region are less than three miles. The 2016 RTP/SCS includes land use strategies, Complete Streets integration and a set of state and local policies to encourage the use of alternative modes of transportation for short trips in new and existing Neighborhood Mobility Areas (NMAs) and Complete Communities. In addition to the active transportation strategies that will be discussed below, land use strategies include pursuing local policies that encourage replacing motor vehicle use with Neighborhood Electric Vehicle (NEV) use. NEVs are a federally designated class of passenger vehicle rated for use on roads with posted speed limits of 35 miles per hour or less.

Neighborhood Mobility Areas

NMAs have a high intersection density, low to moderate traffic speeds and robust residential retail connections. These areas are suburban in nature, but can support slightly higher density in targeted locations. The land use strategies include shifting retail growth from large centralized retail strip malls to smaller distributed centers throughout an NMA. This strategy has shown to improve the use of active transportation or NEVs for short trips. Steps needed to support NEV use include providing state and regional incentives for purchases, local planning for charging stations, designating a local network of low speed roadways and adopting local regulations that allow smaller NEV parking stalls. NMAs are applicable in a wide range of settings in the SCAG region. The strategies associated with this concept are intended to provide sustainable transportation options for residents of the region who do not have convenient access to high-frequency transit options.

Complete Communities

Development of “complete communities” can provide households with a range of mobility options to complete short trips. The 2016 RTP/SCS supports the creation of these mixed-use districts through a concentration of activities with housing, employment, and a mix of retail and services, located in close proximity to each other. Focusing a mix of land uses in strategic growth areas creates complete communities wherein most daily needs can be met within a short distance of home, providing residents with the opportunity to patronize their local area and run daily errands by walking or cycling rather than traveling by automobile.

Support Local Sustainability Planning

To implement the SCS, SCAG supports local planning practices that help lead to a reduction of greenhouse gas emissions. Many local governments in the SCAG region serve as models for implementing the SCS. Sustainable Planning & Design, Zoning Codes and Climate Action Plans are three methods that local agencies have been adopting and implementing to help meet the regional targets for greenhouse gas emission reductions outlined in the SCS.

Sustainable Planning & Design

Many of the local policy documents that SCAG has reviewed are based on best practices that encourage infill and mixed-use development. Mixed-use design guidelines embrace and encourage increased densities and a mixing of uses, while also reflecting community character. For example, numerous suburban specific plans in the SCAG region encourage the revitalization of traditional main streets, downtowns and corridors. Other plans provide guidance for converting single-use office parks and industrial districts into mixed employment, retail and residential districts.

Sustainable Zoning Codes

Many cities and counties in the SCAG region have adopted form-based zoning codes that are tailored to local conditions, such as specifying building size and design parameters but allowing for more flexibility regarding use. Moreover, several cities and counties are updating their zoning codes to make development standards more environmentally friendly and equitable. One example is the City of San Gabriel’s “Greening the Code” strategy, which identifies ways for the city’s existing development code to facilitate more sustainability. New policies can involve coordinating landscaping practices with water conservation, best management practices for stormwater management and capture, creating better pedestrian connectivity, allowing more flexibility for mixed-use development and promoting energy efficient designs.

Climate Action Plans

SCAG is supporting several local governments throughout the region in the formation of Climate Action Plans (CAP). CAPs outline strategies for reducing greenhouse gas emissions in a cost effective manner. This is done by creating greenhouse gas inventories so that local governments can efficiently target their emission reduction practices to sources that pollute the most. Strategies outlined by CAPs in the SCAG region include Green Building guidelines for municipal buildings and facilities, implementing public electric vehicle charging stations and establishing energy retrofit incentive programs for residents.

2016 RTP/SCS Strategy

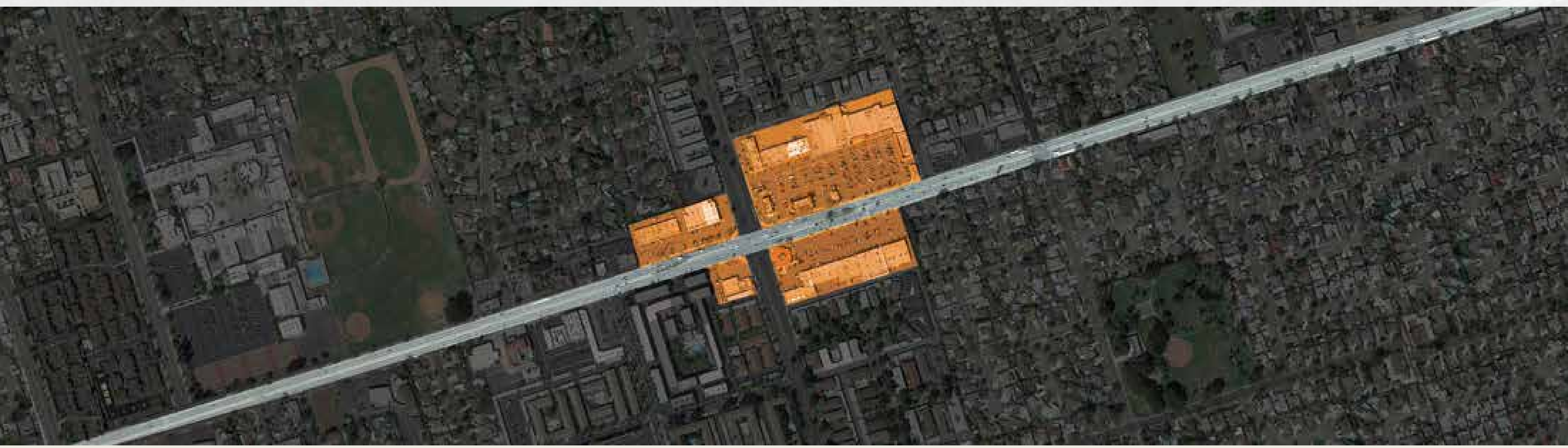
LIVABLE CORRIDORS

Enhancing the Connection Between Transit and Land Use

The SCAG region is crisscrossed by long arterial corridors, many of which are a legacy of Spanish colonial routes that linked the early missions and post-colonial ranchos. The suburban communities that developed rapidly after World War II were formed between these corridors, on a large (often one square mile) grid system. The inland portions of the South Bay, the Gateway Cities, the San Fernando and San Gabriel valleys, as well as the northern portions of Orange County follow this pattern. SCAG's Livable Corridors Strategy considers these suburban development patterns and proposes to encourage development along the boulevards that not only serve as major travel routes, but also destinations.

As the region transitions to higher investments in infill development and high quality, high frequency transit, these arterials are well suited to connect the region. The Livable Corridor Strategy specifically advises local jurisdictions to plan and zone for increased density at key nodes along the corridor and replacement of single-story under-performing strip retail with well-designed higher density housing and employment centers. This development along key corridors, when coordinated with improvements to the frequency and speed of buses along the corridors, will make transit a more convenient and viable option. Additionally, enhanced roadway designs to accommodate active transportation will also increase the vibrancy along these boulevards.

Several important transit investments in the SCAG region will help encourage this land use strategy. The Santa Ana Harbor Blvd Specific Plan incorporates the improved Orange County Transportation Authority (OCTA) Bravo! Route 543 and the planned OC Streetcar into its vision of the future. In Rancho Cucamonga, the City received a SCAG grant to reconcile the various specific plans along Foothill Blvd in anticipation of a future extension of the Omnitrans SbX. Across Los Angeles County, the Los Angeles County Metropolitan Transportation Authority (Metro) is planning for a high frequency network of buses with fewer stops. And the City of Los Angeles incorporated a "Transit Enhanced Network" as part of its General Plan Mobility Element to complement these investments.



Example of a Livable Corridor

Image courtesy of National Association of City Transportation Officials

2016 RTP/SCS Strategy

NEIGHBORHOOD MOBILITY AREAS

Encouraging Active Transportation for Short Trips

About 38 percent of all trips in the region are three miles or less. That is a short enough distance that can be covered by walking or biking, but more than 78 percent of these trips are made by driving. While convenient, driving for short trips can cause unnecessary congestion and pollution. What can be done to make it more convenient for people to walk, bike or even skate instead of driving, when practical?

The Neighborhood Mobility Areas strategy represents a set of state and local policies to encourage the use of active and other non-automobile modes of transportation, particularly for short trips in many suburban areas in Southern California developed between the late 1890s and the early 1960s. These suburban developments often were designed for streetcars and walking, in addition to automobiles and are characterized by small to medium lot single-family homes, a denser grid network of local roads, a higher density of intersections and accessibility to neighborhood retail establishments. By employing Complete Streets strategies, such as bike lanes, roundabouts, wider sidewalks or better lighting, the neighborhood design could encourage a return to greater active transportation use for those short trips. Similarly, planning a connected network of dedicated lanes and roadways with speed limits 35 mph and under can encourage more use of Neighborhood Electric Vehicles (NEV) for short trips. NEVs produce negligible greenhouse gas missions (based on energy production) and zero local pollution. In addition, NEVs take up less roadway capacity, less parking area at both the origin and destination and reduce the probability of an injury or fatality in the event of a collision with a pedestrian or bicyclist.

The Neighborhood Mobility Area concept is not new. Across the country, they are referred to as streetcar suburbs, first generation suburbs or suburban villages. But its application here in Southern California, when coupled with the renaissance some parts of the region are experiencing with transit and active transportation, would provide residents with greater mobility choices and an alternative to driving short distances.

Example of a Neighborhood Mobility Area

Image courtesy of National Association of City Transportation Officials

Protect Natural and Farm Lands

Many natural and agricultural land areas near the edge of existing urbanized areas do not have plans for conservation and they are susceptible to the pressures of development. Many of these lands, such as riparian areas, have high per-acre habitat values and are host to some of the most diverse yet vulnerable species that play an important role in the overall ecosystem.

Developing Conservation Strategies

Local land use decisions play a pivotal role in the fate of some of the region's most valuable habitat and farm lands. Many local governments have taken steps toward planning comprehensively for conserving natural lands and farm lands, while also meeting demands for growth. Across the region, transportation agencies and local governments have used habitat conservation plans and other tools to link land use decisions with comprehensive conservation plans in order to streamline development.

To support those and other comprehensive conservation planning efforts and to inform the local land use decision making process, SCAG studied regional scale habitat values, developed a conservation framework and assembled a natural resource database.[2] To coordinate with and support the viability of the Livable Corridors and HQTA land use strategies, this Plan suggests redirecting growth away from high value habitat areas to existing urbanized areas.

SCAG is engaging numerous stakeholders as it creates a Natural Lands Conservation Plan. Building on this effort may lead to a regional conservation program that CTCs, jurisdictions, agencies and non-profits can align with and support. This strategic and comprehensive approach allows the region to meet its housing and transportation needs, while ensuring that important natural lands, farm lands and water resources are protected. The 2012 RTP/SCS committed to a regional mitigation plan for inclusion in the 2016 RTP/SCS. With that as the foundation, the following are next steps for further developing a conservation strategy. More information can be found in the Natural & Farm Lands Appendix.

- Expanding upon the Open Space Conservation Database and Framework by incorporating strategic mapping layers to build the database and further refine the priority conservation areas
- Encouraging CTCs to develop advanced mitigation programs and/or include them in future transportation measures
- Aligning with funding opportunities and pilot programs to begin implementation of the Natural Lands Conservation Plan through acquisition and restoration
- Providing incentives to jurisdictions that cooperate across county lines to protect and restore natural habitat corridors, especially where corridors cross county boundaries.

[2] SCAG 2014 Inventory of Natural Resources Databases in SCAG region. Accessed at http://sustain.scag.ca.gov/Sustainability%20Portal%20Document%20Library/SCAG%20Inventory%20Natural%20Resources%20GIS%20Databases.pdf.

TRANSPORTATION STRATEGIES

The strategies for land use are tightly integrated with considerations for transportation, and that relationship is vital for our region to achieve its long-term regional goals. The same applies to our discussion of transportation strategies. The success of strategies related to transportation can only be achieved if they are tied closely to how we use land—how and where we grow, where we live, work, go to school, shop and so on. SCAG is pursuing numerous strategies divided into two broad categories: Maximizing Our Current System and Completing Our System. In all, the 2016 RTP/SCS includes $556.5 billion in transportation system investments through 2040.

MAXIMIZING OUR CURRENT SYSTEM

Working to make sure our existing transportation system is operating at maximum efficiency is a leading regional priority—and doing this is critical for the land use strategies discussed above to be effective. Over the past half century, the SCAG region has invested hundreds of billions of dollars into building and expanding the multimodal transportation system that we rely on today. Our investments must be protected and properly maintained to ensure that maximum productivity and efficiency are gained from the system. Under the system management approach, priority is given to maintaining and preserving the system, as well as ensuring that it is being operated as safely, efficiently and effectively as possible. This approach is illustrated in the system management pyramid (FIGURE 5.1). Protecting our previous investments and getting the most out of every component is the highest priority for our region.

Preserve Our Existing System

Southern California's transportation system is becoming increasingly compromised by decades of underinvestment in maintaining and preserving our infrastructure. These investments have not kept pace with the demands placed on the system and the quality of many of our roads, highways, bridges, transit, and bicycle and pedestrian facilities are continuing to deteriorate. Unfortunately, the longer they deteriorate the more expensive they will be to fix in the future. Even worse, deficient conditions compromise the safety of users throughout the network. For all of these reasons, system preservation and achieving a state of good repair are top priorities of the 2016 RTP/SCS.

About $275.5 billion, or nearly half of all of the 2016 RTP/SCS proposed expenditures through 2040, is allocated to system preservation and operation (see FIGURE 5.2). Chapter 6 reflects the allocation of these expenditures for the transit and passenger rail systems, the State Highway System, and regionally significant local streets and roads within the 2016 RTP/SCS. Note that the allocation for the State Highway System includes bridges; the allocation for transit includes funding to both preserve and operate the transit system; and the allocation for regionally significant local streets and roads includes bridges and active transportation safety improvements. The 2016 RTP/SCS system preservation strategies include:

- Protecting and preserving what we have first, supporting a "Fix-it-First" principle.
- Considering life-cycle costs beyond construction.
- Continuing to work with stakeholders to identify and support new sustainable funding sources and/or increased funding levels for preservation and maintenance.

Manage Congestion

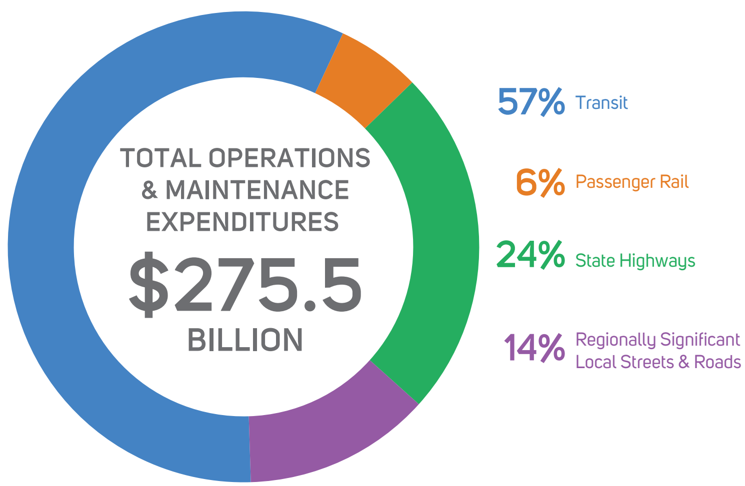
Congestion Management Process (CMP)

Federal regulations for Metropolitan Transportation Planning and Programming require the development, establishment and implementation of a CMP that is fully integrated into the regional planning process.[3] The Federal Highway Administration (FHWA) defines the CMP as a "systematic approach . . . that provides for effective management and operation, based on a cooperatively developed and implemented metropolitan-wide strategy, of new and existing transportation facilities eligible for funding under title 23 U.S.C. and title 49 U.S.C., through the use of operational management strategies." In compliance

[3] 23 CFR 450.320.

FIGURE 5.1 SYSTEM MANAGEMENT PYRAMID

FIGURE 5.2 PRESERVATION AND OPERATIONS EXPENDITURES



Note: Numbers may not sum to total due to rounding.

with federal law,[4] SCAG has made the CMP an integral part of the regional transportation planning process, including the 2016 RTP/SCS and the Federal Transportation Improvement Program (FTIP). The CMP is part of SCAG's integrated approach to improving and optimizing the transportation system, to provide for the safe and effective management of the regional transportation system through the use of monitoring and maintenance, demand reduction, land use, operational management strategies and strategic capacity enhancements. SCAG undertakes eight actions that are considered by FHWA to be the core of the CMP. These include developing regional objectives for congestion management; using performance measures and monitoring to understand the causes of congestion; identifying problems and needs; developing alternative strategies; and evaluating effectiveness. A more complete discussion of SCAG's CMP is provided in the Congestion Management Appendix.

The CMP requires that roadway projects that significantly increase the capacity for single-occupancy vehicles (SOVs) be addressed through a CMP that provides appropriate analysis of reasonable, multimodal travel demand reduction and operational management strategies for the corridor. If alternative strategies are neither practical nor feasible, appropriate management strategies must be considered in conjunction with roadway capacity improvement projects that would increase SOV capacity. SCAG previously used a $50 million threshold to identify SOV capacity-enhancing projects, but the agency is replacing this criterion with a project distance-based length criterion of one mile or more for the 2017 FTIP. Further details of this process are included in the upcoming 2017 FTIP.

Transportation Demand Management (TDM)

The 2016 RTP/SCS commits $6.9 billion toward TDM strategies throughout the region. There are three main areas of focus:

- Reducing the number of SOV trips and overall vehicle miles traveled (VMT) through ridesharing, which includes carpooling, vanpooling and supportive policies for shared ride services such as Uber and Lyft.
- Redistributing or eliminating vehicle trips from peak demand periods through incentives for telecommuting and alternative work schedules.
- Reducing the number of SOV trips through the use of other modes of travel such as transit, rail, bicycling and walking.

In addition, the following strategies expand and encourage the implementation of TDM strategies to their fullest extent:

- Rideshare incentives and rideshare matching.
- Parking management and parking cash-out policies.
- Preferential parking or parking subsidies for carpoolers.
- Intelligent parking programs.
- Promotion and expansion of Guaranteed Ride Home programs.
- Incentives for telecommuting and flexible work schedules.
- Integrated mobility hubs and first/last mile strategies.
- Incentives for employees who bike and walk to work.
- Investments in active transportation infrastructure.
- Investments in Safe Routes to School programs and infrastructure.

Transportation Systems Management (TSM)

The 2016 RTP/SCS includes $9.2 billion for TSM improvements. These include extensive advanced ramp metering, enhanced incident management, bottleneck removal to improve flow (e.g., auxiliary lanes), expansion and integration of the traffic signal synchronization network, data collection to monitor system performance, and other Intelligent Transportation System (ITS) improvements.

The 2016 RTP/SCS identifies a comprehensive set of strategies that work in concert to optimize the performance of the transportation system. This set of strategies does not focus solely on expanding the system, but also considers how we operate the system; how we coordinate land use planning with transportation planning; how we deal with incidents such as collisions or special events; how we provide information to the traveling public so people can make informed decisions about how, where and when to travel; and how we maintain the system. All of these strategies are based on a foundation of comprehensive system monitoring so that we can understand how the transportation system is performing and where we need improvement. This approach is based in part on work that California Department of Transportation (Caltrans) has done for many years to optimize the performance of the State Highway System. Two important categories for TSM strategies are:

1. **Corridor Mobility and Sustainability Improvement Plans:** Caltrans, SCAG and county partners in the past have worked together to improve the efficiency of our highways and arterials through the development of Corridor System Management Plans (CSMPs). Since the passage of Proposition 1B in November 2006 and with the creation Corridor Mobility Improvement Account (CMIA), which

[4] 23 USC 134 and 49 USC 5303-5305.

served to improve mobility on the State Highway System, several CSMPs have been developed for various corridors throughout the SCAG region. Historically, the response to congestion has been to add additional capacity. However, CSMPs have provided a lower cost, higher benefit option toward making highways and parallel arterial systems, transit and incident response management more efficient and were designed to focus primarily on operational strategies to optimize corridor performance through ITS strategies, in conjunction with operational and capacity improvements towards improving productivity along highway corridors. SCAG recognizes the efforts taken thus far under the current CSMP framework to improve mobility, but believes that CSMPs can be further improved upon. SCAG encourages the development of Corridor Sustainability Studies (CSS) which will build upon the existing CSMP framework by analyzing the corridor from a multimodal perspective. More specifically, these studies will include a focus on newer planning priorities such as Complete Streets and a Smart Mobility Framework (not addressed by current CSMPs). SCAG recognizes that the region could benefit from a site specific CSS focused on improving mobility for all modes of travel throughout the region.

2. **Integrated Corridor Management (ICM):** The ICM Initiative was first introduced by the U.S. Department of Transportation (U.S. DOT) back in 2006. Under the ICM approach, all elements within a corridor are considered to evaluate opportunities that move people and goods in the most efficient manner possible, while simultaneously ensuring that the greatest operational efficiencies are achieved. Since the introduction of ICM, great progress has been made. In Los Angeles, Caltrans (in coordination with Los Angeles County Metropolitan Transportation Authority or Metro) and various cities have embarked on the first Integrated Corridor Management pilot project on Interstate 210. This project aims to minimize congestion due to collisions and is also referred to as the Connected Corridors initiative. Over the next ten years, Caltrans plans to implement similar projects on 25 additional congested corridors statewide. ICM strategies to be considered as part of the Interstate 210 project include:

    - Integration of highway ramp meters and arterial signal systems
    - Arterial signal coordination
    - Traffic re-routing due to incidents or events
    - Transit signal priority on arterials and on-ramps
    - Parking management
    - Traveler communication (via changeable message signs, 511, radio, social networks, mobile app) of traffic conditions, transit services, parking, alternate route/trip/mode options
    - System coordination/communication between Caltrans (highway operator) and local jurisdictions (arterial operators).

Additional System Management Initiatives include:

- Arterial Signal Synchronization projects that have been completed on various arterials through the region to optimize traffic flow
- The Dynamic Corridor Congestion Management (DCCM) initiative in Los Angeles County, in which Caltrans is developing a corridor management initiative on Interstate 110 to coordinate highway ramp metering with arterial signals. Various efforts have been completed to inform the traveling public of expected travel times to various destinations and in some cases provide travel time comparisons with transit.
- The Caltrans Advanced Traffic Management (ATM) study for Interstate 105 and the Regional Integration of ITS Projects (RIITS) and IEN data exchange efforts at Los Angeles Metro.

Promote Safety and Security

Ensuring the safety and security of our transportation network for residents and visitors is a top priority. SCAG supports the implementation of the Strategic Highway Safety Plan (SHSP), which has an overarching goal of Toward Zero Deaths. The state's short-term goals are to reduce the number and rate of fatalities by three percent per year and to reduce the number and rate of severe injuries by 1.5 percent per year. SCAG is continuing to work with Caltrans and the CTCs toward identifying other means of improving the safety and security of our transportation system.

Regarding our transportation network's security, there are numerous agencies that participate in the response to incidents and assist with hazard preparations for individual jurisdictions. These include the California Emergency Management Agency, county offices of emergency management, fire departments, police departments and the California Highway Patrol. Collaboration among many of these agencies is essential when addressing incidents regionwide. The Federal Emergency Management Agency (FEMA) oversees this coordination. However, FEMA defines metropolitan areas differently than the U.S. DOT, so this limits SCAG's ability to participate at an agency level. Nevertheless, SCAG seeks to use its strengths and organization to assist first responders, recovery teams and planners alike in a supporting role.

FOCUS

BENEFITS OF TRANSPORTATION SYSTEMS MANAGEMENT/ TRANSPORTATION DEMAND MANAGEMENT (TSM/TDM)

Enhanced Incident Management
Reduces incident-related congestion, which is estimated to represent half of the total congestion in urban areas

Transit Automatic Vehicle Location
Enables monitoring of transit vehicles and ensures on-time performance

Advanced Ramp Metering
Alleviates congestion and reduces collisions at on-ramps and highway-to-highway interchanges

Traffic Signal Synchronization
Minimizes wait times at traffic signals and therefore reduces travel time

Improved Data Collection
Allows implementing agencies and operators to monitor system performance and optimize the impact of transportation investments

Advanced Traveler Information
Provides real-time traffic conditions and alternative routing, and therefore allows the public to make more informed travel decisions

Universal Transit Fare Cards (Smart Cards)
Reduces time required to purchase transit tickets and allows interoperability among transit providers

Case Study: Interstate 210 Pilot Project

Historically, efforts to reduce congestion have focused solely on individual networks, in which underutilized capacity in parallel highway lanes, arterial lanes and transit services were often not considered. In recent years, TSM/TDM strategies have been developed to increase efficiency through the use of technologies. The application of these technologies, such as intelligent transportation systems (ITS), and a commitment by Caltrans and its partner agencies to work together have the potential to transform the ways that corridors are currently operated.

In 2012, Caltrans, with assistance from Metro and California Partners for Advanced Transportation Technology (PATH) at UC Berkeley, developed the first Integrated Corridor Management (ICM) pilot project within the SCAG region along the Interstate 210 (I-210) corridor. The purpose of the pilot is to look at all opportunities to move people and goods in the most efficient manner possible, to ensure the greatest potential gains in operational performance. This includes seeking ways to improve how arterials, highways, transit and parking systems work in conjunction with one another.

Strategies to be considered as part of the project include:

- Integration of highway ramp meters and arterial signal systems
- Arterial signal coordination
- Traffic re-routing due to incidents or events
- Transit signal priority on arterials and on-ramps
- Parking management (e.g., smart parking—locating available parking spaces at transit stations and private parking garages)
- Variable lane configuration systems
- Traveler communication (via changeable message signs, 511, radio, social networks, mobile app) of traffic conditions, transit services, parking, alternate route/trip/mode options
- System coordination/communication between Caltrans and local jurisdictions

The pilot is still under development, but it has already changed the way state and local transportation agencies work together in managing transportation systems. Caltrans aims to eventually expand the application of ICM concepts to other corridors over the next ten years. In this context, the Interstate 210 Pilot is a test bed to demonstrate how an ICM project can be developed by engaging and building consensus among corridor stakeholders, to address congestion for the betterment of an entire network.

Caltrans

CALIFORNIA PATH

SCAG continues to pursue the following strategies toward ensuring safety and security:

- Ensure transportation safety, security and reliability for all people and goods throughout the region.
- Prevent, protect, respond to and recover from major human-caused or natural events in order to minimize the threat and impact to lives, property, the transportation network and the regional economy.
- Provide a policy forum to help develop regional consensus and education on security policies and emergency responses.
- Assist in expediting the planning and programming of transportation infrastructure repairs from major disasters.
- Encourage the integration of transportation security measures into transportation projects early in the development process by leveraging SCAG's relevant plans, programs and processes (including regional Intelligent Transportation Systems (ITS) architecture).

For more details on safety and security and additional policies and strategies, please review the Transportation Safety & Security Appendix.

COMPLETING OUR SYSTEM

Strategies for improving and expanding the many modes of transportation that make up the regional network must be integrated closely with our strategies for how we use land. The success of transit; passenger rail; walking, biking and other forms of active transportation; our highways and arterials; the efficient movement of goods; and our regional airport system all depend on a close relationship with how our region uses land and how we grow. This is particularly true when it comes to improving and building a transit system that can best serve people in communities throughout our region. It is the first transportation category for which numerous strategies are reviewed.

Transit

Since 1991, the SCAG region has spent more than $50 billion dollars on public transportation. This includes high profile investments in rail transit and lower profile, vital investments in operations and maintenance. Looking toward 2040, the 2016 RTP/SCS maintains a significant investment in public transportation across all transit modes and also calls for new household and employment growth to be targeted in areas that are well served by public transportation to maximize the improvements called for in the Plan. This investment package includes a selection of major capital investments described in TABLE 5.2, which displays all locally notable transit capital projects and additional capital investment packages totaling more than $500 million. These investments include new rail transit facilities, vehicle replacements, bus system improvements and capitalized maintenance projects.

When these projects are completed, the region will have a greatly expanded urban rail network, including ten light rail projects and three heavy rail projects on the Metro Rail system. New BRT and rapid bus routes will provide additional higher speed bus service in Los Angeles and Orange Counties and the Inland Empire. Orange County will add new streetcar services to link major destinations in Anaheim, Santa Ana and Garden Grove to the Metrolink system. Riverside County will extend Metrolink to San Jacinto and San Bernardino County will connect Metrolink to Ontario International Airport and to Redlands via Downtown San Bernardino.

In addition, the 2016 RTP/SCS includes extensive local bus, rapid bus, BRT and express service improvements. An expanded point-to-point express bus network will take advantage of the region's carpool and express lane network. New BRT service, limited-stop service and increased local bus service along key corridors, in coordination with transit-oriented development and land use, will encourage greater use of transit for short local trips. See EXHIBIT 5.2.

Also included in the investment package are renewed commitments to asset management and maintaining a state of good repair. TABLE 5.3 describes all transit operations and maintenance investments over $500 million. This list includes bus, urban rail and paratransit operations, the implementation of the Orange County Transportation Authority's (OCTA's) Short Range Transit Plan, expanded bus service on targeted corridors, preventative maintenance and an increased commitment on asset preservation funded from innovative revenue sources.

Aside from capital projects, there are many improvements that can help make transit operate more efficiently and effectively, make it more accessible to more travelers and increase ridership. The 2016 RTP/SCS recommends additional transit initiatives. Among them:

TABLE 5.2 SELECTED TRANSIT CAPITAL PROJECTS

COUNTY	PROJECT
Los Angeles	Airport Metro Connector
Los Angeles	Crenshaw LAX Transit Corridor
Los Angeles	East San Fernando Valley Transit Corridor
Los Angeles	Eastside Transit Corridor Phase 2
Los Angeles	Exposition Transit Corridor, Phase 2 to Santa Monica
Los Angeles	Metro Gold Line Foothill Extension Phase 2A
Los Angeles	Metro Gold Line Foothill Extension: Azusa to County Line
Los Angeles	Purple Line Extension to La Cienega, Century City, Westwood
Los Angeles	Regional Connector
Los Angeles	Sepulveda Pass Corridor
Los Angeles	South Bay Metro Green Line Extension
Los Angeles	West Santa Ana Branch Transit Corridor
Los Angeles	Bus & Rail Capital—LA County Near Term
Los Angeles	Countywide Bus System Improvement–Metro Fleet
Los Angeles	Countywide Bus System Improvement—LA County Muni Fleet
Los Angeles	Metro Rail System Improvements (Capital Costs Only)
Los Angeles	Metro Rail Rehabilitation and Replacement (Capital Costs Only)
Los Angeles	Transit contingency/new rail yards/additional rail cars (Capital costs only)—LA County
Los Angeles	Vermont Short Corridor
Los Angeles	Metro Red Line Extension: Metro Red Line Station North Hollywood to Burbank Bob Hope Airport
Los Angeles	Metro Green Line Extension: Metro Green Line Norwalk Station to Norwalk Metrolink Station
Los Angeles	Slauson Light Rail: Crenshaw Corridor to Metro Blue Line Slauson Station
Orange	Anaheim Rapid Connection
Orange	Countywide Fixed-Route, Express and Paratransit Capital (Baseline)—Orange County
Orange	OC Streetcar
Riverside	Coachella Valley Bus Rapid Service
Riverside	Perris Valley Line
Riverside	Perris Valley Line Extension to San Jacinto
San Bernardino	Foothill/5th Bus Rapid Transit
San Bernardino	Gold Line Phase 2B to Montclair
San Bernardino	Metrolink San Bernardino Line Double tracking
San Bernardino	Passenger Rail Service from San Bernardino to Ontario Airport
San Bernardino	Redlands Rail
San Bernardino	West Valley Connector Bus Rapid Transit

Source: 2016 RTP/SCS Project List

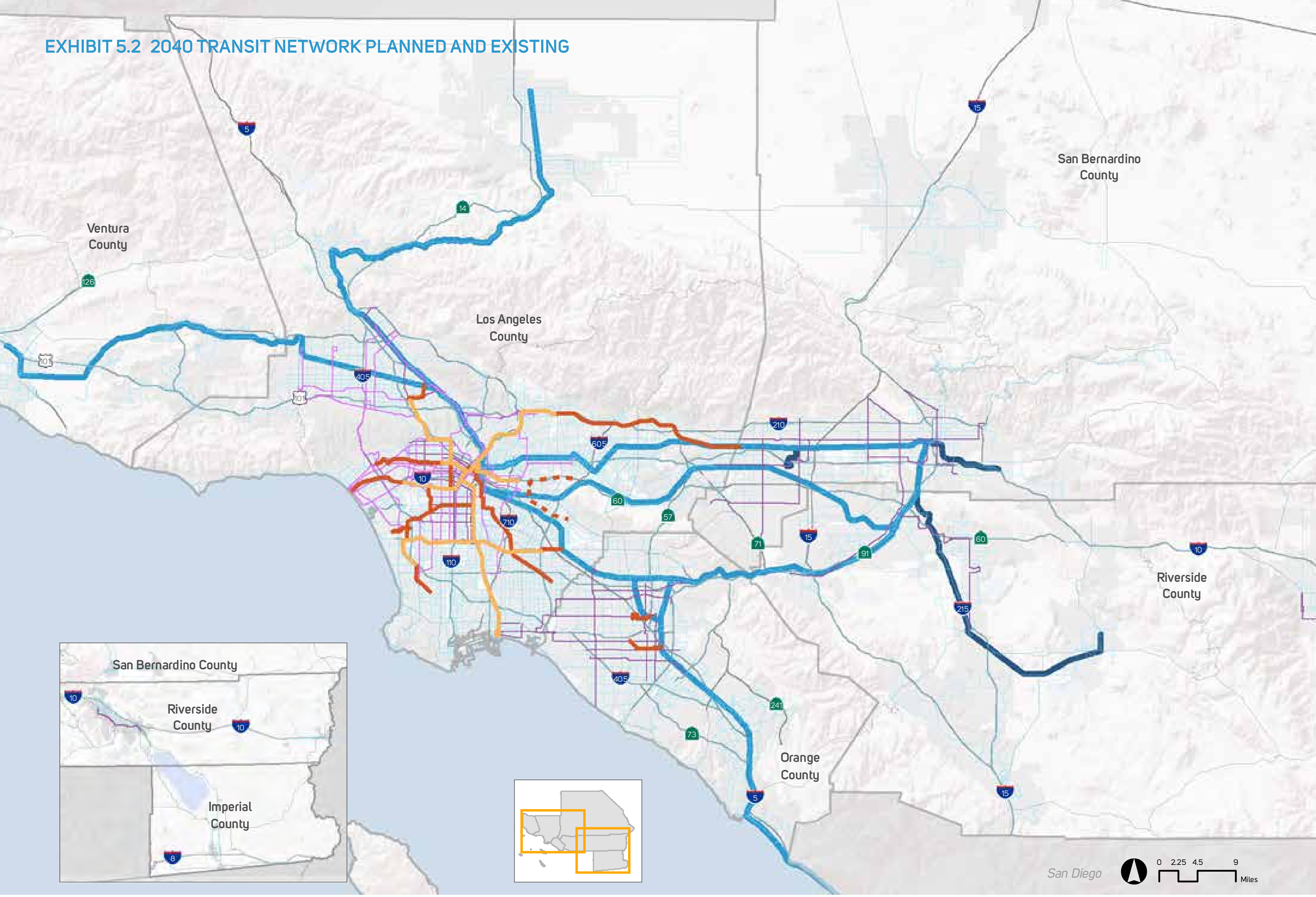
TABLE 5.3 MAJOR TRANSIT OPERATIONS AND MAINTENANCE PROJECTS AND INVESTMENTS

(Over $500 Million)

COUNTY	PROJECT
Los Angeles	Access Services Incorporated (Paratransit)—Metro subsidy
Los Angeles	Preventive Maintenance (Capital & Operating Maintenance Items Only)—LA County
Orange	Countywide Fixed-Route, Express and Paratransit Operations—Orange County
Orange	OCTA SRTP Implementation
Orange	Metrolink Operations—Orange County
Orange	Transit Extensions to Metrolink–Go Local Operations—Orange County
San Bernardino	San Bernardino Countywide Local Transit Service Operations
Regionwide	Regionwide Transit Operations and Maintenance—Preservation
Regionwide	Expand Bus Service: Productive Corridors
Regionwide	Expand Bus Service: BRT
Regionwide	Expand Bus Service: Point-to-Point

Source: 2016 RTP/SCS Project List

EXHIBIT 5.2 2040 TRANSIT NETWORK PLANNED AND EXISTING



Commuter Rail
2012 Base Year
2040 Plan

Urban Rail
2012 Base Year
2040 Plan

Urban Rail Alternatives

Rapid Bus and Bus Rapid Transit
2012 Base Year
2040 Plan

Bus Routes (2012 Base Year & 2040 Plan)

(Source: SCAG)

Implement and Expand Transit Priority Strategies: Transit priority strategies include transit signal priority, queue jumpers and bus lanes. Signal priority is a highly effective treatment that speeds up bus service and attracts new transit riders. The Metro Rapid program in Los Angeles County has increased speeds by more than 20 percent, compared with the local service on the same street. It also has brought new riders to its system. Bus lanes are even more effective at increasing speeds, however in our region there is a dearth of such lanes. SCAG encourages transit agencies and local jurisdictions to implement them, where appropriate.

Implement Regional and Inter-County Fare Agreements and Media: Implementing additional inter-jurisdictional fare agreements and media, such as Los Angeles County's EZ Pass, will make transit more attractive and accessible. A pass that would cover all transit services in Los Angeles and Orange counties, or the whole SCAG region, is an example. OCTA, the LOSSAN Managing Agency, recently secured a California Cap-and-Trade grant to establish fare agreements between the Pacific Surfliner and local transit operators along its corridor where an Amtrak ticket will be good for a connecting transit fare.

Implement New BRT and Limited-Stop Bus Service: BRT service provides frequent, high quality bus service and is characterized by features such as dedicated lanes, traffic signal priority, limited stops, pre-boarding fare payment and unique branding. BRT is about 20 percent faster than traditional local bus service. It is a premium service and has proven to attract new riders to transit. BRT implementation does require some capital investment, but it is scalable so that transit agencies can implement a range of elements to improve bus service depending upon the resources available. In an environment of scarce funding, offering limited-stop service is also an excellent alternative to BRT because it involves strategically reducing the number of stops a bus would serve along a given route. Limited-stop service has been shown to be about 15 percent faster than traditional local service.

Increase Bicycle Carrying Capacity on Transit and Rail Vehicles: Bicycling is becoming more popular and our transit system can do more to accommodate bicyclists. Many buses have bike racks with capacity for only two bikes. Meanwhile, Metro and Metrolink are now allowing more bicycles on their railcars and providing bicycle lockers at rail and fixed guideway bus stations. Allowing more bikes on transit vehicles, to a reasonable point, will increase transit ridership.

Expand and Improve Real-Time Passenger Information Systems: Most medium to large size transit agencies now offer up-to-the-minute updates on arrival and departure times. This allows passengers to make more informed travel decisions and improve the overall travel experience.

Implement First/Last Mile Strategies to Extend the Effective Reach of Transit: This is an area of study with recent focus. Making transit more accessible for biking or walking that first mile to a transit station, or from a transit station, or both, will encourage more transit use and reduce air pollution and greenhouse gas emissions. More than 90 percent of Metrolink riders drive to their origin station, representing a significant potential for providing alternatives. As mentioned before, several cities in Orange County are planning streetcar services to connect Metrolink riders to their final destinations.

Implement Local Circulators: Many jurisdictions in the region already have networks of local community circulators and fixed-route systems. Implementing more of these services would provide alternatives for residents of increasingly compact communities.

Passenger Rail

The 2016 RTP/SCS proposes three main passenger rail strategies that will improve speed, service and safety and provide an attractive alternative to driving alone. They are:

- Improving the Los Angeles–San Diego–San Luis Obispo Rail Corridor (LOSSAN Corridor)
- Improving the existing Metrolink system
- Implementing Phase One of the California High-Speed Train

The state's High-Speed Train will provide an additional intrastate transportation option in California, offering an alternative to air and auto travel and providing new capacity for travel on the state's highways and airports. The California High-Speed Rail Authority (CHSRA), in partnership with the Federal Railroad Administration (FRA), which has provided $3.6 billion in High-Speed and Intercity Passenger Rail funding, have chosen to begin construction in the San Joaquin Valley. The system will then be built south to our region, connecting to Palmdale, Burbank Bob Hope Airport, Los Angeles Union Station and Anaheim by 2029. This is consistent with the CHSRA's adopted 2014 Business Plan and Draft 2016 Business Plan.

Existing passenger rail facilities in Southern California and the Bay Area (the "bookends" of the Phase One system) will also be improved to provide immediate, near-term benefits while laying the groundwork for future integration with High-Speed Train. This "blended approach" to deliver the full integrated system, through phased implementation over time, will help reduce costs and environmental impacts. With the adoption of the 2012 RTP/SCS, the region and the CHSRA committed to spending $1 billion in Prop. 1A funds and other fund sources on these early investments in the "bookends."

This commitment by CHSRA and the transportation agencies was formalized in the memorandum of understanding (MOU) between CHSRA, Metrolink, SCAG, San Diego Association of Governments (SANDAG), Metro, Riverside County Transportation Commission (RCTC) and the City of Anaheim. The MOU includes a candidate project list to which $1 billion will be programmed in order to provide interconnectivity to the California High-Speed Train project and improve the speed, capacity and safety of our existing passenger rail network. The list includes 74 projects totaling nearly $4 billion and it shows the need for capital investments to improve the speed and service of the existing rail network regionwide. The top six projects on this list are each of the five county's (Los Angeles, Orange, Riverside, San Bernardino and San Diego) top projects—plus the Southern California Regional Interconnector Project (SCRIP, formerly called the Los Angeles Union Station Run-Through Tracks). See TABLE 5.4.

TABLE 5.4 TOP SIX MOU PROJECTS

Los Angeles	Southern California Regional Interconnector Project
Los Angeles	CP Brighton to CP Roxford Double Track
Orange	State College Blvd. Grade Separation
Riverside	McKinley St. Grade Separation
San Bernardino	CP Lilac to CP Rancho Double Track
San Diego	San Onofre to Pulgas Double Track

CP = A track switch, or the location of a track signal or other marker with which dispatchers can specify when controlling trains.

SCRIP is number one on the list because it will deliver regional benefits for all counties. Los Angeles Union Station was originally designed as a "stub" rail facility, with tracks only leaving the station in a northerly direction and no through-train operation capability. Up to six tracks will be built to extend out of the south of Union Station and across U.S. Route 101 to connect with the main tracks along the Los Angeles River. These additional tracks will increase Union Station's capacity by 40 to 50 percent, enabling the scheduling of many more through trains with improved running times. They will also result in sharply reduced air pollution and greenhouse gas emissions from idling locomotives.

Several additional strategies are designed to increase rail ridership in our region by making rail travel more attractive as an alternative to commuting alone by car. These strategies will serve three distinct rail markets: commuter, intercity and interregional. The first is served by Metrolink, the second by Amtrak and the third will be served by California High-Speed Train service. However, the three carriers can be attractive to multiple rail travel markets. Passenger rail strategies for these markets include:

Increase Speed and Service: As noted above, the high-speed rail system MOU partners are in the process of planning and implementing the MOU capital projects to improve capacity, speed and service, bringing at least some segments of our rail network up to the federally defined high speed of 110 miles per hour or greater and to implement a blended system of rail services. In addition to the MOU project list, these projects are detailed in the LOSSAN Strategic Implementation Plan for 2030 and the Metrolink 2015 Strategic Assessment that looks out 10 years to 2025. As speeds and service levels improve, these services will become more competitive with SOV travel and as a result ridership will continue to grow. Further, their schedules should be adjusted once the state's High-Speed Train project is implemented, so that all rail services complement and feed one another.

Improve Accessibility and Connectivity: This strategy includes establishing rail connections to our region's airports, and improving transit, bicycling and walking accessibility and connectivity to rail stations. Burbank Bob Hope Airport is presently the region's best-served airport by rail, and will soon host two rail stations in the near future with service provided by two Metrolink lines, Amtrak and the state's High-Speed Train in the future. Ontario International Airport (ONT) is not directly served by rail, although SCAG together with Metro, SANBAG and CHSRA are studying various options to provide direct rail service to the airport. LAX is also currently not served by any rail, but will be within the next decade via the Crenshaw Line and the Airport Metro Connector. Improving transit bicycling and walking accessibility to our region's passenger rail stations is also critical. Increasing rail feeder bus services in our region to passenger rail stations would reduce the incentive for SOV travel. Establishing more transit services such as OCTA's Stationlink service would provide this incentive. Finally, there is still little BRT or BRT-Lite service in our region outside of Los Angeles County, and establishing more BRT routes to serve rail stations such as the current Omnitrans sbX Green Line and the Riverside Transit Agency's future RapidLink Line 1 will help meet this goal.

Secure Increased Funding and Dedicated Funding Sources: Passenger rail has traditionally lacked dedicated funding streams. Amtrak is funded annually by the U.S. Congress, usually resulting in funding amounts insufficient to meet state of good repair needs or to increase Amtrak's levels of service and expand the network. With local control of the Pacific Surfliner now complete, the State of California has guaranteed funding levels to maintain current service levels (but not to increase service levels) for the first three years. One new funding source is California's Cap-and-Trade Transit and Intercity Rail Capital Program, which received $25 million in FY2014-15 and 10 percent of annual Cap-and-Trade auction proceeds beginning in FY2015-16. This FY2015-16 allocation is currently estimated to be more than $200 million. Similarly, the CHSRA has been given a dedicated Cap-and-Trade funding stream of 25 percent of funds, beginning in FY2015-16 (for FY2014-15 CHSRA received $250 million). FY2015-16 funding is estimated at more than $600 million.

Support Increased TOD and First/Last Mile Strategies: Increased TOD and first/last mile planning and investments are crucial to passenger rail station area planning. Increased and effective TOD improves our region's jobs/housing balance, and it reduces VMT, air pollution and greenhouse gas emissions. First/last mile investments also reduce VMT, air pollution and greenhouse gas emissions and encourage rail users to access rail stations with options other than driving alone.

Implement Cooperative Fare Agreements and Media: Cooperative fare agreements and media also offer opportunities for increasing rail ridership and attracting new riders. For example, the Rail2Rail pass allows Metrolink monthly pass riders who have origin and destination points along the LOSSAN corridor to ride Amtrak. In 2014, the North County Transit District (NCTD) reached an agreement with Caltrans Division of Rail (DOR), in which five daily Pacific Surfliner trains stop at all non-Pacific Surfliner Amtrak (Coaster) stops in San Diego County. This service has proven quite popular and successful. Agreements like this one could be expanded once the California High-Speed Train is built.

Active Transportation

The 2016 RTP/SCS includes $12.9 billion for active transportation improvements, including $8.1 billion in capital projects and $4.8 billion as part of the operations and maintenance expenditures on regionally significant local streets and roads. The Active Transportation portion of the 2016 Plan updates the Active Transportation portion of the 2012 Plan, which has goals for improving safety, increasing active transportation usage and friendliness, and encouraging local active transportation plans. It proposes strategies to further develop the regional bikeway network, assumes that all local active transportation plans will be implemented, and dedicates resources to maintain and repair thousands of miles of dilapidated sidewalks. To accommodate the growth in walking, biking and other forms of active transportation regionally, the 2016 Active Transportation Plan also considers new strategies and approaches beyond those proposed in 2012. Among them:

- Better align active transportation investments with land use and transportation strategies to reduce costs and maximize mobility benefits
- Increase the competitiveness of local agencies for federal and state funding
- Develop strategies that serve people from 8–80[5] years old to reflect changing demographics and make active transportation attractive to more people
- Expand regional understanding of the role that short trips play in achieving RTP/SCS goals and performance objectives, and provide a strategic framework to support local planning and project development geared toward serving these trips
- Expand understanding and consideration of public health in the development of local plans and projects.

[5] 8–80 years old is an age span that is used as a shorthand to refer to expanding the potential for all people to use active transportation. The term refers to addressing the needs school aged children who would be conceivably allowed to walk or bike to school unaccompanied if the environment were safer and older senior citizens who prefer physical separation from the noise and speed of vehicles.

Active Transportation has 11 specific strategies to maximize active transportation in the SCAG region. These are grouped into four broad categories: regional trips, transit integration, short trips and education/encouragement. All 11 strategies are based on a comprehensive local bikeway and pedestrian network that uses Complete Streets principles. These strategies include:

Regional Trips Strategies:

1. Regional Greenway Network
2. Regional Bikeway Network
3. California Coastal Trail Access

Transit Integration Strategies:

4. First/last mile (to transit)
5. Livable Corridors
6. Bike Share Services

Short Trips Strategies:

7. Sidewalk Quality
8. Local Bikeway Networks
9. Neighborhood Mobility Areas

Education/Encouragement Strategies:

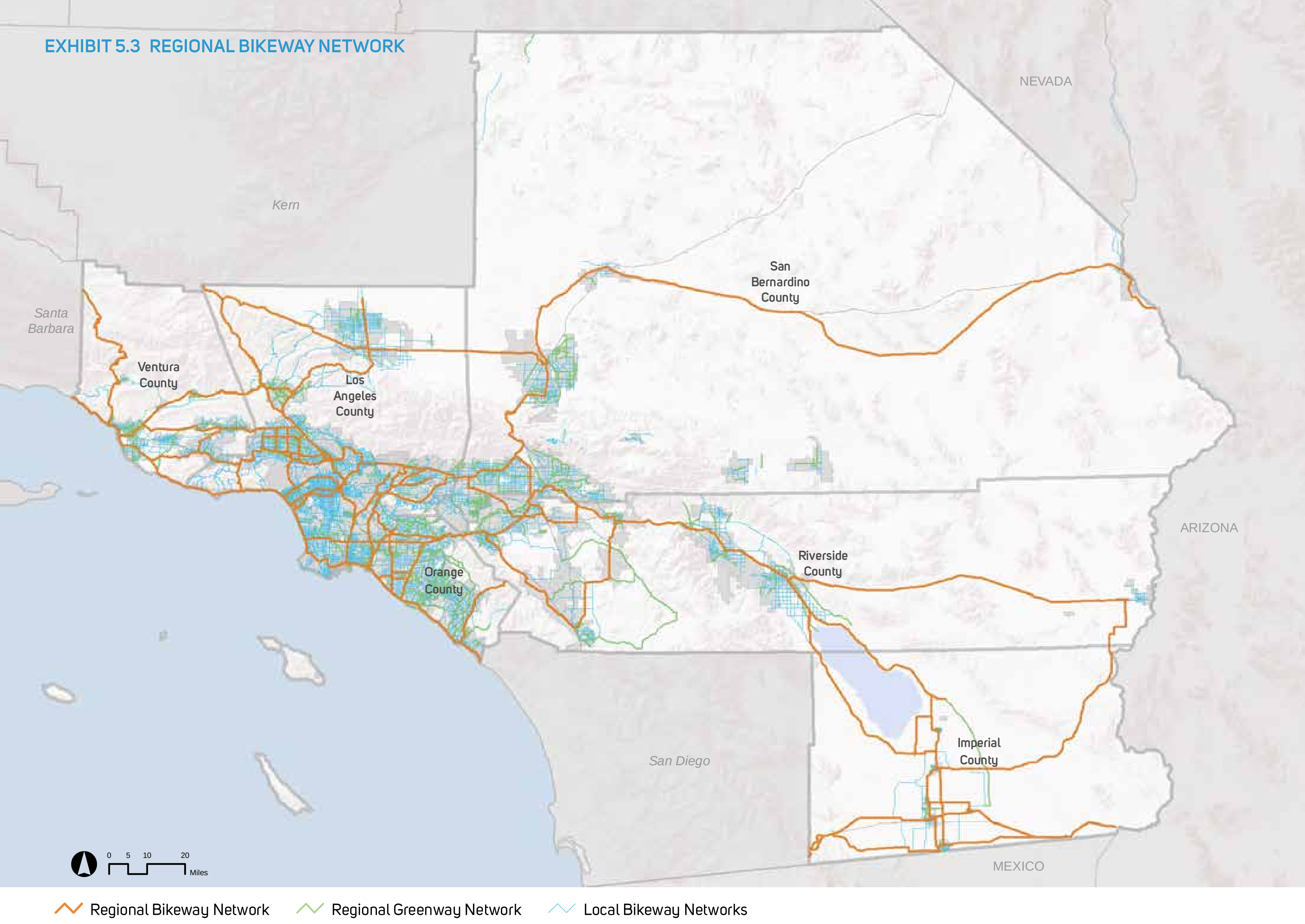
10. Safe Routes to School
11. Safety/Encouragement Campaigns

Regional Trips Strategies

Developing the following networks will serve those longer trips that people make less frequently, but add to total miles traveled. They are primarily biking trips for commuting and recreation. Although trips covering the full length of these corridors may be a small percentage of active transportation travel, the networks provide a backbone for shorter trips, much in the way the Interstate Highway System is used by many people as a bypass for short trips from one on-ramp to the next off-ramp. Completing the following networks are key strategies for promoting regional trips:

1. **Regional Greenway Network (RGN):** The planned RGN is a 2,200-mile system of separated bikeways mostly using riverbeds, drainage channels and utility corridors. The RGN connects to the regional bikeway network. This strategy provides the opportunity to better integrate urban green space, active transportation and watershed management, providing new urban green space for residents to go to for travel and recreation, including low-stress access to the California Coastal Trail. Benefits include increased health, improved safety and enhanced quality of life. These low-stress bikeways, connected to the regional bikeway network and local bikeways, should provide an attractive option for those bicyclists who do not wish to ride along roadways with motor vehicles. They include the High Desert Corridor; Santa Ana River Trail; OC Loop; Los Angeles River; San Gabriel River; San Jose Creek; Rio Hondo River; Ballona Creek; Bike Route 33; and CVLink.
2. **Regional Bikeway Network (RBN):** The planned RBN consists of 2,220 miles of interconnected bikeways that connect to jurisdictions, local bikeways and destinations. It connects to the RGN and has designated routes and wayfinding signage that help bicyclists easily understand the route structure and destinations. The primary purpose is to serve regional trips, commuting and recreational bicycling. Using locally existing and planned local bikeways as the foundation, the RBN closes gaps, connects jurisdictions, and provides a regional backbone for local bikeways and greenways. By having assigned route names/numbers, bicyclists can more easily travel across jurisdictions without having to frequently consult maps or risk having bikeways end on busy streets. It is anticipated that trips longer than three miles will likely be used in part on the RBN. SCAG has identified 12 regionally significant bikeways that connect the region. These include Bike Route 66; Bike Route 10; Bike Route 126; Pacific Coast Bike Route; Bike Route 5; Santa Ana River Trail; High Desert Corridor; Bike Route 33; Los Angeles River; San Gabriel River; Bike Route 86; and Bike Route 76 (see EXHIBIT 5.3).
3. **California Coastal Trail (CCT)Access:** Trails along the coast of California have been utilized as long as people have inhabited the region. The CCT was established by the Coastal Act of 1976 to develop a "continuous public right-of-way along the California coastline; a trail designed to foster appreciation and stewardship of the scenic and natural resources of the coast through hiking and other complementary modes of non-motorized transportation." The 2016 RTP/SCS Active Transportation Appendix identifies the improvements necessary to help complete the portions of the CCT in Ventura, Los Angeles and Orange counties and to provide biking and walking access to the CCT.

EXHIBIT 5.3 REGIONAL BIKEWAY NETWORK



(Source: SCAG)

Transit Integration Strategies

Transit Integration refers to a suite of strategies designed to better integrate active transportation and transit by improving access for pedestrians, bicyclists and other people traveling under their own power around transit stations. Active transportation projects that fall within this suite of strategies are particularly competitive for Cap-and-Trade funding programs. Cap-and-Trade funding programs include the Affordable Housing and Sustainable Communities Program (AHSC), which aims to better link housing, transit and active transportation to reduce greenhouse gas emissions. With this in mind, the strategies detailed below will be most successful if they are coordinated with land use strategies such as TOD and providing affordable housing.

4. **First/Last Mile (to rail):** This strategy uses a Complete Streets approach to maximize the number of people walking or biking to rail. By 2040, 11 percent of people will live within one half mile of a rail station, and 27 percent will live within one mile of a rail station. By increasing the comfort and removing barriers to walking or biking, more people will walk or bike to transit stations. These stations include all Los Angeles County light rail, subway and fixed guideway bus stations and Metrolink stations; all Orange County Metrolink Stations and OC Bravo busways; all San Bernardino County Metrolink stations and SBx busways; all Riverside County Metrolink stations; and all Ventura County Metrolink stations.

   The existing transit access "shed" is considered the half-mile radius around a station (requiring a 10-minute walk), although in many cases the access shed is much smaller due to barriers in the built environment (a lack of crosswalks, long blocks, unsafe overpasses or underpasses). The strategy of developing first/last mile solutions will increase the number of people walking within and beyond one half mile, by creating the conditions that allow people to travel a longer distance in the same amount of time (10 minutes). The number of bicyclists accessing transit is also anticipated to increase, both within the one-mile bike access shed and beyond to a new bike access shed of three miles (requiring a 15-minute bike ride). Infrastructure improvements may include dedicated bike routes, sidewalk enhancements, mid-block crossings (short-cuts), reduced waiting periods at traffic signals, bicycle parking, signage and wayfinding, and others.

   In Los Angeles County, Metro has proposed an extensive active transportation network to support first/last mile access, including pathways that extend one half mile around each of the Metro stations. The pathways are envisioned to provide facilities and design elements that are consistent across the transit system, enabling seamless and intuitive door-to-door journeys. Pathways will be established along the most heavily traveled routes to transit stations, connecting riders to and from population and employment centers and other major destinations. They will improve and shorten the time it takes to access transit, enhancing the overall transit experience. The pathways will also facilitate transfers between modes, including traditional modes such as buses and park and ride lots, as well as new mobility options such as bike share and car share that can be integrated throughout active transportation networks.

   First/last mile plans that include many of the same investments as outlined in Metro's first/last mile plan have been completed in Orange and San Bernardino counties as well. The regional strategy builds upon these planned investments, proposing enhancements at 224 rail stations by 2040.

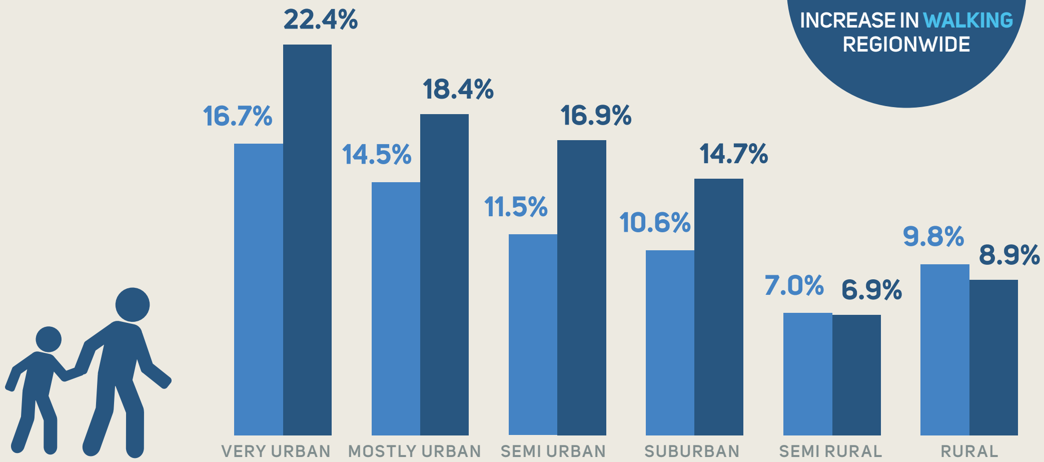
5. **Livable Corridors:** From an active transportation standpoint, this strategy is similar to the first/last mile strategy noted above, but it targets high-quality bus corridors rather than the rail and fixed guideway system. (Planning for growth around Livable Corridors is also an important land use strategy) Livable Corridors share many of the same characteristics as transit-oriented rail corridors, but they have lower density development. Active transportation investments focus on sidewalk maintenance/enhancement, intersection improvements, bicycle lanes and bicycle boulevards to facilitate safe and easy access to mixed-use commercial nodes where residents can meet most of their daily needs and access bus service. In addition, this strategy promotes the inclusion of bike lanes, shared bus-bike lanes or separated bikeways. These run along or parallel to the main corridor to promote inter-regional connectivity. In developing the 2016 RTP/SCS, SCAG identified just under 3,000 miles of potential Livable Corridors. However, the investments proposed in the Plan under this strategy are not tied to a specific corridor; rather, the Plan assumes resources to support 670 miles accessing and along 154 miles of corridor. The Plan also provides policy language to support a much broader rollout of Livable Corridors to inspire and support local planning for projects. Having plans prepared with shovel-ready projects will allow our region to effectively compete for Affordable Housing and Sustainable Communities Program Inter-Connected Projects.

FOCUS ACTIVE TRANSPORTATION

Biking & Walking in the Region

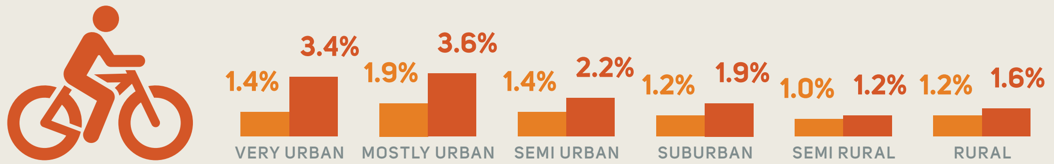
WALK TRIPS 2012 BASE YEAR 2040 PLAN

28% INCREASE IN WALKING REGIONWIDE



BIKE TRIPS 2012 BASE YEAR 2040 PLAN

71% INCREASE IN BIKING REGIONWIDE



Go Human and Traffic Safety

Across the SCAG region, the nature of streets and types of travel on them is changing dramatically. Bicycling is growing in popularity and the expansion of transit and explosion of new mobility services, like Uber and Lyft, means more people are walking and biking to make connections. However, as more people bicycle and walk, safety for these modes becomes increasingly important. In the SCAG region in 2012, 27 percent and five percent of all traffic fatalities were pedestrians and bicyclists, respectively.

Funded by a $2.3 million grant from the 2014 California Active Transportation Program, SCAG and its partners launched Go Human, a campaign to promote traffic safety and encourage people to walk or bike. Go Human is a reminder to all that people on the road are not just objects that get in our way—they are human beings. In late September 2015, messaging encouraging drivers to slow down and look for pedestrians and cyclists was distributed across all six counties in both English and Spanish. Advertisements appeared on local transit buses, bus shelters, Facebook, Pandora and local radio stations throughout the region. The launch date coincided with the decline in daylight hours, a period when pedestrian collisions begin to peak.

Go Human is a collaborative effort with county transportation commissions, county health departments and local cities and jurisdictions across the region. SCAG has worked with partners to expand the initial advertising purchases through partner newsletters, advertisements on websites, posters in local facilities and on social media. For example, the Los Angeles County Department of Public Works donated advertising space at 100 bus shelters. SCAG's funding also includes the production of toolkits and trainings to promote active transportation and the implementation of open streets and temporary events starting in spring 2016. For more information on the campaign, visit **www.gohumansocal.org**.

gohuman

6. **Bike Share Services:** Bike share is a point-to-point service combining the convenience of a bicycle with the accessibility of public transportation.[6] Using closely packed bike rental kiosks in heavily urbanized areas, bike share is designed to replace short-distance motor vehicle trips, reduce parking demand and complement local bus services such as DASH in the City of Los Angeles. Most importantly, bike share acts as a first/last mile strategy and it will be closely integrated with high quality transit stations. Los Angeles Metro, Santa Monica and Long Beach are currently implementing bike share within Los Angeles County. Bike share is anticipated to grow beyond these initial areas over the course of the Plan. A pilot program was recently completed in the City of Fullerton, in Orange County. The University of California, Irvine already has a bike share system in place for students and faculty. The regional bike share system will be comprised of about 8,800 bikes and 880 stations/kiosks.

Short Trips Strategies

For the purposes of this RTP/SCS, SCAG considers short trips as any trip less than three miles. These trips are primarily the utilitarian trips we take every day to the store, school or a restaurant. Planning policy objectives, including reducing VMT and greenhouse gas emissions and improving public health, depend highly on our region's ability to address these short trips. That's because trips less than three miles account for 38 percent of all trips in the region. Short trips can easily be taken by walking or biking.

The land use strategies described earlier in this chapter and promoted by the 2016 RTP/SCS seek to improve location efficiency—in other words, minimize the distance between origins and destinations to create even more short trips in the future. The short trip strategies described below aim to ensure that the roadway network evolves to help realize the walkable/bikeable vision advanced by land use strategies in regional and local plans, and improve mobility and reduce travel times in locations that are already considered location-efficient.

7. **Sidewalk Quality:** The Plan calls for 10,500 miles of sidewalks to be repaired or improved. This includes making them Americans with Disabilities Act (ADA) compliant and adding amenities such as exercise spots (logs or other no-maintenance objects that can be used for sitting, stretching or mild exercise) and rest seats for older walkers. These improvements are in addition to sidewalk enhancements incorporated into the other active transportation strategies.

8. **Local Bikeway Networks:** The region's Local Bikeway Networks promote local mobility, while also providing the needed bikeway density to interconnect with the regional bikeway network. The Plan proposes expanding the local bikeway network by an additional 6,016 miles. This is in addition to the 2,760 additional bikeway miles incorporated into other active transportation strategies, bringing total regional, local and greenway bikeway mileage to 12,700.

9. **Neighborhood Mobility Areas:** This strategy is targeted to locations that have a high proportion of short trips due to the mix of land uses, a fairly dense street grid pattern and the presence of locally serving retail destinations. These locations, however, do not benefit from high quality transit. Where Livable Corridors focus on connections to a corridor, Neighborhood Mobility Areas focus on connections within the neighborhood—to schools, places of worship, parks or greenways, and other destinations. SCAG has identified potential locations in the region to establish Neighborhood Mobility Areas. However, the investments proposed in the Plan under this strategy are not tied to a specific community. Some of the practices that inform this concept include: Level of Traffic Stress (LTS) bicycle planning, NEV planning, Plug-in Vehicle (PEV) readiness planning and a geographic analysis of commute trip lengths. These planning practices are based on the idea that non-auto trips increase as the perceived danger and anxiety for the user decreases.

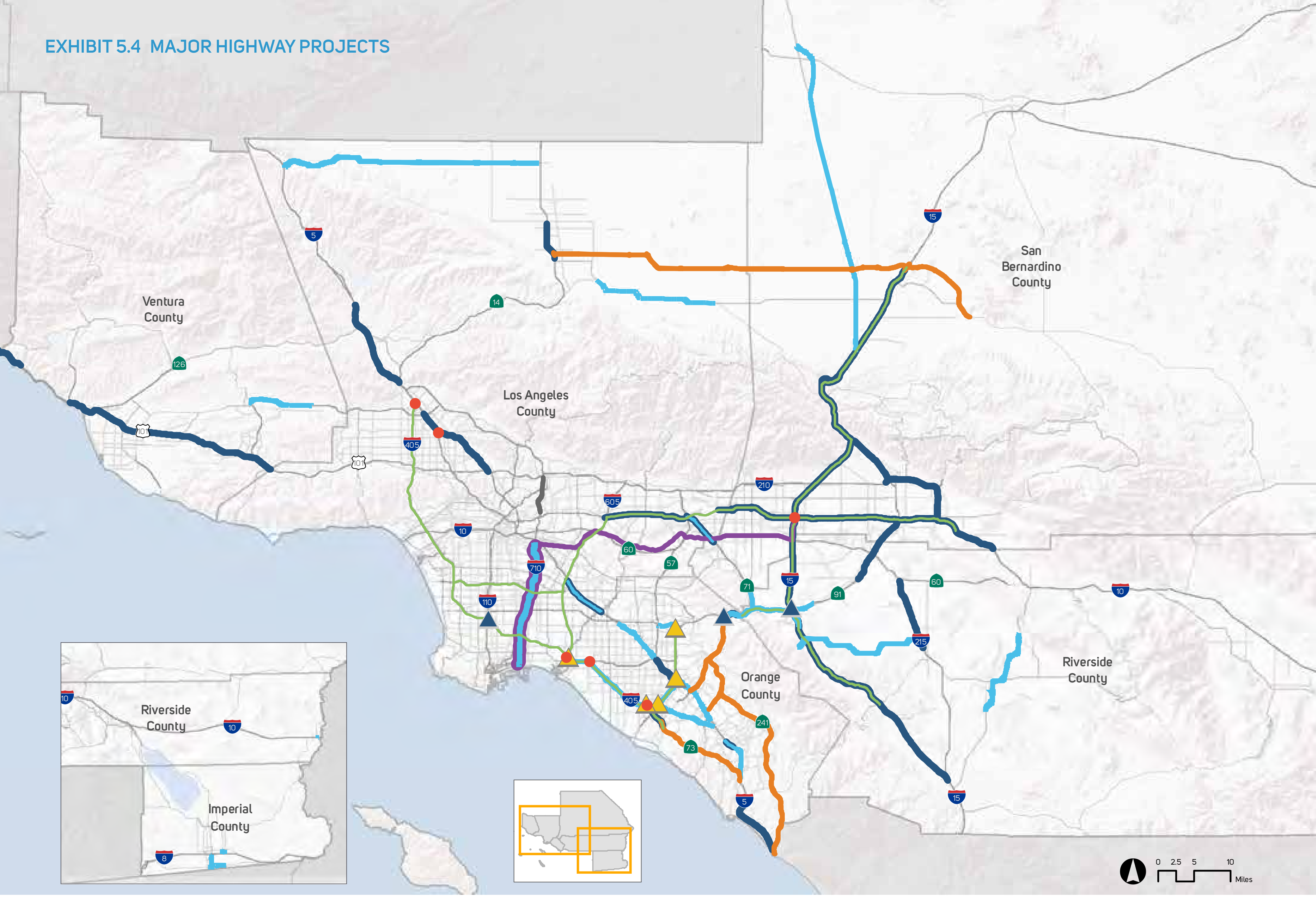
Education/Encouragement Strategies

Getting more people to bike and walk is not just about building the infrastructure. Individuals must feel safe biking and walking. The 2016 RTP/SCS Safety campaigns have two strategies: Safe Routes to School, which focuses on instilling safe habits at a young age while encouraging walking and biking to school; and a Safety/Encouragement campaign, which aims to reach all roadway users through a mix of education and training seminars and encouragement strategies.

10. **Safe Routes to School:** Safe Routes to School is a comprehensive TDM strategy aimed at encouraging children to walk and bicycle to school. It includes a wide variety of implementation strategies centered on the "6 Es"—Education, Encouragement, Engineering,

[6] King County Bike Share Business Plan. (2012). The Bike Share Partnership. Accessed at http://altaplanning.com/wp-content/uploads/King_County_Bike_Share_Business_Plan_0.pdf.

EXHIBIT 5.4 MAJOR HIGHWAY PROJECTS



Express Lanes | Toll Lanes | Mixed-Flow Lanes | Freight Corridors | HOV Lanes | Improvement TBD

Planned/Proposed Express Lane Direct Connectors | Proposed HOV-to-Express Lane Direct Connector Conversions | HOV Lane Connectors

(Source: SCAG)

Enforcement, Evaluation and Equity. When implemented, the 6 Es improve safety, reduce congestion and VMT, improve air quality and increase the physical activity of students and their parents—which improves public health outcomes. SCAG works with each county through SCAG's sustainability joint work programs, which are collaborative planning programs designed to support regional sustainability goals through local projects. Each joint-work program includes a Safe Routes to School program component.

11. **Education/Encouragement Campaigns:** Safety campaigns that employ advertising, public service announcements and media kits are designed to educate the public on the importance of safety. Other efforts aim to educate bicyclists, pedestrians and motorists on the rights and responsibilities of sharing the road. The 2016 RTP/SCS anticipates that these campaigns will be conducted every five years during the course of the Plan.

Highways and Arterials

The majority of trips in our region today is still made on our region's highways and arterials. Yet, the expansion of our highways and arterials has slowed down over the last decade. Revenue from traditional sources to fund transportation improvements is declining and costly expansions to address congestion may not be financially feasible. However, given that critical gaps and congestion chokepoints still exist within the network, improvements beyond TSM and TDM strategies need to be considered. Closing these gaps to complete the system will allow residents and visitors alike to enjoy improved access to opportunities such as jobs, education, recreation and healthcare.

Our highways and arterials serve as a crucial backbone of our overall regional transportation network. As part of the 2016 RTP/SCS, SCAG continues to advocate for a comprehensive solution based on a system management approach to manage and maintain our highway and arterial network. Although we recognize that we can no longer rely on system expansion alone to address our mobility needs, critical gaps and congestion chokepoints in the network still hinder access to certain parts of the region. County transportation plans have identified projects to close these gaps, eliminate congestion chokepoints and complete the system. Such improvements are included in the 2016 RTP/SCS. EXHIBIT 5.4 and TABLE 5.5 highlight some of the proposed highway completion projects. For projects that are currently or will be going through environmental clearance, SCAG would update the list as part of future RTP amendments if warranted by the nature of the project changes. A comprehensive list of projects is provided in the Project List Appendix.

Our region boasts one of the most comprehensive High Occupancy Vehicle (HOV) systems in the nation and heavy investments have been made to expand it. As part of the Plan, strategic HOV gap closures, highway-to-highway direct HOV connectors, and HOV direct access ramps need to be proposed as a strategy to complete the system. In addition, it should be noted that various highways within Orange County feature continuous access on certain HOV lanes. Studies have shown that continuous access HOV lanes do not perform any worse compared with limited access HOV lanes. TABLE 5.6 highlights some of the Plan's major HOV projects.

Our region's arterial system is comprised of local streets and roads that serve many different functions. One is to link our region's residents with schools, jobs, healthcare, recreation, retail and other destinations. Our region's arterials account for more than 80 percent of the total road network and they carry a majority of overall traffic. A number of arterials run parallel to major highways and they can provide alternatives to them. Beyond motor vehicles, our arterials serve other modes of travel, including transit and active transportation. The 2016 RTP/SCS proposes a variety of arterial projects and improvements throughout the region. Operational and technological improvements can maximize system productivity through various cost-effective and non-labor intensive means—beyond improvements to expand capacity. These include signal synchronization, spot widening and adding grade separations at major intersections. In addition, as part of the Complete Streets Deputy Directive[7] (DD-64-R2), improvements such as bicycle lanes, lighting, landscaping, sidewalk widening and ADA compliance measures have shifted the focus of arterials toward considering multiple users—while also providing a greater sense of place. The 2016 RTP/SCS highways and local arterials framework and guiding principles are summarized here:

- Focus on achieving maximum productivity through strategic investments in system management and demand management.
- Focus on adding capacity primarily (but not exclusively) to:
  - Close gaps in the system.
  - Improve access where needed.
- Support policies and system improvements that will encourage the seamless operation of our roadway network from a user perspective.

[7] Complete Streets – Integrating the Transportation System. (2014) [Deputy Directive]. California Department of Transportation. Accessed at: http://www.dot.ca.gov/hq/tpp/offices/ocp/docs/dd_64_r2.pdf.

TABLE 5.5 SAMPLE MAJOR HIGHWAY PROJECTS COMMITTED BY THE COUNTIES

	COUNTY	ROUTE	DESCRIPTION	COMPLETION YEAR	COST ($1,000s)
MIXED-FLOW LANES	Imperial	SR-98	Widen and improve SR-98 or Jasper Rd to 4/6 lanes	2025	$1,170,483
	Imperial	SR-111	Widen and improve to a 6-lane highway with interchanges to Heber, McCabe, and Jasper, and overpass at Chick Rd	2030	$999,136
	Los Angeles	SR-57/SR-60	Improve the SR-57/SR-60 interchange	2029	$475,000
	Orange	I-5	Add one mixed-flow lane in each direction from SR-57 to SR-91	2040	$305,924
	Orange	SR-55	Add one mixed-flow lane in each direction and fix chokepoints from I-405 to I-5 and add one auxiliary lane in each direction between select on/off ramps and operational improvements through project limits	2030	$274,900
	Orange	SR-91	Add one eastbound mixed-flow lane on SR-91 from SR-57 to SR-55 and one westbound mixed-flow lane from Kraemer to State College	2030	$425,000
	Orange	I-405	Add one mixed-flow lane in each direction from I-5 to SR-55	2030	$374,540
	Orange	I-405	Add one mixed-flow lane in each direction from SR-73 and I-605	2022	$1,300,000
	Ventura	SR-118	Add one mixed-flow lane in each direction from Tapo Canyon Rd to LA Avenue	2025	$216,463
EXPRESS LANES	Los Angeles	I-110	Construct express lane off-ramp connector from 28th St to Figueroa St	2023	$55,000
	Riverside	I-15	Add one express lane in each direction from Cajalco Rd to SR-7	2029	$453,174
	San Bernardino	I-15	Add two express lanes in each direction from US-395 to I-15/I-215 interchange	2030	$687,994
HOV LANES	Los Angeles	I-5	Add one HOV lane in each direction from Weldon Canyon Rd to SR-14	2017	$410,000
	Los Angeles	SR-14	Add one HOV lane in each direction from Ave P-8 to Ave L	2027	$120,000
	Los Angeles	SR-71	Convert expressway to highway-add one HOV lane and one mixed-flow lane	2028	$13,392
	Orange	I-5	Add one HOV lane in each direction from Pico to SD County Line	2040	$237,536
	Riverside	I-15	Add one HOV lane in each direction from SR-74 to I-15/I-215 interchange	2039	$375,664
	San Bernardino	I-10	Add one HOV lane in each direction from Ford to RV County Line	2030	$126,836
	San Bernardino	I-215	Add one HOV lane in each direction from SR-210 to I-15	2035	$249,151
	San Bernardino	I-210	Add one HOV lane in each direction from I-215 to I-10	2040	$178,780
	Ventura	US-101	Add one HOV lane in each direction from LA/VEN County Line to SR-33	2029	$132,000

TABLE 5.6 MAJOR HOV LANE PROJECTS

COUNTY	ROUTE	FROM	TO	COMPLETION YEAR
Los Angeles	I-5	Weldon Canyon	SR-14	2017
Los Angeles	I-5	Pico Canyon	Parker Rd	2025
Los Angeles	SR-14	Ave P-8	Ave L	2027
Los Angeles	SR-71	Mission Blvd	Rio Rancho Rd	2028
Orange	I-5	Pico	SD County Line	2040
Orange	I-5	SR-55	SR-57	2018
Orange	SR-73	I-405	MacArthur	2040
Riverside	I-15	SR-74	I-15/I-215 Interchange	2039
Riverside	I-215	Nuevo Rd	Box Springs Rd	2030
San Bernardino	I-10	Ford St	RV/SB County Line	2030
San Bernardino	I-215	SR-210	I-15	2035
San Bernardino	I-210	I-215	I-10	2040
Ventura	US-101	Moorpark Rd	SR-33	2029
HIGHWAY TO HIGHWAY HOV CONNECTORS				
Los Angeles	I-5/I-405	Connector (partial)		2029
Los Angeles	I-405/I-110	Connector Improvements		2021
Orange	I-405/SR-73	Connector		2040
San Bernardino	I-10/I-15	Connector (partial)		2035

TABLE 5.7 REGIONAL EXPRESS LANE NETWORK

	COUNTY	ROUTE	FROM	TO
EXPRESS LANE ADDITIONS	Los Angeles	I-10	I-605	San Bernardino County Line
	Los Angeles	I-105*	I-405	I-605
	Los Angeles	I-405**	I-5	Orange County Line
	Los Angeles	I-605	I-10	Orange County Line
	Orange	SR-55	SR-91	I-405
	Orange	SR-73	I-405	MacArthur Boulevard
	Orange	I-405**	Los Angeles County Line	SR-55
	Orange	I-605	Los Angeles County Line	I-405
	Riverside	I-15**	San Bernardino County Line	SR-74
	Riverside	SR-91*	Orange County Line	I-15
	San Bernardino	I-10**	Los Angeles County Line	Ford Street
	San Bernardino	I-15**	High Desert Corridor	Riverside County Line
EXPRESS LANE DIRECT CONNECTORS	Los Angeles	I-405/I-110	I-405 NB to I-110 NB and I-110 SB to I-405 SB	
	Orange	I-5/SR-55	Existing HOV to proposed express lane direct connector	
	Orange	SR-91/SR-55	Existing HOV to proposed express lane direct connector	
	Orange	SR-91/SR-241	SR-241 NB to SR-91 EB and SR-91 WB to SR-241 SB	
	Orange	I-405/SR-55	Existing HOV to proposed express lane direct connector	
	Orange	I-405/SR-73	Planned HOV to proposed express lane direct connector	
	Orange	I-405/I-605	Existing HOV to proposed express lane direct connector	
	Riverside	SR-91/I-15	SR-91 EB to I-15 SB and I-15 NB to SR-91 WB	

*Notes: * Dual express lanes for entire length ** Dual express lanes for a section*

- Any new roadway capacity project must be developed with consideration and incorporation of congestion management strategies, including demand management measures, operational improvements, transit and ITS, where feasible.
- Focus on addressing non-recurring congestion with new technology.
- Support Complete Streets opportunities where feasible and practical.

Regional Express Lane Network

Consistent with our regional emphasis on the system management pyramid, recent planning efforts have focused on enhanced system management, including the integration of value pricing to better use existing capacity and offer users greater travel time reliability and choices. Express lanes that are appropriately priced to reflect demand can outperform non-priced lanes in terms of throughput, especially during congested periods. Moreover, revenue generated from priced lanes can be used to deliver the needed capacity provided by the express lanes sooner and to support complementary transit investments.

The regional express lane network included in the 2016 RTP/SCS builds on the success of the State Route 91 express lanes in Orange County, as well as the Interstate 10 and Interstate 110 express lanes in Los Angeles County. Additional efforts underway include the extension of the State Route 91 express lanes to Interstate 15, as well planned express lanes on Interstate 15 in Riverside County. Express lanes are also planned for Interstate 15 and Interstate 10 in San Bernardino County and Interstate 405 in Orange County. TABLE 5.7 displays the segments in the proposed regional express lane network.

Goods Movement

Recent regional efforts have focused on strategies to develop a coherent, refined and integrated regional goods movement system that would address expected growth trends. Key strategies are highlighted below.

Regional Clean Freight Corridor System

The 2016 RTP/SCS continues to envision a system of truck-only lanes extending from the San Pedro Bay Ports to downtown Los Angeles along Interstate 710, connecting to the State Route 60 east-west segment and finally reaching Interstate 15 in San Bernardino County. Such a system would address the growing truck traffic and safety issues on core highways through the region and serve key goods movement industries. Truck-only lanes add capacity in congested corridors, improve truck operations and safety by separating trucks and autos, and provide a platform for the introduction of zero- and near zero-emission technologies. Ongoing evaluation of a regional freight corridor system is underway, including recent work on an environmental impact report (expected to be recirculated in 2016) for the Interstate 710 segment. Additionally, as a part of the 2016 RTP/SCS, SCAG continues to refine the east-west corridor component of the system along the State Route 60 corridor. Current efforts have focused on working to identify an initial operating segment. Additional study is underway to evaluate the East-West Freight Corridor project concept.

The East-West Freight Corridor would carry between 58,000 and 78,000 clean trucks per day that would be removed from adjacent general-purpose lanes and local arterial roads. The corridor would benefit a broad range of goods movement markets, both port-related and local goods movement-dependent industries. Truck delay would be reduced by up to 11 percent. Truck traffic on State Route 60 general purpose lanes would be reduced by 42 to 82 percent, depending on location; it would be reduced by as much as 33 percent on Interstate 10 and as much as 20 percent on adjacent arterials. Separating trucks and autos would also reduce truck-involved collisions on east-west highways that currently have some of the highest collision levels in the region (20–30 collisions a year on certain segments).

The regional freight corridor system also includes an initial segment of Interstate 15 that would connect to the East-West Freight Corridor, reaching just north of Interstate 10. Additional study is anticipated for this segment.

Truck Bottleneck Relief Strategy

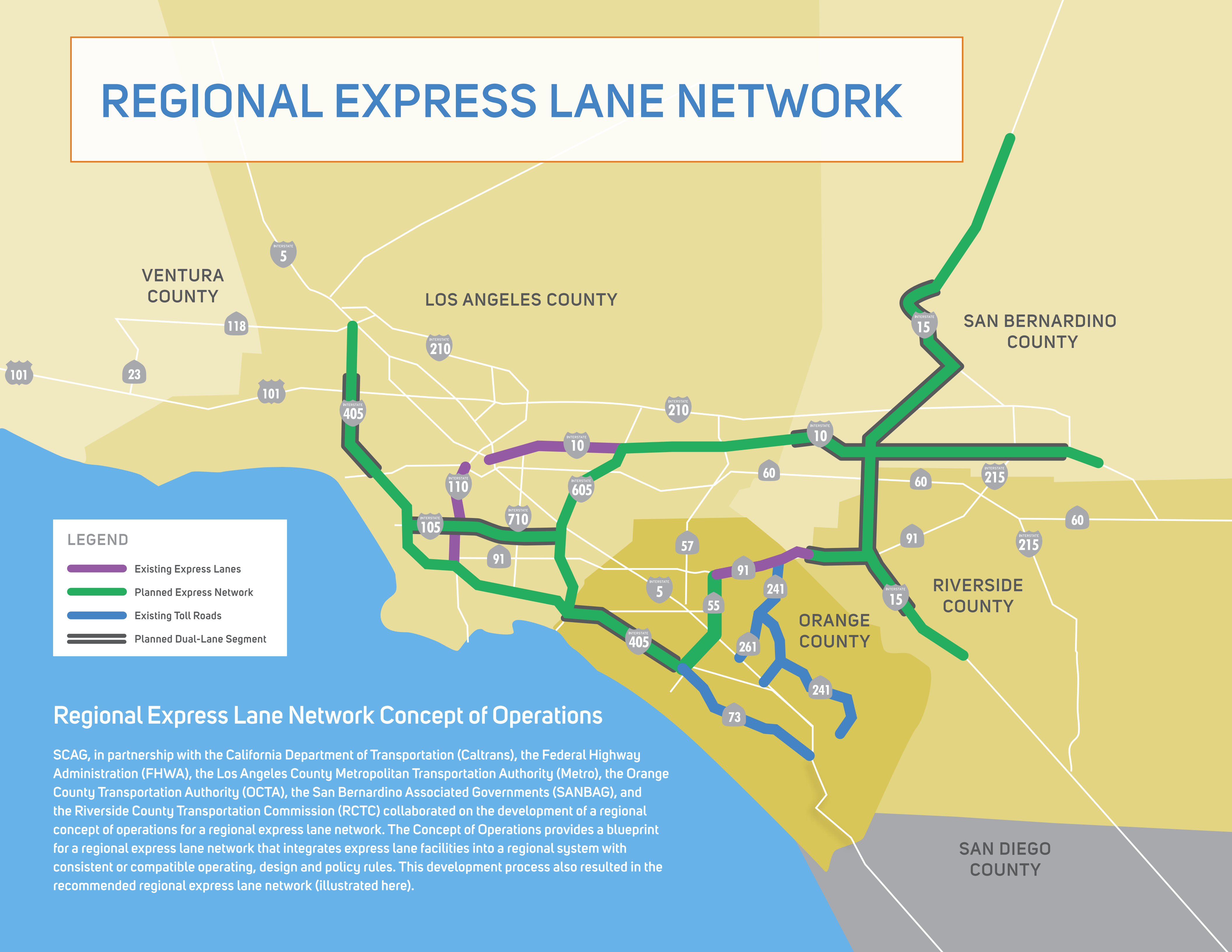
In 2013, the American Transportation Research Institute (ATRI) identified the Los Angeles Metropolitan Area as leading the nation in costs to the trucking industry caused by traffic congestion, with nearly $1.1 billion in added operational costs to truckers.[8] The SCAG region had five of the top 100 truck bottlenecks in the U.S. in 2014—identified by ATRI as follows:

#8	State Route 60 at State Route 57 in Los Angeles County
#17	Interstate 710 at Interstate 105 in Los Angeles County
#37	Interstate 10 at Interstate 15 in San Bernardino County
#39	Interstate 15 at State Route 91 in Riverside County
#55	Interstate 110 at Interstate 105 in Los Angeles County.[9]

8 Cost of Congestion to the Trucking Industry. (2014). American Transportation Research Institute.

9 Congestion Impact Analysis of Freight Significant Highway Locations. (2014). American Transportation Research Institute.

REGIONAL EXPRESS LANE NETWORK



Regional Express Lane Network Concept of Operations

SCAG, in partnership with the California Department of Transportation (Caltrans), the Federal Highway Administration (FHWA), the Los Angeles County Metropolitan Transportation Authority (Metro), the Orange County Transportation Authority (OCTA), the San Bernardino Associated Governments (SANBAG), and the Riverside County Transportation Commission (RCTC) collaborated on the development of a regional concept of operations for a regional express lane network. The Concept of Operations provides a blueprint for a regional express lane network that integrates express lane facilities into a regional system with consistent or compatible operating, design and policy rules. This development process also resulted in the recommended regional express lane network (illustrated here).

With driver wages and fuel costs representing more than 50 percent of total motor carrier costs, truck congestion has major impacts on the bottom line of the trucking industry. Truck bottlenecks are also emission "hot spots" that generally have significantly degraded localized air quality because of increased idling from passenger vehicles and trucks.

In past RTPs, SCAG directly addressed truck bottlenecks by developing a coordinated strategy to identify and mitigate the top-priority truck bottlenecks. This analysis has been updated for the 2016 RTP/SCS and includes a "refresh" of truck bottleneck delays for the locations where congestion data were available. It also identifies potential new truck bottlenecks.

The 2016 RTP/SCS allocates an estimated $5 billion toward strategies to relieve goods movement bottlenecks. Examples of bottleneck relief strategies include ramp meterings, extending merging lanes, improving ramps and interchanges, improving capacity and adding auxiliary lanes. Additional information is provided in the Goods Movement Appendix.

Rail Strategy

The region's railroad system provides critical connections between the largest port complex in the country and producers and consumers throughout the U.S. More than half of the international cargo arriving at the San Pedro Bay Ports uses rail. Railroads also serve domestic industries, predominantly for long-haul freight leaving the region. The extensive rail network in the SCAG region offers shippers the ability to move large volumes of goods over long distances at lower costs, compared with other transportation options. The 2016 RTP/SCS continues to incorporate the following rail strategies for goods movement:

- **Mainline Rail Improvements and Capacity Expansion:** This includes double or triple tracking certain rail segments, implementing new signal systems, building universal crossovers and constructing new sidings. These improvements would benefit both freight rail and passenger rail service, depending on their location.
- **Rail Yard Improvements:** This includes upgrades to existing rail yards, as well as construction of new yards to handle the projected growth in cargo volumes.
- **Grade Separations of Roads From Rail Lines:** These projects reduce vehicular delay, improve emergency vehicle access, reduce the risk of accidents and lower emissions levels.
- **Rail Operation Safety Improvements:** This includes technology such as Positive Train Control (PTC) that can greatly reduce the risk of rail collisions.

The benefits of the rail strategies to the region are considerable and include mobility, safety and environmental gains. These strategies could eliminate nearly 5,500 hours of vehicle delay per day at grade crossings, decrease emissions (NOx, CO2 and PM 2.5) by nearly 44,000 lb. per day, and reduce overall train delay to the year 2000 level.

Goods Movement Environmental Strategy

Along with growth in the region's population and economy comes a growing demand to deliver goods in areas where people live and work. As a result, goods movement transportation has been a major source of emissions that contributes to regional air pollution problems, as well as localized air pollution "hot spots" that can have adverse health impacts. Moreover, much of the SCAG region (and nearly all of the urbanized area) does not meet federal ozone and fine particulate (PM 2.5) air quality standards. The transportation of goods is also a major source of greenhouse gas emissions that contribute to global climate change. Because of the need to maintain and improve our quality of life, economically and environmentally, SCAG proposes the environmental strategy below to address the air quality impacts of goods movement, while also allowing for the efficient and safe goods movement flow throughout the region. A critical component of this strategy, as described below, is the integration of advanced technologies that have co-benefits such as air quality, energy security and economic growth opportunities.

The 2016 RTP/SCS focuses on a two-pronged approach for achieving an efficient freight system that reduces environmental impacts. For the near term, the regional strategy supports the deployment of commercially available low-emission trucks and locomotives while centering on continued investments into improved system efficiencies. For example, the region envisions increased market penetration of technologies already in use, such as heavy-duty hybrid trucks and natural gas trucks. Applying ITS solutions to improve operational efficiency is also recommended. In the longer term, the strategy focuses on advancing technologies—taking critical steps now toward the phased implementation of a zero- and near zero-emission freight system. SCAG is cognizant of the need to incorporate evolving technologies with plans for new infrastructure. These include technologies to fuel vehicles, as well as to charge batteries and provide power.

The plan to develop and deploy advanced technologies includes phased implementation, during which technology needs are defined, prototypes are tested and developed, and efforts are scaled up. FIGURE 5.3 illustrates this process. The phases are summarized as follows:

FIGURE 5.3 PHASES OF TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

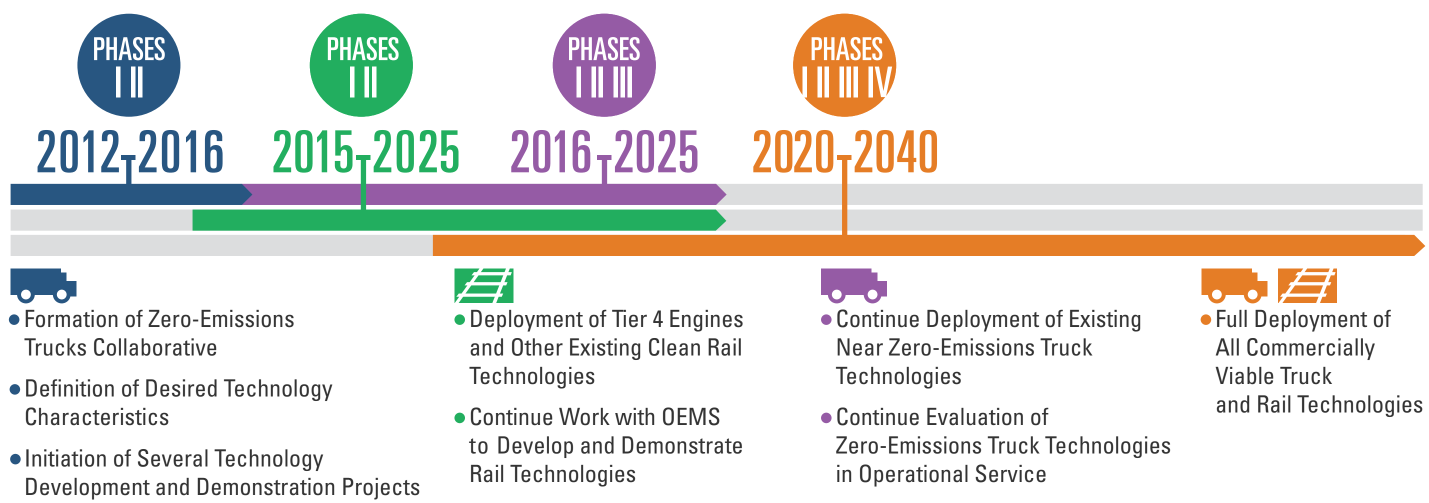
PHASE I Project Scoping and Evaluation of Existing Work: Continue to build on current regional research and technology testing efforts to further define the needs that the new technology must provide and to better understand the current capabilities, costs and stage of development of potential technologies.

PHASE II Evaluation, Development and Prototype Demonstrations: Evaluate, develop and test initial vehicle prototypes. Work with public and private sector partners to secure funding commitments for the development of new technology prototypes and demonstrations.

PHASE III Initial Deployment and Operational Demonstration: Initially deploy potential technologies, preferably with industry partners who can evaluate and report on their performance in the real world. Funding may be used for incentives for initial deployment and the continued evaluation and development of technologies.

PHASE IV Full-Scale Demonstrations and Commercial Deployment: Scale up deployment of viable technologies and implement needed regulatory and market mechanisms to launch them commercially. The Phase IV time frame accommodates the readiness of different levels of technology for various applications.

FIGURE 5.4 TRUCK AND RAIL TECHNOLOGY DEVELOPMENT AND DEPLOYMENT TIMELINE



Phases of New Technology Development and Deployment

The time frames illustrated in FIGURE 5.4 suggest a path toward implementing the phases described above. This cycle of technology development is continuous, and it will renew itself as new innovations emerge and technologies continue to evolve. The timelines presented are broad, to capture the breadth of technologies in various stages of development and to allow for further innovation in this sector. This path is discussed in greater detail in the Goods Movement Appendix.

Since SCAG adopted the 2012 RTP/SCS, the region has attracted outside funding and committed its own funding to support research and development efforts. Several studies have been conducted to date that contribute to "project scoping" by providing a greater understanding of the regional truck market and how truck use defines key performance parameters such as range and power needs. To evaluate and develop prototypes, three large-scale research and development efforts are underway to develop and test zero-emission trucks and charging infrastructure. These projects require continuing collaboration between original equipment manufacturers and public sector agencies.

Meeting Airport Demand

As discussed in Chapter 2, our region is served by a multiple airport system that includes commercial airports, military airfields and general aviation airports. All of these airports function as part of a system that provides a high level of air service to our residents and to visitors. Services that are not practical or financially viable at one airport in the system can be provided at an alternative facility. In addition, many of our airports function as relievers for other airports in case of emergencies or irregular operations due to inclement weather or other unusual events.

The commercial passenger and cargo airports in our region, especially those in the urbanized areas, each face constraints on their operations. At each airport, these constraints may include airspace conflicts, runway configurations, terminal capacity, ground access congestion and legal restrictions such as noise control ordinances. Because of the varying constraints on individual airports, it is important to maintain a diverse group of airports to serve the overall air travel demand of the region extending into the future.

Accommodating the future demand for air passenger and air cargo is critical to the economic health of the region. The economic impact of air travel to the region is expected to increase from $27.4 billion in 2012 to $43.8 billion in 2040 (in 2012 dollars), an increase of nearly 60 percent. The number of jobs supported by visitors arriving by air is expected to increase from 275,000 to 452,000. If the region's aviation system and supporting ground access network cannot accommodate the expected demand, some of this potential economic activity could be lost to other regions.

Forecasting Air Passenger Demand Based on the historical relationship between economic activity and the demand for air travel, as well as expected future economic conditions in our and other regions, total air passenger demand in our region is expected to increase from 91.2 million annual passengers (MAP) in 2014 to 136.2 MAP in 2040. This represents a 1.6 percent annual growth rate over the forecast period. This regional demand forecast for air passenger travel is strong and reflects the potential for the region to have long-term economic recovery and growth. More detail about the forecast methodology is presented in the Aviation & Airport Ground Access Appendix.

Some of the airports in our region benefit from having long runways, uncongested airspace and spacious, modern terminals. Airports with these benefits are expected to be able to accommodate any growth in demand foreseeable through 2040. However, four of the commercial airports in urban parts of the region face physical or policy constraints that may limit their capacity to accommodate increases in demand by 2040. The individual airport demand forecasts reflect the following constraints:

- Burbank Bob Hope Airport: 7.3 MAP (airfield capacity)
- Los Angeles International Airport: 82.9–96.6 MAP (airfield capacity)
- Long Beach Airport: 5.0 MAP (noise compatability ordinance)
- John Wayne Airport: 12.5 MAP (settlement agreement adopted by Board of Supervisors)

An analysis of these constraints is included in the Aviation & Airport Ground Access Appendix.

Several recent trends in the airline industry were considered in the capacity analyses. For example, the average number of seats on commercial flights in and out of airports in our region increased from 107 in 2007 to 119 in 2014, so each "operation" (take-off or landing) on the airfield and each "turn" (arrival and departure) of a gate can include more passengers. Therefore, as a result of airline industry trends, the estimated capacity of several constrained airports has increased compared to prior analyses, although there may not have been any physical change at the airport itself.

2040 AIR PASSENGER FORECAST

Airport Specific Demand, *Million Annual Passengers (MAP)*

Midpoint of 2040 Total Regional Aviation Demand:

136.2 MAP

Based on the overall forecast regional demand for air travel, the origins and destinations of trips within the region and the capacity constraints of individual airports, the figure "2040 Airport Demand Forecasts" on the previous page presents the anticipated air travel demand at each commercial airport in our region in 2040.

Forecasting Air Cargo

The development of the air cargo demand forecasts is similar to that of the air passenger forecasts. The demand for air cargo is driven largely by the economic interrelationship of our region and other regions around the world. Because of its high cost, shipment by air is used primarily for time-sensitive and high-value goods. Total air cargo transported through our region's airports has experienced an uneven recovery since the recession of 2007, but remained below year 2000 levels even in 2014. Based on the historical relationship between economic activity and the demand for air cargo, as well as expected future economic conditions in our and other regions, total air cargo demand in our region is expected to increase from 2.43 million metric tons in 2014 to 3.78 million metric tons in 2040. This represents a 1.8 percent annual growth rate over the forecast period.

In 2014, more than 99 percent of air cargo in our region was handled at five airports: Los Angeles International Airport (77 percent), Ontario International Airport (19 percent), Burbank Bob Hope Airport (2 percent), John Wayne Airport (0.7 percent) and Long Beach Airport (0.6 percent). Air cargo can be classified as "belly" cargo (carried in the bellies of passenger airplanes) or full-freighter cargo (carried in dedicated freighter aircraft). LAX handled nearly 99 percent of the region's belly cargo and 70 percent of the full-freighter cargo.

Following the 2012 RTP/SCS, the air cargo forecasts assume some redistribution of air cargo across the airports in the region. Cargo carried on passenger airlines or by their cargo divisions is unlikely to be redistributed because these carriers benefit from consolidation of their passenger and cargo facilities at the same airport. Cargo carried by integrated delivery services, such as FedEx and UPS, is also unlikely to be redistributed because of the major investments these companies have made in facilities at individual airports (primarily, Ontario International Airport). Therefore, only cargo carried by charter airlines or all-cargo airlines would potentially diversify to other airports and, of the cargo that could potentially diversify, only some actually will.

Airport Ground Access

The ground access network serving the region's airports is critical to both the aviation system and the ground transportation system. Passengers' choice of airports is based in part on the travel time to the airport and the convenience of access, so facilitating airport access is essential to the efficient functioning of the aviation system. In addition, airport related ground trips can contribute to local congestion in the vicinity of the airports.

Currently, more than 200,000 air passengers arrive at or depart from the region's airports every day. By 2040, this number is forecast to increase to more than 330,000. Passenger surveys indicate that three percent of passengers take transit to LAX and one percent take transit to Burbank Bob Hope Airport. Surveys are not available at other airports, but because these two airports have the best transit access in the region it is likely that the transit share at the remaining airports is significantly below one percent.

The large majority of air passengers use a motor vehicle, either their own or a rental vehicle, to get to and from the airport. About half of all air passengers in the region are picked up or dropped off at the airport by a friend or relative. Each end of these pick-up/drop-off air trips results in two ground trips: one to the airport followed by one returning from the airport. Therefore, taking steps to encourage travelers to use transit or other modes of shared transportation is vital.

To reduce ground transportation congestion related to air passenger travel, the 2016 RTP/SCS includes the following strategies:

- Support the regionalization of air travel demand
- Continue to support regional and inter-regional projects that facilitate airport ground access (e.g., High-Speed Train, High Desert Corridor)
- Support ongoing local planning efforts by airport operators, CTCs and local jurisdictions
- Encourage the development and use of transit access to the region's airports
- Encourage the use of modes with high average vehicle occupancy (AVO)
- Discourage the use of modes that require "deadhead" trips to/from airports

In recent years, airport operators, CTCs and SCAG have all undertaken their own initiatives to improve ground access at the region's aviation facilities. The sections below discuss recent efforts and recommended strategies to improve ground access at three existing commercial airports in the region that have invested considerably in improving ground access. A more detailed discussion of ground access improvement strategies at airports across the region is included in the Aviation & Airport Ground Access Appendix.

Burbank Bob Hope Airport

Burbank Bob Hope Airport is the only airport in the region with a direct rail-to-terminal connection, via the recently completed Regional Intermodal Transportation Center (RITC). The RITC serves multiple modes, including public parking, a consolidated rental car facility, regional bus service and bicycles, and commuter rail at the Metrolink Ventura line station. A pedestrian bridge currently in design will further facilitate access between the train station and the airport. In addition, a second rail station is currently planned on the Metrolink Antelope Valley line. BurbankBus has recently begun operating all-day bus service between the North Hollywood Metro Red Line Station and the airport, utilizing the RITC.

Key 2016 RTP/SCS projects for Burbank Bob Hope Airport include:

- Increased Metrolink service systemwide
- Metro Red Line extension from North Hollywood to Burbank Bob Hope Airport
- New east-west BRT service from Orange Line/North Hollywood to Pasadena (no direct connection to Burbank Bob Hope Airport)

Additional strategies include:

- Construct new Metrolink Station on Antelope Valley Line
- Support increased Metrolink service to stations on Ventura Line and Antelope Valley Line
- Support recommendations of recent Ground Transportation and Land Use Study:
  - Improve transit connection to North Hollywood Red/Orange Line Station
  - Improve transit connection to Pasadena and Glendale
- Support the development of a High-Speed Train station on Hollywood Way and provide convenient access between the station and the airport

Los Angeles International Airport

LAX is owned and operated by Los Angeles World Airports (LAWA), a proprietary department of the City of Los Angeles. In December 2014, LAWA's Board of Airport Commissioners approved a plan to overhaul and modernize LAX's ground access and transportation connections for arriving and departing passengers. The approved program includes:

- The LAX Train (Automated People Mover System)
- Intermodal Transportation Facilities (ITF)
- Consolidated Rent-A-Car Center (CONRAC)
- Central terminal area improvements
- Connection with the under-construction Metro Crenshaw Line

The CONRAC will consolidate the numerous off-site rental car facilities in the surrounding area into one convenient location 1.5-miles east of LAX and adjacent to Interstate 405 for convenient regional highway access. Two ITFs are included in the program offering airport travelers locations for parking, passenger pick-up and drop off, and flight check-in outside the terminal and away from the congested World Way roadway within LAX. The eastern ITF will include Metro facilities to connect with Metro's planned 96th Street/Aviation Boulevard Station serving the under-construction Metro Crenshaw/LAX Transit Project and existing Metro Green Line, as well as a bus plaza for Metro and municipal buses. The LAX Train will be an elevated automated people mover system with six stations connecting the CONRAC, both ITFs and Metro facilities to the LAX passenger terminals. The environmental review process for this project began in 2015 and construction is expected to begin in 2017.

Key 2016 RTP/SCS projects for LAX include:

- New Crenshaw/Green Line station at 96th/Aviation
- Automated People Mover

Additional strategies include:

- Support construction of Automated People Mover (APM) with connection to Metro Crenshaw Line
- Support construction of Consolidated Rental Car facility and Intermodal Transportation Facilities to reduce private vehicles and shuttles in Central Terminal Area
- Support expansion of FlyAway service to new markets
- Support ability of ride-hailing services to pick up passengers, to reduce deadhead trips in the central terminal area

Ontario International Airport

The 2014 SANBAG Ontario Airport Rail Access Study examined six alternatives to connect Ontario Airport to the regional rail system. One of these alternatives is the Metro Gold Line Foothill Extension Phase 2C that would extend the eastern terminus of the Metro Gold Line to the airport. However, Phase 2C is not funded at this time. Improved transit access from the Rancho Cucamonga Metrolink Station is included in the 2016 RTP/SCS project list.

Key 2016 RTP/SCS projects for Ontario Airport include:

- New Rancho Cucamonga Metrolink to ONT rail connection
- Numerous local highway interchange, arterial and grade separation improvements

Additional strategies include:

- Support recommendations of SANBAG Ontario Airport Rail Access Study to initiate transit connection to Metrolink and build transit market
- Continue analysis of transit options in upcoming SCAG Inter-County Transit and Rail Study
- Support development of intermodal transportation center
- Explore possibility of direct access from future Interstate 10 Express Lanes
- Consider focus on tourist charters that can attract passengers and use high-capacity vehicles for ground access
- Continue improvements to highways and arterials

For more details on how the region is expected to meet demands for airport service in the future, see the Aviation & Airport Ground Access Appendix.

TECHNOLOGICAL INNOVATION AND 21ST CENTURY TRANSPORTATION

Since SCAG adopted the 2012 RTP/SCS, technology and innovation have emerged as major themes of this Plan update. Technology as a concept is a very broad topic. The term has myriad connotations and encompasses products such as smart phones and electric cars; advancements in software development such as real-time travel information and online banking; and new service paradigms such as ride sourcing and peer-to-peer home sharing. Some of these so-called "new" concepts have actually been around for a long time, but only recently have they scaled up because of technological innovations. For example, car sharing and bike sharing concepts have been in development since the 1980s, but only in recent years has the ubiquity of cellular phones with Internet access, precise geographic mapping and the ability to instantly approve payments between users and providers made these systems more useful to a wider audience. The 2016 RTP/SCS uses the term "mobility innovations" to characterize the new technologies that help us move about the region.

MOBILITY INNOVATIONS

The 2016 RTP/SCS includes policies and analyzes the market growth of four key new mobility innovations: Zero-Emissions Vehicles, Neighborhood Electric Vehicles, Car sharing services and Ridesourcing (also known as Transportation Network Companies or TNCs). Please see the Mobility Innovations Appendix for policy recommendations and additional information.

Zero-Emissions Vehicles

While SCAG's policies are technology neutral with regard to supporting zero- and/or near zero-emissions vehicles, this section will focus on zero-emissions vehicles. Since SCAG adopted the 2012 RTP/SCS, the Governor's Office released the Zero Emissions Vehicle (ZEV) Action Plan for 2013 and 2015. These plans identified state level funding to support the implementation of Plug-in Electric Vehicle (PEV) and Hydrogen Fuel Cell refueling networks. As part of the 2016 RTP/SCS, SCAG modeled PEV growth specific to Plug-in Hybrid Electric Vehicles (PHEV) in the SCAG region. These are electric vehicles that are powered by a gasoline engine when their battery is depleted. The 2016 RTP/SCS proposes a regional charging network that will increase the number of PHEV miles driven on electric power. In many instances, these chargers may double the electric range of PHEVs. A fully funded regional charging network program would result in a reduction of one percent per capita greenhouse gas emissions.

Neighborhood Electric Vehicles (NEVs)

Neighborhood Mobility Areas reflect state and local policies to encourage the use of alternative modes of transportation for short trips. In the SCAG region, about 38 percent of all trips are three miles or less, but nearly 78 percent of these trips are made by driving full-sized cars. These short trips can easily be taken using an NEV. Policies to increase the purchase and roadway designs that increase the use of NEVs for short trips in Neighborhood Mobility Areas would result in a reduction of 0.1 percent per capita greenhouse gas emissions.

Shared Mobility (Includes the concept of Ridesourcing)

Shared Mobility refers to new mobility paradigms as well as old models that

GHG REDUCTIONS FROM MOBILITY INNOVATIONS 2040

ZERO-EMISSIONS VEHICLE (ZEV)

1.0%

NEIGHBORHOOD ELECTRIC VEHICLE (NEV)

0.1%

CARSHARING/ RIDESOURCING

0.9%

are finding new markets and methods of delivery, thanks to new technology platforms. Shared Mobility encompasses a wide range of services including:

- Return Trip Car Sharing
- Point-to-Point Car Sharing
- Peer-to-Peer Car Sharing
- Ridesourcing (also known as Transportation Network Companies)
- Dynamic On-Demand Private Transit
- Vanpool and Private Employer Charters

For all these services, mobile computing and payment systems are reducing transaction costs and opening up traditional mobility services to a wider population of producers and consumers. The net effect of these services on transportation mode choices and per capita VMT is still to be determined. However, preliminary research shows that the availability and use of these services correlates with a reduction in individual vehicle ownership. This reduction in ownership, meanwhile, results in an increase in non-motor vehicle modes for discretionary trips. In other words, people who no longer own a car will be more selective in their car trips.

In developing the 2016 RTP/SCS, SCAG looked at areas in which shared mobility services are expected to increase. The Plan anticipates robust growth in car sharing and ridesourcing. Ridesourcing is a term coined by researchers to refer to mobile phone-based applications that put riders in touch with drivers for a fee. Some drivers on one platform are professionals, while many other drivers are non-professionals earning income from giving rides. Policies to increase the use of car sharing and ridesourcing would result in a combined reduction of 0.9 percent greenhouse gas emissions.

ANTICIPATING CAR-TO-CAR COMMUNICATION AND AUTOMATED VEHICLE TECHNOLOGIES

Automakers already are manufacturing and installing advanced driver assist systems that can automatically center, reduce speed and brake in anticipation of vehicles ahead. Trucking companies are road testing automated driving and "platooning"—in which automated trucks safely follow or draft each other at very close distances to conserve fuel. Global corporations and research labs are testing small, fully automated vehicles on public roads. Certain automakers have begun experimenting with new service models like "fractional ownership" in which targeted customers collectively lease and share a vehicle. Locking and ignition packages are being offered to simplify the use of peer-to-peer car sharing platforms. These developments point to a very different vehicle ownership paradigm 25 years from now.

Automated/Connected Vehicle (ACV) innovations cover a range of enabling advancements that allow vehicles to operate with less driver input and coordinate with other vehicles to achieve improvements in safety, throughput and user experience. The term ACV covers on-board sensing capabilities, data integration and vehicle-to-vehicle (V2V) communication. ACV covers two distinct innovation paths: autonomous operation, where vehicles rely on digital maps and on-board sensing to operate without any driver input; and connected vehicle operation, where vehicles communicate with one another as well as the roadways they are traveling on. However, these two paths are being developed simultaneously and they may need to be integrated to achieve full benefits in terms of safety and reducing congestion, as promised by researchers. Vehicle to Infrastructure (V2I) communication is another aspect that is covered under roadway ITS operations. It is important to note that vehicles capable of partially automated operation, such as the top-of-the-line Mercedes S-Class and Infiniti Q35, are already available to the public. The California and Nevada Departments of Motor Vehicles (DMV) have already licensed manufacturers for on-road testing and those agencies will be releasing consumer model permitting rules by 2016.

Due to the uncertainty of deployment timelines and operational characteristics, initial research shows inconsistent impacts on travel behavior and locational choice. Some traffic simulations show that in the initial phases ACVs may increase congestion, especially if safety features are mandated at the expense of system operational efficiency. On the other hand, if fully automated vehicles change the vehicle ownership paradigm, they may facilitate more on-demand transportation services and an increased reduction in household vehicle ownership. In the long term, ACVs have the ability to dramatically increase the carrying capacity of the regional roadway network.

PROTECTING THE ENVIRONMENT

Integrating the many transportation and land use strategies discussed in this chapter will help protect the region's natural environment—in numerous ways. SCAG has been committed to this integration, as well as protecting the environment, for years. However, environmental protection is now a major requirement of Moving Ahead for Progress in the 21st Century Act (MAP-21). Pursuant to Section 23 U.S. Code Section 134, "a long-range transportation plan shall include a discussion of types of potential environmental mitigation activities and potential areas to carry out these activities, including activities that may have the greatest potential to restore and maintain the environmental functions affected by the plan." The 2016 RTP/SCS also considers and is consistent with the provisions of the Fixing America's Surface Transportation Act (FAST Act).

The 2016 RTP/SCS, therefore, includes a discussion of mitigation measures consistent with these requirements. As a public agency in California, SCAG first and foremost fulfills mitigation requirements by complying with the California Environmental Quality Act (CEQA), so this section of the Plan includes a summary of mitigation as laid out in the Program Environmental Impact Report (PEIR) accompanying the 2016 RTP/SCS.

In addition, as part of the planning process, MPOs "shall consult, as appropriate, with State and local agencies responsible for land use management, natural resources, environmental protection, conservation and historic preservation concerning the development of the transportation plan." They also must consider, if available, "State conservation plans or maps" and "inventories of natural or historic resources."

California law requires SCAG to prepare and certify a PEIR prior to adopting the 2016 RTP/SCS. The PEIR evaluates potential environmental impacts of the 2016 RTP/SCS when compared with existing conditions, and proposes measures at the program level to mitigate impacts to the maximum extent feasible for those resource areas that would be affected by the Plan (and associated induced growth). These impact areas include Aesthetics; Agriculture and Forestry Resources; Air Quality; Biological Resources; Cultural Resources; Energy; Geology and Soils; Greenhouse Gas Emissions and Climate Change; Hazards and Hazardous Materials; Hydrology and Water Quality; Land Use and Planning; Mineral Resources; Noise; Population, Housing and Employment; Public Services; Recreation; Transportation, Traffic and Safety; and Utilities and Service Systems. The 2016 RTP/SCS also acts as a "self-mitigating" plan in certain impact areas, in that its policies and strategies lead to improved environmental outcomes for air quality, greenhouse gas emissions, public health, congestion and other indicators, while accommodating existing and projected population growth. The section below summarizes the mitigation program contained within the PEIR for this Plan. The general purpose of the mitigation measures included in the PEIR is to identify how to protect the environment, and natural and cultural resources; improve the linkage between transportation and environmental planning; and enhance public health in concert with the proposed transportation improvements and related land use planning strategies.

It should be clearly noted that the 2016 RTP/SCS itself leads to improved environmental outcomes for per capita greenhouse gas emissions, the preservation of natural lands, recreational and active transportation opportunities and improved public health, among other key environmental indicators compared to the No Project Alternative. Nevertheless, the implementation of Plan programs, policies and strategies may lead to environmental impacts compared to the existing conditions. As such, program-level performance-based mitigation measures designed to offset any identified potentially significant adverse programmatic level environmental effects are summarized below. Project-level environmental mitigation should be appropriately identified and prepared by implementing agencies on a project-by-project or site-by-site basis as projects proceed through the design and decision-making process. Transportation project implementation and development decisions are subject to their own environmental review process and are expected to implement project-specific mitigation measures to minimize environmental impacts. This section, along with more detailed information in the PEIR, provides a framework that identifies feasible measures as resources which lead agencies can and should implement when they identify and mitigate project-level environmental impacts.

MITIGATION STRATEGIES

The PEIR provides a list of mitigation measures, which would be implemented by SCAG on a regional level, in order to assist in reducing environmental impacts related to implementation of the 2016 RTP/SCS. SCAG is also responsible for developing a plan to monitor mitigation activities to track progress on implementation of these measures at the regional level. SCAG's mitigation is consistent with the general role played by a Metropolitan Planning Organization, including developing and sharing information, collaborating with partners and developing regional policies. SCAG works with member agencies and stakeholders but it does not identify, evaluate or implement projects or project-specific mitigation.

In addition, the PEIR includes a "catch-all" mitigation measure for each of the CEQA resource categories, stating that lead agencies "can and should" comply with generally applicable performance standards that are linked to existing statutes, regulations and adopted general plans, where available and appropriate. They are not intended to supersede compliance with existing law, regulations and adopted general plans. Instead, they help explain to lead agencies that the existing regulatory framework that could assist in mitigating potential environmental impacts at the project level.

CONSERVATION PLANNING POLICY

Long-range transportation plans are required to discuss the types of potential environmental mitigation activities and potential areas to carry out these activities. This includes activities that may have the greatest potential to restore and maintain the environmental functions affected by the Plan [23 U.S. Code Sec. 134]. As such, this is being addressed in the 2016 RTP/SCS and is separate and distinct from the mitigation measures addressed in the PEIR.

SCAG could approach federal requirements for mitigation by continuing and expanding the efforts already undertaken since the adoption of the 2012 RTP/SCS. Those efforts included mapping potential priority conservation areas, engaging partners, and developing regional mitigation policies and approaches for this plan. As outlined in the 2012 RTP/SCS, the goal of these efforts is the development of a program of large-scale acquisition and management of important habitats lands to mitigate impacts related to future transportation projects. In the 2016 RTP/SCS, regional goals also include supporting local land use strategies that reduce the demand for building outside of the existing development footprint, especially in important habitat areas. Building on this effort has the potential to create a regional conservation program that stakeholders such as CTCs, local jurisdictions, agencies, and non-profits can align with and support. SCAG has already engaged many of these stakeholders by convening a working group. This strategic and comprehensive approach allows for regional growth and progress, while at the same time ensuring that important natural and working lands and water resources are protected in perpetuity. With that as the foundation, the following suggested next steps for further development of a conservation policy could include the following:

• Expanding on the Natural Resource Inventory Database and Conservation Framework and Assessment by incorporating strategic mapping layers to build the database and further refine the priority conservation areas

• Encouraging CTCs to develop advance mitigation programs or include them in future transportation measures

• Aligning with funding opportunities and pilot programs to begin implementation of the Conservation Plan through acquisition and restoration

• Providing incentives to jurisdictions that cooperate across county lines to protect and restore natural habitat corridors, especially where corridors cross county boundaries

Please see the Natural & Farm Lands Appendix for additional detail.

SUMMARY OF THE ENVIRONMENTAL MITIGATION PROGRAM

The 2016 RTP/SCS includes an environmental mitigation program that links transportation planning to the environment. Building on its strong commitment to the environment as demonstrated in the 2012 RTP/SCS, SCAG's mitigation program is intended to function as a resource for lead agencies to consider in identifying mitigation measures to reduce impacts anticipated to result from future projects as deemed applicable and feasible by such agencies. This mitigation discussion also utilizes documents created by federal, state and local agencies to guide environmental planning for transportation projects. The following discussion focuses on specific resource areas and example mitigation measures to avoid or substantially reduce the significant environmental impacts in these areas.

AESTHETICS

The SCAG region includes several highway segments that are recognized by the State as designated scenic highways or are eligible for such designation. Construction and implementation of projects in the 2016 RTP/SCS could impact designated scenic highways and restrict or obstruct views of scenic resources such as mountains, ocean, rock outcroppings, etc. In addition, some transportation projects could add urban visual elements, such as transportation infrastructure (highways, transit stations) to previously natural areas.

Mitigation measures developed by SCAG to minimize impacts to Aesthetics include, but are not limited to, information sharing regarding the locations of designated scenic vistas, and regional program development as part of SCAG's ongoing regional planning efforts, such as web-based planning tools for local government and direct technical assistance efforts such as the Toolbox Tuesday Training series and the sharing of associated online training materials.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines and review of county and city general plans and Caltrans designated scenic vistas, aesthetics performance standards-based mitigation measures may include, but are not limited to:

- Encourage the implementation of design guidelines by counties and cities, local policies, and programs aimed at protecting views of scenic corridors and avoiding visual intrusions in design of projects to minimize contrasts in scale and passing between the project and surrounding natural forms and developments.
- Design landscaping along highway corridors to add significant natural elements and visual interest to soften the hard-edged, linear transportation corridors.

- Remove blight or nuisances that compromise visual character or visual quality of project areas including graffiti abatement, trash removal, landscape management, maintenance of signage and billboards in good condition, and replacing compromised native vegetation and landscape.

AGRICULTURE AND FORESTRY RESOURCES

Approximately 2.6 million acres of important agricultural lands in the SCAG region currently exists. Out of the 2.6 million acres, 1.1 million acres are designated as Important Farmland and the other 1.5 million acres are designated as grazing land. With respect to forests and timberlands, forest lands include the Angeles National Forest, Cleveland National Forest, Los Padres National Forest, and San Bernardino National Forest, as well as forest lands with open space zones in Imperial and Los Angeles counties. No Timberland Production Zone exists within the SCAG region. However, the harvesting of timberland is only permitted in two agricultural zones, with one limited to Christmas tree harvesting. The 2016 RTP/SCS includes transportation projects and strategies that would have the potential to convert some Prime Farmland, Farmland of Statewide Importance, and Unique Farmland in all six counties and affect Local Farmland and Grazing land in five of the six counties. Forest and timberland zones would result in less than significant impacts.

SCAG-developed mitigation measures include, but are not limited to, coordination among applicable resource agencies, information sharing, and regional program development as part of SCAG's ongoing regional planning efforts, such as web-based planning tools for local government including CA LOTS, and other GIS tools and data services, including, but not limiting to, Map Gallery, GIS library, and GIS applications; and direct technical assistance efforts such as the Toolbox Tuesday Training series and sharing of associated online Training materials. Lead agencies, such as county and city planning departments, shall be consulted during this update process.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, review of county and general plans and consistent with the Farmland Protection Policy Act of 1981 and the Farmland Mapping and Monitoring Program of the California Resources Agency, agriculture and forestry resource performance standards-based mitigation measures may include, but are not limited to:

- Encourage enrollments of agricultural lands that have Williamson Act programs.
- Develop project relocation realignment to avoid lands in Williamson Act contracts.
- Establish conservation easements consistent with the recommendations of the Department of Conservation, Farmland Security Zones, Williamson Act contracts, or other conservation tools.

AIR QUALITY

The 2016 RTP/SCS includes programs, policies and measures to address air emissions. Measures that help mitigate air emissions are comprised of strategies that reduce congestion, increase access to public transportation, improve air quality, and enhance coordination between land use and transportation decisions. In order to disclose potential environmental effects of the 2016 RTP/SCS, SCAG has prepared an estimated inventory of the region's emissions, and identified mitigation measures. The mitigation measures seek to achieve the maximum feasible and cost-effective reductions in emissions.

Mitigation measures developed by SCAG to minimize impacts to Air Quality include, but are not limited to, the determination as part of its conformity findings, pursuant to the federal CAA, that the Plan and its subsequent updates provided for the timely implementation of transportation control measures (TCM). Demonstration of TCM timely implementation including a list of these TCMs is documented in the Transportation Conformity Analysis Appendix. Additionally, during the 2016 to 2040 planning period, SCAG shall pursue activities to reduce the impacts associated with health risks for sensitive receptors within 500 feet of highways and high-traffic volume roadways.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, and within the responsibility and jurisdiction of ARB, air quality management districts and other regulatory agencies, air quality performance standards-based mitigation measures may include, but are not limited to:

- Reduce emissions with the use of clean fuels and reducing petroleum dependency.
- Use watering trucks to minimize dust; watering should be sufficient to confine dust plumes to the project work areas.
- Revegetate disturbed lands, including vehicular paths created during construction to avoid future off-road vehicular activities.
- As appropriate, require that portable engine-driven equipment units used at the project work site, with the exception of on-road and off-road motor vehicles, obtain ARB Portable Equipment Registration with the state or local district permit.

BIOLOGICAL RESOURCES

The 2016 RTP/SCS seeks to minimize transportation-related impacts on wildlife, and also better integrate transportation infrastructure into the environment.

Impacts to biological resources generally include displacement of native vegetation and habitat on previously undisturbed land; habitat fragmentation and decrease in habitat connectivity; and displacement and reduction of local, native wildlife including sensitive species. Building new transportation routes and facilities through undisturbed land or expanding facilities and increasing the number of vehicles traveling on existing routes will directly injure wildlife species, cause wildlife fatalities, and disturb natural behaviors such as breeding and nesting. Without appropriate mitigation, this will result in the direct reduction or elimination of species populations (including sensitive and special-status species) and native vegetation (including special-status species and natural communities) as well as the disruption and impairment of ecosystem services provided by native habitat areas.

Mitigation measures developed by SCAG to minimize impacts to biological resources include, but are not limited to, consultation with resource agencies, as well as local jurisdictions to incorporate any local HCPs or other similar planning documents. Development of a conservation strategy with local jurisdictions and agencies and maintaining a list/map of potential conservation opportunity areas based on the most recent land use data.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, within county and city general plans, the responsibility and jurisdiction of the USFWS, the CDFW, and other applicable agencies, biological resources performance standards-based mitigation measures may include, but are not limited to:

- Design projects to avoid sensitive natural communities and riparian habitats.
- Install fencing and/or mark sensitive habitat to be avoided during construction activities.
- Salvage and stockpiling topsoil and perennial plants for use in restoring native vegetation to all areas of temporary disturbance within the project area.

CULTURAL RESOURCES

Impacts to cultural resources, inclusive of tribal cultural resources, generally include substantial adverse changes to historical and archaeological resources and direct or indirect changes to unique paleontological resources or sites or unique geological features. These impacts can occur at the localized scale and in relation to existing conditions, as the Plan itself does not affect the total amount of growth in the region. Adverse changes include the destruction of culturally and historically (recent or geologic time) significant and unique historical, archaeological, paleontological, and geological features.

Mitigation measures developed by SCAG to minimize impacts to Cultural resources include, but are not limited to, sharing of information and SCAG's ongoing regional planning efforts such as web-based planning tools for local government including CA LOTS, and direct technical assistance efforts such as the Toolbox Tuesday series. Resource agencies, such as the Office of Historic Preservation shall be consulted during this process.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, and review of county and city general plans, cultural resources performance standards-based mitigation measures may include, but are not limited to:

- Comply with Section 106 of the National Historic Preservation Act (NHPA) including, but not limited to, projects for which federal funding or approval is required for the individual project.
- Employ design measures to avoid historical resources and undertake adaptive reuse where appropriate and feasible. If resources are to be preserved, as feasible, project sponsors should carry out the maintenance, repair, stabilization, rehabilitation, restoration, preservation, conservation or reconstruction in a manner consistent with the Secretary of the Interior's Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings.
- Comply with California Health and Safety Code, Section 7050 and Sections 18950–18961, in the event of discovery or recognition of any human remains during construction or excavation activities associated with the project, in any location other than a dedicated cemetery, ceasing further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until the coroner of the county has been informed and has determined that no investigation of the cause of death is required.

ENERGY

California consumes more energy than any other state except Texas. However, in terms of energy consumption per person, California ranks 49th among the 50 states and District of Columbia. Current annual energy consumption in

California (including transportation) is approximately 7,641 trillion Btu, which represents approximately 7.9 percent of the nation's energy consumption. Transporting water into California is also a very energy intensive process. The California State Water Project (SWP) is the single largest user of energy in the state. The SWP uses approximately 5 billion kWh/year of electricity which is equal to 2 to 3 percent of the total electricity consumed in California. Water-related energy consumes approximately 20 percent of the total electricity in California. Implementation of the 2016 RTP/SCS would result in an increase in energy use due to the increase in households and transportation projects in the SCAG region.

SCAG developed mitigation measures include, but are not limited to, working with local jurisdictions and energy providers, through its Energy and Environment Committee, and administration of the Clean Cities program, Sustainability Planning grants program, and other SCAG energy-related planning activities, to encourage energy efficient building development. Additional measures include, pursuing partnerships with Southern California Edison, municipal utilities, and the California Public Utilities Commission to promote energy efficient development in the SCAG region, through coordinated planning, data and information sharing activities

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, county and city form-based zoning codes and future updated zoning codes, energy performance standards-based mitigation measures may include, but are not limited to:

- Using energy efficient materials in building design, construction, rehabilitation, and retrofit.
- Reduce lighting, heating, and cooling needs by taking advantage of light colored roofs, trees for shade, and sunlight.

GEOLOGY AND SOILS

Impacts to geological resources generally include the disturbance of unstable geologic units (rock type) or soils, causing the loss of topsoil and soil erosion, slope failure, subsidence, project-specific seismic activity and structural damage from expansive soils. These activities, in addition to building projects on and around Alquist-Priolo Fault Zones and other local faults, could expose people and/or structures to the risk of loss, injury, or death.

Mitigation measures developed by SCAG to minimize impacts to Geology and Soils include, but are not limited to, sharing of information, and regional program development as part of SCAG's ongoing regional planning efforts, such as web-based planning tools for local government including CA LOTS, and direct technical assistance efforts such as the Toolbox Tuesday series. Resource agencies, such as the U.S. Geology Survey shall be consulted during this update process.

Based on County and City General Plans, geology and soils performance standards-based mitigation measures may include, but are not limited to:

- Comply with Section 4.7.2 of the Alquist-Priolo Earthquake Fault Zoning Act, requiring a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults.
- Comply with the CBC and local regulatory agencies with oversight of development associated with the project, ensuring that projects are designed in accordance with county and city code requirements for seismic ground shaking.
- Adhere to design standards described in the California Building Code and all standard geotechnical investigation, design, grading, and construction practices to avoid or reduce impacts from earthquakes, ground shaking, ground failure, and landslides.

GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

California is the fifteenth largest emitter of greenhouse gases on the planet. The transportation sector, primarily cars and trucks that move goods and people, is the largest contributor with 37 percent of the state's total greenhouse gas emissions in 2013. On road emissions (from passenger vehicles and heavy duty trucks) constitute 90 percent of the transportation sector total. In order to disclose potential environmental effects of the 2016 RTP/SCS, SCAG has prepared an estimated inventory of the region's existing greenhouse gas emissions, identified mitigation measures, and compared alternatives in the PEIR. Although the 2016 RTP/SCS demonstrates a reduction in per capita greenhouse gas emissions and meets Senate Bill 375 targets, mitigation is identified here in summary form, and in the PEIR, to provide information on how greenhouse gas emissions can be reduced from other sectors as well as through subsequent planning and implementation.

SCAG developed mitigation measures include, but are not limited to, updating any future RTP/SCS to incorporate polices and measures that lead to reduced greenhouse gas emissions in accordance with Assembly Bill 32; coordination with ARB and air districts in efforts to implement the Assembly Bill 32 plan; continuing the coordination with other metropolitan planning organizations regarding statewide strategies to reduce greenhouse gas emissions and facilitate the implementation of Senate Bill 375. Additional measures include, working with utilities, sub-regions, and other stakeholders to promote an accelerated penetration of zero (and/or near zero) emission vehicles in the region, including developing a strategy for the deployment of public charging infrastructure.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, and within the responsibility and jurisdiction of ARB, local air districts, and/or lead agencies, greenhouse gas emissions and climate change standards-based mitigation measures may include, but are not limited to:

- Reduce emissions resulting from a project through implementation of project features, project design, or other measures.
- Incorporate Best Available Control Technology (BACT) during design, construction and operation of projects to minimize greenhouse gas emissions.
- Adopt plan or mitigation program for the reduction of emissions that are required as part of the Lead Agency's decision.
- Use energy and fuel efficient vehicles and equipment.
- Use the minimum feasible amount of greenhouse gas emitting construction materials that is feasible.
- Incorporate design measures to reduce greenhouse gas emissions from solid waste management through encouraging solid waste recycling and reuse.
- Incorporate design measures to reduce energy consumption and increase use of renewable energy.
- Plant shade trees in or near construction projects where feasible.
- Construct buildings to Leadership in Energy and Environmental Design (LEED) certified standards.

HAZARDS AND HAZARDOUS MATERIALS

Implementation of the 2016 RTP/SCS would affect the transportation and handling of hazardous materials in the SCAG region. Expected significant impacts include risk of accidental releases due to an increase in the transportation of hazardous materials and the potential for such releases to reach neighborhoods and communities adjacent to transportation facilities. The hazardous materials mitigation program aims to minimize the significant hazard to the public or the environment that involves the release of hazardous materials into the environment.

SCAG developed mitigation measures include, but are not limited to, coordination efforts with the United States Department of Transportation (U.S. DOT), the Office of Emergency Services, California Department of Transportation (Caltrans) and the private sector to continue to conduct driver safety training programs. Additionally, SCAG shall encourage the U.S. DOT and the California Highway Patrol to continue to enforce speed limits and existing regulations governing goods movement and hazardous materials transportation.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, provisions of the Hazardous Waste Control Act, the Unified Hazardous Waste and Hazardous Materials Management Regulatory Program, the Hazardous Waste Source Reduction and Management Review Act of 1989, and the California Vehicle Code, hazards and hazardous materials standards-based mitigation measures may include, but are not limited to:

- Provide a written plan of proposed routes of travel demonstrating use of roadways designated for the transport of hazardous materials.
- Follow the manufacturer's recommendations on use, storage, and disposal of chemical products used during construction.
- During routine maintenance of construction equipment, properly contain and remove grease and oils.

HYDROLOGY AND WATER QUALITY

Impacts to hydrology and water quality from the 2016 RTP/SCS include potential water quality impairment from increased impervious surfaces. Increased impervious surfaces in water recharge areas potentially impact groundwater recharge and groundwater quality. Cumulative impacts include increased impervious surfaces; increased development in alluvial fan floodplains; and increased water demand and associated impacts, such as drawdown of groundwater aquifers. These impacts can occur at the localized scale and in relation to existing conditions, as the Plan itself does not affect the total amount of growth in the region. Increased output of greenhouse gases from the region's transportation system impacts the security and reliability of the imported water supply.

SCAG developed mitigation measures include, but are not limited to, working with local jurisdictions and water quality agencies, to encourage regional-scale planning for improved water quality management/demand and pollution prevention, providing opportunities for information sharing with respect to wastewater treatment and regional program development to promote Low Impact Development (LID) and reduce hydromodification.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, and within the jurisdiction and authority of the Regional Water Quality Control Boards and other regulatory agencies, hydrology and water quality standards-based mitigation measures may include, but are not limited to:

- Complete, and have approved, a Stormwater Pollution Prevention Plan (SWPPP) prior to initiation of construction.
- Complete, and have approved, a Standard Urban Stormwater Management Plan, prior to occupancy of residential or commercial structures.
- Incorporate as appropriate, treatment and control features such as detention basins, infiltration strips, and porous paving, other features to control surface runoff and facilitate groundwater recharge into the design of new projects early on in the process to ensure that adequate acreage and elevation contours are provided during the right-of-way acquisition process.

LAND USE AND PLANNING

The 2016 RTP/SCS contains transportation projects to help more efficiently distribute population, housing, and employment growth, as well as a forecasted Land Development Category pattern of development described in detail in the SCS. These transportation projects and land use strategies are generally consistent with the county- and regional-level general plan data available to SCAG; however, general plans are not updated consistently. The Plan includes a projected Land Development Category pattern of development that, in order to maximize the effectiveness of the transportation system differs from local General Plan land uses beyond 2020.

SCAG developed mitigation measures include, but are not limited to, coordinate with member cities and counties to encourage that general plans consider and reflect as appropriate RTP/SCS policies and strategies. Other measures include infill, mixed-use, higher density and other sustainable development, and work with partners to identify incentives to support the creation of affordable housing in mixed-use zones. Additionally, SCAG shall work with its member cities and counties to encourage that transportation projects and growth are consistent with the RTP/SCS and general plans.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines and review of county and city general plans, land use and planning standards-based mitigation measures may include, but are not limited to:

- Ensure that the project is consistent with the applicable goals and policies of the adopted general plan where the project is located.
- Where an inconsistency is identified, determine if the environmental, social, economic, and engineering benefits of the proposed land use strategy or transportation improvement warrant a variance from adopted zoning or an amendment to the general plan.
- Wherever feasible incorporate direct crossings, overcrossings, or undercrossings at regular intervals for multiple modes of travel (e.g., pedestrians, bicyclists, vehicles).

MINERAL RESOURCES

Transportation projects as well as Land Development Category development patterns influenced by land use strategies identified in the 2016 RTP/SCS would require substantial amounts of aggregate resources to construct facilities. This would result in a significant impact. The six-county and 191 cities SCAG region has about 1,446 million tons of permitted aggregate reserves. The California Geological Survey (CGS) estimates that the SCAG region would need about 4,728 million tons of aggregate over the next 50 years. The difference of 3,282 million tons in demand could result in a shortage of aggregate supply. Based on this anticipated shortage of aggregate supply over the next 50 years, there would be an anticipated shortage during the next 25 years during implementation of the 2016 RTP/SCS.

SCAG developed mitigation measures include, but are not limited to, the coordination with the Department of Conservation, the CGS to maintain a database of (1) available mineral resources in the SCAG region including permitted and un-permitted aggregate resources and (2) the anticipated 50-year demand for aggregate and other mineral resources. Based on the results of this survey, SCAG shall work with local agencies on strategies to address anticipated demand, including identifying future sites that may seek permitting and working with industry experts to identify ways to encourage and increase recycling to reduce the demand for aggregate.

Based on County and City General Plans, mineral resources standards-based mitigation measures may include, but are not limited to:

- Recycle and reuse building materials resulting from demolition, particularly aggregate resources, to the maximum extent practicable.
- Identify and use building materials, particularly aggregate materials, resulting from demolition at other construction sites in the SCAG region, or within a reasonable hauling distance of the project site.

- Design transportation network improvements in a manner (such as buffer zones or the use of screening) that does not preclude adjacent or nearby extraction of known mineral and aggregate resources following completion of the improvement and during long-term operations.

NOISE

Some of the principal noise generators within the SCAG region are associated with transportation (i.e., airports, highways, arterial roadways, seaports, and railroads). Additional noise generators include stationary sources, such as industrial manufacturing plants and construction sites. Noise impacts resulting from the 2016 RTP/SCS generally include exposure of sensitive receptors to noise in excess of normally acceptable noise levels or substantial increases in noise as a result of the operation of expanded or new transportation facilities.

SCAG developed mitigation measures include, but are not limited to, the coordination with member agencies as part of SCAG's outreach and technical assistance to local governments under Toolbox Tuesday Training series, to encourage that projects involving residential and commercial land uses are encouraged to be developed in areas that are normally acceptable to conditionally acceptable, consistent with the Governor's Office of Planning and Research Noise Element Guidelines.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines and review of county and city general plans, noise standards-based mitigation measures may include, but are not limited to:

- Install temporary noise barriers during construction.
- Include permanent noise barriers and sound-attenuating features as part of the project design.
- Schedule construction activities consistent with the allowable hours pursuant to applicable general plan noise element or noise ordinance where construction activities are authorized outside the limits established by the noise element of the general plan or noise ordinance; notify affected sensitive noise receptors and all parties who will experience noise levels in excess of the allowable limits for the specified land use, of the level of exceedance and duration of exceedance; and provide a list of protective measures that can be undertaken by the individual, including temporary relocation or use of hearing protective devices.

POPULATION, HOUSING AND EMPLOYMENT

Transportation projects and land use strategies including new and expanded infrastructure are necessary to improve travel time and can enhance quality of life for those traveling throughout the region. The package of transportation improvements in the 2016 RTP/SCS is designed to accommodate total growth while maintaining or improving for mobility. The Plan would not affect the total growth in population in the region. The 2016 RTP/SCS can affect the distribution of that growth. Land use and housing impacts associated with transportation projects and development influenced by land use strategies, such as dividing established communities through right-of-way acquisition, can occur at a localized scale.

SCAG developed mitigation measures include, but are not limited to, working with member agencies to encourage and assist growth strategies to create an urban form designed to focus development in HQTAs in accordance with the polices, strategies and investments contained in the 2016 RTP/SCS, enhancing mobility and reducing land consumption.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines and review of county and city general plans, population, housing and employment standards-based mitigation measures may include, but are not limited to:

- Evaluate alternate route alignments and transportation facilities that minimize the displacement of homes and businesses. Use an iterative design and impact analysis where impacts to homes or businesses are involved to minimize the potential of impacts on housing and displacement of people.
- Prioritize the use of existing ROWs, wherever feasible.
- Develop a construction schedule that minimizes potential neighborhood deterioration from protracted waiting periods between right-of-way acquisition and construction.
- Construct affordable housing units, deed restricted to remain affordable for an appropriate period of time, as feasible or payment of fee, with the appropriate nexus to the impact, where such fees were established to address loss of affordable housing.

PUBLIC SERVICES

Any impacts to public services are identified only in relation to existing conditions or at a localized scale. These impacts generally include additional demands on fire and police services, schools and landfills. Additional police and fire personnel would be needed to adequately respond to emergencies and routine calls, particularly on new or expanded transportation facilities. Other potential impacts at a localized scale could entail demands on public schools, solid waste facilities and disposal facilities.

SCAG developed mitigation measures include, but are not limited to, supporting local jurisdictions and other service providers in their efforts to develop sustainable communities and provide, equally to all members of society, accessible and effective services such as: public education, housing, health care, social services, recreational facilities, law enforcement, and fire protection.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines and review of county and city general plans, public services standards-based mitigation measures may include, but are not limited to:

- Coordinate with local public protective security services to ensure that the existing public protective security services would be able to handle the increase in demand for their services. If the current levels of services at the project site are found to be inadequate, provide fair share contributions towards infrastructure improvements and/or personnel requirements for the appropriate public services
- Identify projects that have the potential to generate the need for expanded emergency response services. Where such services and related staffing needs exceed the capacity of existing facilities, provide for the construction of new facilities directly as an element of the project or through a dedicated fair share contributions toward infrastructure improvements.

RECREATION

Impacts to recreation from the 2016 RTP/SCS would result from an increase in population. The use of regional parks and other recreational facilities are expected to increase and result in a substantial physical deterioration of facilities at an accelerated rate. Additionally, transportation projects included in the 2016 RTP/SCS could result in potentially significant impacts to recreational facilities which include closures to gaps in the highway network through areas that currently service as open space lands.

SCAG developed mitigation measures include, but are not limited to, facilitating the reduction of impacts as a result of increased use in recreational facilities through cooperation with member agencies, information sharing, and program development in order to ensure consistency with planning for expansion of new neighborhood parks within or in nearby accessible locations to HQTAs in funding opportunities and programs administered by SCAG.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines and review of county and city general plans, recreation standards-based mitigation measures may include, but are not limited to:

- Where projects require the construction or expansion of recreational facilities or the payment of equivalent Quimby fees, consider increasing the accessibility to natural areas and lands for outdoor recreation from the proposed project area, in coordination with local and regional open space planning or management agencies.
- Where construction or expansion of recreational facilities is included in the project or required to meet public park service ratios, apply necessary mitigation measures to avoid or reduce significant environmental impacts associated with the construction or expansion of such facilities, through the imposition of conditions required to be followed to avoid or reduce impacts associated with air quality, noise, traffic, biological resources, greenhouse gas emissions, hydrology and water quality, and others that apply to specific construction or expansion of new or expanded public service facilities.

TRANSPORTATION, TRAFFIC AND SAFETY

The 2016 RTP/SCS takes into account the population, households, and employment projected for 2040, and therefore the largest demand on the transportation system expected during the lifetime of the plan. In accounting for the effects of regional population growth, the model output provides a regional, long-term and cumulative level of analysis for the impacts of the 2016 RTP/SCS on transportation resources. The regional growth, and thus, cumulative impacts, is captured in the vehicle miles traveled (VMT), vehicle hours traveled (VHT), and heavy-duty truck VHT data. Consistent with Senate Bill 375 Regional Target Advisory Committee's final report to the California Air Resources Board, the 2016 RTP/SCS includes projects and strategies to reduce congestion and promote friendly speeds on the roadways. A subset of projects included in the 2016 RTP/SCS reduces greenhouse gas emissions by providing relief of existing and projected congestion. Those include toll roads, express lanes, high occupancy vehicle lanes, and dedicated truck toll lanes. Congestion pricing is a transportation demand management tool incorporated into the 2016 RTP/SCS that would reduce greenhouse gas emissions in addition to more efficient utilization of existing facilities. The SCAG region is vulnerable to numerous threats that include both natural and human caused incidents. As such, a mitigation program related to safety is included in the PEIR.

SCAG developed mitigation measures include, but are not limited to, the facilitation of minimizing impacts to emergency access through ongoing regional planning efforts such as meetings with local member agencies, maintain forums with policy makers, and workshops with local, regional, and state partners such as Department of Transportation, Congestion Management Agencies, Fire Department, and other local enforcement agencies during consultation on development and maintenance of the Regional Transportation Plan.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, county and city general plans and congestion management programs, transportation standards-based mitigation measures may include, but are not limited to:

- Promote ride sharing programs e.g., by designating a certain percentage of parking spaces for high-occupancy vehicles, providing larger parking spaces to accommodate vans used for ride-sharing, and designating adequate passenger loading and unloading and waiting areas.
- Encourage bicycling to transit facilities by providing additional bicycle parking, locker facilities, and bike lane access to transit facilities when feasible.
- Encourage the use of public transit systems by enhancing safety and cleanliness on vehicles and in and around stations, providing shuttle service to public transit, offering public transit incentives and providing public education and publicity about public transportation services.
- Encourage bicycling and walking by incorporating bicycle lanes into street systems in regional transportation plans, new subdivisions, and large developments, creating bicycle lanes and walking paths directed to the location of schools and other logical points of destination and provide adequate bicycle parking, and encouraging commercial projects to include facilities on-site to encourage employees to bicycle or walk to work.
- Build or fund a major transit stop within or near transit, or transit-oriented development.

UTILITIES AND SERVICE SYSTEMS

Impacts to utilities and service systems from the 2016 RTP/SCS include the potential for the construction of new utility infrastructure or expansion of existing infrastructure. Additional impacts could result in an increased amount of pollutants in urban runoff attributed to landscape irrigation, highway runoff, and illicit dumping. As mentioned previously, implementation of the Plan would increase impervious surfaces in the SCAG region through a combination of transportation projects and development influenced by land use strategies. Additional impacts such as insufficient water supply, strain to wastewater and solid waste treatment plants could also occur.

SCAG developed mitigation measures include, but are not limited to, working with local jurisdictions and water quality agencies, to encourage regional-scale planning for improved water quality management/demand and pollution prevention, providing opportunities for information sharing with respect to wastewater treatment and program development in the region.

Consistent with the provisions of Section 15091 of the State CEQA Guidelines, and within the responsibility of local jurisdictions including the Imperial, Riverside, San Bernardino, Los Angeles, Ventura and Orange Counties Flood Control District, utilities and service systems standards-based mitigation measures may include, but are not limited to:

- Reduce exterior consumptive uses of water in public areas, and should promote reductions in private homes and businesses, by shifting to drought-tolerant native landscape plantings (xeriscaping), using weather-based irrigation systems.
- Reuse and minimize construction and demolition (C&D) debris and diversion of C&D waste from landfills to recycling facilities.
- Implement or expand city or county-wide recycling and composting programs for residents and businesses.

CONCLUSION

These transportation and land use strategies, programs and projects are ambitious, but based on our history SCAG is confident that together they will advance our movement toward a more mobile and sustainable region that achieves our long-term goals for people across our region. By closely integrating transportation and land use planning, the 2016 RTP/SCS places the region firmly on that path. For more details on the planned investments reviewed in this chapter, including a project list, please see the Project List Appendix.

The following chapter, "Paying for Our Plan," presents a review of how we expect to fund our ambitious list of transportation investments—that is, where the money will come from and what economic and policy developments could impact the availability of public funds needed to realize our goals.

Image courtesy of Samer Momani

06

CHAPTER 6 HIGHLIGHTS

PAYING FOR THE PLAN

In accordance with federal fiscal constraint requirements, this chapter and a more detailed appendix on our financial plan identify how much money SCAG reasonably expects will be available to support our region's surface transportation investments.

INTRODUCTION

The financially constrained 2016 RTP/SCS includes both a "traditional" core revenue forecast comprised of existing local, state and federal sources and more innovative but reasonably available sources of revenue to implement a program of infrastructure improvements that keeps freight and people moving. As in the past, the financial plan describes steps we can take to obtain needed revenues to implement the region's transportation vision.

The financial plan highlights the importance of finding new and innovative ways to pay for transportation, including our ever-expanding backlog of projects to preserve our existing transportation system. Nationally, we continue to face an insolvency crisis with the Federal Highway Trust Fund, as fuel tax receipts have declined precipitously. Similarly, the viability of California's State Highway Account remains in question, as only a fraction of our needs are funded through state sources. Our region continues to rely heavily on local sources of tax revenue. Seven sales tax measures in the region generate 71 percent of core revenues for transportation improvements.

It is vital that we find new ways to make transportation funding more sustainable in the long term, and efforts are underway to explore how we can transition from our current system based on fuel taxes to a more direct system based on user fees. Recent action by the state Legislature to launch the California Road Charge Pilot Program is a critical step in this transition.

In our region, numerous policy and technical studies have been conducted on the subject and more work is planned to examine and demonstrate the viability of user fee systems, including toll networks. Our region has successfully implemented toll systems in the past, with the Transportation Corridor Agencies' network of privately financed toll roads, the State Route 91 Express Lanes in Orange County and more recently with the express lanes along Interstate 10 and Interstate 110 in Los Angeles County.

The SCAG region has secured the necessary resources to support transportation investments detailed in past RTPs, and our current financial plan will continue to meet necessary milestones to implement the 2016 RTP/SCS. The following sections describe the financial assumptions and methodologies used for forecasting revenues and expenditures for transportation investments. Other SCS implementation costs are not included in this analysis.

ECONOMIC OUTLOOK AND KEY FINANCIAL ASSUMPTIONS

SCAG's financial model reflects historical growth trends and reasonable future expectations for key revenue sources. The inability of existing excise taxes to keep pace with increasing transportation needs and the impacts of increasing fuel efficiency on traditional revenue sources are key considerations in the financial plan.

INFLATION

Inflation can have a profound impact over the long-term time horizon of our Plan. SCAG's revenue model accounts for historical inflation trends, as measured by the Gross Domestic Product (GDP) Price Deflator.

FIGURE 6.1 shows the trends in inflation by the GDP Price Deflator. Although inflation rates have varied considerably over time, they have generally trended between two and four percent. Accordingly, a 2.4 percent inflation rate is used to adjust constant dollar (revenue) forecasts into nominal (year-of-expenditure) dollars.

CONSTRUCTION COST INCREASES

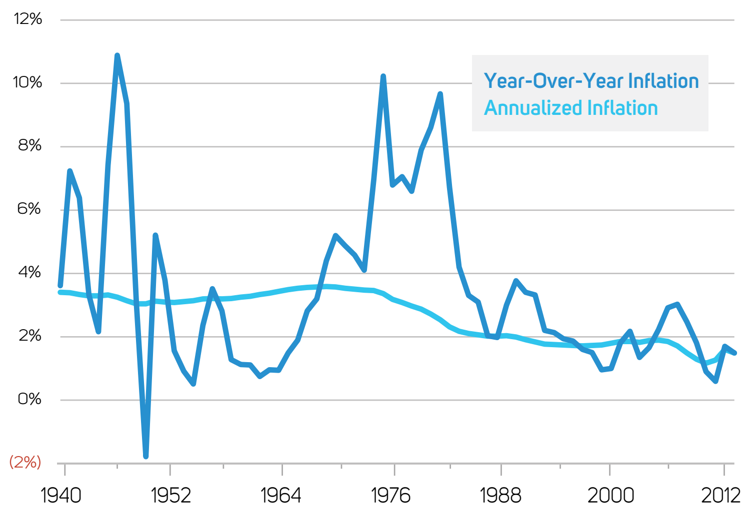
The rise in construction costs can further erode the purchasing power of transportation revenues. FIGURE 6.2 shows the increase and decline in California highway construction costs since the early 1970s. While recent corrections have slowed the longer-term increase in costs, the growth still remains above general inflation. The financial plan uses a 3.2 percent annual inflation factor to estimate future and nominal (year-of-expenditure) costs.

RETAIL SALES GROWTH

Changes in personal consumption patterns and the overall population are main contributors to the growth in retail sales. Over the 30-year period from FY1981-82 to FY2011-12, statewide retail sales grew by 1.8 percent in real terms (when the effects of inflation are eliminated). The financial plan assumes retail sales growth ranging from 1.8 percent to 3.9 percent in real terms.

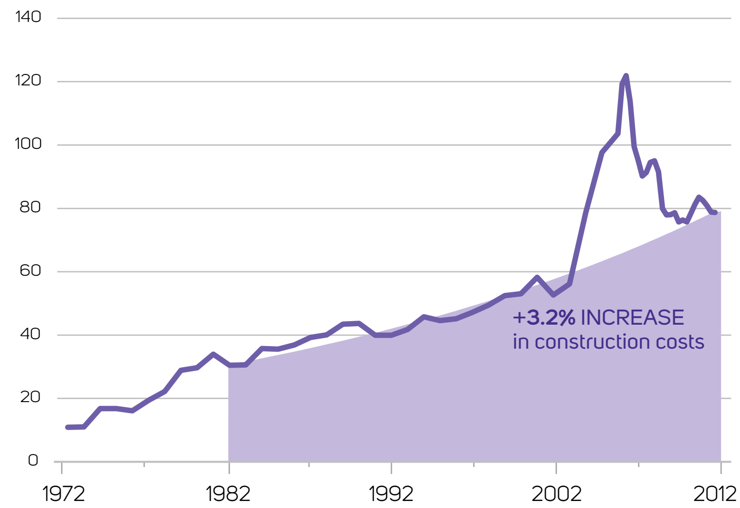
Growth in construction costs (3.2%) outpaces general inflation (2.4%)

FIGURE 6.1 HISTORICAL INFLATION TRENDS (ANNUAL INFLATION)



Source: Office of Management and Budget, Budget of the United States Government, FY 2016 Budget

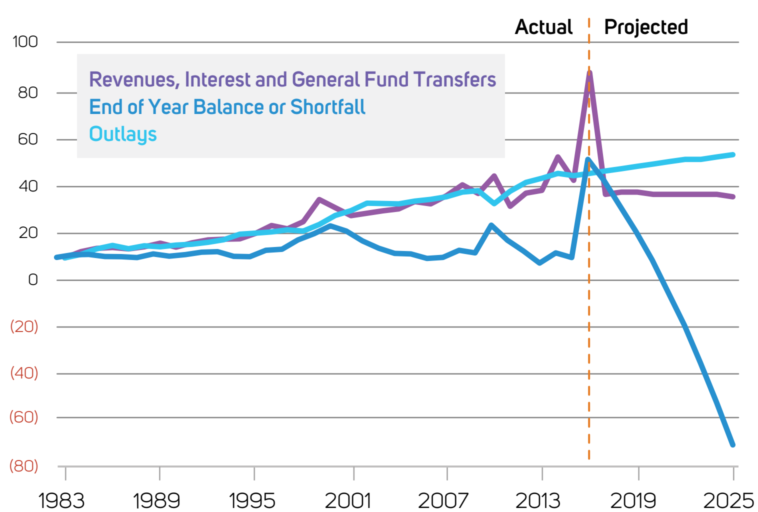
FIGURE 6.2 GROWTH IN HIGHWAY CAPITAL COSTS (INDEX VALUE)



Source: California Department of Transportation

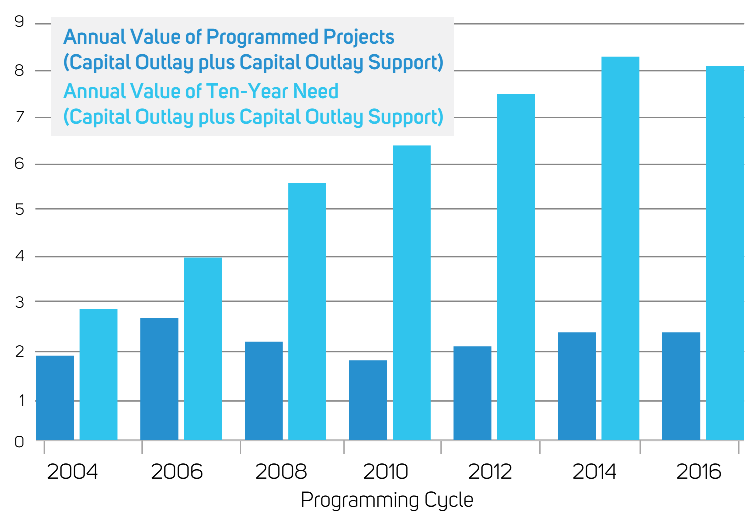
The viability of the state and federal revenue sources is of concern

FIGURE 6.3 STATUS OF THE FEDERAL HIGHWAY TRUST FUND ($ BILLIONS)



Source: Congressional Budget Office and Federal Highway Administration

FIGURE 6.4 STATUS OF THE STATE HIGHWAY OPERATION AND PROTECTION PROGRAM (SHOPP) ($ BILLIONS)



Source: California Department of Transportation, 2015 Ten-Year SHOPP Plan

FUEL CONSUMPTION

Excise taxes on gasoline and diesel fuels are the basis of most federal and state transportation funding sources. Since these taxes are based on cents-per-gallon purchased, they depend solely on fuel consumption and are not indexed to inflation or construction costs. While changes in vehicle miles traveled (VMT) will continue to play a role during the Plan period, increases in conventional fuel efficiency and the adoption of alternative fuel vehicles will reduce overall fuel consumption. The financial plan assumes that increases in vehicle fuel efficiency will reduce fuel consumption by 0.9 percent per year during the Plan period.

STATUS OF THE FEDERAL HIGHWAY TRUST FUND

The Federal Highway Trust Fund provides federal highway and transit funding from a nationally-imposed 18.3 cent-per-gallon gasoline excise tax. Since 2008, the Trust Fund has failed to meet its obligations and has required the United States Congress to authorize $141.1 billion in transfers from the General Fund to keep it solvent. The negative balances shown on FIGURE 6.3 illustrate the projected inability of the Trust Fund to pay its obligations into the highway account.

At the time of the 2016 RTP/SCS, nearly a decade has passed without substantive Congressional agreement on a long-term solution to provide adequate funding for the Trust Fund. The recently passed transportation reauthorization known as the FAST Act relies on $70 billion of one-time, non-user fees to keep the Trust Fund solvent through 2020. It does not address the present, long-term structural deficiency that exists in funding the Trust Fund. Although the financial plan assumes that Congress will reach agreement on reauthorizing federal spending for transportation programs over the Plan horizon, the core revenues available from the Trust Fund are expected to decline due to increasing fuel efficiency and other factors.

STATUS OF THE STATE HIGHWAY ACCOUNT

Despite the "Gas Tax Swap," the effective state gas excise tax rate of 18 cents-per-gallon has remained unadjusted for more than 20 years. Gas tax revenues remain the only source of funding for the State Highway Operation and Protection Program (SHOPP), which funds projects to maintain the State Highway System. As shown in FIGURE 6.4, previous levels of funding have been considerably less than actual needs. Statewide, the 2015 Ten-Year SHOPP Plan identifies $8.0 billion in statewide annual needs, while expenditures programmed for the next four years are only $2.3 billion annually. Continued underinvestment in the maintenance needs of the State Highway System will only increase the cost of bringing our highway assets back to a state of good repair.

LOCAL SALES TAX MEASURES

The SCAG region continues to rely heavily on local sales tax measures for the timely delivery of transportation projects. While most counties impose a 0.5 percent sales tax to fund transportation projects, Los Angeles County levies a 1.5 percent tax—a combination of two permanent half-cent sales taxes and Measure R at 0.5 percent. Measure R is not permanent and expires in 2039. Riverside County's Measure A also expires in 2039. Measure I in San Bernardino County expires in 2040, followed by Orange County's Measure M in 2041. Measure D in Imperial County expires in 2050. Ventura County is the only county in the region without an existing dedicated sales tax for transportation. However, Ventura County is in the process of seeking voter approval on a half-cent sales tax, which is reflected as part of the reasonably available revenues.

TRANSIT OPERATING AND MAINTENANCE (O&M) COSTS

Future transit O&M costs depend on a variety of factors, such as future revenue-miles of service, labor contracts and the age of rolling stock. For the 2016 RTP/SCS, transit O&M costs are estimated based upon historical increases. The regional average increase of 2.7 percent is used for most operators. For Los Angeles County, the financial plan relies on detailed forecasts from the county transportation commission, which is also consistent with historical data.

MULTIMODAL SYSTEM PRESERVATION AND MAINTENANCE

The 2016 RTP/SCS identifies $275.5 billion in total system preservation and maintenance needed to bring transit, passenger rail, regionally significant local streets and roads, and the State Highway System to a state of good repair. While the Plan includes core revenue sources for system preservation, these sources are limited due to restrictions on the use of funds and voter-approved commitments to major capital initiatives.

REVENUE & EXPENDITURE CATEGORIES

CORE AND REASONABLY AVAILABLE REVENUES

The 2016 RTP/SCS financial plan includes two types of revenue forecasts. Both are included in the financially constrained plan:

- Core revenues
- Reasonably available revenues

The *core revenues* identified are existing transportation funding sources projected to FY2039-40. The core revenue forecast does not include future increases in state or federal gas excise tax rates (other than the adjustments reflecting the state gasoline sales tax swap) or adoptions of regional gasoline taxes, mileage-based user fees and new tax measures. These revenues provide a benchmark from which additional funding can be identified.

MULTIMODAL SYSTEM PRESERVATION & MAINTENANCE NEEDS

(in nominal dollars)

TOTAL **$275.5** BILLION

TRANSIT **$156.7** BILLION

STATE HIGHWAYS **$65.8** BILLION

REGIONALLY SIGNIFICANT LOCAL STREETS & ROADS **$37.3** BILLION

PASSENGER RAIL **$15.7** BILLION

Note: Numbers may not sum to total due to rounding.

The region's *reasonably available revenues* include new sources of transportation funding likely to materialize within the 2016 RTP/SCS time frame. These sources include adjustments to existing state and federal gas tax rates, value capture strategies, potential national freight program funds, tolls for specific facilities and private equity participation. Federal guidelines on fiscal constraint permits the inclusion of revenues that are reasonably available. In accordance with federal guidelines, the Plan includes strategies for ensuring the availability of these sources.

EXPENDITURE CATEGORIES

Transportation expenditures in the SCAG region are summarized into three main categories:

- Capital costs for transit, state highways and regionally significant arterials (local streets and roads)
- Operating and maintenance costs for transit, state highways and regionally significant arterials (local streets and roads)
- Debt service payments (for current and anticipated bond issuances)

CORE REVENUES

SCAG's regional core revenue model forecasts transportation revenues over the entire 2016 RTP/SCS time horizon. The revenue model is comprehensive and supports analysis by county or funding source. The revenue forecast was developed using the following framework:

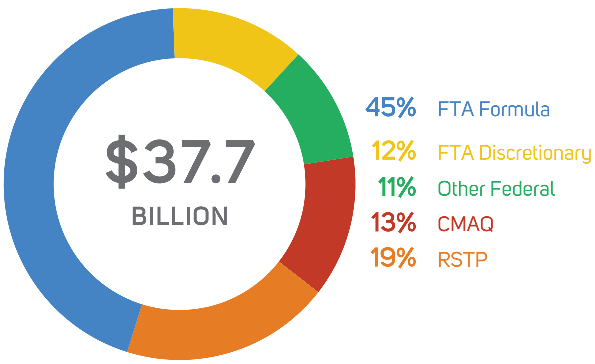
- Incorporate financial planning documents developed by local county transportation commissions and transit operators in the region, where available
- Ensure consistency with both local and state planning documents
- Utilize published data sources to evaluate historical trends
- Conduct sensitivity testing of assumptions to augment local forecasts, as needed

The region's revenue forecast horizon for the financial plan is FY2015-16 through FY2039-40. Consistent with federal guidelines, the plan takes into account inflation and reports statistics in nominal (year-of-expenditure) dollars. TABLE 6.1 shows these core revenues in five-year increments by county.

FIGURE 6.5 CORE REVENUES (IN NOMINAL DOLLARS)

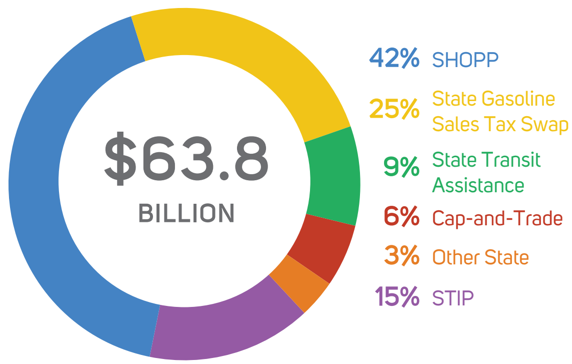
FEDERAL

Federal sources are expected to comprise a small portion of overall transportation funds ($37.7 billion). Federal Transit Administration (FTA) funds account for 57 percent of federal funding in the SCAG region. The financial plan also assumes that CMAQ funding will decline in 2022, 2031 and 2036 due to the region achieving attainment for a number of criteria pollutants and reducing the severity level of others.



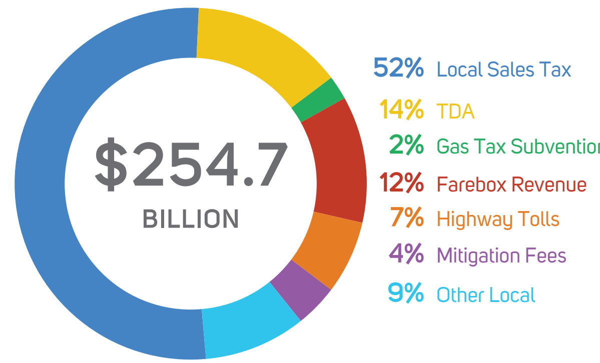
STATE

The State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP) and the State Gasoline Sales Tax Swap account for the bulk of the state funding available.



LOCAL

Local sales taxes provide the largest single source of local funding. When local sales taxes in all five counties with such measures are included, these taxes account for more than half (52 percent) of local sources.



The majority of revenues in the SCAG region come from local sources. The share of state sources (18 percent) has increased since the last RTP as a result of Cap-and-Trade Auction Proceeds.

LOCAL + STATE + FEDERAL= $356.1 BILLION

TABLE 6.1 CORE REVENUE FORECAST FY 2016–2040

(in Nominal Dollars, Billions)

COUNTY	FY 2016–2020	FY 2021–2025	FY 2026–2030	FY 2031–2035	FY 2036–2040	TOTAL
Imperial	$0.5	$0.5	$0.6	$0.7	$0.8	**$3.2**
Los Angeles	$34.3	$38.0	$45.4	$53.1	$55.0	**$225.8**
Orange	$8.5	$8.5	$10.1	$12.1	$14.2	**$53.4**
Riverside	$5.4	$6.3	$7.6	$9.3	$10.0	**$38.6**
San Bernardino	$4.2	$4.8	$5.6	$6.5	$7.5	**$28.6**
Ventura	$1.0	$1.1	$1.3	$1.5	$1.7	**$6.5**
TOTAL	**$53.9**	**$59.2**	**$70.6**	**$83.1**	**$89.3**	**$356.1**

Source: SCAG Revenue Model 2015 Note: Numbers may not sum to total due to rounding.

REASONABLY AVAILABLE REVENUES

There are several new funding sources that are reasonably expected to be available for the 2016 RTP/SCS. The following guiding principles were used for identifying reasonably available revenues:

- Establish a user fee-based system that better reflects the true cost of transportation, provides firewall protection for new and existing transportation funds, and ensures an equitable distribution of costs and benefits.
- Promote national and state programs that include return-to-source guarantees, while maintaining flexibility to reward regions that continue to commit substantial local resources.
- Leverage locally available funding with innovative financing tools (e.g., tax credits and expansion of the Transportation Infrastructure Finance and Innovation Act [TIFIA]) to attract private capital and accelerate project delivery.
- Promote funding strategies that strengthen the federal commitment to the nation's goods movement system, recognizing the pivotal role that our region plays in domestic and international trade.

TABLE 6.2 identifies eight categories of funding sources that are considered to be reasonably available and are included in the financially constrained plan. These sources were identified on the basis of their potential for revenue generation, historical precedence and the likelihood of their implementation within the time frame of the 2016 RTP/SCS. For each funding source, SCAG has examined the policy and legal context of implementation and has prepared an estimate of the potential revenues generated. Additional documentation of funding sources included in the financial plan are provided in the Transportation Finance Appendix.

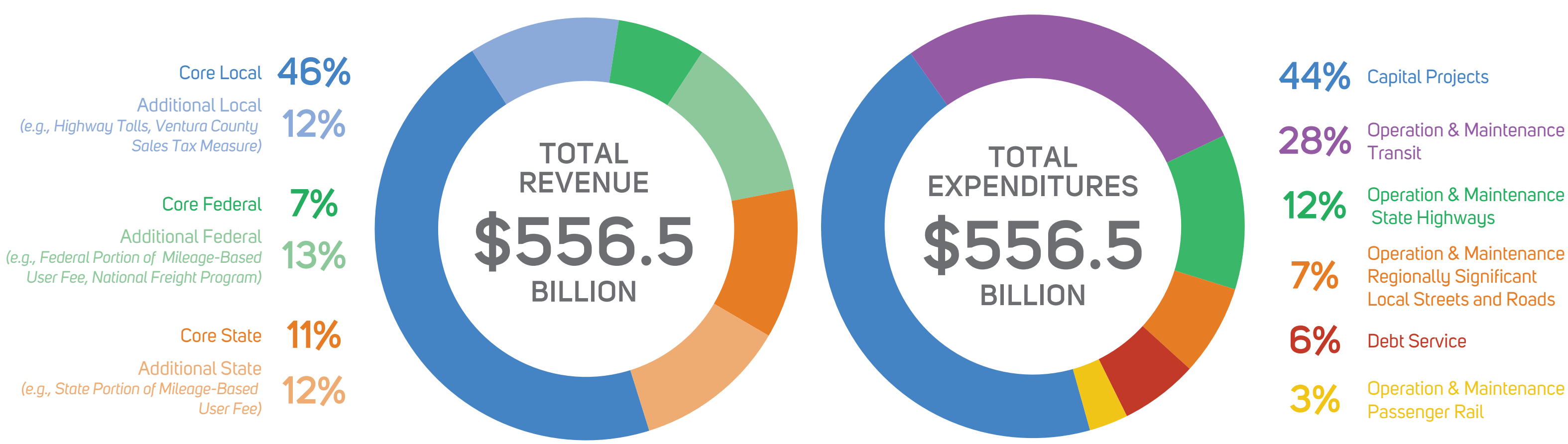
SUMMARY OF REVENUE SOURCES AND EXPENDITURES

The SCAG region's financially constrained 2016 RTP/SCS includes revenues from both core and reasonably available revenue sources, which together total $556.5 billion from FY2015-16 through FY2039-40 (see TABLE 6.3). The Plan is funded 57 percent by local sources, 23 percent by state sources and 19 percent by federal sources, as illustrated in FIGURE 6.6.

Capital projects total $246.6 billion in nominal dollars. Operating and maintenance (O&M) costs total $275.5 billion, while debt service obligations total $34.5 billion. Transit-related costs comprise the largest share of O&M costs for the region, totaling $156.7 billion.

TABLE 6.4 presents the SCAG region's revenue forecast by source in five-year increments, from FY2015-16 through FY2039-40. This is followed by TABLE 6.5, which provides details of the region's expenditures by category in five-year increments.

FIGURE 6.6 FY 2016–2040 SUMMARY OF REVENUE AND EXPENDITURES (IN NOMINAL DOLLARS)



Source: SCAG Revenue Model 2015 Note: Numbers may not sum to total due to rounding.

TABLE 6.2 NEW REVENUE SOURCES AND INNOVATIVE FINANCING STRATEGIES

(in Nominal Dollars, Billions)

REVENUE SOURCE	DESCRIPTION	AMOUNT	ACTIONS TO ENSURE AVAILABILITY	RESPONSIBLE PARTY(IES)
State and Federal Gas Excise Tax Adjustment to Maintain Historical Purchasing Power	Additional $0.10 per gallon gasoline tax imposed at the state and the federal levels starting in 2020 to 2024 to maintain purchasing power.	$6.0	Requires action of state Legislature and Congress. Strategy is consistent with recommendations from two national commissions to move immediately with augmenting fuel tax resources through conventional Highway Trust Fund mechanisms. Rate is also consistent with proposals introduced in state Legislature during 2015–2016 session.	State Legislature, Congress
Mileage-Based User Fee (or equivalent fuel tax adjustment)	Mileage-based user fees would be implemented to replace gas taxes—estimated at about $0.04 (in 2015 dollars) per mile starting in 2025 and indexed to maintain purchasing power.	$124.8 (est. increment only)	Requires action of state Legislature and Congress. Strategy is consistent with recommendations from two national commissions to move toward a mileage-based user fee system. In 2014, state Legislature passed Senate Bill (SB) 1077 (DeSaulnier) directing California to conduct a pilot program to study the feasibility of a road charge as a replacement to the gas tax beginning no later than January 1, 2017. The FAST Act establishes the Surface Transportation System Funding Alternatives program, which provides grants to states to demonstrate alternative user-based revenue mechanisms that could maintain the long-term solvency of the Trust Fund.	State Legislature, Congress
Highway Tolls (includes toll revenue bond proceeds)	Toll revenues generated from East-West Freight Corridor and regional express lane network.	$23.5	Assembly Bill (AB) 1467 (Nunez) Chapter 32, Statutes of 2006 authorized Caltrans and regional transportation agencies to enter into comprehensive development lease agreements with public and private entities or consortia of those entities for certain types of transportation projects. Further, AB 521 (Runner) Chapter 542, Statutes of 2006 modified provisions in AB 1467. Senate Bill Second Extraordinary Session 4 (SBX2 4) Chapter 2, Statutes of 2009 (Cogdill) established the legislative authority until January 1, 2017, allowing for regional transportation agencies and Caltrans to enter into an unlimited number of public-private partnerships (PPP) and deleted the restrictions on the number and type of projects that may be undertaken. Chapter 474, Statutes of 2009 (AB 798) established the California Transportation Financing Authority (CTFA). Highway projects that meet planning and environmental review requirements are eligible for tolling subject to meeting requirements of the CTFA. AB 798 also lifted the requirement for express lane projects authorized under AB 1467 to have separate legislative approval. SB 1316 (Correa) enabled RCTC to impose tolls along SR-91 Express Lanes. The I-15 Express Lanes in Riverside County were authorized by AB 1954 (Jeffries). SB 1298 (Hernandez) authorized continued tolling along the I-10 and I-110 Express Lanes in Los Angeles County. AB 914 (Brown) allowed express lanes along I-10 and the I-15 in San Bernardino County. AB 194 (Frazier) allowed the California Transportation Commission to authorize additional express lane projects.	MPO, CTCs, Caltrans, CTFA, and FHWA as may be applicable

TABLE 6.2 CONTINUED

REVENUE SOURCE	DESCRIPTION	AMOUNT	ACTIONS TO ENSURE AVAILABILITY	RESPONSIBLE PARTY(IES)
Private Equity Participation	Private equity share as may be applicable for key initiatives: e.g., toll facilities; also, freight rail package assumes railroads' share of costs for main line capacity and intermodal facilities.	$3.4	Region has authority as noted above. Current funding plans for specific intermodal facilities assume private sources.	MPO, CTCs, private consortium, state Legislature, and Union Pacific/ BNSF as appropriate for specific facilities
Freight Fee/National Freight Program	The recent reauthorization of the federal surface transportation act (the FAST Act) provides dedicated federal funding for infrastructure improvements supporting the national freight network through the newly created National Highway Freight Program and the Nationally Significant Freight and Highway Projects program. These programs are funded at approximately $2.1 billion per year nationally. Regional estimate assumes a conservative percentage of national totals.	$5.4	Current efforts at the local/regional level continue to endorse a federal program for freight. Other mechanisms to ensure the establishment of a funding program for freight may entail working with local/regional, state, and federal stakeholders to assess a national freight fee. Freight fees could be assessed in proportion to relative impacts on the transportation system.	Congress and potentially state Legislature as well as local/regional stakeholders
State Bond Proceeds, Federal Grants & Other for California High-Speed Rail Program	State general obligation bonds authorized under the Bond Act approved by California voters as Proposition 1A in 2008; federal grants authorized under American Recovery and Reinvestment Act and High-Speed Intercity Passenger Rail Program; Cap-and-Trade Auction Proceeds; potential use of qualified tax credit bonds; and private sources.	$34.0	Estimate for Southern California segments based on statewide system total per 2014 California High-Speed Rail Business Plan. Further coordination anticipated with the California High-Speed Rail Authority in finalizing business plan; additionally, the High-Speed Rail Authority will pursue private-sector participation as a source of system financing.	MPO, California High-Speed Rail Authority, local/regional stakeholders, private-sector partners
Value Capture Strategies	Assumes formation of special districts (Enhanced Infrastructure Financing Districts) including use of tax increment financing for specific initiatives.	$1.2	Pursue necessary approvals for special districts by 2020. Benefit assessment districts require majority approval by property owners; community facility districts require two-thirds approval; work with private entities for joint development opportunities as may be applicable.	MPO, CTCs, local jurisdictions, property owners along project corridors, developers
Local Option Sales Tax	Half-cent sales tax measure for Ventura County	$2.1	Local sales tax measure to be placed on ballot by 2020	Ventura County

TABLE 6.3 SUMMARY OF REVENUE SOURCES

TABLE 6.3.1 CORE AND REASONABLY AVAILABLE REVENUE PROJECTIONS—LOCAL REVENUE SOURCES

(in Nominal Dollars, Billions)

REVENUE SOURCE	REVENUE PROJECTION ASSUMPTIONS	REVENUE ESTIMATE
Local Option Sales Tax Measures	**Description:** Locally imposed ½ percent sales tax in four counties (Imperial, Orange, Riverside, and San Bernardino). Permanent 1 percent (combination of two ½ cent sales taxes) plus Measure R through 2039 in Los Angeles County. Measure D in Imperial County expires in 2050; Measure M in Orange County expires in 2041; Measure A in Riverside County expires in 2039; and Measure D in San Bernardino County expires in 2040. **Assumptions:** Sales taxes grow consistent with county transportation commission forecasts and historical trends.	$132.7
Transportation Development Act (TDA)—Local Transportation Fund	**Description:** The Local Transportation Fund (LTF) is derived from a ¼ cent sales tax on retail sales statewide. Funds are returned to the county of generation and used mostly for transit operations and transit capital expenses. **Assumptions:** Same sales tax growth rate as used for local option sales tax measures.	$35.6
Gas Excise Tax Subventions (to Cities and Counties)	**Description:** Subventions to counties and local jurisdictions in region from the California state gas tax. Revenues for the forecast are proportionate to the percentage of streets and roads that are regionally significant. **Assumptions:** Gasoline fuel consumption declines in real terms by 1.6 percent due to increasing fuel efficiency in conventional vehicles and adoption of electric and hybrid vehicles. Regionally significant streets and roads (28 to 48 percent of total roads) are classified as either arterials or collectors.	$5.6
Transit Farebox Revenue	**Description:** Transit fares collected by transit operators in the SCAG region. **Assumptions:** Farebox revenues increase consistent with historic trends, planned system expansions, and operator forecasts.	$29.7
Highway Tolls (in core revenue forecast)	**Description:** Revenues generated from toll roads operated by the Transportation Corridor Agencies (TCA), from the SR-91 Express Lanes operated by the Orange County Transportation Authority (OCTA) and Riverside County Transportation Commission (RCTC), and from the express lanes along I-10 and I-110 in Los Angeles County. **Assumptions:** Toll revenues grow consistent with county transportation commission forecasts and historical trends.	$17.2
Mitigation Fees	**Description:** Revenues generated from development impact fees. The revenue forecast includes fees from the Transportation Corridor Agency (TCA) development impact fee program, San Bernardino County's development impact fee program and Riverside County's Transportation Uniform Mitigation Fee (TUMF) for both the Coachella Valley and Western Riverside County. **Assumptions:** The financial forecast is consistent with revenue forecasts from TCA, Riverside County Transportation Commission (RCTC), and the San Bernardino Associated Governments (SANBAG).	$10.1
Other Local Sources	**Description:** Includes committed local revenue sources such as transit advertising and auxiliary revenues, lease revenues, and interest and investment earnings from reserve funds. **Assumptions:** Revenues are based on financial data from transit operators and local county transportation commissions.	$23.8
LOCAL SUBTOTAL		$254.7

Note: Numbers may not sum to total due to rounding.

TABLE 6.3.2 CORE AND REASONABLY AVAILABLE REVENUE PROJECTIONS—STATE REVENUE SOURCES

(in Nominal Dollars, Billions)

REVENUE SOURCE	REVENUE PROJECTION ASSUMPTIONS	REVENUE ESTIMATE
State Transportation Improvement Program (STIP)	**Description:** The STIP is a five-year capital improvement program that provides funding from the State Highway Account (SHA) for projects that increase the capacity of the transportation system. The SHA is funded through a combination of state gas excise tax, the Federal Highway Trust Fund, and truck weight fees. The STIP may include projects on state highways, local roads, intercity rail, or public transit systems. The Regional Transportation Planning Agencies (RTPAs) propose 75 percent of STIP funding for regional transportation projects in Regional Transportation Improvement Programs (RTIPs). Caltrans proposes 25 percent of STIP funding for interregional transportation projects in the Interregional Transportation Improvement Program (ITIP). **Assumptions:** Funds are based upon the 2014 Report of STIP Balances County and Interregional Shares, August 1, 2014. Fuel consumption declines in real terms by 0.9 percent due to increasing fuel efficiency in conventional vehicles and adoption of electric and hybrid vehicles.	$9.6
State Highway Operation and Protection Plan (SHOPP)	**Description:** Funds state highway maintenance and operations projects. **Assumptions:** Short-term revenues are based on overlapping 2012 and 2014 SHOPP programs. Long-term forecasts are consistent with STIP forecasts and assume decline in fuel consumption.	$26.7
State Gasoline Sales Tax Swap	**Description:** Prior to 2010, state sales tax on gasoline funded discretionary projects through the Transportation Investment Fund, which distributed revenues to the STIP, local streets and roads, and transit. In 2010, the sales tax revenues were "swapped" for an increased excise tax (initially 17.3 cents) recalculated each year to ensure revenue neutrality. **Assumptions:** The forecast is based on current funding levels as reported by the State Controller. Future revenues grow by 1.8 percent (in real terms) to be revenue neutral consistent with the gasoline sales tax swap.	$15.7
State Transit Assistance Fund (STA)	**Description:** STA is funded from the diesel sales tax and is distributed by population share and revenue share of the transit operators. **Assumptions:** The forecast is based on current funding levels reported by the State Controller. Future funding declines with fuel consumption using assumptions consistent with other sources.	$5.8
Cap-and-Trade Auction Proceeds	**Description:** The Global Warming Solutions Act of 2006 (AB 32) established the goal of reducing greenhouse gas (GHG) emissions statewide to 1990 levels by 2020. In order to help achieve this goal, the California Air Resources Board (ARB) adopted a regulation to establish a Cap-and-Trade program that places a "cap" on the aggregate GHG emissions from entities responsible for roughly 85 percent of the state's GHG emissions. As part of the Cap-and-Trade program, ARB conducts quarterly auctions where it sells emission allowances. Revenues from the sale of these allowances fund projects that support the goals of AB 32, including transit and rail investments. Funds associated with non-transportation investments and High-Speed Rail are not included in this amount. Funds associated with High-Speed Rail are address under Innovative Financing and New Revenue Sources. **Assumptions:** The forecast is based on current revenue estimates from the Legislative Analyst's Office (LAO). The LAO projects statewide revenues to reach a cumulative program total of $15 billion by 2020. Given the uncertainty about future allowance prices, annual growth is assumed to be flat beyond 2020. SCAG's revenue projection for Cap-and-Trade Auction Proceeds is conservative and represents a bottom floor estimate for the region. Proceeds for transportation could be significantly greater.	$3.7
Other State Sources	**Description:** Other state sources include remaining Highway Safety, Traffic, Air Quality, and Port Security Bond Act of 2006 (Proposition 1B), Active Transportation Program, and other miscellaneous state grant apportionments for the SCAG region. **Assumptions:** Short-term revenues are based on actual apportionments. Future Active Transportation Program funding declines with fuel consumption using assumptions consistent with other sources.	$2.2
STATE SUBTOTAL		$63.8

Note: Numbers may not sum to total due to rounding.

TABLE 6.3.3 CORE AND REASONABLY AVAILABLE REVENUE PROJECTIONS—FEDERAL REVENUE SOURCES

(in Nominal Dollars, Billions)

REVENUE SOURCE	REVENUE PROJECTION ASSUMPTIONS	REVENUE ESTIMATE
FHWA Non-Discretionary Congestion Mitigation and Air Quality (CMAQ) Program	**Description:** Program to reduce traffic congestion and improve air quality in non-attainment areas. **Assumptions:** Short-term revenues are based upon the Caltrans apportionment estimates. Long-term revenues assume that fuel consumption declines by 0.9 percent (in real terms) annually. CMAQ funding is assumed to be reduced by 25 percent in 2022, an additional 25 percent in 2031, and an additional 25 percent in 2036 due to improved air quality.	$4.9
FHWA Non-Discretionary Regional Surface Transportation Program (RSTP)	**Description:** Projects eligible for RSTP funds include rehabilitation and new construction on any highways included in the National Highway System (NHS) and Interstate Highways (including bridges). Also, transit capital projects, as well as intracity and intercity bus terminals and facilities, are eligible. **Assumptions:** Short-term revenues are based upon the Caltrans apportionment estimates. Long-term revenues assume that fuel consumption declines by 0.9 percent (in real terms) annually.	$7.3
FTA Formula Programs 5307 Urbanized Area Formula, 5310 Enhanced Mobility of Seniors and Individuals with Disabilities Formula, 5311 Rural Formula, 5337 State of Good Repair Formula, and 5339 Bus and Bus Facilities Formula	**Description:** This includes a number of FTA programs distributed by formula. 5307 is distributed to state urbanized areas with a formula based upon population, population density, number of low-income individuals, and transit revenue and passenger miles of service. Program funds capital projects, planning, job access and reverse commute projects, and operations costs under certain circumstances. 5310 funds are allocated by formula to states for projects providing enhanced mobility to seniors and persons with disabilities. 5311 provides capital, planning, and operating assistance to states to support public transportation in rural areas with populations less than 50,000. 5337 is distributed based on revenue and route miles and provides funds for repairing and upgrading rail transit systems, high-intensity bus systems that use High-Occupancy Vehicle (HOV) lanes, including bus rapid transit (BRT). 5339 provides capital funding to replace, rehabilitate, and purchase buses and related equipment and to construct bus-related facilities. **Assumptions:** Formula funds are assumed to decline in proportion with the Federal Highway Trust Fund. As with the FHWA sources, fuel consumption declines by 0.9 percent (in real terms) annually.	$16.8
FTA Non-Formula Program 5309 Fixed Guideway Capital Investment Grants ("New Starts")	**Description:** Provides grants for new fixed guideways or extensions to fixed guideways (projects that operate on a separate right-of-way exclusively for public transportation, or that include a rail or a catenary system), bus rapid transit projects operating in mixed traffic that represent a substantial investment in the corridor, and projects that improve capacity on an existing fixed guideway system. **Assumptions:** Operators are assumed to receive FTA discretionary funds in rough proportion to what they have received historically. As with the FHWA sources, fuel consumption declines by 0.9 percent (in real terms) annually.	$4.7
Other Federal Sources	**Description:** Includes other federal programs, such as Transportation Investment Generating Economic Recovery (TIGER) competitive grant program, Highway Safety Improvement Program, Federal Safe Routes to School, Highway Bridge Program, and earmarks. **Assumptions:** Short-term revenues are based on actual apportionments. Long-term revenues assumes a 0.9 percent (in real terms) annual decline in fuel consumption as used for other federal funding sources.	$4.0
FEDERAL SUBTOTAL		$37.7

Note: Numbers may not sum to total due to rounding.

TABLE 6.3.4 CORE AND REASONABLY AVAILABLE REVENUE PROJECTIONS—INNOVATIVE FINANCING AND NEW REVENUE SOURCES

(in Nominal Dollars, Billions)

REVENUE SOURCE	REVENUE PROJECTION ASSUMPTIONS	REVENUE ESTIMATE
State and Federal Gas Excise Tax Adjustment to Maintain Historical Purchasing Power	**Description:** Additional 10-cents-per-gallon gasoline tax imposed by the state and federal government starting in 2020 through 2024. **Assumptions:** Forecast consistent with historical tax rate adjustments for both state and federal gas taxes.	$6.0
Mileage-Based User Fee (or equivalent fuel tax adjustment)	**Description:** Mileage-based user fees would be implemented to replace existing gas taxes (state and federal) by 2025. **Assumptions:** Consistent with recommendations from two national commissions established under SAFETEA-LU, it is assumed that a national mileage-based user fee system would be established during the latter years of the RTP/SCS. An estimated $0.04 per mile (in 2015 dollars) is assumed starting in 2025 to replace existing gas tax revenues.	$124.8 (est. increment only)
Highway Tolls (includes toll revenue bond proceeds)	**Description:** Toll revenues generated from regional toll facilities (e.g., East-West Freight Corridor and regional express lane network). **Assumptions:** Toll revenues based on recent feasibility studies for applicable corridors. Also includes toll revenue bond proceeds.	$23.5
Private Equity Participation	**Description:** Private equity share as may be applicable for key initiatives. **Assumptions:** Private capital is assumed for a number of projects, including toll facilities; also, freight rail package assumes railroads' share of costs for main line capacity and intermodal facilities.	$3.4
Freight Fees/National Freight Program	**Description:** Establishment of a national freight program consistent with federal surface transportation reauthorization (FAST ACT) and/or establishment of freight fees imposed nationally. **Assumptions:** The recently passed federal transportation reauthorization bill provides dedicated freight funding of approximately $2.1 billion per year nationally. Regional estimate assumes a conservative percentage of proposed national program.	$5.4
State Bond Proceeds, Federal Grants & Other for California High-Speed Rail Program	**Description:** Estimated total per 2014 California High-Speed Rail Business Plan. **Assumptions:** State general obligation bonds authorized under the Bond Act approved by California voters as Proposition 1A in 2008; federal grants authorized under ARRA and the High-Speed Intercity Passenger Rail Program (HSIPR); Cap-and-Trade Auction Proceeds; potential use of qualified tax credit bonds; and private sources.	$34.0
Value Capture Strategies	**Description:** Formation of special districts—Enhanced Infrastructure Financing Districts. **Assumptions:** This strategy refers to capturing the incremental value generated by transportation investments. Specifically, SCAG assumes the formation of special districts, including Enhanced Infrastructure Financing Districts (EIFDs) for specific projects (e.g., East-West Freight Corridor).	$1.2
Local Option Sales Tax	**Description:** Locally imposed ½ percent sales tax measure for Ventura County. **Assumptions:** Sales tax grows consistent with historical trends in county retail sales.	$2.1
NEW REVENUE SOURCE SUBTOTAL		$200.4
GRAND TOTAL		$556.5

Note: Numbers may not sum to total due to rounding.

TABLE 6.4 FY 2016–2040 RTP/SCS REVENUES

(in Nominal Dollars, Billions)

	REVENUE SOURCES	FY 2016–2020	FY 2021–2025	FY 2026–2030	FY 2031–2035	FY 2036–2040	TOTAL
LOCAL	Sales Tax	$21.1	$26.6	$32.8	$40.9	$46.8	$168.3
	• Local Option Sales Tax Measures	$16.8	$21.2	$26.1	$32.4	$36.3	$132.7
	• Transportation Development Act (TDA)—Local Transportation Fund	$4.3	$5.4	$6.8	$8.5	$10.6	$35.6
	Gas Excise Tax Subventions (to Cities and Counties)	$1.0	$1.1	$1.1	$1.2	$1.2	$5.6
	Transit Farebox Revenue	$3.9	$4.9	$5.9	$6.9	$8.2	$29.7
	Highway Tolls (in core revenue forecast)	$2.0	$2.6	$3.3	$4.2	$5.2	$17.2
	Mitigation Fees	$1.7	$1.9	$2.1	$2.3	$2.1	$10.1
	Other Local Sources	$7.0	$3.6	$5.3	$5.6	$2.4	$23.8
	Local Total	$36.7	$40.5	$50.5	$61.0	$65.9	$254.7
STATE	State Transportation Improvement Program (STIP)	$1.4	$1.8	$2.0	$2.1	$2.3	$9.6
	• Regional Transportation Improvement Program (RTIP)	$1.1	$1.4	$1.5	$1.6	$1.7	$7.2
	• Interregional Transportation Improvement Program (ITIP)	$0.4	$0.5	$0.5	$0.5	$0.6	$2.5
	State Highway Operation and Protection Plan (SHOPP)	$4.3	$5.0	$5.4	$5.8	$6.2	$26.7
	State Gasoline Sales Tax Swap	$2.0	$2.4	$3.0	$3.7	$4.6	$15.7
	State Transit Assistance Fund (STA)	$0.9	$1.0	$1.2	$1.3	$1.4	$5.8
	Cap-and-Trade Auction Proceeds	$0.7	$0.8	$0.8	$0.8	$0.8	$3.7
	Other State Sources	$0.7	$0.3	$0.4	$0.4	$0.4	$2.2
	State Total	$10.0	$11.4	$12.6	$14.1	$15.7	$63.8
FEDERAL	Federal Transit	$4.0	$4.1	$4.2	$4.7	$4.3	$21.5
	• Federal Transit Formula	$2.9	$3.1	$3.3	$3.6	$3.9	$16.8
	• Federal Transit Non-Formula	$1.2	$1.0	$0.9	$1.1	$0.5	$4.7
	Federal Highway & Other	$3.1	$3.1	$3.3	$3.3	$3.3	$16.2
	• Congestion Mitigation and Air Quality (CMAQ)	$1.2	$1.1	$1.1	$0.9	$0.7	$4.9
	• Regional Surface Transportation Program (RSTP)	$1.2	$1.3	$1.4	$1.6	$1.7	$7.3
	• Other Federal Sources	$0.7	$0.7	$0.8	$0.9	$0.9	$4.0
	Federal Total	$7.2	$7.3	$7.5	$8.0	$7.7	$37.7
INNOVATIVE FINANCING & NEW REVENUE SOURCES	State and Federal Gas Excise Tax Adjustment	$1.3	$4.8	$0.0	$0.0	$0.0	$6.0
	Mileage-Based User Fee	$0.0	$5.5	$31.9	$39.6	$47.9	$124.8
	Highway Tolls (includes toll revenue bond proceeds)	$0.2	$9.0	$4.2	$4.6	$5.5	$23.5
	Private Equity Participation	$1.1	$0.1	$2.1	$0.1	$0.0	$3.4
	Freight Fee/National Freight Program	$0.7	$0.9	$1.0	$1.2	$1.5	$5.4
	State Bond Proceeds, Cap-and-Trade Auction Proceeds, & Other for California High-Speed Rail Program	$6.0	$10.0	$8.0	$5.0	$5.0	$34.0
	Value Capture Strategies	$0.0	$1.2	$0.0	$0.0	$0.0	$1.2
	Local Option Sales Tax (Ventura County)	$0.1	$0.4	$0.5	$0.6	$0.7	$2.1
	Innovative Financing & New Revenue Sources Total	$9.4	$31.8	$47.6	$51.1	$60.5	$200.4
	REVENUE TOTAL	$63.3	$91.1	$118.2	$134.2	$149.8	$556.5

Note: Numbers may not sum to total due to rounding.

TABLE 6.5 FY 2016–2040 RTP/SCS EXPENDITURES

(in Nominal Dollars, Billions)

RTP COSTS	FY 2016–2020	FY 2021–2025	FY 2026–2030	FY 2031–2035	FY 2036–2040	TOTAL
CAPITAL PROJECTS:	$27.6	$46.7	$56.0	$57.0	$59.2	$246.6
Arterials	$3.3	$2.2	$2.4	$5.0	$5.4	$18.4
Goods Movement (includes Grade Separations)	$8.0	$18.9	$19.5	$12.2	$12.1	$70.7
High-Occupancy Vehicle/Express Lanes	$2.7	$2.2	$2.5	$3.7	$4.1	$15.2
Mixed-Flow and Interchange Improvements	$2.2	$1.4	$2.6	$2.9	$3.0	$12.2
Toll Facilities	$1.8	$3.2	$2.3	$0.6	$0.5	$8.4
Transportation Systems Management (including ITS)	$0.9	$1.1	$1.4	$2.9	$2.9	$9.2
Transit	$6.4	$8.6	$11.0	$14.4	$15.7	$56.1
Passenger Rail	$0.8	$6.3	$10.3	$10.4	$10.8	$38.6
Active Transportation	$0.8	$1.7	$1.7	$2.0	$2.0	$8.1
Transportation Demand Management	$0.2	$0.2	$1.6	$2.3	$2.6	$6.9
Other (includes Environmental Mitigation, Landscaping, and Project Development Costs)	$0.5	$0.6	$0.7	$0.7	$0.2	$2.7
OPERATIONS AND MAINTENANCE:	$30.8	$38.0	$54.9	$69.3	$82.5	$275.5
State Highways	$9.0	$10.5	$12.4	$15.7	$18.2	$65.8
Transit	$18.5	$23.3	$29.4	$38.6	$46.9	$156.7
Passenger Rail	$1.6	$2.3	$3.0	$3.8	$5.0	$15.7
Regionally Significant Local Streets and Roads*	$1.7	$1.9	$10.1	$11.1	$12.5	$37.3
DEBT SERVICE	$4.9	$6.4	$7.3	$7.9	$8.0	$34.5
COST TOTAL	$63.3	$91.1	$118.2	$134.2	$149.8	$556.5

Note: Numbers may not sum to total due to rounding.
** Includes $4.8 billion for active transportation in addition to capital project investment level of $8.1 billion for a total of $12.9 billion for active transportation improvements*

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Image courtesy of Alameda Corridor-East Construction Authority

CHAPTER 7 HIGHLIGHTS

A PLAN THAT CREATES ECONOMIC OPPORTUNITY: THE BIG PICTURE

Southern California is a huge geographic region. Often, employers in one area cannot easily access workers living in another. A more efficient transportation system, with increased public transit, will create a more efficient and competitive labor market and add economic activity and jobs into the economy.

The 2016 RTP/SCS outlines strategies for investing in transportation infrastructure that will benefit Southern California, the state and the nation in terms of economic development, job creation, economic growth and poverty reduction—as well as overall business and economic competitive advantages in the global economy. Over the 2016–2040 period, the 2016 RTP/SCS calls for spending more than $556.5 billion on transportation improvement projects. The economic analysis prepared for the 2016 RTP/SCS, shown in more detail in the Economic & Job Creation Analysis Appendix, shows that significant employment will be generated throughout our region over the 25-year period of the Plan. The 2016 RTP/SCS boosts employment in two ways—providing jobs for people in highway and rail construction, operation and maintenance; and boosting the economic competitiveness of the region by making it a more attractive place to do business.

Even though we have gained back many of the jobs lost in the Great Recession, the region is contending with a larger population base and stagnant wages, which has resulted in even more of Southern California's population slipping into poverty. More concerning is the fact that a staggering one in four children live below the poverty line in the region. The 2016 RTP/SCS is a major job creation engine, and the types of jobs created by the Plan, coupled with improved access to those jobs, have the potential to provide greater economic opportunity throughout the region. With jobs that can help sustain people in need, we can rebuild our infrastructure, rebuild our middle class and move citizens throughout Southern California from poverty to prosperity.

The economic analysis shows that construction, maintenance and operations expenditures specified in the 2016 RTP/SCS, as well as the indirect and induced jobs that flow from those expenditures, will generate an average of more than 188,000 new jobs annually on average.

When investments are made in the transportation system, the economic benefits go far beyond the jobs created building, operating and maintaining it. Unlike spending to satisfy current needs, infrastructure delivers benefits for decades. The infrastructure, once built, can enhance the economic competitiveness of a region. Projects that reduce congestion may help firms produce at lower cost, or allow those firms to reach larger markets or hire more capable employees. An economy with a well-functioning transportation system is a more attractive place for firms to do business, enhancing the economic competitiveness of our region. An additional 351,000 annual jobs will be created by the SCAG region's increased competitiveness and improved economic performance that will result from congestion reduction and improvements in regional amenities due to implementation of the 2016 RTP/SCS.

THE ECONOMIC BENEFITS OF INVESTING IN TRANSPORTATION

As we mentioned briefly above, the 2016 RTP/SCS will lead to more jobs in at least two ways:

1. Providing direct jobs in highway and rail construction, transportation, and transit operations and maintenance
2. Enhancing economic competitiveness in the region by making it a more attractive place to do business and to live

These two impacts are summarized below.

- **Providing direct jobs in highway and rail construction, transportation, and transit operations and maintenance:** The 2016 RTP/SCS will employ people to build, operate and maintain transportation projects as a result of the Plan's regional infrastructure investments. Economists refer to these jobs as the "direct effect" of the investments. Direct effects ripple through the economy, creating additional jobs in two ways:
    - **Indirect Effects:** Indirect effects are the jobs in companies that support the direct jobs created by the RTP/SCS spending. The firms and agencies that build and maintain the transportation system with RTP/SCS funding buy materials, office supplies and business services. All of those supply purchases that are necessitated by the RTP/SCS spending are indirect effects.
    - **Induced Effects:** Additionally, employees of the firms and agencies that build, operate and maintain the Southern California regional transportation system use their wages to buy all kinds of goods—housing, food, clothing, entertainment and more—and that supports additional jobs. This ripple effect creates what economists call "induced effects." Employees who build, operate and maintain the RTP/SCS will earn wages to buy goods and services associated with daily living.
- **Enhancing economic competitiveness in the region by making it a more attractive place to do business:** Academic scholars have long understood that public infrastructure investments create direct jobs and additional multiplier effects from those jobs. But recently, economic research has illuminated how transportation spending also improves the viability and productivity of firms in regions, by increasing economic competitiveness through the increased

efficiency of a transportation system. A well-planned, well-functioning transportation system and integrated land use pattern can allow firms to communicate and conduct business with one another more quickly, draw workers from larger labor market pools, and ship and receive goods and services at lower costs. All of this can contribute to enhanced regional economic competitiveness, raising the productivity of firms in the region and leading to more jobs than those generated to build, operate and maintain the RTP/SCS.

WHY TRANSPORTATION ACCESS IS IMPORTANT FOR THE REGIONAL ECONOMY

Two economic transformations have occurred over the past two to three decades that have made transportation access an increasingly important element of regional economies. First, metropolitan economies increasingly rely on the value of proximity—what urban economists call "agglomeration economies," or the propensity of successful local economies to cluster. Second, congestion has risen to levels that limit economic growth, research shows.

- **Agglomeration Economies and the Need for Access:** Firms benefit from being near other firms. Santa Monica's "Silicon Beach" is a location where technology firms have easy access to other nearby peer firms, creating an environment of shared ideas, talent and interaction. Yet, that access is not always as readily available as it might seem. A video gaming company in Santa Monica might benefit from access to talent at Caltech or movie studios in Burbank, but both are easily an hour away during much of the day because of traffic congestion. So, the benefit of agglomeration—nearby access to business partners, customers and ideas—is diminished by a congested transportation system.

  The benefits of local concentrations of firms are increasingly based on face-to-face communication. Research has shown that firms have higher productivity when locating near other firms, and those productivity benefits are often short-distance phenomena. Good transportation access "shrinks distance" by allowing businesses to more quickly access knowledge, suppliers and customers. Well-performing transportation systems, by contributing to dense, lively, walkable neighborhoods, can also create communities that are conducive to serendipitous meetings and face-to-face communication. This is particularly important in knowledge-intensive or creative industries.

- **Congestion and Employment:** Traffic congestion has been increasing in nearly all U.S. metropolitan areas. Research shows that traffic delays inhibit job growth. In the Los Angeles metropolitan area, actual employment growth from 1990 to 2003 was 567,983 new jobs, but researchers have estimated that with a 50 percent reduction in congestion in the region's metropolitan areas, employment growth from 1990 to 2003 would have been 700,235 new jobs. Research suggests that the employment enhancing effect of reducing congestion by implementing the 2016 RTP/SCS investments is larger in more congested urban areas. This is intuitive; the "distance shrinking" effect of managing congestion is more important in more congested urban areas. This is also a non-linear effect; congestion relief grows more important for the economy as congestion levels rise.

This sets the background and context for the economic impact study of the 2016 RTP/SCS. Metropolitan economies are increasingly relying on agglomeration benefits, as knowledge-based firms desire to locate near other similar firms. This phenomenon has long been familiar in Silicon Valley, and evidence suggests that the need to locate near similar firms is becoming pervasive in many segments of modern economies. At the same time, congestion has increased the "effective distance" within metropolitan areas and the evidence suggests that the negative economic effects of congestion are largest (and growing) in our most congested cities. Creating better access and mobility, a key goal of 2016 RTP/SCS, can be a clear pathway toward stimulating economic growth.

There are five possible paths through which transportation improvements can increase regional economic competitiveness. Each of these is described in the following sections.

1. **Improved labor market matching:** Reducing travel time allows firms to hire from a larger geographic area. This effectively increases the firm's labor market—particularly in a large urban area like the SCAG region where reductions in commuting time can yield access to many more potential employees. Increasing the size of the labor pool allows firms to find a better employee match for its needs. By hiring employees who better suit their needs, the firm can produce more (i.e., employees are more productive) for the same cost. This allows the firm to be more competitive and capture a larger market share. And that, in turn, can lead to increased hiring if the increase in market share overcomes

the tendency of firms to produce more with fewer employees due to improved employer-employee job matches.

2. **Firms move into the region in response to enhanced economic competitiveness:** This effect flows in part from the first effect. If the region's transportation system supports more efficient commutes, then employers will be encouraged to draw from larger labor market pools. And if that larger employee pool allows firms to hire better employees, eventually those firms will move into the region in response to those improved hiring prospects. This is especially true for firms that rely on a skilled workforce. The increases in firm productivity that initially come from improved labor market matching will result in firms moving into the SCAG region from other locations over longer periods of time.

3. **Reduced congestion increases labor supply:** Metropolitan regions compete for mobile labor. That means that those regions with lower traffic congestion will (when all else is equal) lure more migrants—simply due to the value of offering commuters lower traffic congestion. This increases the supply of available labor. In metropolitan areas with high traffic congestion and longer commutes, the labor pool will have to be compensated either in the form of higher wages, lower house prices or both. These two related effects are, in fact, one and the same—the higher wages in high congestion metropolitan areas reflect the need to lure in a labor pool that otherwise might choose to locate in lower congestion locales. Reduced congestion can attract more workers to a region, allowing a firm to hire quality workers at reasonable wages.

4. **Increased market for firms' products:** Reductions in travel time also can allow firms to supply a larger market area, leading to increased economic competitiveness and regional job growth. One example is the goods movement/freight traffic that moves through the Ports of Los Angeles and Long Beach. Larger ports can build infrastructure that speeds up the processing of shipments, therefore lowering costs. Supply chain managers favor Southern California because of the speed and reliability that goods can be moved around the region and to the rest of the nation. As the economy expands, congestion robs the area of this competitive advantage. Reducing shipping times for landside freight, from the ports to points within and beyond the region, can help increase shipping volumes and lead to lower costs. This ultimately can add up to higher productivity, making the region's ports more cost effective than other competitive points of entry.

5. **Learning:** In a growing knowledge-based economy, cities are increasingly engines of economic innovation. Nearly all economic advances—in consumer products, technology, medicine, consumer services, retailing and logistics, and entertainment and fine arts—are created in metropolitan areas. A large and growing body of literature argues that much of the economic advantage of cities is the learning that is possible when individuals and firms are in close proximity. Engineers in Silicon Valley interact regularly, within and across different firms, creating a world-class hub of knowledge and innovation that is unrivaled in the computing, advanced electronics and software industries. The movie industry in Los Angeles provides the same center for knowledge and learning in the entertainment industry. Such learning effects are central to many industries, including manufacturing processes and services that increasingly rely on innovations to remain competitive. Transportation investments that reduce traffic congestion can allow people to interact more readily with a larger pool of like-minded experts, increasing the learning and innovation in a regional economy. That can allow local firms to innovate in ways that lowers costs, improves products and leads to larger market share. Over time, that improved innovation environment will attract mobile labor and capital (workers and firms) from other regions, further boosting economic activity.

QUANTIFYING THE ECONOMIC IMPACT OF THE PLAN

To quantify the economic impact of the Plan's implementation, the SCAG economic team used data and software from Regional Economic Models, Inc. (REMI). The REMI TranSight model is an advanced economic analysis model that combines input-output approaches, coupled with a model of resident and firm migration into and out of our region to model the direct, indirect and induced effects of the 2016 RTP/SCS spending. REMI also includes a general equilibrium model combined with New Economic Geography approaches to model changes in economic competitiveness. REMI TranSight is the most advanced tool commercially available for analysis that forecasts the total economic effects of changes to transportation systems. All of the economic analysis of the Plan was conducted using REMI models. More details on the REMI models and the methodologies that SCAG used can be found in the Economic & Job Creation Analysis Appendix.

THE RESULTS OF OUR ANALYSIS

Results are reported in two parts:

1. Jobs that result from the 2016 RTP/SCS investment spending (direct, indirect and induced effects)
2. Additional jobs that flow from the improvements to the transportation network, resulting in network efficiencies and related increases in regional economic and business competitiveness

JOBS THAT RESULT FROM THE RTP/SCS INVESTMENT SPENDING (DIRECT, INDIRECT AND INDUCED EFFECTS)

TABLE 7.1 shows the annual average new jobs from the 2016 RTP/SCS financial plan spending. The job impact is reported as annual average jobs in five-year periods (starting with 2016–2020), for each county and for the entire region. The last column in TABLE 7.1 shows jobs, averaged over all Plan years, from 2016 RTP/SCS construction, operations and maintenance spending.

REMI TranSight model outputs predicted that jobs from transit operations and maintenance (O&M) expenditures in the region grow from an annual average of 119,000 in 2016–2020 to 173,000 in the last five years of the Plan (2036–2040). As a fraction of the total jobs from the Plan's spending (construction and O&M), transit O&M jobs grow from half of the jobs in 2016–2020 to nearly two-thirds of all jobs in 2036–2040. Transit O&M spending, as a fraction of the total Plan spending, was virtually constant across those two time periods—increasing from 37 percent of total Plan spending in 2016–2020 to 39 percent of Plan spending in 2036–2040. The large increase in the share of the Plan's jobs from transit O&M while the share of the Plan's spending from transit O&M stays constant is not consistent.

Upon examination, the research team concluded that the size of the SCAG region's transit spending is outside of what REMI can accurately model in the later years of the Plan. In the years 2036–2040, the region will spend $7.5 billion per year on transit O&M, while REMI's baseline forecast of the size of the transit industry in the region during that same time period is about $2 billion per year. The large difference is not due to any fault of the REMI model, but rather is due to the fact that the SCAG region is building the largest transit public works project in the history of the U.S.—an investment at a scale well beyond what has been experienced in other similar metropolitan areas during recent decades and even of a magnitude unprecedented compared to prior SCAG RTPs. The scale of the transit investment and the resulting magnitude of the increase in transit O&M are beyond what the research team believes the REMI TranSight model can reliably forecast at this point in time, therefore, the growth in jobs from transit O&M spending was adjusted downward.

TABLE 7.1 2016 RTP/SCS EMPLOYMENT IMPACT FROM CONSTRUCTION, OPERATIONS AND MAINTENANCE SPENDING

Annual Average Jobs Relative to Baseline (Thousands)

REGION	2016–2020	2021–2025	2026–2030	2031–2035	2036–2040	AVG PER YEAR
Imperial	1.68	2.14	4.54	4.55	4.55	3.49
Los Angeles	110.74	112.71	99.16	86.01	93.78	100.48
Orange	52.99	21.17	16.75	17.41	20.05	25.67
Riverside	31.99	19.33	25.09	28.84	24.90	26.03
San Bernardino	32.53	26.41	26.98	27.11	25.13	27.63
Ventura	7.13	6.00	6.02	3.71	4.04	5.38
SCAG REGION	237.06	187.76	178.53	167.63	172.45	188.69

Source: SCAG calculations from 2016 RTP/SCS financial plan input into REMI model. Note that the REMI model reports full and part-time jobs and the job numbers include both full-time and part-time jobs. Figures may not add up due to rounding.

ADDITIONAL JOBS THAT FLOW FROM THE IMPROVEMENTS TO THE TRANSPORTATION NETWORK, RESULTING IN NETWORK EFFICIENCIES AND RELATED INCREASES IN REGIONAL ECONOMIC AND BUSINESS COMPETITIVENESS

Network efficiency in the form of improved transportation access is a second source of job growth. TABLE 7.2 shows the jobs from improved economic competitiveness that result from decreases in travel times and less costly trip-making relative to the baseline. Note that the economic competitiveness jobs grow over time, as the effect of the 2016 RTP/SCS relative to baseline results in increasingly larger transportation improvements and resulting cumulative network efficiencies over the course of the Plan.

FULL RESULTS

The full economic results of the 2016 RTP/SCS investment are summarized in the table, with millions of new jobs (annual average) resulting from the Plan in five-year time periods and an annual average shown for 2016-2040. The total combined jobs from the two effects—Plan investment (construction, operations and maintenance spending) and network efficiency/economic competitiveness—are shown summed together in the table to highlight the total economic impact of the 2016 RTP/SCS.

TABLE 7.2 2016 RTP/SCS JOBS FROM ENHANCED ECONOMIC COMPETITIVENESS, REMI ESTIMATES OF JOBS FROM NETWORK EFFICIENCY PLUS AMENITIES AND OPERATIONS

Annual Average Jobs Relative to Baseline (Thousands)

REGION	2016–2020	2021–2025	2026–2030	2031–2035	2036–2040	AVG PER YEAR
Imperial	0.1	0.4	0.73	1.19	1.73	0.83
Los Angeles	40.62	137.22	225.15	292.13	320.1	203.04
Orange	7.43	25.6	42.42	65.98	99	48.09
Riverside	9.11	31.37	48.78	66.25	83.43	47.78
San Bernardino	6.36	25.56	47.08	65.72	79.91	44.93
Ventura	0.81	3.6	7.33	10.1	10.7	6.51
SCAG REGION	64.4	223.74	371.49	501.38	594.87	351.19

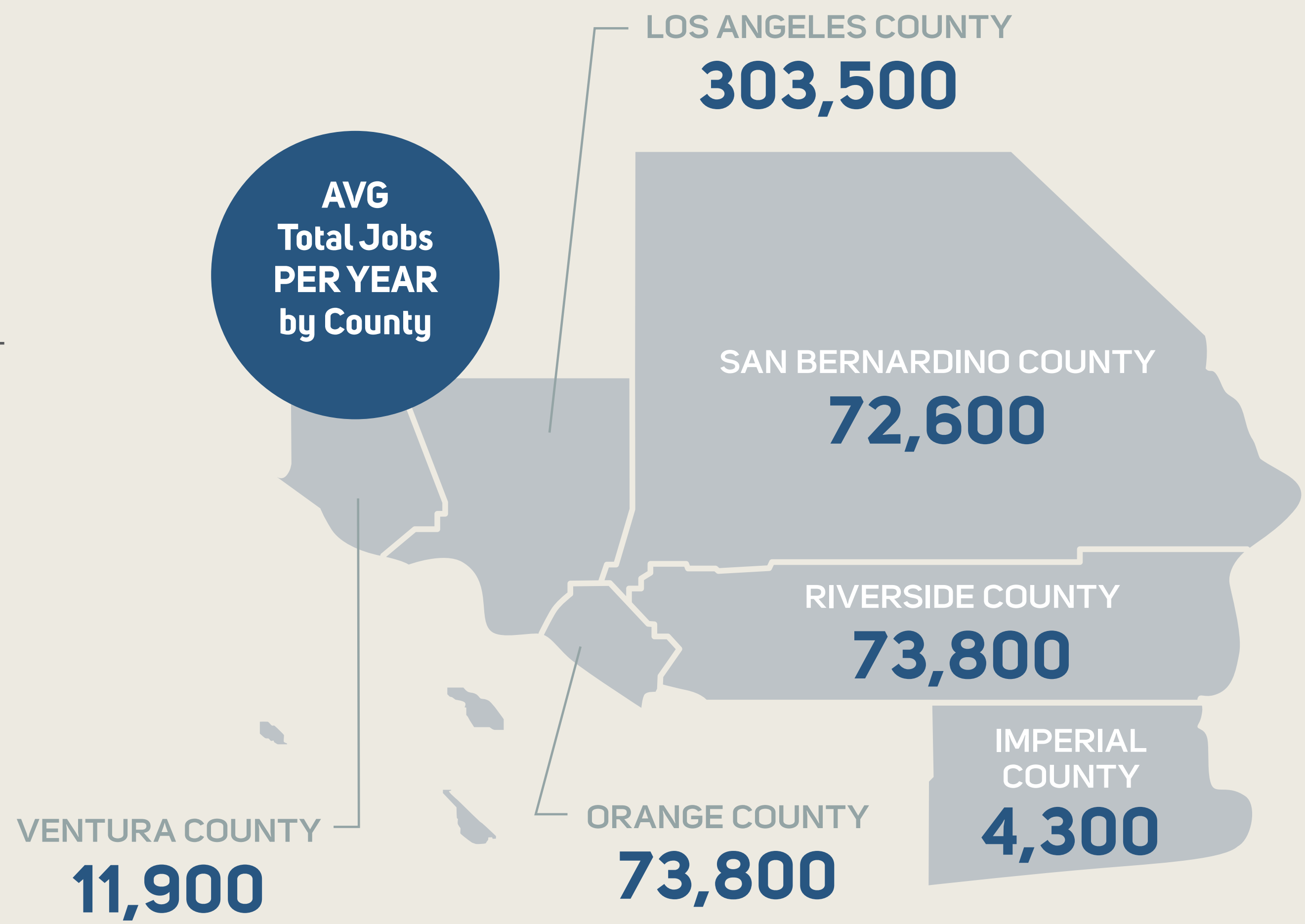
Source: SCAG calculations from 2016 RTP/SCS travel model results input into REMI TranSight model.
Figures may not add up due to rounding.

CREATING JOBS IN THE SCAG REGION

539,900

AVG Total JOBS
per year
in the SCAG region

Total jobs, all sources, construction, operations and maintenance, network benefits, from 2016 RTP/SCS. In comparison, the 2012 RTP/SCS would create 528,500 average total jobs during the life of the plan.



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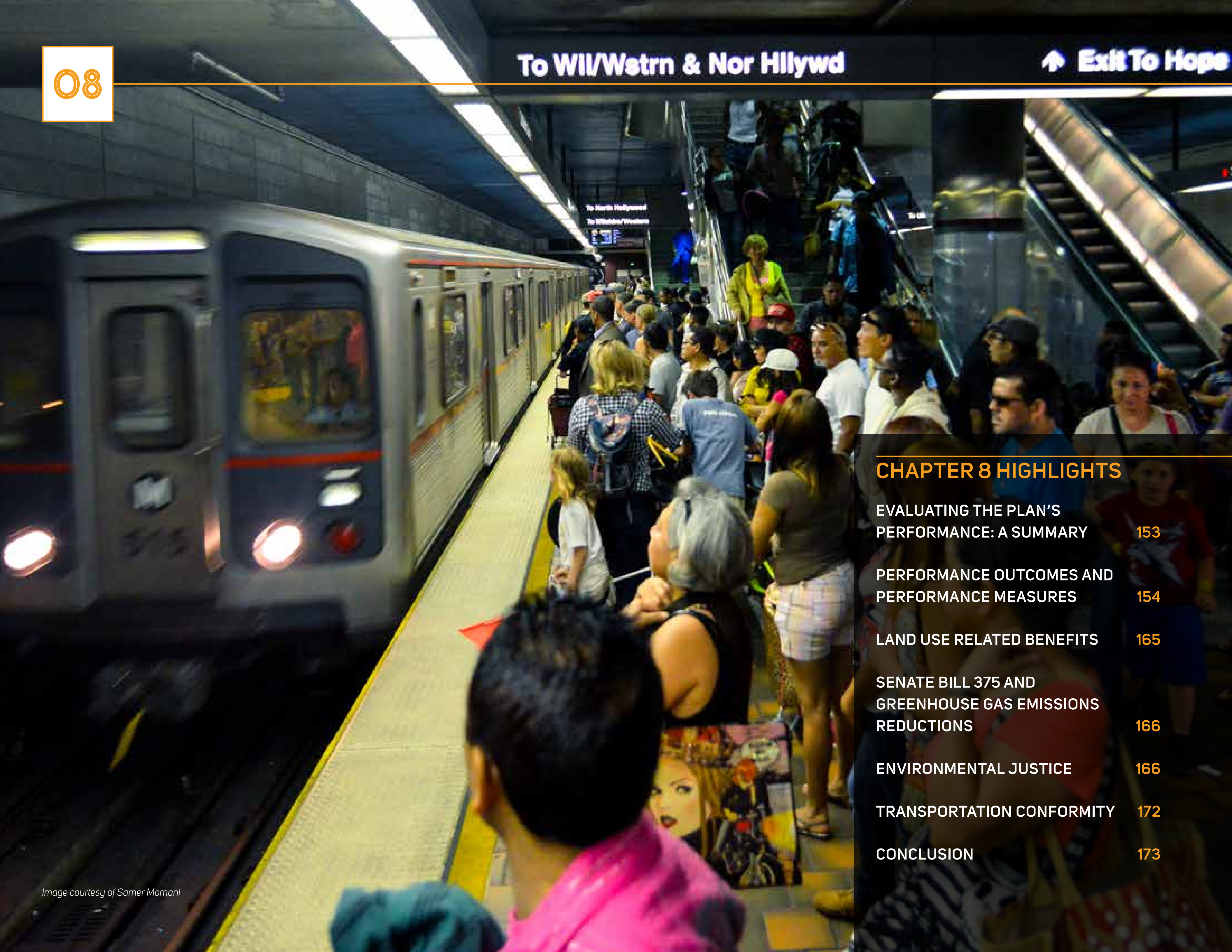


Image courtesy of Samer Momani

CHAPTER 8 HIGHLIGHTS

MEASURING OUR PROGRESS FOR THE FUTURE

The 2016 RTP/SCS uses a number of performance measures to help gauge progress toward meeting the goals and objectives of our region, as well as how the Plan meets federal requirements, including the intent of the current federal transportation authorization. The measures also address state requirements for reducing greenhouse gas emissions and planning for a more sustainable future. The 2016 RTP/SCS is expected to result in significant benefits to our region with respect to mobility and accessibility, air quality, economic growth and job creation, sustainability, and environmental justice. An extended discussion on how the Plan performs, along with the outcomes it achieves, is the topic of this chapter.

FOCUS

PLAN PERFORMANCE RESULTS

This graphic highlights the key benefits of implementing the 2016 RTP/SCS in terms of mobility, economy, efficiency and air quality.

Spending Less Time on the Road

20.5 miles
average daily vehicle miles driven per person

7.4% ↓

9.2 mins
daily delay per capita (extra time spent in traffic)

39% ↓

More Economic Opportunities

$1.00 INVESTMENT = **$2.00** BENEFIT

351,000
additional jobs supported by improving competitiveness

Efficiency Cost Savings

HOUSEHOLD COSTS
(transportation/energy/water use)
$14,000/yr

12% ↓

REDUCTION IN BUILDING ENERGY COSTS

4% ↓

PASSENGER VEHICLE FUEL USE

10% ↓

Improved Air Quality

ROG
49.1 TONS
↓ **8%**
45.0 TONS

CO
338.6 TONS
↓ **9%**
307.7 TONS

NOx
96.4 TONS
↓ **9%**
88.2 TONS

PM2.5
13.3 TONS
↓ **5%**
12.6 TONS

GHG REDUCTIONS

2020 ↓ **8%**

2035 ↓ **18%**

2040 ↓ **21%**

EVALUATING THE PLAN'S PERFORMANCE: A SUMMARY

COMPARING THE PLAN VS. NO PLAN

Implementation of the 2016 RTP/SCS will secure a safe, efficient, sustainable and prosperous future for our region. To demonstrate how effective the Plan would be toward achieving our regional goals, SCAG conducted a "Plan vs. No Build" (or Baseline) analysis—essentially comparing how the region would perform with and without implementation of the Plan. This analysis is summarized in this chapter. More details on this analysis and its results can be found in the Performance Measures Appendix.

First and foremost, the 2016 RTP/SCS meets all of the federal and state requirements. It meets all provisions for transportation conformity under the federal Clean Air Act. Cleaner fuels and new vehicle technologies will help significantly reduce many of the pollutants that contribute to smog and other airborne contaminants that may impact public health in the region. The Plan also performs well when it comes to meeting state-mandated targets for reducing greenhouse gas emissions from cars and light trucks. The state-determined targets for the SCAG region are an eight percent per capita reduction in greenhouse gas emissions from automobiles and light trucks by 2020, and a 13 percent reduction by 2035 (compared with 2005 levels). The Plan would result in an eight percent reduction in emissions by 2020, an 18 percent reduction by 2035, and a 21 percent reduction by 2040 as compared to 2005 levels.

Overall, the analysis clearly demonstrates that implementing the 2016 RTP/SCS would result in a regional transportation network that improves travel conditions and air quality, while also promoting an equitable distribution of benefits—that is, social equity. Trips to work, schools and other key destinations would be quicker and more efficient under the Plan. The 2016 RTP/SCS integrates multiple transportation modes, leading to increases in carpooling, demand for transit and use of active transportation modes for trips during peak travel hours and at other times. More specifically, our analysis found that, in comparison to the Baseline, the Plan will:

- Increase the combined percentage of work trips made by active transportation and public transit by about four percent, with a commensurate reduction in the share of commuters traveling by single occupant vehicle.
- Reduce Vehicle Miles Traveled (VMT) per capita by 7.4 percent and Vehicle Hours Traveled (VHT) per capita by about 17 percent (for automobiles and light/medium duty trucks) as a result of more location efficient land use patterns and improved transit service.
- Increase daily transit travel by nearly one-third, as a result of improved transit service and more transit-oriented development patterns.
- Reduce delay per capita by 39 percent.
- Reduce total heavy duty truck delay by 40 percent.
- Create an estimated 351,000 (or more) additional new jobs annually, due the region's increased competitiveness and improved economic performance that will result from congestion reduction and improvements in regional amenities with implementation of the Plan.
- Reduce the amount of previously undeveloped (greenfield) lands converted to more urbanized use by 23 percent. Conservation of open space and other rural lands is achieved by focusing new residential and commercial development in higher density areas. Through this strategy of conservation, the Plan provides a solid foundation for more sustainable development in the SCAG region.

The 2016 RTP/SCS also focuses on improving public health outcomes in the SCAG region. Some key performance results include a reduction in our regional obesity rate and reductions in the share of our population that suffers with hypertension and type 2 diabetes. The total annual health costs for respiratory disease will be reduced under the Plan more than 13 percent compared with the Baseline. These public health improvements are the result of investments in active transportation, more walkable communities and improved regional air quality as promoted in the 2016 RTP/SCS.

PERFORMANCE OUTCOMES AND PERFORMANCE MEASURES

This section summarizes how well the 2016 RTP/SCS is expected to perform when fully implemented. TABLE 8.1 lists the 2016 RTP/SCS performance outcomes and the associated measures used to evaluate performance, using the SCAG Regional Travel Demand Model (RTDM) and other tools. The table also includes specific performance results for both the Baseline and the Plan for each of the measures. Additional performance measures that will be used for ongoing regional monitoring are discussed in the Performance Measures Appendix.

In the discussion of performance outcomes, three scenarios are referenced: Base Year, Baseline and Plan.

- **Base Year** represents existing conditions as of 2012—that is, our region as it was in 2012: our transportation system, land use patterns and socio-economic characteristics (e.g., households and employment). The year 2012 was selected as the Base Year for this analysis because it is the year of the previous RTP/SCS.
- **Baseline** assumes a continuation of the development trends of recent decades, with local General Plans not including the intensified policies regarding growth distribution as promoted in the Plan. This scenario represents a future in 2040 in which only the following have been implemented: transportation projects currently under construction or undergoing right-of-way acquisition; those transportation programs and projects programmed and committed to in the 2015 Federal Transportation Improvement Program (FTIP); and/or transportation projects that have already received environmental clearance.
- **Plan** represents future conditions in 2040, in which the transportation investments and strategies detailed in the 2016 RTP/SCS are fully realized.

The Base Year, Baseline and Plan scenarios discussed in this chapter were developed to help evaluate the performance of the strategies, programs and projects presented in Chapter 5—the core of the 2016 RTP/SCS—and to meet various state and federal requirements.

On the following pages, a summary is provided of the Plan's performance outcomes, along with their associated performance measures. Some of the significant co-benefits provided by the Plan are summarized in TABLE 8.2.

LOCATION EFFICIENCY

The Location Efficiency outcome reflects the degree to which improved coordination of land use and transportation planning impacts the movement of people and goods in the SCAG region. This outcome has several associated performance measures that will be used for monitoring the degree to which the region is advancing toward our Location Efficiency goals:

1. Share of Growth in High Quality Transit Areas (HQTAs)
2. Land Consumption
3. Vehicle Miles Traveled (VMT)
4. Transit Mode Share
5. Average Distance for Work and Non-Work Trips
6. Percent of Trips Less than Three Miles
7. Work Trip Length Distribution

In addition to these seven metrics, measures of mobility and accessibility also serve to further reinforce the importance of the location efficiency outcome. Measures supporting the Mobility and Accessibility outcome are discussed in the next section of this chapter.

The following is a summary of the Location Efficiency performance measures:

SHARE OF GROWTH IN HIGH QUALITY TRANSIT AREAS (HQTAS)

Between 2012 and 2040, growth in the regional share of both households and employment in the HQTAs is projected to increase from the Baseline scenario to the Plan scenario.

LAND CONSUMPTION

The land consumption metric measures the amount of agricultural land that has changed from rural to more intensive development patterns to accommodate new growth. Greenfield land consumption refers to development that occurs on land that has not previously been developed for, or otherwise impacted by, urban uses, including agricultural lands, forests, deserts and other undeveloped sites. As shown in TABLE 8.2, new land consumption under the Plan would be substantially less than what would occur under the Baseline.

PLAN PERFORMANCE RESULTS IN THE SCAG REGION

Daily Vehicle Miles Traveled (VMT)

per capita

2012 BASE YEAR	2040 BASELINE	2040 PLAN
22.8 MILES	22.1 MILES	20.5 MILES

Baseline to Plan Comparison **-7.4%**

Base Year to Plan Comparison **-10.2%**

Daily Minutes of Delay

per capita

2012 BASE YEAR	2040 BASELINE	2040 PLAN
11.8 MINUTES	15.0 MINUTES	9.2 MINUTES

Baseline to Plan Comparison **-39%**

Base Year to Plan Comparison **-22%**

County		2012 BASE YEAR	2040 BASELINE	2040 PLAN
IMPERIAL COUNTY	DAILY VMT *per capita*	24.8 MILES	26.3 MILES	25.1 MILES
	DAILY DELAY *per capita*	0.7 MINUTES	2.7 MINUTES	2.0 MINUTES
LOS ANGELES COUNTY	DAILY VMT *per capita*	21.5 MILES	20.2 MILES	18.4 MILES
	DAILY DELAY *per capita*	14.7 MINUTES	16.4 MINUTES	11.5 MINUTES
ORANGE COUNTY	DAILY VMT *per capita*	23.8 MILES	22.8 MILES	21.4 MILES
	DAILY DELAY *per capita*	11.9 MINUTES	13.2 MINUTES	7.9 MINUTES
RIVERSIDE COUNTY	DAILY VMT *per capita*	23.3 MILES	23.7 MILES	21.7 MILES
	DAILY DELAY *per capita*	5.9 MINUTES	12.3 MINUTES	5.6 MINUTES
SAN BERNARDINO COUNTY	DAILY VMT *per capita*	26.6 MILES	27.1 MILES	25.9 MILES
	DAILY DELAY *per capita*	7.6 MINUTES	17.1 MINUTES	7.4 MINUTES
VENTURA COUNTY	DAILY VMT *per capita*	22.4 MILES	21.9 MILES	20.2 MILES
	DAILY DELAY *per capita*	7.0 MINUTES	11.5 MINUTES	5.7 MINUTES

TABLE 8.1 2016 RTP/SCS PERFORMANCE MEASURES AND RESULTS (IN THOUSANDS OF HOURS)

PERFORMANCE MEASURE	DEFINITION	OBJECTIVE	CATEGORY	2040 BASELINE	2040 PLAN	INDICATOR
OUTCOME: LOCATION EFFICIENCY						
Share of growth in High Quality Transit Areas (HQTAs)	Share of the region's growth in households and employment in HQTAs	Improvement (increase) over No Project Baseline	Percent of households in HQTAs	36%	46%	↑
			Percent of jobs in HQTAs	44%	55%	↑
Land consumption	Greenfield land consumed and refill land consumed	Improvement (decrease) over No Project Baseline	Greenfield land consumed	154 sq miles	118 sq miles	↓
Vehicle Miles Traveled (VMT) per capita	Average daily vehicle miles driven per person	Improvement (decrease) over No Project Baseline	Automobiles and light-duty trucks	22.1 miles	20.5 miles	↓
Transit mode share	The share of total trips that use transit for work and non-work trips	Improvement (increase) over No Project Baseline	All Trips	2.2%	3.1%	↑
			Work Trips	5.6%	8.2%	↑
Average distance traveled for work and non-work trips	The average distance traveled for work or non-work trips	Improvement (decrease) over No Project Baseline	Work Trips	15.1 miles	15.5 miles	↑ (orange)
			Non-Work Trips	7.8 miles	7.9 miles	
Percent of trips less than 3 miles	The share of work and non-work trips which are fewer than 3 miles	Improvement (increase) over No Project Baseline	Work Trips	20.4%	20.3%	↑
			Non-Work Trips	41.7%	41.9%	↑
Work trip length distribution	The statistical distribution of work trip length in the region	Improvement (increase) over No Project Baseline	Trip Length: 10 miles or Less	51.6%	50.9%	↓ (orange)
			Trip Length: 25 miles or Less	81.8%	81.0%	↓ (orange)
OUTCOME: MOBILITY AND ACCESSIBILITY						
Person delay per capita*	Delay per capita can be used as a supplemental measure to account for population growth impacts on delay	Improvement (decrease) over No Project Baseline	Daily minutes of delay per capita	15.0 mins	9.2 mins	↓
Person delay by facility type*	Delay: Excess travel time resulting from the difference between a reference speed and actual speed	Improvement (decrease) over No Project Baseline	Highway	3,035,105 hrs	2,023,417 hrs	↓
			HOV	251,547 hrs	42,590 hrs	↓
			Arterial	2,254,896 hrs	1,327,235 hrs	↓
Truck delay by facility type*	Delay: Excess travel time resulting from the difference between a reference speed and actual speed	Improvement (decrease) over No Project Baseline	Highway	274,456 hrs	171,828 hrs	↓
			Arterial	47,561 hrs	20,998 hrs	↓
Travel time distribution for transit, SOV and HOV modes for work and non-work trips*	Travel time distribution for transit, SOV and HOV for work and non-work trips	Improvement (increase) over No Project Baseline	% of PM peak transit trips <45 minutes	22%	26%	↑
			% of PM peak HOV trips <45 minutes	72%	79%	↑
			% of PM peak SOV trips <45 minutes	82%	89%	↑

TABLE 8.1 CONTINUED

PERFORMANCE MEASURE	DEFINITION	OBJECTIVE	CATEGORY	2040 BASELINE	2040 PLAN	INDICATOR
OUTCOME: SAFETY AND HEALTH						
Collision rates by severity by mode (per 100 million vehicle miles)*	Collision rate per 100 million vehicle miles by mode and number of fatalities and serious injuries by mode (all, bicycle/pedestrian)	Improvement (decrease) over No Project Baseline	Serious injuries	N/A	1.60	
			Fatalities	N/A	0.31	
Criteria pollutants emissions (tons per day)	CO, NOx, PM 2.5, PM 10 and VOC	Meet Federal air quality conformity requirements (FR)	Reactive organic gases (ROG)	49.1 tons	45.0 tons	↓
			Carbon monoxide (CO)	338.6 tons	307.7 tons	↓
			Oxides of nitrogen (NOx)	96.4 tons	88.2 tons	↓
			Particulate matter (PM 10)	32.6 tons	30.8 tons	↓
			Particulate matter (PM 2.5)	13.3 tons	12.6 tons	↓
			Nitrogen dioxide (NO2)	94.6 tons	86.8 tons	↓
Air pollution-related health measures	Pollution-related respiratory disease incidence and cost	Improvement (decrease) over No Project Baseline	Pollution-related health incidences (annual)	270,328	234,363	↓
			Pollution-related health costs (annual)	$4.48 billion	$3.88 billion	↓
Physical activity-related health measures	Physical activity/weight related health issues and costs	Improvement over No Project Baseline	Daily per capita walking	12.1 mins	16.0 mins	↑
			Daily per capita biking	1.6 mins	2.0 mins	↑
			Daily per capita driving	64.8 mins	61.9 mins	↓
			Obese population (%)**	26.3%	25.6%	↓
			High blood pressure (%)**	21.5%	20.8%	↓
			Heart disease (%)**	4.4%	4.2%	↓
			Diabetes Type 2 (%)**	6.1%	6.0%	↓
Mode share of walking and bicycling	Mode share of walking and biking for work trips, non-work trips and all trips	Improvement (increase) over No Project Baseline	Walk share (Work)	4.4%	5.6%	↑
			Bike share (Work)	0.5%	0.7%	↑
			Walk share (Non-Work)	12.0%	15.0%	↑
			Bike share (Non-Work)	1.8%	2.5%	↑
			Walk share (All Trips)	10.7%	13.5%	↑
			Bike share (All Trips)	1.6%	2.2%	↑

TABLE 8.1 CONTINUED

PERFORMANCE MEASURE	DEFINITION	OBJECTIVE	CATEGORY	2040 BASELINE	2040 PLAN	INDICATOR
OUTCOME: ENVIRONMENTAL QUALITY						
Greenhouse gas emissions	CO, NOx, PM 2.5, PM 10 and VOC emissions; and per capita greenhouse gas emissions (CO2)	Meet state greenhouse gas reduction targets (SR)	Reduction in per capita greenhouse gas emissions from 2005 levels	N/A	8% in 2020 18% in 2035 21% in 2040	
OUTCOME: ECONOMIC OPPORTUNITY						
Additional jobs supported by improving competitiveness	Number of jobs added to the economy as a result of improved transportation conditions which make the region more economically competitive	Improvement (increase) over No Project Baseline	Annual number of new jobs generated	N/A	351,000+	
Additional jobs supported by transportation investments	Total number of jobs supported in the economy as a result of transportation expenditures	Improvement (increase) over No Project Baseline	Annual number of new jobs generated	N/A	188,000+	
OUTCOME: INVESTMENT EFFECTIVENESS						
Benefit/Cost Ratio	Ratio of monetized user and societal benefits to the agency transportation costs	Greater than 1.0	Benefit ratio per $1 investment	N/A	2.0	
OUTCOME: TRANSPORTATION SYSTEM SUSTAINABILITY						
Cost to preserve multimodal system to current and state of good repair	Annual cost per capita required to preserve the regional multimodal transportation system to current conditions	Improvement (decrease) over Base Year	Cost per capita (per year)	N/A	$368	
OUTCOME: ENVIRONMENTAL JUSTICE						
See Table 8.4: Performance Measures: Environmental Justice		Meet Federal requirements. No unaddressed disproportionately high and adverse effects for low income or minority communities (FR)				

Notes:

(FR) Federal requirement

(SR) State requirement

* MAP-21 calls for performance measures and targets associated with congestion, safety, reliability, freight movement, infrastructure condition, environment and project delivery. However, federal rule-making in support of MAP-21 performance measures in still in progress.

** Results are for areas experiencing land use and population changes not the entire SCAG region.

Acronyms

HOV: High-Occupancy Vehicle

SOV: Single-Occupancy Vehicle

TABLE 8.2 2016 RTP/SCS KEY BENEFITS

BENEFIT CATEGORIES	BASELINE	RTP/SCS	SAVINGS	% SAVINGS
Local Infrastructure and Services Costs: Capital and Operations and Maintenance Costs to Support New Growth, 2012–2040[1]	$40.6 billion	$37.3 billion	$3.3 billion	8.1%
Household Costs: Transportation and Home Energy/Water Use, All Households, Annual (2040)	$16,000	$14,000	$2,000	12.3%
Land Consumption: New (greenfield) Land Consumed to Accommodate New Growth 2012–2040	154 sq miles	118 sq miles	36 sq miles	23.4%
Building Energy Use: Residential and Commercial Buildings, Cumulative, 2012–2040 (measured in British Thermal Units (BTUs))	20,311 trillion	19,563 trillion	748 trillion	3.7%
Building Energy Costs: Residential and Commercial Buildings, Cumulative, 2012–2040	$762 billion	$735 billion	$27 billion	3.5%
Building Water Use: Residential and Commercial Buildings, Cumulative, 2012–2040 (measured in Acre Feet (AF))	134 million	133.2 million	0.8 million	0.6%
Building Water Costs: Residential and Commercial Buildings, Cumulative, 2012–2040	$186 billion	$185 billion	$1 billion	0.5%
Household Driving: Annual Passenger VMT, 2040	177.7 billion	150 billion	27.7 billion	15.6%

Note: [1] Operations and maintenance costs referenced here include costs beyond those for transportation (e.g., sewer and water operations and maintenance costs).

VEHICLE MILES TRAVELED (VMT) PER CAPITA

This measure is new to the 2016 RTP/SCS. VMT (for automobiles and light trucks) per capita has become an increasingly significant metric since the passage of Senate Bill 375, which led to state-determined reduction targets for regional greenhouse gas emissions from automobiles and light trucks. Automobiles and light duty trucks are a major contributor to greenhouse gas emissions, producing more than 60 percent of transportation sector emissions. Therefore, VMT reduction is a critical component of a comprehensive regional strategy for reducing greenhouse gas emissions. By monitoring progress in reducing per capita VMT through implementation of the various transportation investments and land use strategies outlined in this Plan, we will be better able to accurately gauge our momentum toward achieving our goals for reducing regional greenhouse gas emissions. Daily per capita VMT in the SCAG region is projected to decrease significantly in 2040 under the Plan.

TRANSIT MODE SHARE

Transit mode share is another new metric for the 2016 RTP/SCS. It measures the share of transit trips made throughout the region for work and non-work purposes. This new measure will help us to identify how well the transit strategies and improvements proposed in the 2016 RTP/SCS are working toward providing better and more diverse commuting options for the traveling public. Ideally, with better transit service, more commuters will choose that option over driving alone, further reducing VMT and regional greenhouse gas emissions. TABLE 8.3 shows transit mode share by county for work trips and for all trips in 2040 as projected under the Plan.

TABLE 8.3 TRANSIT MODE SHARE BY COUNTY

(Plan 2040)

COUNTY	WORK TRIPS	ALL TRIPS
Imperial	0.6%	0.3%
Los Angeles	12.0%	4.7%
Orange	3.8%	1.7%
Riverside	1.1%	0.5%
San Bernardino	2.1%	0.7%
Ventura	1.6%	0.7%
SCAG Region	8.2%	3.1%

AVERAGE DISTANCE FOR WORK AND NON-WORK TRIPS

The average distance for work trips in 2040 is projected to increase slightly under the Plan. The average distance traveled for non-work trips in 2040 is projected to remain relatively constant between the Baseline and the Plan.

PERCENT OF TRIPS LESS THAN THREE MILES

The vast majority of trips in Southern California today are made by people driving alone. As the length of trips becomes shorter, particularly to within a few miles, people are more likely to use transit, bike, walk or choose other alternatives to driving alone. By 2040, the share of work trips and non-work trips less than three miles is projected to remain relatively unchanged.

WORK TRIP LENGTH DISTRIBUTION

The share of trips less than ten miles in 2040 is projected to be just over 50 percent under both the Baseline and the Plan. Likewise, the share of trips under 25 miles would be about 81 percent for both the Baseline and the Plan.

MOBILITY AND ACCESSIBILITY

The Mobility and Accessibility outcome is defined as the ability to reach desired destinations with relative ease and within a reasonable time, using reasonably available transportation choices. This section discusses the mobility and accessibility performance measures for the 2016 RTP/SCS.

MOBILITY

The Mobility performance measure relies on the commonly used measure of delay. Delay is defined as the difference between actual travel time and the travel time at a pre-defined reference or optimal speed for each modal alternative. It is measured in vehicle-hours of delay (VHD), which can then be used to derive person-hours of delay. The mobility measures used to evaluate alternatives for this outcome include:

- Person Delay by Facility Type (Highway, High Occupancy Vehicle (HOV) Lanes, Arterials)
- Person Delay per Capita
- Truck Delay by Facility Type (Highway, Arterial)

One additional measure for delay that is readily available for ongoing monitoring, but which cannot be readily forecast, is non-recurrent delay. Recurrent delay is the day-to-day delay that occurs because too many vehicles are on the road at the same time. Non-recurrent delay is the delay that is caused by collisions, weather, special events or other atypical incidents. Non-recurrent delay can be mitigated or reduced by improving incident management strategies. Other uses of intelligent transportation technologies, such as traffic signal coordination and the provision of real-time information about unexpected delays, allow travelers to make better informed decisions regarding the availability of transportation alternatives, including transit. Non-recurrent delay as an on-going regional monitoring measure is discussed in greater detail in the Performance Measures Appendix.

Person Delay by Facility Type (Highway, High Occupancy Vehicle (HOV) Lanes, Arterials)

Since the 2012 RTP/SCS, the person delay measure has been expanded to differentiate between single-occupancy vehicle (SOV) and HOV delay. Person delay on our highways under the Plan would improve on Baseline conditions, while delay on HOV facilities will be reduced more dramatically. Delay on our regional arterial roadways would also improve between the Baseline and the Plan. FIGURE 8.1 shows total person hours of delay by facility type.

Person Delay Per Capita

Normalizing delay by the number of people living in an area provides insight as to how well the region is mitigating traffic congestion in light of increasing population growth. Delay per capita is expected to grow considerably, particularly in the Inland Empire counties of Riverside and San Bernardino, under Baseline conditions. However, implementation of the Plan would reduce per capita delay substantially to below 2012 levels.

Truck Delay by Facility Type (Highway, Arterial)

This measure estimates the average daily truck delay by facility type for highways and arterials. The 2016 RTP/SCS includes significant investments in a regional freight corridor and other improvements to facilitate goods movement. It is estimated that the Plan would reduce heavy-duty truck delay on the highway and arterial systems. However, truck delay under the Plan would still be above Base Year levels, partly due to the projected growth in trade and associated truck traffic.

Highway Non-Recurrent Delay

As indicated previously, this measure will be used only for ongoing regional monitoring, not for evaluation of alternatives for the 2016 RTP/SCS. Non-recurrent delay refers to the share of congestion that is considered to be atypical. FIGURE 8.2 shows the relative proportion of highway congestion that is estimated to be caused by non-recurrent events by county.

Highway Speed Maps

Maps illustrating highway speed conditions during the afternoon peak period (3 PM to 7 PM) based upon the SCAG RTDM results for the Base Year, Baseline and Plan are provided in the Performance Measures Appendix. Additional speed maps are provided in the Highways & Arterials Appendix.

ACCESSIBILITY

The Accessibility outcome is used to evaluate how well the transportation system performs in providing people access to opportunities. Opportunities may include jobs, education, medical care, recreation, shopping or any other activities that may help enhance a person's quality of life. For the 2016 RTP/SCS, accessibility is simply defined as the distribution of trips by mode by travel time.

As with the 2012 RTP/SCS, accessibility is measured by taking afternoon or PM peak period travel demand model results for the base and forecast years and identifying the percentage of commute or home-based work trips that are completed within 45 minutes. Peak periods are those times during the weekday when commuting travel on regional roadways reaches its highest levels. Typically, peak periods occur twice daily, first during the morning commute when people are traveling to their workplaces and again in the late afternoon when people are returning home from work. FIGURE 8.3 shows these results. In all cases, the 2040 Plan would improve accessibility for home-based work trips over the Baseline.

The 2016 RTP/SCS provides a comprehensive measure of accessibility, including the transit, SOV, and HOV modes, for both work and non-work trips. The results of these mode-specific accessibility analyses can be found in the Performance Measures Appendix.

FIGURE 8.1 DAILY PERSON-HOURS OF DELAY BY FACILITY TYPE (IN THOUSANDS)

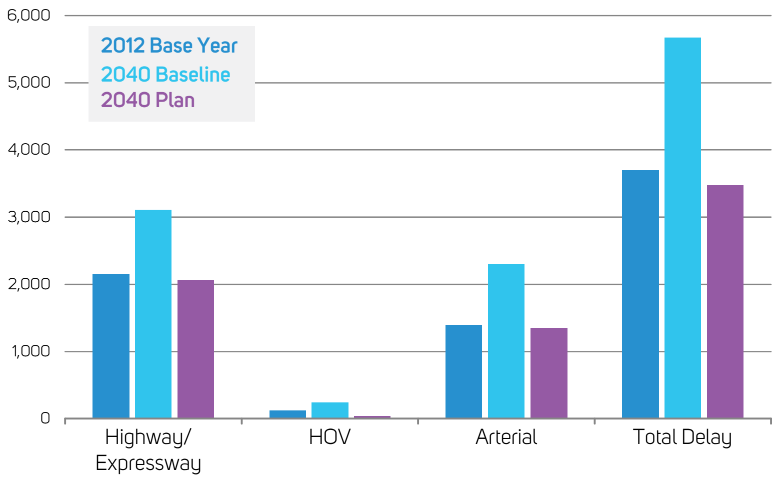


FIGURE 8.3 WORK TRIPS COMPLETED WITHIN 45 MINUTES

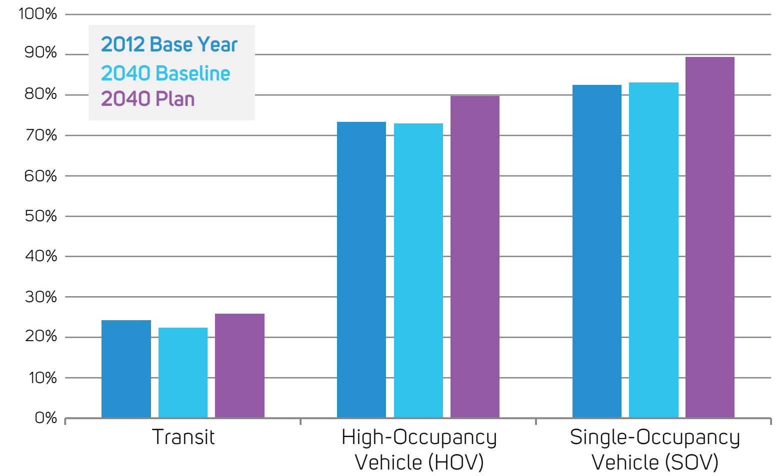
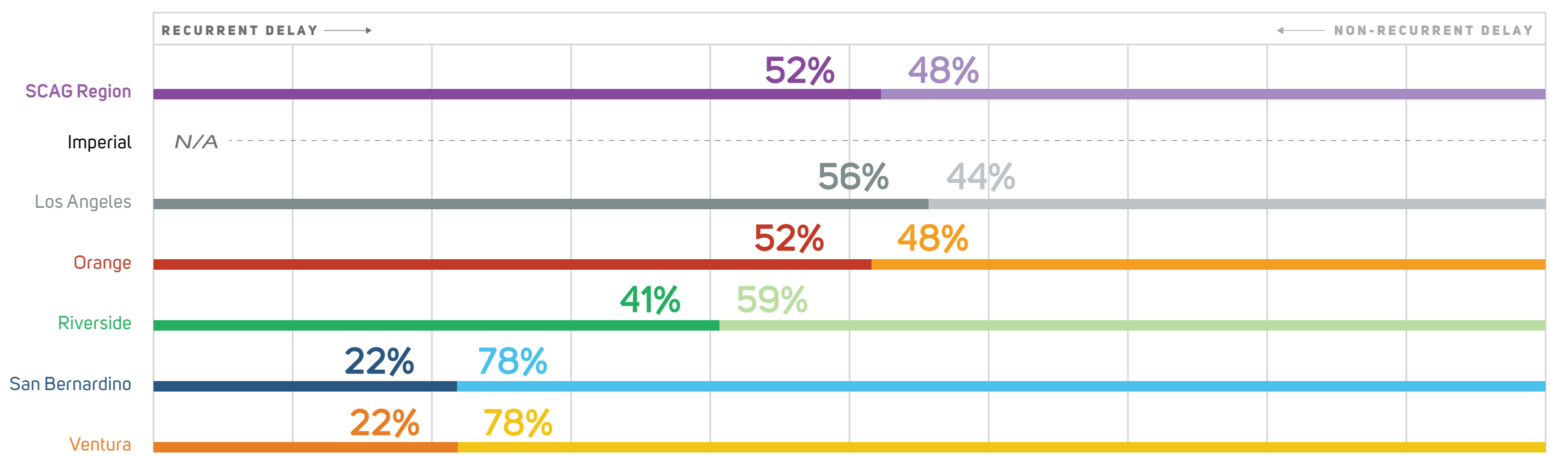


FIGURE 8.2 RECURRENT AND NON-RECURRENT CONGESTION (2011)



SAFETY AND HEALTH

The Safety and Health outcomes have been carried over from the 2012 RTP/SCS. In addition, the 2016 RTP/SCS includes new measures to evaluate the health outcomes of the Plan, including three new measures discussed below. The safety and health impacts of regional transportation improvements cannot be easily forecast, but total collisions can show a reduction in future years, particularly if people shift from travel modes with higher collision risk to modes with lower collision risk. The total number of collisions is generally used as the performance measure for safety and it can be partially projected by using mode and facility specific collision rates (highways, arterials and transit). This approach is used for the 2016 RTP/SCS, but it is important to note that this methodology does not take into account safety improvements specific to each mode. It only reflects changes based on modal or facility shifts. For monitoring, this measure can be reported historically by time period (month) and by mode (including for active transportation). Safety and Health outcome trends are discussed in greater detail in the Performance Measures Appendix.

Recognizing that the RTP/SCS integrates transportation and land use and has impacts beyond those exclusively transportation-related, the 2016 RTP/SCS includes three new health-related measures: mode share for walking and biking, rates of physical activity and weight-related disease, and incidence of respiratory/pollution-related disease.[1]

The health benefits of an active lifestyle have become increasingly apparent in recent years, and there is growing support for improving the walkability and bikability of the communities where we live and work. The linkage between obesity and disease has been well documented, and providing the appropriate community design and infrastructure to support a more active lifestyle is an important first step toward promoting healthy communities. Walking and biking mode shares can be used to evaluate the 2016 RTP/SCS alternatives, while the disease-focused measures may also be useful for on-going regional monitoring.

A health measure carried over from the 2012 RTP/SCS is tons of criteria air pollutants, which is highly correlated to public health concerns such as asthma. There are six common air pollutants that are monitored in accordance with federal air quality regulations.[2] These criteria pollutants include particulate matter (PM 10 and PM 2.5), carbon monoxide (CO), nitrogen oxides (NOx), and nitrogen dioxide (NO2). These pollutants require careful monitoring because of their known adverse effects on human health. While children, older residents and persons with existing respiratory illnesses are most vulnerable to the effects of air pollutants, the health effects of long-term exposure are a concern for everyone in the region. Some of the major health concerns of exposure to high levels of these criteria pollutants include respiratory irritation, reduced lung capacity, chest pain, and aggravation of asthma and other respiratory illnesses.[3]

Airborne particulate matter comes in all sizes. However, particles smaller than ten micrometers in diameter are considered the most dangerous to human health because they are small enough to be absorbed into the lungs. The finer the particle size, the more dangerous they are. Particulate matter smaller than 2.5 micrometers is a particularly serious concern for people with existing heart or lung disease, as even short-term exposure to high levels of PM 2.5 may aggravate symptoms. High levels of carbon monoxide (CO) is also considered a health hazard, especially for people with compromised respiratory or coronary function, as CO is known to reduce the flow of oxygen through the human body. Long-term exposure to high levels of nitrogen dioxide, which is produced primarily through the burning of fossil fuels, may cause a narrowing of the bronchial airways, resulting in chronic bronchitis or aggravation of asthma symptoms.[4] The criteria pollutant performance measure supports both the Safety and Health outcome and the Environmental Quality outcome.

The 2016 RTP/SCS would improve physical activity outcomes through improved location efficiency, which increases the share of short trips and through the provision of additional investments in active transportation networks including first/last mile improvements, Safe Routes to School projects and regional bikeway infrastructure. It would also increase access to natural lands and parks, which would further increase opportunities for physical activity.

New to the 2016 RTP/SCS is the development of a new Public Health module for the Urban Footprint/Scenario Planning Model to measure the Plan's impact on physical activity. The model was evaluated by a statewide review panel consisting of representatives of state, regional and local agencies. The Plan is expected to result in 4.3 additional minutes of physical activity per capita over the Baseline in areas experiencing changes in land use, which would improve

1 Ogden, Ph.D., C., & Carroll, M.S.P.H, M. (2010). Prevalence of Overweight, Obesity, and Extreme Obesity Among Adults: United States, Trends 1960–1962 Through 2007–2008. Center for Disease Control and Prevention. Accessed at http://www.cdc.gov/nchs/data/hestat/obesity_adult_07_08/obesity_adult_07_08.htm.

2 For more information on Federal air quality standards, see U.S. Environmental Protection Agency, National Ambient Air Quality Standards (NAAQS): http://www3.epa.gov/ttn/naaqs/criteria.html.

3 For more information on the health impacts of criteria air pollutants, see U.S. Environmental Protection Agency, Six Common Air Pollutants: http://www3.epa.gov/airquality/urbanair/.

4 For more information on the health impacts of particulate matter, see U.S. Environmental Protection Agency, Particle Matter (PM) Health, Last Accessed October 7, 2015: http://www3.epa.gov/pm/health.html.

health outcomes related to obesity by 2.7 percent and high blood pressure by 3.3 percent for residents in those areas. For a broader discussion of the Scenario Planning Model, please see the SCS Background Documentation Appendix. For more detailed information on the connection between physical activity and health outcomes, please see the Public Health Appendix.

ENVIRONMENTAL QUALITY

This outcome is measured in terms of criteria pollutant and greenhouse gas emissions. Emissions are estimated using the SCAG RTDM results, which are used as input to the California Air Resources Board's (ARB) Emission Factors (EMFAC) model. Pollutant emissions are reported in detail as part of the Transportation Conformity Analysis Appendix. The impact of air quality on public health is discussed in the Safety and Health outcome section of this chapter. Monitoring of regional greenhouse gas emissions is discussed in the Performance Measures Appendix.

ECONOMIC OPPORTUNITY

The economic opportunity outcome is measured in terms of additional jobs created through improved regional economic competitiveness as a result of the transportation investments provided through the 2016 RTP/SCS. An annual average of more than 188,000 new jobs would be generated by the construction and operations expenditures in the 2016 RTP/SCS, in addition to more than 351,000 annual jobs that would be created in a broad cross-section of industries by the region's increased competitiveness and improved economic performance—as a result of the improved transportation system. Additional economic benefits of the 2016 RTP/SCS are discussed in Chapter 7.

INVESTMENT EFFECTIVENESS

The investment effectiveness outcome indicates the degree to which the Plan's expenditures generate benefits that transportation users can experience directly. This outcome is important because it describes how the Plan's transportation investments make productive use of increasingly scarce funds.

The benefit/cost ratio is the measure used to evaluate the cost-effectiveness outcome, as it compares the incremental benefits with the incremental costs of multimodal transportation investments. The benefits are divided into several categories, including:

- Savings resulting from reduced travel delay
- Air quality improvements
- Safety improvements
- Reductions in vehicle operating costs

For these categories, travel demand and air quality models are used to estimate the benefits of the Plan compared with the Baseline. Most of these benefits are a function of changes in VMT and VHT. Not all impacts are linear, so reductions in congestion can increase or decrease vehicle operating costs and emissions. Delay savings are reflected directly in the VHT statistics. To estimate the benefit/cost ratio, the benefits in each category are converted into dollars and added together. These are divided by the total incremental costs of the Plan's transportation improvements to produce a ratio. The investments in the 2016 RTP/SCS would provide a return of $2.00 for every dollar invested, for a benefit/cost ratio of 2.0. For this analysis, all benefits and costs are expressed in 2012 dollars. Benefits are estimated over the RTP/SCS planning period through 2040. The user benefits are estimated using California's Cal-B/C framework and incorporate SCAG's RTDM outputs. The costs include the incremental public expenditures over the entire 2016 RTP/SCS planning period.[5]

TRANSPORTATION SYSTEM SUSTAINABILITY

A transportation system is sustainable if it maintains its overall performance over time in an equitable manner with minimum damage to the environment, and at the same time does not compromise the ability of future generations to address their transportation needs. Sustainability, therefore, pertains to how our decisions today impact future generations. One of the measures used to evaluate system sustainability is the total inflation-adjusted cost per capita to maintain our overall multimodal transportation system performance at current conditions. The 2016 RTP/SCS includes two additional new measures to support this outcome: State Highway System pavement condition and local roads pavement condition. These additional performance measures will strengthen the transportation system sustainability outcome and further support implementation of MAP-21.

5 California Department of Transportation. (2009). California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) User's Guide (Version 4.0). Accessed at http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_files/CalBC_User_Guide_v8.pdf.

The 2016 RTP/SCS is committed to maintaining a sustainable regional transportation system by allocating $275.5 billion toward maintaining and operating the system in a state of good repair over the period of the Plan. This amounts to an average annual per capita investment of about $368 (in 2015 dollars) for each year of the Plan period. More details on performance measures for the Transportation System Sustainability outcome are presented in the Performance Measures Appendix.

LAND USE RELATED BENEFITS

Unlike the Plan, the Baseline scenario relies more heavily on growth in undeveloped lands at the edges of cities and beyond and focuses more new housing toward single-family developments in suburban settings. Using a different modeling process from that used for the mobility-based performance measures, additional land use related performance results were derived

RTP/SCS GREENHOUSE GAS REDUCTIONS

Percent Reduction from 2005 Levels Per Capita

	2020	2035	2040
ARB TARGET	8%	13%	N/A
2016 RTP/SCS	8%	18%	21%
% DIFFERENCE	0%	5%	N/A

* ARB has set GHG emissions reduction targets for 2020 and 2035, but not for 2040

using the single framework model as described in the SCS Background Documentation Appendix.

The land use strategy of the 2016 RTP/SCS promotes location efficiency by orienting new housing and job growth in areas served by high quality transit and in other targeted opportunity areas including existing main streets, downtowns and corridors where infrastructure already exists. This more compact land use pattern, combined with the transportation network improvements and strategies identified in the 2016 RTP/SCS, would result in improved pedestrian and bicycle access to community amenities, shorter average trip lengths and reduced vehicle miles traveled. This strategy also supports the development of more livable communities that provide more housing choices, conserve natural resources, offer more and better transportation options, and promote an overall better quality of life.

The more focused land use pattern promoted in the Plan also reduces the need for significant capital investments. Because new development is focused in areas where infrastructure already exists, there is not as much need to extend or build new local roads, water and sewer systems, and parks. However, in other instances, modernization of utilities needs to be considered and completed to accommodate the additional use.There are also operations and maintenance (O&M) cost savings. O&M costs include the ongoing local expenditures required to operate and maintain the infrastructure serving new residential growth. It is important to note the O&M costs referred to in this section are not the same O&M costs discussed in other sections of the 2016 RTP/SCS.

The 2016 RTP/SCS land use strategy also reduces the average household costs associated with driving and residential energy and water use. A land use pattern that contains more mixed-use/walkable and urban infill development accommodates a higher proportion of growth in more energy-efficient housing types like townhomes, apartments and smaller single-family homes, as well as more compact commercial building types. It should be noted that location is also an important factor in determining energy costs: buildings located in the warmer areas of the region use more energy each year, in part because they require more energy for cooling during the summer months.

As California is facing major constraints on water supplies due to ongoing drought conditions throughout the state, there is a strong emphasis on reducing residential water use. Residential water use is a function of both indoor and outdoor water needs, with outdoor use (landscape irrigation) accounting for the majority of the difference among housing types. Because homes with larger yards require more water for landscape irrigation, lot size is generally highly correlated with a household's overall water consumption. Therefore, a land use pattern with a greater proportion of large lot single-family homes will require more water than a land use pattern that features a larger share of compact and urban infill development, which includes more attached and multifamily homes. And, as is the case for energy use, the location and type of new development has a significant bearing on water use: homes in the warmer and more arid locations of the region will consume more water to maintain lawns and other landscaping.

SENATE BILL 375 AND GREENHOUSE GAS EMISSIONS REDUCTIONS

As discussed previously in this Plan, Senate Bill 375 requires that SCAG and other Metropolitan Planning Organizations (MPOs) throughout the state develop a Sustainable Communities Strategy to reduce per capita greenhouse gas emissions through integrated transportation, land use, housing and environmental planning.

Pursuant to Senate Bill 375, ARB set per capita greenhouse gas emissions reduction targets from passenger vehicles for each of the state's 18 MPOs. For the SCAG region, the targets are set at eight percent below 2005 per capita emissions levels by 2020 and 13 percent below 2005 per capita emissions levels by 2035. Although ARB has not adjusted SCAG's regional targets since the 2012 RTP/SCS, SCAG anticipates that the region's targets could change—considering the Governor's recent Executive Order.[6] Because the transportation sector is the largest contributor to California's greenhouse gas emissions (more than 36 percent), SCAG anticipates updated and more stringent regional greenhouse gas reduction targets may be forthcoming.[7]

In the meantime, the 2016 RTP/SCS achieves per capita greenhouse gas emissions reductions relative to 2005 of eight percent in 2020, 18 percent in 2035, and 21 percent in 2040—exceeding the reductions that ARB currently requires. For more detailed information and analysis regarding monitoring of air quality and greenhouse gas emissions in the SCAG region, please see the Transportation Conformity Analysis Appendix.

[6] California Air Resources Board. (2015). Frequently Asked Questions About Executive Order B-30-15 2030 Carbon Target and Adaptation. [Fact Sheet]. Retrieved from http://www.arb.ca.gov/newsrel/2030_carbon_target_adaptation_faq.pdf

[7] California Air Resources Board. California Greenhouse Gas Emission Inventory. (2015) [Website]. Retrieved from http://www.arb.ca.gov/cc/inventory/data/data.htm.

ENVIRONMENTAL JUSTICE

The concept of environmental justice is about equal and fair access to a healthy environment, with the goal of protecting minority and low-income communities from incurring disproportionate negative environmental impacts. SCAG's environmental justice program includes two main elements: technical analysis and public outreach. In the regional transportation-planning context, SCAG's role is to 1) ensure that when transportation decisions are made, low-income and minority communities have ample opportunity to participate in the decision-making process, and 2) identify whether such communities receive an equitable distribution of benefits and not a disproportionate share of burdens.

As such, SCAG adheres to all federal and state directives on environmental justice. All public agencies that use federal funding must make environmental justice part of their mission and adhere to three fundamental environmental justice principles:

1. To avoid, minimize or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.
2. To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.
3. To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations.

The 2016 RTP/SCS program of environmental justice public outreach and analysis, described in detail in the Environmental Justice Appendix, reviews federal legislation pertaining to environmental justice; major equity issues specific to our region; SCAG policies and programs related to this important topic; outreach efforts in communities across the region; and SCAG's efforts to identify demographic groups to ensure environmental justice in all of our communities.

TABLE 8.4 2016 RTP/SCS PERFORMANCE MEASURES: ENVIRONMENTAL JUSTICE

PERFORMANCE MEASURE	DEFINITION	PERFORMANCE TARGET	SUMMARY OF IMPACTS
2016 RTP/SCS revenue sources in terms of tax burdens[1]	Proportion of 2016 RTP/SCS revenue sources (taxable sales, income, and gasoline taxes) for low income and minority populations	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—households in poverty will not contribute disproportionately to the overall funding of the Plan. Minority households will not pay a higher proportion of taxes to fund the 2016 RTP/SCS than their relative representation in the region as a whole
Share of transportation system usage[1]	Comparison of transportation system usage by mode for low income and minority households vs each group's population share in the greater region	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—low income and minority groups show a higher usage of transit and active transportation modes and positions these communities to benefit from the investments in the 2016 RTP/SCS
2016 RTP/SCS investments[1]	Allocation of Plan investments by mode (bus, HOV lanes, commuter/high speed rail, highways/arterials, and light/heavy rail transit)	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the share of transportation investments for low income and minority communities outpaces these groups' financial burdens for the 2016 RTP/SCS
Distribution of travel time savings and travel distance reductions[1]	Details what groups are overall benefiting as a result of the Plan in terms of travel time and distance savings	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan's travel time and person-mile savings for low income households and minority communities is in line with each group's usage of the transportation system
Geographic distribution of transportation investments	Examination of transit, roadway and active transportation infrastructure investments in various communities throughout the region	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan's transportation infrastructure investments are distributed throughout the region in proportion to population density
Jobs-housing imbalance[1]	Comparison of median earnings for intra-county vs inter-county commuters for each county in the SCAG region; analysis of relative housing affordability and jobs throughout the region	Establish existing conditions (not a performance measure for the Plan)	Existing conditions show that higher wage workers tend to commute longer distances than lower wage workers. Inland counties show a lower job-to-worker ratio than coastal counties, indicating that there are more long distance commuters in inland counties. Please refer to the Environmental Justice Appendix for potential strategies to improve conditions at the local level
Accessibility to employment and services[1]	Percentage of employment and shopping destinations within a one- and two-mile travel buffer from each neighborhood; also, share of employment and shopping destinations that can be reached within 30 minutes by auto or 45 minutes by bus or all transit modes during the evening peak period	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan will improve the number of accessible destinations within 45 minutes of travel and within short distances for low income and minority communities both by auto and transit
Accessibility to parks and schools	Share of population within a one- and two-mile travel buffer from a regional park or school; also, share of park acreage that can be reached within 30 minutes by auto or 45 minutes by bus or all transit modes during the evening peak period	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan will improve the number of destinations accessible within 45 minutes of travel and short distances for low income and minority communities both by auto and transit
Gentrification and displacement[1]	Examination of historical demographic and economic trends for areas surrounding rail transit stations	Establish existing conditions (not a performance measure for the Plan)	Historic trends from 2000 to 2012 show that population living in areas within a half mile of rail transit stations are not strongly influenced by the larger region's demographic and economic trends. For example, the growth of Hispanics and seniors (age 65 and above) in these areas has not kept pace with regional trends. Patterns in residents' income and housing prices suggest that gentrification may be happening and low income and minority households are at risk for displacement. Refer to the Environmental Justice Appendix for potential strategies to reduce impacts at the local level
Emissions Impact Analysis[1]	Comparison of Plan and Baseline scenarios; identification of areas that are lower performing as a result of the Plan, along with a breakdown of demographics for those areas	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan will result in reductions in carbon monoxide and particulate matter emissions for on-road vehicles and benefits will be experienced both by minority and low income households and in communities with a high concentration of minority and low income groups

TABLE 8.4 CONTINUED

PERFORMANCE MEASURE	DEFINITION	PERFORMANCE TARGET	SUMMARY OF IMPACTS
Air quality health impacts along highways and highly traveled corridors[1]	Comparison of Plan and Baseline scenarios and demographic analysis of communities in close proximity to highways and highly traveled corridors	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan will result in an overall reduction in emissions in areas that are near roadways, which have been seen to have a higher concentration of minority and low income groups than the region as a whole
Aviation noise impacts[1]	Comparison of Plan and Baseline scenarios; breakdown of population by race and ethnicity for low performing airport noise impacted areas	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan will result in aviation noise areas that are geographically smaller than the Baseline scenario, and will benefit minority and low income households as a result
Roadway noise impacts[1]	Comparison of Plan and Baseline scenarios, identification of areas that are low performing as a result of the Plan; breakdown of population for these impacted areas by race/ ethnicity and income	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—the Plan results in a reduction of roadway noise when compared to the Baseline scenario, which has a benefit to minority and low income households who represent a higher share of population who live in close proximity to major roadways
Active transportation hazard	Breakdown of population by demographic group for areas that experience the highest rates of bicycle and pedestrian collisions	Establish existing conditions (not a performance measure for the Plan)	Collision data from 2012 shows that low income and minority communities incur a higher rate of bicycle and pedestrian risk. Improvements in active transportation infrastructure and Complete Streets measures, such as those proposed in the Plan, have been shown to reduce hazard to bicyclists and pedestrians. Refer to the Environmental Justice Appendix for potential strategies to reduce risk at the local level
Rail-related impacts[1]	Breakdown of population by demographic group for areas in close proximity to rail corridors and planned grade separations	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—there is no significant difference between the Plan and the Baseline in the concentration of minority and low income communities in areas directly adjacent to commercial and passenger railways
Public health analysis	Historical emissions and health data summarized for areas that have high concentrations of minority and low income population	Establish existing conditions (not a performance measure for the Plan)	Recent trends indicate that air quality is improving throughout the region. For select areas that show increase, there is sometimes a higher proportion of minority and low income population. When examining public health indicators from the CalEnviroScreen tool, it appears that areas with the highest concentrations of minority and low income population incur some of the highest risks in the region. Refer to the Environmental Justice Appendix for potential strategies to improve conditions at the local level
Climate vulnerability	Breakdown of population by demographic group for areas potentially impacted by substandard housing, sea level rise and wildfire risk	Establish existing conditions (not a performance measure for the Plan)	Existing conditions indicate that minority and low income populations are at a greater risk for experiencing negative impacts of climate change. Refer to the Environmental Justice Appendix for potential strategies to reduce impacts at the local level.
Proposed mileage-based user fee impacts	Examination of potential impacts from implementation of a mileage-based user fee on low income households in the region	No unaddressed disproportionately high and adverse effects for low income or minority communities	No unaddressed disproportionate impacts—results show that the mileage-based user fee is less regressive to low income residents than the current gasoline tax.

Note: [1] Performance measures used in the Environmental Justice Analysis for the 2012 RTP/SCS

ENVIRONMENTAL JUSTICE PERFORMANCE MEASURES

In the development of the analysis, SCAG identified 18 performance measures to analyze existing environmental justice parameters in the region and to address any potential impacts of the 2016 RTP/SCS on the various environmental justice population groups. SCAG also examined potential impacts at various geographies and specifically employed a community-based approach for the 2016 RTP/SCS based on guidance from stakeholders. A brief description of the environmental justice performance measures is provided in this section. A more detailed presentation of the results of the 2016 RTP/SCS environmental justice analysis can be found in the Environmental Justice Appendix. TABLE 8.4 describes the 2016 RTP/SCS environmental justice performance measures and provides a summary of impacts for each of the measures.

PERFORMANCE MEASURE 1: 2016 RTP/SCS REVENUE SOURCES IN TERMS OF TAX BURDENS

Different funding sources (i.e., income, property, sales and fuel taxes) can impose disproportionate burdens on lower-income and minority groups. Sales and gasoline taxes, which are the primary sources of funding for the region's transportation system, were evaluated for the purposes of this analysis. The amount of taxes paid was broken down to demonstrate how tax burdens fall on various demographic groups. As in previous RTP environmental justice reports, the 2016 RTP/SCS environmental justice analysis examined in detail the incidence, distribution and burden of taxation.

PERFORMANCE MEASURE 2: SHARE OF TRANSPORTATION SYSTEM USAGE

SCAG analyzed the use of various transportation modes by race/ethnicity and by income quintile (an income quintile is a category into which 20 percent of households ranked by income fall).

PERFORMANCE MEASURE 3: 2016 RTP/SCS INVESTMENTS

The strategy that public agencies pursue to invest in transportation has a huge impact on environmental justice. In short, it can determine what transportation choices will be available to low-income and minority communities. A disproportionate allocation of resources for various transit investments, for example, can indicate a pattern of discrimination.

PERFORMANCE MEASURE 4: DISTRIBUTION OF TRAVEL TIME SAVINGS AND TRAVEL DISTANCE REDUCTIONS

SCAG assessed both the distribution of travel time and distance savings that are expected to result from implementing the 2016 RTP/SCS, by analyzing demographic data and the associated mode usage statistics for each Transportation Analysis Zone (TAZ) in the region. With this input, an estimate for the time savings for each income group and ethnic group can be identified for trips involving transit (bus and rail) and automobiles.

PERFORMANCE MEASURE 5: GEOGRAPHIC DISTRIBUTION OF TRANSPORTATION INVESTMENTS

This section is a new addition to the environmental justice analysis for the 2016 RTP/SCS and examines where transportation investments are planned throughout the region. Building on the new community-based approach for the overall effort, a summary of investments for areas with a high concentration of minority population and/or low income population is included for roadway, transit and active transportation investments.

PERFORMANCE MEASURE 6: JOBS-HOUSING IMBALANCE

An imbalance or mismatch between employment and housing in a community is considered to be a key contributor to local traffic congestion. Some argue that these imbalances and mismatches are also impediments to environmental justice. Driving is expensive and people who can't afford to own a car generally need to live near to their jobs so they can get to work using transit, or by walking or biking.

PERFORMANCE MEASURE 7: ACCESSIBILITY TO EMPLOYMENT AND SERVICES

Accessibility is vital for social and economic interactions. As a measure, accessibility is determined by the spatial distribution of potential destinations; the ease of reaching each destination by various transportation modes; and the magnitude, quality and character of the activities at the destination sites. Travel costs are central: the lower the costs of travel, in terms of time and money, the more places people can reach within a certain budget—that is, the greater the accessibility. The number of destination choices that people have is equally crucial: the more destinations and the more varied the destinations, the higher the level of accessibility.

PERFORMANCE MEASURE 8: ACCESSIBILITY TO PARKS AND NATURAL LANDS

Similar to the method used for measuring accessibility to jobs, accessibility to parks is defined as the percentage of park acreage reachable within a 30-minute travel time by auto and 45-minute travel time by local bus and all transit options. For this round of SCAG's environmental justice effort, analysis was included that measured accessibility to the recently designated San Gabriel Mountains National Monument. Also included in our accessibility analysis (for employment and services) is a measurement of the share of population within a one- and two-mile travel distance of all regional parks and open space under the Plan and Baseline scenario, based on the principle that shorter trips should be encouraged through implementation of the 2016 RTP/SCS.

PERFORMANCE MEASURE 9: GENTRIFICATION AND DISPLACEMENT

The integration of transportation and land use planning has been recognized for its ability to reduce VMT, air pollution and greenhouse gases, while also increasing opportunities for physical activity. However, there has been some criticism of smart growth strategies in relation to housing affordability, specifically in regard to Transit-Oriented Development (TOD). In response to these concerns, SCAG developed a methodology to monitor demographic trends in and around transit-oriented communities. For the 2016 RTP/SCS, recent indicators show that emerging trends for areas in close proximity to rail transit stations (one half mile surrounding a rail transit stop) are not consistent with those for the greater region. From 2000 to 2012, the region experienced huge growth for certain cohorts, specifically the Hispanic population and seniors aged 65 and over. This same trend was also seen in areas near rail transit stations, but to a much lesser degree. At the same time, median household income has decreased less, and median gross rent has increased more, in these transit oriented communities than has been the trend for the greater region. These divergent growth patterns represent evidence indicating likely gentrification, which may lead to displacement for low income households.[8]

SCAG will continue to monitor growth in TOD areas and is committed to promoting affordable housing throughout the region. Additional tools that local jurisdictions may use to combat displacement of low income and minority residents are provided in the Environmental Justice Toolbox, located in the Plan's Environmental Justice Appendix.

PERFORMANCE MEASURE 10: EMISSIONS IMPACT ANALYSIS

Air pollution comes from many different sources and can be classified into two types: ozone and particulate matter. Ozone pollution takes a gaseous form and is generated as vapor emitted from fuels commonly used in motor vehicles and industrial processes. Ozone is formed by the reaction between volatile organic compounds (VOC) and oxides of nitrogen (NOx) in the presence of sunlight. Ozone negatively impacts the respiratory system. Particulate matter (PM 10 and PM 2.5) are very fine particles made up of materials such as soot, ash, chemicals, metals and fuel exhaust that are released into the atmosphere. Particulate pollution has been linked to significant health problems, including aggravated asthma, respiratory disease, chronic bronchitis, decreased lung function and premature death.

Transportation projects can have both positive and negative impacts on the environment. Conversely, appropriate transportation investments can motivate travelers to shift to less polluting modes (e.g., bus, train, carpooling or commuter rail). On the other hand, investments that increase traffic on a particular facility typically degrade air quality in the immediate vicinity of that facility. Low-income and minority groups may be at particular risk for health hazards resulting from air pollution, and the objective for this analysis is to assess impacts for these groups as a result of the Plan versus Baseline (no-build) scenario.

PERFORMANCE MEASURE 11: AIR QUALITY HEALTH IMPACTS ALONG HIGHWAYS AND HIGHLY TRAVELED CORRIDORS

Exposure to air pollutants is considered an environmental justice issue due to the disproportionate share of minority and low-income populations living in close proximity to heavily traveled corridors, particularly near port and logistics activities. This exposure to unhealthy air results in nearly 5,000 premature deaths annually in the SCAG region, as well as 140,000 children with asthma and other respiratory symptoms. More than half of Americans exposed to PM 2.5 pollution that exceeds the national standard live in the SCAG region.[9] This measure examines the potential emissions impacts of the RTP/SCS for PM and ozone emissions that result from on-road vehicles both at the TAZ level and for areas in close proximity to highways and highly traveled corridors.

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8 Environmental Justice Emerging Trends and Best Practices Guidebook, Document Number: FHWAHEP-11-024 (2011). U.S. Department of Transprtation, Federal Highway Administration.

9 California Air Resources Board, South Coast Air Quality Management District, and SCAG. (2011). Powering the Future: A Vision for Clean Energy, Clear Skies, and a Growing Economy. [Fact Sheet]. http://www.arb.ca.gov/newsrel/2011/powering_the_future.pdf.

PERFORMANCE MEASURE 12: AVIATION NOISE IMPACTS

The SCAG region supports the nation's largest regional airport system, in terms of the number of airports and overall aircraft operations operating in a very complex airspace environment. This system has six established air carrier airports, including Los Angeles International (LAX), Burbank Bob Hope, John Wayne, Long Beach, Ontario and Palm Springs. There are also four emerging air carrier airports within the Inland Empire and in North Los Angeles County. These include San Bernardino International Airport, March Inland Port (joint use with March Air Reserve Base), Southern California Logistics Airport and Palmdale Airport (joint use with Air Force Plant 42).

The regional aviation system also includes more than 40 general aviation airports and two commuter airports—for a total of more than 55 public use airports. Although the projected demand for airport capacity has decreased in comparison with what was projected in the 2012 RTP/SCS, there is still moderate growth expected in the future. The challenge is striking a balance between the aviation capacity needs of Southern California and the quality of life for people living near airports. This measure evaluates the impact of aviation noise on neighborhoods close to airports and examines the potential impacts on environmental justice populations specifically.

PERFORMANCE MEASURE 13: ROADWAY NOISE IMPACTS

The SCAG region has an extensive roadway system consisting of more than 70,000 lane miles. It includes one of the country's most extensive HOV lane systems and a growing network of toll lanes, as well as express lanes. The region also has a vast network of arterials and other minor roadways and noise may cause significant environmental concerns. Noise associated with highway traffic depends on a number of factors that include traffic volumes, vehicle speed, vehicle fleet mix (cars, trucks) and the location of the highway with respect to schools, daycare facilities, parks and other "sensitive receptors." According to FHWA guidance, noise impacts occur when noise levels increase substantially in comparison with existing levels. Impacts are assessed in this section by examining how the RTP/SCS affects roadway noise and by determining the population groups that could potentially be most impacted by roadway noise.

PERFORMANCE MEASURE 14: ACTIVE TRANSPORTATION HAZARDS

Encouraging a healthier, more active lifestyle in all of our communities is one of the featured goals of this Plan. Making walking and bicycling safer transportation options is key to attracting more people to choose these alternatives. Bicycling or walking along roadways in close proximity with motor vehicles is often perceived as dangerous, and reducing hazards in the pedestrian and cycling environment is a primary strategy toward achieving our goal of promoting healthier, more active communities.

As a new environmental justice indicator for the 2016 RTP/SCS, Active Transportation Hazards seeks to evaluate incidences of motor vehicle collisions involving bicyclists and pedestrians in our communities, with the goal of promoting an improved environment for active transportation users and encouraging more residents to make the choice to walk or bicycle in their communities. As with other environmental justice performance measures, this indicator will be used to identify patterns of active transportation hazards and potential disparities among our various communities.

PERFORMANCE MEASURE 15: RAIL-RELATED IMPACTS

Freight rail emissions account for five percent of all NOx emissions and four percent of all PM emissions generated by regional goods movement activities, as described in the Goods Movement Appendix. When compared with all regional PM and NOx sources, the contributions by freight rail emissions is even lower. However, environmental pollution from locomotives, rail yards and other rail facilities must be considered, as concentrations of rail activities can cause localized rail-related pollution. In response to input from our federal partners, SCAG developed a summary analysis to address potential environmental justice impacts in areas adjacent to railroads and rail facilities, although further discussion and analysis is recommended. This outcome analyzes environmental justice communities adjacent to railroads and rail facilities, rail impacts to sensitive receptors, and examines environmental justice concerns that may potentially be alleviated by grade separation projects.

PERFORMANCE MEASURE 16: PUBLIC HEALTH IMPACT

A new environmental justice indicator for the 2016 RTP/SCS, the Public Health measure seeks to evaluate the potential disparity among communities in the SCAG region in terms of public health issues that may be associated with historical toxic exposure and local transportation infrastructure. Like the Active Transportation Hazards measure discussed previously, inclusion of this new analysis is intended to further the goal of fostering healthier lifestyle choices in all of our communities. It is a key goal of this Plan to provide more and better opportunities for physical activity and other healthy lifestyle choices throughout the SCAG region.

PERFORMANCE MEASURE 17: CLIMATE VULNERABILITY

This is another new environmental justice performance indicator that seeks to identify regional disparities in regard to vulnerability to the consequences of climate change among the various communities in the SCAG region. Of particular interest in this analysis will be relative risk for sea level rise, wildfires, and flooding. It is understood that climate change is expected to impact different regions in different ways. In Southern California, we may expect development of a general trend of warmer temperatures, less precipitation and higher sea levels along our coasts.

This combination of climatic changes will likely result in increased wildfire danger, particularly in the foothill areas where our cities adjoin our local mountains. Due to melting ice caps in the polar regions, a steady rise in global sea level is expected. This may impact the coastal regions of Southern California. This new measure will allow SCAG to obtain a better understanding of how these anticipated changes in our local climate may impact our more vulnerable communities.[10]

PERFORMANCE MEASURE 18: PROPOSED MILEAGE-BASED USER FEE IMPACTS

This analysis is based on a proposed transportation improvement funding strategy that recommends implementation of a user fee based on VMT. If implemented, the mileage-based user fee would replace the current gasoline tax and is estimated to cost about four cents (2015 value) per mile and would be indexed to maintain its purchasing power beginning in 2025. Implementation of this financing strategy would require action by the California State Legislature and/or the U.S. Congress. This measure examines the impact of the gasoline tax on low income households and assesses the mileage-based user fee as a replacement option.

[10] For more information on potential climate change impact in Southern California, see Southern California Association of Governments and Dan Cayan, Climate Change: What Should Southern California Prepare for?: http://www.scag.ca.gov/documents/climat-echange_dancayan.pdf.

TRANSPORTATION CONFORMITY

REQUIREMENTS

The Federal Clean Air Act (CAA) establishes the National Ambient Air Quality Standards (NAAQS) and planning requirements for certain air pollutants. To comply with the CAA in achieving the national air quality standards, the ARB develops a State Implementation Plan (SIP) for each federal designated non-attainment and maintenance area within California. SIP development is a joint effort of the local air agencies and ARB working with federal, state and local agencies, including regional MPOs.

Transportation conformity is required under the CAA section 176(c) to ensure that federally supported highway and transit project activities "conform" to, or are consistent with, the purpose of the applicable SIP. Conformity for the purpose of the SIP means that transportation activities including regional transportation plans, transportation improvement programs and transportation projects will not cause new air quality violations, worsen existing air quality violations, or delay timely attainment of the relevant NAAQS. Conformity applies to areas that are designated by the U.S. Environmental Protection Agency (EPA) as being in non-attainment or maintenance for the following transportation related criteria pollutants: carbon monoxide (CO), nitrogen dioxide (NO2), ozone, and particulate matter (PM 2.5 and PM 10).

Under the U.S. Department of Transportation Metropolitan Planning regulations and the EPA's Transportation Conformity regulations, the 2016 RTP/SCS is required to pass the following four conformity tests in order to demonstrate transportation conformity:

- Regional Emissions
- Timely Implementation of Transportation Control Measures (TCMs)
- Financial Constraint
- Interagency Consultation and Public Involvement

The Regional Council adopts the initial transportation conformity determination, while FHWA/Federal Transit Administration (FTA) approves the final transportation conformity determination for the 2016 RTP/SCS.

CONFORMITY ANALYSIS AND FINDINGS

As documented in the Transportation Conformity Analysis Appendix, the 2016 RTP/SCS meets all federal transportation conformity requirements and demonstrates transportation conformity. The findings associated with the conformity tests are described in detail in the Transportation Conformity Analysis Appendix.

TRANSPORTATION CONFORMITY AND GREENHOUSE GAS EMISSION REDUCTION TARGETS

Although transportation conformity is a federal requirement and reducing greenhouse gas emissions is a state mandate, both requirements are highly interrelated. First of all, each of the 2016 RTP/SCS policies, strategies, programs and projects that contribute to transportation conformity are the same policies, strategies, programs and projects that help to meet state targets for reducing greenhouse gas emissions—and vice versa. Secondly, although transportation conformity addresses emissions of criteria pollutants and their precursors, such emissions originate from the same source as greenhouse gas emissions: the combustion of fossil fuels in motor vehicles.

Any strategies that result in reduction or elimination of use of fossil fuels in motor vehicles may help the 2016 RTP/SCS meet both federal transportation conformity requirements and state greenhouse gas emissions reduction targets. In addition, the regional emissions analysis used for transportation conformity and the emissions analysis conducted for meeting greenhouse gas reduction targets use the same regional transportation model and ARB's Emission Factors (EMFAC) model. Finally, there is greater awareness of the need for more concerted efforts at the federal, state and local levels to integrate the SIP development process with planning and actions to address climate change. As a result, transportation conformity and greenhouse gas emissions reductions will become even more interconnected and more mutually supportive.

CONCLUSION

As we look toward mid-century, it is important to consider what the region can do beyond the transportation projects for which we expect to have funding. In our final chapter, 'Looking Ahead,' additional strategies and investments will be presented that would bring the SCAG region closer to achieving our goals for improved mobility and accessibility, a strong economic future, sustainable growth, and ultimately an enhanced quality of life for everyone in our region.

09

Image courtesy of Allan Crawford

CHAPTER 9 HIGHLIGHTS

LOOKING AHEAD

This Plan has discussed many long-term needs for our region's transportation system. Despite $556.5 billion in investments reviewed in the 2016 RTP/SCS, this still will not be enough to address all of our needs as we head toward mid-century. In addition, as noted earlier, state policies will continue to push the region to achieve sustainability goals beyond the horizon of the plan.

INTRODUCTION

The implication of the Governor's Executive Order B-30-15, referenced earlier, is that state-mandated targets to reduce greenhouse gas emissions will likely become more ambitious and will be extended to target years beyond 2040. The first part of this chapter describes the 2016 Regional Strategic Plan, a list of projects without identified funding that would benefit mobility in the region. The second part of this chapter, which concludes this presentation of the 2016 RTP/SCS, provides insight into developments that will impact the region beyond 2040.

THE 2016 STRATEGIC PLAN

This chapter serves as a Strategic Plan for discussing what strategies, programs and projects the region should pursue in coming decades if and when additional funding becomes available. This Strategic Plan is intended to help inform future updates to SCAG's RTP/SCS, beyond the 2016 RTP/SCS. Back in 2008, SCAG first developed a Strategic Plan to guide long-term decisions for transportation investments and strategies. The Strategic Plan in the agency's 2008 RTP helped inform what kinds of investments to include in the 2012 RTP/SCS—as part of that Plan's financially constrained transportation network.

Not surprisingly, the Strategic Plan included in the 2012 RTP/SCS played a large role in informing the investments and strategies detailed in the Financially Constrained Plan of the 2016 RTP/SCS (also referred to as the "Constrained Plan"). Among these are:

- **Promoting Active Transportation:** The 2012 Strategic Plan called for further enhancements to the active transportation system, including an increased focus on first/last mile connections to and from public transit, increasing the density of bikeways, incorporating Complete Streets practices that make streets friendlier to pedestrians and bicyclists, and increasing connectivity for pedestrians and bicyclists between jurisdictions. As part of the 2012 RTP/SCS, $6.7 billion was allocated for active transportation. Since the 2012 RTP/SCS was adopted, active transportation has been recognized as a regional priority, not just a local priority. Orange County began work on a strategic bikeway network and completed the first portion in 2012, and it is fully incorporated into the 2016 RTP/SCS. Meanwhile, Los Angeles County is developing its own Active Transportation Strategic Plan.
- **Expanding the High-Occupancy Vehicle (HOV) Lanes System:** The 2012 Strategic Plan recommended expanding our regionwide HOV lane network, although these improvements were unfunded. The 2016 RTP/SCS now fully funds an HOV expansion project within Orange County as part of its Constrained Plan.
- **Improving Local Highway Grade Separations:** The 2012 Strategic Plan recommended constructing grade separations on our local highways, although these improvements were unfunded as well. The 2016 RTP/SCS fully funds several grade separation projects throughout the region as part of its Constrained Plan.

It is clear that the 2012 Strategic Plan played a large role in influencing the 2016 Constrained Plan, as intended. Moving forward, we expect the Strategic Plan discussed in this chapter will help inform future RTP/SCS updates. Should additional funding become available to pursue projects beyond our Constrained Plan, more consensus would be needed and in some cases further studies would be warranted before specific projects could move forward.

LONG-TERM EMISSIONS-REDUCTION STRATEGIES FOR RAIL

As part of our current Strategic Plan, we will continue ongoing work with railroads, air quality management agencies and other stakeholders to reach our goal of a zero-emissions rail system.

FREIGHT RAIL

Achieving a rail system with zero emissions will be challenging because freight rail operates as a national system and locomotives cannot remain captive to our region. Any new technology will require an operational strategy to change out locomotive types, or it will require compatible infrastructure nationwide to provide new types of cleaner power and/or fuel to locomotives.

These challenges are formidable, but several near zero- and zero-emissions rail technologies are actually under development. A zero-emissions rail system would require full electrification and such a system could be powered by electric catenary or linear synchronous motors. There are also options for a hybrid-electric engine or a battery tender car, which provide additional power, allowing locomotives to operate in zero-emissions mode while battery power is available.

Opportunities for near zero-emissions include incorporating liquid natural gas tender cars and after treatment systems. Tier 4 engines and earlier engine types can be retrofitted to operate with natural gas, though safety and operational issues remain challenging. Additional after-treatment options are in the conceptual stage, which could go beyond Tier 4 standards.

Please see the Goods Movement Appendix for more detail on these technologies, as well as a plan to deploy these technologies as they become commercially viable.

CALIFORNIA HIGH-SPEED TRAIN

The California High-Speed Train will be electrified and will therefore produce no emissions along its operating corridors. Furthermore, the California High-Speed Rail Authority (CHSRA) has committed to using 100 percent renewable energy to power its trains. Because of the expected reduction in air and auto travel, the CHSRA estimates its service will save 2.0 million to 3.2 million barrels of oil annually, beginning in 2030.[1] With plans for a zero-emissions high-speed rail system in Southern California, and as the freight rail sector makes advances in near zero- and zero-emissions technologies, the region's passenger and commuter rail systems should pursue a similar strategic vision.

LONG-TERM EMISSIONS-REDUCTION STRATEGIES FOR TRUCKS

The reduction or elimination of emissions from heavy-duty trucking is equally important to our long-term vision of a zero-emissions goods movement system. In the near term, our 2016 RTP/SCS proposes an aggressive program to bring into service more clean fuel trucks and hybrid trucks that are now available. For the longer term, we provide a detailed plan to advance zero-emissions truck technologies, as described in the Goods Movement Appendix.

The trucking market offers unique challenges because of heavy vehicle and load weights, operational performance requirements, and high incremental costs. However, several reduced-emissions trucks are commercially available now and many zero- and near zero-emissions trucks are under development. Reduced-emissions natural gas trucks already have been deployed at our region's ports and several hundred hybrid electric trucks are on the road due to the Hybrid Truck and Bus Voucher Incentive Project (HVIP) at the California Air Resources Board.

Other promising technologies include plug-in hybrid-electric trucks, which have batteries that are charged through an external power source; battery-electric trucks, which can generate their own power or receive power from an outside source; and hydrogen fuel cell electric trucks. The South Coast Air Quality Management District (SCAQMD) is leading several ongoing demonstration programs, with funding from regional partners and state and federal agencies that are developing prototype zero-emissions trucks. These programs are also accessing the compatibility of these trucks with wayside power charging infrastructure. These demonstration programs rely on partnerships with original equipment manufacturers that can develop truck prototypes and with private sector partners that can test and evaluate prototypes in real world operating conditions.

For more information on the steps toward development and deployment of these technologies and more detail about potential technologies, please see the Goods Movement Appendix.

UNFUNDED OPERATIONAL IMPROVEMENTS

Well-targeted investments to improve our roadways can yield numerous benefits. Adding auxiliary lanes and managed lanes; improving interchanges; deploying on-ramp metering devices and adaptive signals; and other ITS enhancements can make the entire roadway system more efficient, increase capacity and help reduce congestion. Caltrans Corridor System Management Plans (CSMPs) have identified a number of improvements throughout the State Highway System (SHS) to improve productivity. The future development of corridor mobility and sustainability improvement plans (i.e., Corridor Sustainability Studies) for various corridors throughout the SCAG region may also identify future operational improvements not only within the SHS, but for all modes of travel throughout the region.

UNFUNDED CAPITAL IMPROVEMENTS

Regionally significant major corridor improvements and strategies described in the Strategic Plan are identified in TABLE 9.1. A complete list is contained in the 2016 RTP/SCS Project List contained as part of Project List Appendix.

[1] California High Speed Rail Authority. Environmental Fact Sheet, August 2014.

EXPANDING OUR REGION'S HIGH-SPEED TRAIN SYSTEM

CALIFORNIA HIGH-SPEED TRAIN

The California High-Speed Train will provide people with an additional option for traveling within the state, offering an alternative to flying and driving. This will be especially important as highways and airports continue to become more congested and constrained as California's population continues to grow. Phase One of the system, approved by voters, extends from the Kern County line in our region through Palmdale and Burbank to Los Angeles Union Station and Anaheim. Phase Two, extending from downtown Los Angeles to San Diego, will link many urban areas and other destinations within our Southern California region via the San Gabriel Valley and the Inland Empire. This corridor is about 160 miles long and it traverses Los Angeles, Riverside, San Bernardino and San Diego counties. With more than 21 million residents, these four counties make up about 56 percent of the state's current population. And they're projected to grow significantly by 2050.

Upon completion, Phase Two will provide important access to planned and existing regional centers, including Ontario International Airport, the March Inland Port, and potentially San Bernardino International and Corona airports—helping to meet SCAG's long-term goal of regionalizing air travel in Southern California. Eventually, Phase Two is expected to be the basis for further high-speed rail extensions into Nevada and Arizona.

Phase One and Two of the California High-Speed Train will provide excellent regional connectivity to our region by connecting with a robust network of intercity and commuter rail, subway, light rail, modern streetcars and fixed-route transit systems. Integrated planning will allow these regional and local transportation networks to complement the High-Speed Train. Commuter, intercity and interregional rail services and transit serve distinct travel markets, but coordinating their schedules will further increase the region's rail and transit ridership by attracting new and crossover passengers to these different market segments.

XPRESSWEST

In addition to the California High-Speed Train, our region has other important high-speed rail projects in development. XpressWest is a high-speed rail service that will connect Victorville and Las Vegas along the Interstate 15 corridor and connect via the High Desert Corridor to Palmdale and California High-Speed Train Phase One. It will use "steel wheel on steel rail" electric multiple unit train technology, at speeds of up to 150 miles per hour (mph).

TABLE 9.1 MAJOR STRATEGIC PLAN PROJECTS
IMPERIAL COUNTY
SR-111 Corridor Improvements
LOS ANGELES COUNTY
Metro Blue Line Extension to California State University Long Beach
Metro Gold Line Eastside Extension Beyond Phase II Terminus
Metro Green Line Extension to San Pedro, Long Beach and LA/Orange County Line
Metro Orange Line Extension to Burbank Bob Hope Airport
Orangeline High-Speed Transit (Union Station to Santa Clarita)
I-605 HOV lanes from I-10 to I-210
ORANGE COUNTY
Additional Transit Station Improvements to Fullerton Transportation Center and Santa Ana Regional Transportation Center
Fullerton College Connector
SR-133 Multimodal Corridor Improvements
RIVERSIDE COUNTY
Coachella Valley Daily Rail Service between Downtown Los Angeles and Indio
CETAP - Riverside County to Orange County
Perris Valley Line Extension to Temecula
SAN BERNARDINO COUNTY
San Bernardino Mountain-Valley Railway System between San Bernardino/Highland and Big Bear Lake
VENTURA COUNTY
Santa Paula Branch Line
VARIOUS COUNTIES
Cordon Pricing Demonstration Projects (locations to be determined)
California High-Speed Train System Phase 2
California/Nevada Super-Speed Train Anaheim to Las Vegas
Expanded Express Lane Network (beyond Constrained Plan)
Long-Term Goods Movement Emission-Reduction Strategies for Rail and Trucks
Mileage-Based User Fee Demonstration Projects and Implementation Strategy
Additional Metrolink and LOSSAN Improvements (beyond financially constrained plan)
XpressWest High-Speed Rail Between Palmdale-Victorville-Las Vegas

That would result in a trip between Victorville and Las Vegas lasting only 80 minutes. XpressWest has secured federal environmental Records of Decision and authorization to construct and operate. In November 2015, XpressWest was awarded the franchise to construct and operate high-speed rail service within Nevada between Southern California and Las Vegas by the Nevada High Speed Rail Authority.

SOUTHWEST HIGH-SPEED RAIL

In September 2014, the Federal Railroad Administration (FRA) released the *Southwest Multi-State Rail Planning Study*. This study analyzed candidate high-speed rail corridors in several southwest states. California, Nevada and Arizona are included as the "primary" area and New Mexico, Utah and Colorado are included as the "extended" area. The study includes:

1. "Core Express" with top speeds greater than 125 mph
2. "Regional" with top speeds of 90 mph to 125 mph
3. "Emerging/Feeder" with top speeds up to 90 mph

The California High-Speed Train and XpressWest corridors were identified as Core Express corridors in the study. The study also recommended a particular emphasis on the Phoenix to Southern California corridor as a future high-speed rail market to be studied.

EXPANDING OUR REGION'S COMMUTER RAIL SYSTEM

METROLINK AND PACIFIC SURFLINER

Both the Amtrak Pacific Surfliner and Metrolink are forecast to significantly increase their ridership and number of daily trains through 2040. The Constrained Plan of this 2016 RTP/SCS includes funding the first $1 billion of the Southern California High-Speed Rail Memorandum of Understanding (MOU). However, this $1 billion investment only funds the top 12 projects on the project list, which contains 74 projects totaling $4 billion. Metrolink recently completed its long-range Strategic Assessment in 2016 and it forecasts growth in the number of daily trains from 165 current weekday trains today to 240 weekday trains by 2025. In addition, the 2012 Los Angeles–San Diego–San Luis Obispo Rail Corridor (LOSSAN) Strategic Implementation Plan (SIP) forecasts up to 310 weekday Metrolink trains by 2040. For the Amtrak Pacific Surfliner, the SIP forecasts up to 18 daily round trips between downtown Los Angeles and San Diego, and additional round trips between downtown Los Angeles and Santa Barbara and San Luis Obispo. Additionally, the SIP includes:

- New East Ventura to Santa Barbara commuter service with four round trips per day
- New Los Angeles to San Diego commuter service with five round trips per day (operations split between Metrolink and Coaster)
- New express service with four round trips per day (operations split between Metrolink and the Pacific Surfliner)
- New Metrolink service to San Jacinto with eight round trips per day

Today, the average speed for Metrolink is about 37 mph, and the average speed for the Pacific Surfliner is 46 mph. Average speeds vary by line, and while top speeds are 79 mph (and a segment of 90 mph through Camp Pendleton), predominant one-track operations in our region greatly reduce the average system speed. Even if all 74 of the MOU projects are built, our region will still have large portions of its rail network constrained by one-track operations. This reinforces the need to fund capital projects in order to speed up service and make passenger rail more attractive to the commuter who drives alone. SCAG's Strategic Plan vision for speed and service improvements to Metrolink and Pacific Surfliner calls for an intensive investment in capital projects to further increase speed and service levels over and above the Constrained Plan. The Strategic Plan results in even more segments of the network operating at speeds of 110 mph or more. These projects include additional double tracking, sidings, station improvements, grade separations and grade crossings. Not only will this benefit commuter rail trips in our region, it will benefit Amtrak intercity and California High-Speed Train interregional trips also, as the three systems feed and complement one another. While these rail networks serve three distinct travel markets, improving all three will encourage people to consider and use all three in their travel decisions, rather than be limited to any single mode of transportation.

In addition to capital improvements, our strategic vision calls for considerably more express trips, regular special event services, and implementation of new Bus Rapid Transit (BRT) services that directly connect with Metrolink and the Pacific Surfliner.

EXPANDING ACTIVE TRANSPORTATION

There is great potential for walking, biking and other forms of active transportation to expand beyond what is proposed in this 2016 RTP/SCS. Policies designed to reduce greenhouse gas emissions will continue to highlight active transportation as a key step toward a more sustainable region. As transit service expands and a wider range of shared-mobility options become available, active transportation will serve regional mobility, ensuring that people can quickly, easily and safely transfer from one mode of transportation to the next. Active transportation also plays a critical role in helping the region to realize its vision for how it uses land, which includes accommodating more people in vibrant, mixed-use communities and urban centers. Sidewalks and active transportation networks contribute to the attractiveness and economic vitality of mixed-use communities. They also play an important role in reducing congestion and increasing mobility.

EXPANDED REGIONAL GREENWAY NETWORK

New active transportation plans by local jurisdictions will aspire beyond what is considered in the 2016 RTP/SCS Constrained Plan, and as a result new innovative strategies will be tested and proven effective throughout our region. One expected innovation is to create greater physical separations between bicyclists and motor vehicles, particularly on higher-speed streets. Separated bikeways and Class 1 bikeways are considerably more expensive options than installing bike lanes or sharrows, but these more expensive options have been shown to increase ridership.[2] The SCAG region currently has four miles of separated bikeways and these now operate on an "experimental" basis in local jurisdictions such as Long Beach and Redondo Beach. Caltrans is developing guidelines to incorporate separated bikeways into the California Manual for Uniform Traffic Control Devices (MUTCD). Once incorporated, local governments will be able to freely incorporate separated bikeways without incurring liability. In this Strategic Plan, SCAG assumes that our region will have about 230 miles of new separated bikeways converted from bike lanes on arterial streets. As part of the effort to develop separated bikeways, this Strategic Plan envisions greater integration of watershed planning, river rehabilitation, and access for bicyclists and pedestrians. It further envisions the use of open area drainage channels that were once creeks, and the maintenance roads next to them for walking and biking. It envisions greater coordination of rights of way under utility lines.

[2] Chapter 3: Why Choose Separated Bike Lanes? (2015). In Separated Bike Lane Planning and Design Guide. Federal Highway Administration.

EXPANDED BIKE SHARE

Bike Share, an innovative program in which people can share bicycles, can be expanded beyond the 880 stations regionwide that are envisioned in the Constrained Plan. Because it is such a new service, more local jurisdictions may wish to deploy bike share facilities where they can. This Strategic Plan anticipates an additional 1,084 stations regionwide, should funding become available.

FIRST/LAST MILE

The first/last mile challenge, which deters many people from using transit, can be alleviated as more than 200 high quality transit stations identified in the Strategic Plan Project List increases to nearly 700 stations as urban areas become more developed and more bus routes offer people higher quality transit choices.

LIVABLE CORRIDORS

Pedestrian travel will also increase substantially as a consequence of higher density development. New treatments installed as part of routine roadway maintenance, such as bulb-outs, sanctuary islands and innovative midblock crossing signals such as the high-intensity activated crosswalk beacon (commonly referred to as "HAWK") will increase pedestrian safety. These treatments will expand livable corridors by 93 percent beyond the 16 areas in the Constrained Plan into new areas focusing on transit growth and new "village" development along new corridors. Funding for some of these treatments will come during the development process, through focused developer fees, or by pursuing other innovative funding strategies. Meanwhile, bicycle treatments such as bike racks and long-term secure bike parking will increase the convenience of biking.

NEIGHBORHOOD MOBILITY AREAS

Utilizing Complete Streets principles and applying them aggressively in the planning and implementation of neighborhood roadway improvements will increase mobility further. Traffic calming, combined with land use changes, will provide more opportunities for bicycling and walking in less urban settings such as local "village areas" with sidewalk café seating and local farmers markets. Connections to these villages will be promoted by strategies that tackle the first/last mile challenge that transit faces. Bicycle boulevards and other lower-speed streets that give bicycles priority have been shown to be effective at calming traffic, while increasing safety and bicyclist connectivity. This Strategic Plan sees local governments increasing the use of Complete Streets principles in their roadway improvements, expanding these areas beyond what is in the

Constrained Plan, increasing bikeway density and improving the quality of life for even more residents.

STRATEGIC FINANCE

VALUE PRICING STRATEGY

Following the adoption of the 2008 RTP, SCAG initiated a comprehensive study of value pricing strategies, which has come to be known as the Express Travel Choices Study. The emerging regional value pricing strategy is structured to help the region meet its transportation demand management and air quality goals, while also providing a reliable and dedicated source of revenue. The value pricing strategy could allow users of the transportation system to know the true cost of their travel, resulting in informed decision-making and a more efficient use of the transportation system. Value pricing strategies evaluated through the Express Travel Choices Study include a regional express lane network, cordon pricing and a mileage-based user fee. Although some of these pricing concepts have been incorporated into the Constrained Plan as elements are pursued as pilot initiatives or are under construction for implementation (e.g., segments of the regional express lane network), these strategies still face a number of significant hurdles before their full benefits can be realized. A second phase of the Express Travel Choices Study, initiated after the adoption of the 2012 RTP/SCS and ongoing, continues to establish an implementation plan for the regional value pricing strategy.

As we discussed in Chapter 6, SCAG will also continue to participate in state and national efforts to address the long-term transition of excise fuel taxes to mileage-based user fees.

OUR REGION BEYOND 2040

TECHNOLOGY AND NEW MOBILITY INNOVATIONS BEYOND 2040

Technological innovations have the potential to make existing transportation choices more widely available and easier to use throughout the region. By providing more options for local and regional trips, technological innovations have the potential to shift travel to less environmentally damaging modes, lessen the negative environmental impacts associated with current vehicle use, increase system efficiency, improve safety, and reduce auto-related collisions and fatalities. However, realizing the potential benefits (and potential negative impacts) depends on the rate of development and the adoption of a wide range of public and private sector innovations. Although SCAG and its partners should be prepared for the widest possible range of technological advancements related to the transportation system, quantifying the benefits of certain new mobility innovations may be premature due to uncertain fluctuations in future market demand.

Many of these new applications and transportation services are being discussed in the media, and there are some reservations about how long they will last. Although they may have limited applicability in many parts of our region today, there is little doubt that certain technological innovations in transportation will grow significantly during the time frame of the 2016 RTP/SCS and beyond. The population in 2040 will have an entirely different expectation of the role of technology in their everyday lives than generations past. Changing demographics and broad economic trends have led to a demand for more flexible transportation options, the expansion of the sharing economy and calls for communities where people can live, work and play within a small area. This Plan reflects the ever-expanding portfolio of new mobility innovations that advanced technologies can enable and considers their long-term, regional impacts.

Currently, the clean technology industry and application developers outpace government in delivering technological innovation to the transportation sector. In light of this, SCAG continues to research the impacts of transportation innovation in terms of scale and longevity, looking at things such whether a technology or innovation will be amenable to only a small segment of the population and/or last for 10, 15 or 30 years? Or, are we at the outset of a major paradigm shift? Are tipping points just around the corner? Will the longstanding trend of the majority of trips taken by automobile persist?

The 2012 RTP/SCS identified policies to support a number of best practices and technological innovations that were not fully modeled at the time, such as alternative fuel vehicles and neighborhood electric vehicles. This 2016 RTP/SCS addresses new transportation innovations that have been planned and deployed since 2012, such as neighborhood electric vehicles (NEV), car sharing, bike sharing and ridesourcing (identified by the California Public Utilities Commission (CPUC) as Transportation Network Companies). SCAG has developed modeling assumptions and methodologies to analyze these mobility innovations and local land use regulations.

In addition to the new mobility innovations mentioned above, the region can expect to see significant growth in the deployment and use of automated vehicles. By some estimates, automation features being introduced within the next five years could be available in up to 70 percent of the vehicles on the road in 2040. The following are some examples of automated driving features that need to be considered and supported. There are a wide range of demonstration projects that could be pursued by SCAG and its partners, in collaboration with private sector organizations with increased federal, state and local funding:

- **Jam-Assist and Advanced Collision Avoidance:** Combining advanced collision detection and avoidance technology currently in development, vehicles will operate "hands-off" and "feet-off" on highways. These features could also improve operation in low-speed environments. Equipping transit vehicles with jam assist could dramatically improve vehicle throughput in congested transit-only corridors, or in Bus Rapid Transit systems.
- **Semi-Automated Mode Vehicles:** Vehicles will operate without driver input under certain limited conditions, while requiring driver input for most portions of the trip. This is the current state of technology with the Google car. However, safety and traffic benefits will begin to spread throughout the roadway network as this technology advances. Vehicles will be able to operate without driver input, although the driver will need to monitor the vehicle's operation. These features could be available in both consumer and commercial vehicles as early as 2018–2020 and could represent a sizable minority of the fleet mix as early as 2030–2035.
- **Fully Automated Mode Vehicles:** Vehicles will operate without driver input in certain conditions, requiring driver input for other portions of the trip. Most researchers agree that this will be the mid-term state of vehicle automation. In highway driving conditions, drivers will turn over full control of the vehicle and vehicle systems will communicate with one another. Vehicles will be able to form "platoons" in order to operate at closer distances (less than 1.8 seconds apart in one Japanese study) in order to improve fuel consumption and traffic flows. Freight industry representatives are interested in whether the National Highway Traffic Safety Administration (NHTSA) will waive driver work hour limits for following vehicles under platooning conditions. In low-speed conditions, "platooning" could improve transit bus operations and automation could improve bus/curb alignment. To some researchers, this could facilitate a new business model of mobility—as a service similar to the way cellphone plans are priced, especially in dense urban areas.
- **Fully Automated Vehicles:** Vehicles will operate without driver input, but will still require a driver to monitor the vehicle. The vehicle will navigate trips from beginning to end and possibly self-park within low-speed environments. This technology could potentially be available as early as 2025–2030, but it will not be used in a significant share of vehicles until 2035–2040.
- **Fully Autonomous Vehicles:** Passenger vehicles will operate with or without drivers, resulting in radical changes to urban form. Cars will park themselves, attend to maintenance and refueling, or alter ownership patterns so that they stay in constant circulation. Driverless taxi, freight and transit vehicles could have a dramatic impact on various professional driving careers.

ADDRESSING SUSTAINABILITY AND GREENHOUSE GAS EMISSIONS BEYOND 2040

In addition to Governor Brown's Executive Order discussed earlier, a number of policy trends are converging that will continue to push the state and region toward increasing de-carbonization of the transportation and energy sectors. Over the past 20 years, the international community has outlined a goal of limiting global warming to two degrees Celsius above pre-industrial levels. In the context of California, these trends include advancing beyond the Governor's Executive Order goal of reducing greenhouse gas emissions by 80 percent below 1990 levels by 2050 to reducing greenhouse gas emissions by 100 percent later in the century. This could be accomplished in stages through various market and regulatory tools such as the Cap-and-Trade program and updates to the Assembly Bill 32 Scoping Plan. Electrification of the transportation sector over the next few decades is likely to be one outcome of these trends. The California Energy Commission (CEC) is also developing net zero energy building policies. Caltrans has prepared a new state transportation plan to significantly reduce vehicle miles traveled. Through the Senate Bill 375 target setting process, ARB will likely propose higher greenhouse gas reduction targets for metropolitan planning organizations through the continued integration of transportation and land use planning. Finally, Cap-and-Trade Triennial Investment Plans will continue to be updated to fund the implementation of greenhouse reduction goals.

However, the international science community is increasingly concerned that the two degrees Celsius goal is not stringent enough to avoid significant and perhaps irreversible climate damage to the planet, and serious discussions are occurring to reduce the international goal to 1.5 degrees Celsius. Whether or not a consensus develops to intensify the climate change goals, California policymakers recognize the incredibly significant role of local jurisdictions and regions in taking climate action. Local jurisdictions and regions should expect to face new regulations and targets to significantly reduce greenhouse gas emissions for many decades ahead.

PREPARING THE REGION FOR RESILIENCY AGAINST CLIMATE CHANGE

In addition to creating a low-carbon sustainable future, the state and region will also be facing the human and infrastructure costs of adapting to climate change impacts that already are occurring. These include growing wildfire threats, sea-level rise and coastal flooding, increased mudslides and flooding, extreme heat waves and large reductions in water supplies.

Our region must prepare to confront these changes, and an important objective of this Strategic Plan is to build a region that is more resilient to these and other consequences of climate change. The twin policy goals of mitigation and adaptation will dominate state, regional and local planning for energy, water and transportation for the rest of this century. New collaborative programs and partnerships between businesses, academia, community groups, residents and all levels of government will be required.

Here is a simple but compelling example of how our region can become more resilient to the consequences of climate change: first/last mile strategies call for steps to make it easier for people to get to and from transit stops, such as building sidewalks and bike paths and installing places where people can lock up their bicycles near transit stations. These investments make transit more accessible while helping the region meet its goal of reducing the number of miles that people travel alone in their cars. But to make first/last mile strategies effective as our region faces more frequent days of extreme heat and intense rainstorms, they have to be refined. A more climate resilient strategy would be to design sidewalks and bike paths with native drought tolerant shade trees, as well as adding shade features at transit stations. Also, as pedestrian infrastructure is built, it should include adequate drainage and other storm water management features, to ensure access and safety during heavy rainstorms.

Looking to the state for recommendations on how to mitigate and adapt to climate change is challenging because its policies are evolving. Still, they come with a sense of urgency.[3] The State of California recognizes the increasingly significant role that regional planning and local actions can play in meeting the state-level goals related to climate change. SCAG will continue to help the region further develop into a hub for local and regional government innovation, leadership and collaboration. For example, SCAG funded the Green Region Initiative category of projects, as part of the Sustainability Planning Grant Program. These grants provide local governments with technical expertise so they can develop local climate action plans, energy plans, water plans, open space strategies and public health plans. Working to make our region more resilient to the inevitable consequences of continued climate change is a major priority of this Plan, and it will continue to resonate in future updates as we head toward 2040 and well beyond.

CONCLUSION

As our region continues to grow in the coming years, we must ensure that effective strategies are in place toward fulfilling the needs of our growing population. With the understanding that our Constrained Plan can only get us so far, additional strategies must be considered to truly address the diverse needs of everyone who uses the regional transportation network.

The challenges ahead as we strive toward increased mobility, more livable and healthy communities and a more sustainable region are significant. But this Plan, the 2016 RTP/SCS, charts a course toward progress. It serves as a roadmap toward 2040 and a vision for a better future. It is a living document and it will change as circumstances change as we progress toward mid-century.

Above all, our RTP/SCS is a collective and inclusive effort—one that aims for a bright future for all of us.

[3] See California State Executive Order B-30-15.

GLOSSARY

AASHTO American Association of State Highway and Transportation Officials – A nonprofit, non-partisan association representing highway and transportation departments in the 50 states, the District of Columbia and Puerto Rico.

AB 32 Assembly Bill 32 – Signed into law on September 26, 2006, it requires that the state's global warming emissions be reduced to 1990 levels by 2020. This reduction will be accomplished through an enforceable statewide cap on global warming emissions that will be phased in starting in 2012 in addition to other measures. In order to effectively implement the cap, AB 32 directs the California Air Resources Board (ARB) to develop appropriate regulations and establish a mandatory reporting system to track and monitor global warming emissions levels.

AB 169 Assembly Bill 169 – Provides for the sixteen federally recognized tribes in the SCAG region to join the SCAG Joint Powers Authority (JPA) to participate in the Southern California Association of Governments by voting at the SCAG General Assembly.

ACE Alameda Corridor East – A 35-mile corridor extending through the San Gabriel Valley between East Los Angeles and Pomona and connecting the Alameda Corridor to the transcontinental railroad network.

Active Transportation A mode of transportation that includes walking, running, biking, skateboarding and other human powered forms of transportation. It can also include low-speed electrical devices such as motorized wheel chairs, Segways, electric-assist bicycles and neighborhood electric vehicles, such as golf carts.

ADA Americans with Disabilities Act of 1990 – Guarantees equal opportunity for individuals with disabilities in public accommodations, employment, transportation, state and local government services and telecommunications. It prescribes federal transportation requirements for transportation providers.

Agricultural Lands Land designated for farming; specifically the production of crops and rearing of animals to provide food and other products.

AHSC Affordable Housing and Sustainable Communities – A state grant program from the Greenhouse Gas Reduction Fund that addresses land-use, housing, transportation and land preservation projects to support infill and compact development to reduce greenhouse gas emissions.

AJR 40 Assembly Joint Resolution No. 40 – Introduced on August 23, 2007, the resolution calls upon the governor to declare a state of emergency in respect to the air quality health crisis in the South Coast Air Quality Basin related to emissions of PM 2.5 and to direct steps necessary to address the emergency.

ANCA Federal Airport Noise and Capacity Act of 1990 – Establishes a national aviation noise policy that reviews airport noise and access restrictions on operations for Stage 2 and Stage 3 aircraft.

Antelope Valley AQMD Antelope Valley Air Quality Management District – The air pollution control agency for the portion of Los Angeles County north of the San Gabriel Mountains.

AQMP Air Quality Management Plan – Regional plan for air quality improvement in compliance with federal and state requirements.

ARB Air Resources Board – State agency responsible for attaining and maintaining healthy air quality through setting and enforcing emissions standards, conducting research, monitoring air quality, providing education and outreach and overseeing/assisting local air quality districts. ARB is also responsible for implementing AB 32 and establishing regional greenhouse gas emission reduction targets for automobile and light trucks under SB 375.

ATIS Advanced Traveler Information Systems – Technology used to provide travelers with information, both pre-trip and in-vehicle, so they can better utilize the transportation system.

ATMS Advanced Transportation Management Systems – Technology used to improve the operations of the transportation network.

ATP Active Transportation Program – Provides state funds for city and county projects that improve safety and convenience for bicycle commuters, recreational riders and safe routes to school programs. Replaces the Bicycle Transportation Account (BTA).

Automated Vehicle U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) has defined five increasing levels of vehicle automation at five levels:
0. No-Automation: The driver is in complete and sole control of the primary vehicle controls .
1. Function-Specific Automation: Automation at this level involves one or more specific control functions.
2. Combined Function Automation: This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions.
3. Limited Self-Driving Automation: Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions.
4. Full Self-Driving Automation: The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip.

Autonomous Vehicle Vehicles in which operation of the vehicle occurs without direct driver input to control the steering, acceleration and braking and are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode.

AVO Average Vehicle Occupancy – Calculated by dividing the total number of travelers by the total number of vehicles.

Base Year The year 2012, used in the RTP/SCS performance analysis as a reference point for current conditions.

Baseline Future scenario which includes only those projects that are existing, undergoing right-of-way acquisition or construction, come from the first year of the previous RTP or RTIP, or have completed the NEPA process. The Baseline is based upon the adopted 2015 FTIP. The Baseline functions as the "No Project" alternative used in the RTP/SCS Program EIR.

BEV Battery Electric Vehicle – An electric drive vehicle powertrain that is powered by an on-board battery. A BEV is a sub-class of Plug-in Electric Vehicle.

Bikeway Common term for any designated bicycle facility, such as a bike path, bike lane, bike route, sharrow, bicycle boulevard or cycle-track.

Bike Share An integrated network of bicycle rental kiosks in heavily urbanized areas. The bike share network is intended to reduce short-distance driving by providing low-cost bicycle rentals at regular intervals (200 yards apart) throughout the heavily urbanized area.

BLS Bureau of Labor Statistics – The principal fact-finding agency for the federal government in the broad field of labor economics and statistics.

BNSF Burlington Northern and Santa Fe Railway Company.

BTA Bicycle Transportation Account – Provides state funds for city and county projects that improve safety and convenience for bicycle commuters. Replaced by the California Active Transportation Program (ATP).

Bus A transit mode comprised of rubber-tired passenger vehicles operating on fixed-routes and schedules over roadways.

BRT Bus Rapid Transit – Bus transit service that seeks to reduce travel time through measures such as traffic signal priority, automatic vehicle location, dedicated bus lanes, limited-stop service and faster fare collection policies.

CAA Clean Air Act – 1970 federal act that authorized EPA to establish air quality standards to limit levels of pollutants in the air. EPA has promulgated such standards (or NAAQS) for six criteria pollutants sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone, lead and particulate matter (PM 10). All areas of the United States must maintain ambient levels of these pollutants below the ceilings established by the NAAQS; any area that does not meet these standards is a "non-attainment" area. States must develop SIPs to explain how they will comply with the CAA. The act was amended in 1977 and again in 1990.

CAFR Comprehensive Annual Financial Report – Official annual financial report that encompasses all funds and financial components associated with any given organization.

Cal B/C Model California Life-Cycle Benefit/Cost Analysis Model – Developed for the California Department of Transportation (Caltrans) as a tool for benefit-cost analysis of highway and transit projects. It is an Excel (spreadsheet) application structured to analyze several types of transportation improvement projects in a corridor where there already exists a highway facility or a transit service (the base case).

Caltrans California Department of Transportation – State agency responsible for the design, construction, maintenance and operation of the California State Highway System, as well as that portion of the Interstate Highway System within the state's boundaries.

Cap-and-Trade A market based regulation that is designed to reduce greenhouse gases (GHGs) from multiple sources. Cap-and-Trade sets a firm limit or cap on GHGs and minimize the compliance costs of achieving California's AB 32 goals. The cap will decline approximately 3 percent each year beginning in 2013. Trading creates incentives to reduce GHGs below allowable levels through investments in clean technologies. With a carbon market, a price on carbon is established for GHGs. Market forces spur technological innovation and investments in clean energy. Cap-and-Trade is an environmentally effective and economically efficient response to climate change.

Car Share An integrated network of passenger vehicles available for short-term rental in heavily urbanized areas. Car share can take the form of return systems in which a vehicle must be returned to the parking space from which it was rented. Alternatively, it can take the form of point-to-point systems in which the car can be returned to another space, or left anywhere within a pre-determined geographic zone.

Catalytic Demand Additional aviation demand that is created by companies that locate in the proximity of expanding airports with developable land around them to reduce airport ground access time and costs for their employees and clients. Catalytic demand is greatest for large hub airports, particularly international airports.

CEHD Community, Economic and Human Development Committee – A SCAG committee that studies the problems, programs and other matters which pertain to the regional issues of community, economic and human development and growth. This committee reviews projects, plans and programs of regional significance for consistency and conformity with applicable regional plans.

CEQA California Environmental Quality Act – State law providing certain environmental protections that apply to all transportation projects funded with state funds.

CETAP Community Environmental and Transportation Acceptability Process – Part of the Riverside County Integrated Project that is examining where to locate possible major new multimodal transportation facilities to serve the current and future transportation needs of Western Riverside County, while minimizing impacts on communities and the environment.

CHSRA California High-Speed Rail Authority – Agency responsible for planning, designing, constructing and operating a state-of-the-art high-speed rail system in California.

CIP Capital Improvement Program – Long-range strategic plan that identifies capital projects; provides a planning schedule and financing options.

CMAQ Congestion Mitigation and Air Quality Program – Federal program initiated by ISTEA to provide funding for surface transportation and other related projects that contribute to air quality improvements and reduce congestion.

CMIA Corridor Mobility Improvement Account – These funds would be allocated by the California Transportation Commission to highly congested travel corridors in the state. Projects in this category must be a high priority; be able to start construction by 2012; improve mobility in a highly congested corridor by improving travel times and reducing vehicle hours of delay; connect the State Highway System; and improve access to jobs, housing, markets and commerce.

CMP Congestion Management Program – Established by Proposition 111 in 1990, requires each county to develop and adopt a CMP that includes highway and roadway system monitoring, multimodal system performance analysis, transportation demand management program, land-use analysis program and local conformance.

CNSSTC California-Nevada Super-Speed Train Commission – Public-private partnership developed to promote a high-speed link between California and Nevada.

CO Carbon Monoxide – A colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It is a byproduct of highway vehicle exhaust, which contributes about 60 percent of all CO emissions nationwide.

COG Council of Governments – Under state law, a single or multi-county council created by a joint powers agreement.

Complete Streets Streets designed and operated to enable safe access for all roadway users of all ages and abilities, including pedestrians, bicyclists, motorists and transit riders.

Complete Streets Approach An approach to funding for planning, designing and maintaining roadways that incorporates Complete Streets implementation as the variable costs in larger road construction or rehabilitation projects. This approach can dramatically reduce the costs of Complete Streets as compared to implementation of stand-alone projects.

Commuter Bus (CB) Fixed-route bus systems that are primarily connecting outlying areas with a central city through bus service that operates with at least five miles of continuous closed-door service. This service typically operates using motorcoaches (aka over-the-road buses) and usually features peak scheduling, multiple-trip tickets and multiple stops in outlying areas with limited stops in the central city.

Commuter Rail (CR) A transit mode that is an electric or diesel propelled railway for urban passenger train service consisting of local short distance travel operating between a central city and adjacent suburbs. Service must be operated on a regular basis by or under contract with a transit operator for the purpose of transporting passengers within urbanized areas (UZAs), or between urbanized areas and outlying areas. Such rail service, using either locomotive hauled or self-propelled railroad passenger cars, is generally characterized by multi-trip tickets, specific station to station fares, railroad employment practices and usually only one or two stations in a central business district. Commuter Rail does not include heavy rail rapid transit, or light rail/ streetcar transit service, or intercity rail service.

Congestion Management Process Systematic approach required in transportation management areas (TMAs) that provides for effective management and operation, based on a cooperatively developed and implemented metropolitan-wide strategy, of new and existing transportation facilities eligible for funding under Title 23 U.S.C. and Title 49 U.S.C., through the use of operational management strategies.

Connected/ Automated Vehicles Refers to the interrelated nature of connectivity and automation in new vehicle technology. Connected vehicles are vehicles that use any of a number of different communication technologies to communicate with the driver, other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]) and the "Cloud" to improved safety, user experience and collision avoidance.

Constant Dollars Dollars expended/received in a specific year adjusted for inflation/deflation relative to another time period.

Corridor In planning, a broad geographical band that follows a general directional flow or connects major sources of trips. It may contain a number of streets and highways, as well as transit lines and routes.

CSMP Corridor System Management Plans.

CTC California Transportation Commission – Eleven voting members and two non-voting ex-officio members. Nine of the members are appointed by the Governor, one is appointed by the Senate Rules Committee and one is appointed by the Speaker of the Assembly, to oversee and administer state and federal transportation funds and provide oversight on project delivery.

CTIPS California Transportation Improvement Program System – A project programming database system used to efficiently and effectively develop and manage various transportation programming documents as required under state and federal law.

CTP California Transportation Plan – A statewide, long-range transportation policy plan that provides for the movement of people, goods, services and information. The CTP offers a blueprint to guide future transportation decisions and investments that will ensure California's ability to compete globally, provide safe and effective mobility for all persons, better link transportation and land-use decisions, improve air quality and reduce petroleum energy consumption.

CVO Commercial Vehicle Operations – Management of commercial vehicle activities through ITS.

Deficiency Plan Set of provisions contained in a Congestion Management Plan to address congestion when unacceptable levels of congestion occur. Projects implemented through the Deficiency Plan must, by statute, have both mobility and air quality benefits.

Demand Response A transit mode comprised of automobiles, vans, or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations. A demand response (DR) operation is characterized by vehicles that do not operate over a fixed route or on a fixed schedule except on a temporary basis.

Displacement The process that occurs when the increasing property values brought about through gentrification drive out the existing residents and business operators and attract a new and different demographic population to an area. Lower income residents may also become unable to access housing in certain areas due to increasing housing prices. Please also see Gentrification.

DTIM Direct Travel Impact Model – A vehicle emissions forecasting model.

EDF Environmental Defense Fund – A national non-profit organization that seeks to protect the environmental rights of all people, including future generations.

EIR Environmental Impact Report – An informational document, required under CEQA, which will inform public agency decision-makers and the public generally of the significant environmental effects of a project, possible ways to minimize significant effects and reasonable alternatives to the project.

EIS Environmental Impact Statement (federal) – National Environmental Policy Act (NEPA) requirement for assessing the environmental impacts of federal actions that may have a significant impact on the human environment.

EMFAC Emission Factor – Model that estimates on-road motor vehicle emission rates for current year as well as backcasted and forecasted inventories.

Enabling Technology This term refers to a technological innovation which lays the foundation or creates a platform that allows a separate unrelated technology to achieve commercialization. For example, car share and bike share systems have been under development since the early 1970s. However the explosion of smart phone usage and the convergence of mobile banking and GPS location services have made these systems viable for a larger portion of the population.

Environmental Justice (EJ) The concept of Environmental Justice is about equal and fair access to a healthy environment, with the goal of protecting minority and low-income communities from incurring disproportionate negative environmental impacts.

EPA Environmental Protection Agency – Federal agency established to develop and enforce regulations that implement environmental laws enacted by Congress to protect human health and safeguard the natural environment.

Executive Order B-30-15 Executive Order signed by Governor Brown on April 29, 2015, which establishes a California Greenhouse Gas (GHG) reduction target of 40 percent below 1990 levels by 2030.

Express Lane An HOV lane that single-occupant drivers can pay to drive in, also referred to as "High Occupancy Toll Lanes."

EWFC An east-west segment of the Regional Clean Freight Corridor System that connects I-710 to the west and I-15 to the east.

EV Electric Vehicle – A vehicle fully or partially powered by an electric engine. Synonymous with Plug-In Electric Vehicle (PEV).

EV Charging Station A location where a vehicle can be parked and the electric storage or battery can be recharged. EV Charging Stations can be private or publicly accessible and can be free to the user or used for a fee. EV Charging Stations are configured in three different levels defined by the amount of electricity that can be transmitted to the vehicle. Level 1 provides energy through a 120 Volt AC Plug comparable to a household product. Based on the battery type and vehicle, AC Level 1 charging adds about 2 to 5 miles of range to a PEV per hour of charging time. Level 2 equipment offers charging through 208 or 240 V AC electrical connection comparable to a household appliance such as a washing machine. AC Level 2 adds about 10 to 20 miles of range per hour of charging time. Direct-current (DC) fast charging equipment, or Level 3 (typically 208/480 V AC three-phase input), enables rapid charging along heavy traffic corridors and can add 50 to 70 miles of range in about 20 minutes.

FAA Federal Aviation Administration – Federal agency responsible for issuing and enforcing safety regulations and minimum standards, managing air space and air traffic and building and maintaining air navigation facilities.

FAST Act Fixing America's Surface Transportation Act (H.R. 22) – Signed into law by President Obama on December 4, 2016. Funding surface transportation programs at over $305 billion for five years through 2020.

FCV Fuel Cell Vehicle – Electric vehicles that are powered by hydrogen fuel cells.

FHWA Federal Highway Administration – Federal agency responsible for administering the Federal-Aid Highway Program, which provides federal financial assistance to the states to construct and improve the National Highway System, urban and rural roads and bridges.

Financially Constrained Expenditures are said to be financially constrained if they are within limits of anticipated revenues.

First Mile/Last Mile Strategies designed to increase transit usage by making it more convenient and safe to walk or bike to transit stations. Includes such strategies as wayfinding, bikeways, sidewalk repair and bike share.

FRA Federal Railroad Administration – Federal agency created to promulgate and enforce rail safety regulations, administer railroad assistance programs, conduct research and development in support of improved railroad safety and national rail transportation policy and consolidate government support of rail transportation activities.

FTA Federal Transit Administration – The federal agency responsible for administering federal transit funds and assisting in the planning and establishment of areawide urban mass transportation systems. As opposed to FHWA funding, most FTA funds are allocated directly to local agencies, rather than to Caltrans.

FTIP Federal Transportation Improvement Program – A six-year comprehensive listing of transportation projects proposed for federal funding, that require a federal action, or are regionally significant and are within the planning area of an MPO. The last two years are for informational purposes only.

FTZ Foreign Trade Zones.

FY Fiscal Year – The twelve-month period on which the budget is planned. The state fiscal year begins July 1 and ends June 30 of the following year. The federal fiscal year begins October 1 and ends September 30 of the following year.

GAO Government Accountability Office – Congressional agency responsible for examining matters related to the receipt and payment of public funds.

Gentrification While holding many definitions, is commonly understood as a change process in historically low-wealth communities that results in rising real estate values coupled with shifts in the economic, social and cultural demographics and feel of the communities. Please also see Displacement.

GHG Greenhouse Gases – Components of the atmosphere that contribute to the greenhouse effect. The principal greenhouse gases that enter the atmosphere because of human activities are carbon dioxide, methane, nitrous oxide and fluorinated gases.

GGRF Greenhouse Gas Reduction Funds are administered by state and local agencies for a variety of greenhouse gas (GHG) emission reductions programs, including energy efficiency, public transit, low-carbon transportation and affordable housing.

GIS Geographic Information System – Powerful mapping software that links information about where things are with information about what things are like. GIS allows users to examine relationships between features distributed unevenly over space, seeking patterns that may not be apparent without using advanced techniques of query, selection, analysis and display.

GNP Gross National Product – An estimate of the total value of goods and services produced in any specified country in a given year. GNP can be measured as a total amount or an amount per capita.

Grade Crossing A crossing or intersection of highways, railroad tracks, other guideways, or pedestrian walks, or combinations of these at the same level or grade.

Greenfield Also known as "raw land," land that is privately owned, lacks urban services, has not been previously developed and is located at the fringe of existing urban areas.

GRP Gross Regional Product.

HCP Habitat Conservation Plan – Established under Section 10 of the federal Endangered Species Act to allow development to proceed while protecting endangered species. A federal Habitat Conservation Plan is typically accompanied by a state Natural Communities Conservation Plan or NCCP.

HDT Heavy-Duty Truck – Truck with a gross vehicle weight of 8,500 pounds or more.

Heavy Rail A transit mode that is an electric railway with the capacity for a heavy volume of traffic. It is characterized by high speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails, separate rights-of-way (ROW) from which all other vehicular and foot traffic are excluded, sophisticated signaling and raised platform loading.

HiAP Health in All Policies – HiAP is a collaborative strategy that aims to improve public health outcomes by including health considerations in the decision-making process across sectors and policy areas. HiAP addresses the social determinants of health by encouraging transportation practitioners to work with nontraditional partners who have expertise related to public health outcomes, such as city and county public health departments.

HQTA High-Quality Transit Areas – Generally a walkable transit village or corridor, consistent with the adopted RTP/SCS and is within one half-mile of a well-serviced transit stop or a transit corridor with 15-minute or less service frequency during peak commute hours. The definition that SCAG has been using for the HQTA is based on the language in SB 375 which defines:

> **Major Transit Stop** A site containing an existing rail transit station, a ferry terminal served by either a bus or rail transit service, or the intersection of two or more major bus routes with a frequency of service interval of 15 minutes or less during the morning and afternoon peak commute periods (CA Public Resource Code Section 21064.3).
>
> **HQTC** High-Quality Transit Corridor – A corridor with fixed route bus service with service intervals no longer than 15 minutes during peak commute hours.

HICOMP Highway Congestion Monitoring Program (Caltrans) – A report that measures the congestion that occurs on urban area highways in California.

Home-Based Work Trips Trips that go between home and work, either directly or with an intermediate stop. Home-based work trips include telecommuting, working at home and non-motorized transportation work trips.

HOT Lane High-Occupancy Toll Lane – An HOV lane that single-occupant drivers can pay to drive in, also referred to as "Express Lanes."

HOV Lane High-Occupancy Vehicle Lane – A lane restricted to vehicles with two (and in some cases three) or more occupants to encourage carpooling. Vehicles include automobiles, vans, buses and taxis.

HPMS Highway Performance Monitoring System – A federally mandated program designed by FHWA to assess the performance of the nation's highway system.

HSIPR High-Speed Intercity Passenger Rail Program – A Federal Railroad Administration program created to invest in new high-speed rail corridors and existing rail corridors to improve speed and service.

HST High-Speed Train – Intercity passenger rail service that is reasonably expected to reach speeds of at least 110 mile per hour.

HUD U.S. Department of Housing and Urban Development – Federal agency charged with increasing homeownership, supporting community development and increasing access to affordable housing free from discrimination.

ICAPCD Imperial County Air Pollution Control District – Local air pollution control agency mandated by state and federal regulations to implement and enforce air pollution rules and regulations.

ICE Internal Combustion Engine – Refers traditional vehicle engines that are powered by the burning of fuel sources, including gasoline, diesel and natural gas.

ICTC Imperial County Transportation Commission – Agency responsible for planning and funding countywide transportation improvements and administering the county's transportation sales tax revenues.

ICTF Intermodal Container Transfer Facility – a near-dock intermodal rail facility owned and operated by Union Pacific Rail Road, adjacent to the SPB ports.

IGR Intergovernmental Review Process – The review of documents by several governmental agencies to ensure consistency of regionally significant local plans, projects and programs with SCAG's adopted regional plans.

Infrastructure The basic facilities, equipment, services and installations needed for the growth and functioning of a community.

IOS Initial Operating Segment.

ISTEA Intermodal Surface Transportation Efficiency Act – Signed into federal law on December 18, 1991, it provided authorization for highways, highway safety and mass transportation for FYs 1991–1997 and served as the legislative vehicle for defining federal surface transportation policy.

ITIP Interregional Transportation Improvement Program – The portion of the STIP that includes projects selected by Caltrans (25 percent of STIP funds).

ITS Intelligent Transportation Systems – Systems that use modern detection, communications and computing technology to collect data on system operations and performance, communicate that information to system managers and users and use that information to manage and adjust the transportation system to respond to changing operating conditions, congestion, or accidents. ITS technology can be applied to arterials, highways, transit, trucks and private vehicles. ITS include Advanced Traveler Information Systems (ATIS), Advanced Public Transit Systems (APTS), Advanced Traffic Management Systems (ATMS), Advanced Vehicle Control Systems (AVCS) and Commercial Vehicle Operations (CVO).

JPA Joint Powers Authority – Two or more agencies that enter into a cooperative agreement to jointly wield powers that are common to them. JPAs are a vehicle for the cooperative use of existing governmental powers to finance and provide infrastructure and/or services in a cost-efficient manner.

LACMTA Los Angeles County Metropolitan Transportation Authority, also referred to as "Metro" – Agency responsible for planning and funding countywide transportation improvements, administering the county's transportation sales tax revenues and operating bus and rail transit service.

LAWA or LAX Los Angeles World Airports – Aviation authority of the City of Los Angeles. LAWA owns and operates Los Angeles International (LAX), Ontario International, Van Nuys and Palmdale Airports.

LCV Longer-Combination Vehicles – Includes tractor-trailer combinations with two or more trailers that weigh more than 80,000 pounds.

LEM Location Efficient Mortgage – Allows people to qualify for larger loan amounts if they choose a home in a densely populated community that is well served by public transit and where destinations are located close together so that they can also walk and bike instead of driving everywhere.

LRT Light Rail Transit – A mode of transit that operates on steel rails and obtains its power from overhead electrical wires. LRT may operate in single or multiple cars on separate rights-of-way or in mixed traffic.

Livable Communities Any location in which people choose may be viewed as "livable." However, communities that contain a healthy mix of homes, shops, workplaces, schools, parks and civic institutions coupled with a variety of transportation choices, give residents greater access to life's daily essentials and offer higher quality of life to a wider range of residents. In 2009, the U.S. DOT, EPA and HUD established the following 6 Principles of Livability:

1. Provide more transportation choices
2. Expand location- and energy-efficient housing choices
3. Improve economic competitiveness of neighborhoods
4. Target federal funding toward existing communities
5. Align federal policies and funding
6. Enhance the unique characteristics of all communities

Livable Corridors Arterial roadways where local jurisdictions may plan for a combination of the following elements: high-quality bus frequency; higher density residential and employment at key intersections; and increased active transportation through dedicated bikeways. Most, but not all Livable Corridors would be located within HQTAs. Livable Corridor land-use strategies include development of mixed use retail centers at key nodes along corridors, increasing neighborhood-oriented retail at more intersections, applying a "Complete Streets" approach to roadway improvements and zoning that allows for the replacement of underperforming auto-oriented strip retail between nodes with higher density residential and employment.

LTF Local Transportation Fund – A fund which receives TDA revenues.

MAP Million Annual Passengers – Used to quantify airport activity.

MAP-21 Moving Ahead for Progress in the 21st Century – Signed into law by President Obama on July 6, 2012. Funding surface transportation programs at over $105 billion for fiscal years (FY) 2013 and 2014, MAP-21 was the first long-term highway authorization enacted since 2005. To allow more time for development and consideration of a long-term reauthorization of surface transportation programs, Congress has enacted short term extensions of the expiring law, MAP-21.

Market Incentives Measures designed to encourage certain actions or behaviors. These include inducements for the use of carpools, buses and other HOVs in place of single-occupant automobile travel. Examples include HOV lanes, preferential parking and financial incentives.

MCGMAP Multi-County Goods Movement Action Plan

MDAB Mojave Desert Air Basin – Area defined by state law as comprising the desert portions of Los Angeles, Kern, Riverside and San Bernardino Counties.

MDAQMD Mojave Desert Air Quality Management District – Local air agency mandated by state and federal regulations to implement and enforce air pollution rules and regulations; encompasses the desert portion of San Bernardino County from the summit of the Cajon Pass north to the Inyo County line, as well as the Palo Verde Valley portion of Riverside County.

Measure A Revenues generated from Riverside County's local half-cent sales tax.

Measure D Revenues generated from Imperial County's local half-cent sales tax.

Measure I Revenues generated from San Bernardino County's local half-cent sales tax.

Measure M Revenues generated from Orange County's local half-cent sales tax.

Measure R Revenues generated from Los Angeles County's local half-cent sales tax. Los Angeles County has two permanent local sales taxes (Propositions C and A) and one temporary local sales tax (Measure R).

Metrolink Regional commuter rail system connecting Los Angeles, Orange, Riverside, San Bernardino and Ventura Counties and operated by SCRRA.

MIS Major Investment Study – The preliminary study, including preliminary environmental documentation, for choosing alternative transportation projects for federal transportation funding. An MIS is a requirement, which is conducted cooperatively by the study sponsor and the MPO.

Mixed Flow Traffic movement having autos, trucks, buses and motorcycles sharing traffic lanes.

Mode A particular form of travel (e.g., walking, traveling by automobile, traveling by bus, or traveling by train).

Mode Split The proportion of total person trips using various specified modes of transportation.

Model A mathematical description of a real-life situation that uses data on past and present conditions to make a projection.

MPO Metropolitan Planning Organization – A federally required planning body responsible for transportation planning and project selection in a region.

MTS Metropolitan Transportation System – Regional network of roadways and transit corridors.

Multimodal A mixture of the several modes of transportation, such as transit, highways, non-motorized, etc.

NAAQS National Ambient Air Quality Standards – Targets established by the U.S. Environmental Protection Agency (EPA) for the maximum contribution of a specific pollutant in the air.

NAFTA North American Free Trade Agreement – An agreement between the governments of Canada, Mexico and the United States to eliminate barriers to trade and facilitate the cross-border movement of goods and services.

NCCP Natural Communities Conservation Plan – Program under the Department of Fish and Game that uses a broad-based ecosystem approach toward planning for the protection of plants, animals and their habitats, while allowing compatible and appropriate economic activity.

NEPA National Environmental Protection Act – Federal environmental law that applies to all projects funded with federal funds or requiring review by a federal agency.

NGV Natural Gas Vehicle – Vehicles that are powered by internal combustion engines that burn compressed or liquid natural gas.

NIMS National Incident Management System – Nationwide template that enables all government, private-sector and non-governmental organizations to work together during a domestic incident.

Nominal Dollars Actual dollars expended/received in a specific year without adjustments for inflation/deflation.

Non-Reportable TCM The following de minimis committed TCMs are defined in the Final 2015 FTIP Guidelines as non-reportable TCMs for the purpose of TCM timely implementation reporting:
1. Bus/shuttle/paratransit fleet expansion projects with fewer than 5 vehicles
2. Bus stop improvement projects
3. Bicycle facility less than 1 mile and pedestrian facility less than 1/4 mile
4. Intelligent transportation systems/control system computerization projects with fewer than 3 traffic signals,
5. Changeable message sign projects with fewer than 5 signs
6. Bike parking facilities, new or expansion, with nine or fewer bike lockers/slots
7. Expansion of bus station/shelter/transfer facilities with nine or fewer bike lockers/slots and
8. Rail station expansion with addition of nine or fewer bike lockers/slots.

NOx Nitrogen oxides – A group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. NOx are a major component of ozone and smog and they are one of six principal air pollutants tracked by the EPA.

NMA Neighborhood Mobility Areas – Areas Neighborhood Mobility Areas with roadway networks where Complete Streets and sustainability policies support and encourage replacing single and multi-occupant automobile use with biking, walking, skateboarding and slow speed electric vehicles (such as e-bikes, senior mobility devices and neighborhood electric vehicles.) Complete Streets strategies can include traffic calming, bicycle priority streets (bicycle boulevards) and pedestrian connectivity to increase physical activity, improve connectivity to the regional bikeway/greenway networks, local businesses and parks. NEV strategies include network identification, signage, intersection treatments and shared NEV/bike lanes to connect low speed roadway areas.

NTD National Transit Database – The Federal Transit Administration's (FTA) national database for transit statistics.

O&M Operations and Maintenance – The range of activities and services provided by the transportation system and for the upkeep and preservation of the existing system.

OCS Overhead Catenary System – A type of wayside power where vehicles may connect to and draw power from overhead wires.

OCTA Orange County Transportation Authority – Agency responsible for planning and funding countywide transportation improvements, administering the county's transportation sales tax revenues and operating bus transit service.

OEM Original Equipment Manufacturer.

OLDA Orangeline Development Authority – Joint exercise of powers authority developed by the cities located along the Orangeline corridor.

OnTrac Orange-North America Trade Rail Access Corridor – Formed in April of 2000 to build and support the Orangethorpe Avenue Grade Separation and Trade Corridor project, a 5-mile-long railroad-lowering project that will completely grade separate 11 rail crossings in the cities of Placentia and Anaheim.

Open Space Generally understood as any area of land or water which, for whatever reason, is not developed for urbanized uses and which therefore enhances residents' quality of life. However, note that each county and city in California must adopt an open space element as part of its general plan. The element is a statement of local planning policies focusing on the use of unimproved land or water for 1) the preservation or managed production of natural resources, 2) outdoor recreation and 3) the promotion of public health and safety. Therefore, open space will be defined by each jurisdiction based on their own unique resources and environment.

OWP Overall Work Program – SCAG develops an OWP annually, describing proposed transportation planning activities for the upcoming fiscal year, including those required by federal and state law.

Parking Cash-Out Program An employer-funded program under which an employer offers to provide a cash allowance to an employee equivalent to the parking subsidy that the employer would otherwise pay to provide the employee with a parking space.

Parking Subsidy The difference between the out-of-pocket amount paid by an employer on a regular basis in order to secure the availability of an employee parking space not owned by the employer and the price, if any, charged to an employee for use of that space.

PMT Passenger Miles Traveled – The cumulative sum of the distances ridden by each public transportation passenger.

PATH Partners for Advanced Transit and Highways – Joint venture of Caltrans which includes the University of California and other public and private academic institutions and industries.

PEIR Program Environmental Impact Report – An information document that analyzes and discloses potential environmental effects of large-scale plans or programs in accordance with provisions of the California Environmental Quality Act (CEQA).

PeMS Highway Performance Measurement System – A service provided by the University of California, Berkeley, to collect historical and real-time highway data from highways in the state of California in order to compute highway performance measures.

Person Trip A trip made by a person by any mode or combination of modes for any purpose.

PEV Plug-in Electric Vehicle – Refers to all vehicles that can be plugged into an external source of electricity in order to recharge an on-board battery which will provide some or all power to an electric engine.

PHEV Plug-in Hybrid Electric Vehicle – A vehicle powertrain that combines an electric engine with a traditional internal combustion engine. The two engines can operate in parallel with the electric engine operating at certain speeds, or the engines can operate sequentially, with all power being provided by the electric engine until the battery power is exhausted.

PHL Pacific Harbor Line, Inc.

PM 10 Particulate Matter – A mixture of solid particles and liquid droplets found in the air 10 micrometers or less in size (a micrometer is one-millionth of a meter). These coarse particles are generally emitted from sources such as vehicles traveling on unpaved roads, materials handling and crushing and grinding operations, as well as windblown dust.

PM 2.5 Particulate Matter – A mixture of solid particles and liquid droplets found in the air 2.5 micrometers or less in size (a micrometer is one-millionth of a meter). These fine particles result from fuel combustion from motor vehicles, power generation and industrial facilities, as well as from residential fireplaces and wood stoves.

PMD LA/Palmdale Regional Airport – Regional airport located in Palmdale.

POLA Port of Los Angeles.

POLB Port of Long Beach.

PPP Public-Private Partnership – Contractual agreements formed between a public agency and private-sector entity that allow for greater private-sector participation in the delivery of transportation projects.

PRC Peer Review Committee – An "informal" committee of technical experts usually organized and invited to review and comment on various technical issues and processes used in the planning process.

Proposition 1A Passed by voters in 2006, Proposition 1A protects transportation funding for traffic congestion relief projects, safety improvements and local streets and roads. It also prohibits the state sales tax on motor vehicle fuels from being used for any purpose other than transportation improvements and authorizes loans of these funds only in the case of severe state fiscal hardship.

Proposition 1B Highway Safety, Traffic Reduction, Air Quality and Port Security State of California – Passed in November 2006, Proposition 1B provides $19.9 billion to fund state and local transportation improvement projects to relieve congestion, improve movement of goods, improve air quality and enhance safety and security of the transportation system.

Proposition A Revenues generated from Los Angeles County's local half-cent sales tax. Los Angeles County has two permanent local sales taxes (Propositions C and A) and one temporary local sales tax (Measure R).

Proposition C Revenues generated from Los Angeles County's local half-cent sales tax. Los Angeles County has two permanent local sales taxes (Propositions C and A) and one temporary local sales tax (Measure R).

PSR Project Study Report – Defines and justifies the project's scope, cost and schedule. PSRs are prepared for state highway projects and PSR equivalents are prepared for projects not on the State Highway System. Under state law, a PSR or PSR equivalent is required for STIP programming.

PTA Public Transportation Account – The major state transportation account for mass transportation purposes. Revenues include a portion of the sales tax on gasoline and diesel fuels.

Public Transportation As defined in the Federal Transit Act, "Transportation by a conveyance that provides regular and continuing general or special transportation to the public, but does not include school bus, charter, or intercity bus transportation or intercity passenger rail transportation provided by the entity described in chapter 243 (Amtrak or a successor to such entity)."

PUC Public Utilities Commission – Regulates privately owned telecommunications, electric, natural gas, water, railroad, rail transit and passenger transportation companies.

Railroad Siding A short stretch of railroad track used to store rolling stock or enable trains on the same line to pass; also called sidetrack.

RBN Regional Bikeway Network – A system of regionally interconnected bikeways linking cities and counties in the SCAG region.

RC Regional Council – Conducts the affairs of SCAG; implements the General Assembly's policy decisions; acts upon policy recommendations from SCAG policy committees and external agencies; appoints committees to study specific problems; and amends, decreases or increases the proposed budget to be reported to the General Assembly.

RCP Regional Comprehensive Plan – Developed by SCAG, the RCP is a vision of how Southern California can balance resource conservation, economic vitality and quality of life. It will serve as a blueprint to approach growth and infrastructure challenges in an integrated and comprehensive way.

RCTC Riverside County Transportation Commission – Agency responsible for planning and funding countywide transportation improvements and administering the county's transportation sales tax revenues.

RGN Regional Greenway Network – A regional system of bikeways physically separate from traffic. It makes use of riverbeds and under-utilized utility corridors. It is part of the Regional Bikeway Network (RBN).

RHNA Regional Housing Needs Assessment – Quantifies the need for housing within each jurisdiction of the SCAG region based on population growth projections. Communities then address this need through the process of completing the housing elements of their General Plans.

Ridesourcing A generic term coined by researchers at University of California, Berkeley for the act of using a Transportation Network Company such as Lyft or Uber. The term distinguishes this mode from car sharing and from taxi use. A user is "sourcing" a ride from an online community, in exchange for a brokered payment.

Riparian Area Habitats, vegetation, and ecosystems adjacent to or part of rivers and streams.

Robust Flight Portfolio Providing a range of flight offerings in different haul length categories including short-haul, medium-haul, long-haul and international flights.

ROG Reactive Organic Gas – Organic compounds assumed to be reactive at urban/regional scales. Those organic compounds that are regulated because they lead to ozone formation.

RSTIS Regionally Significant Transportation Investment Study – Involves identifying all reasonable transportation options, their costs and their environmental impacts. RSTIS projects are generally highway or transit improvements that have a significant impact on the capacity, traffic flow, level of service, or mode share at the transportation corridor or sub-area level.

RSTP Regional Surface Transportation Program – Established by California state statute utilizing federal Surface Transportation Program funds. Approximately 76 percent of the state's RSTP funds must be obligated on projects located within the 11 urbanized areas of California with populations of 200,000 or more.

RTMS Regional Transportation Monitoring System – Internet-based transportation monitoring system. The RTMS will be the source for real-time and historical transportation data collected from local, regional and private data sources.

RTP Regional Transportation Plan – Federally required 20-year plan prepared by metropolitan planning organizations and updated every four years. Includes projections of population growth and travel demand, along with a specific list of proposed projects to be funded.

RTSS Regional Transit Security Strategy – Strategy for the region with specific goals and objectives related to the prevention, detection, response and recovery of transit security issues.

Rural Areas Rural locales consist of all of the areas within the SCAG region that are not within Urban Areas (please see definition).

SAFETEA-LU Safe, Accountable, Flexible, Efficient Transportation Equity Act A Legacy for Users – Signed into law by President Bush on August 10, 2005, it authorized the federal surface transportation programs for highways, highway safety and transit for the 5-year period of 2005–2009.

SANBAG San Bernardino Associated Governments – The council of governments and transportation planning agency for San Bernardino County. SANBAG is responsible for cooperative regional planning and developing an efficient multimodal transportation system countywide.

SANDAG San Diego Association of Governments.

SB 45 Senate Bill 45 (Chapter 622, Statutes of 1997, Kopp) – Established the current STIP process and shifted control of decision-making from the state to the regional level.

SB 375 Senate Bill 375 (Chapter 728, Steinberg) – Established to implement the state's greenhouse gas (GHG) emission-reduction goals, as set forth by AB 32, in the sector of cars and light trucks. This mandate requires the California Air Resources Board to determine per capita GHG emission-reduction targets for each metropolitan planning organization (MPO) in the state at two points in the future—2020 and 2035. In turn, each MPO must prepare a Sustainable Communities Strategy (SCS) that demonstrates how the region will meet its GHG reduction target through integrated land use, housing and transportation planning.

SB 535 Senate Bill 535 (Chapter 830, De León) – Established that a quarter of the proceeds from the Greenhouse Gas Reduction Fund must also go to projects that provide a benefit to disadvantaged communities. A minimum of 10 percent of the funds must be for projects located within those communities. The legislation gives the California Environmental Protection Agency responsibility for identifying those communities.

SB 974 Senate Bill 974 – Introduced by Senator Alan Lowenthal, SB 974 would impose a $30 fee on each shipping container processed at the Ports of Los Angeles, Long Beach and Oakland for congestion management and air quality improvements related to ports.

SBD San Bernardino International Airport – International airport located in San Bernardino.

SCAB South Coast Air Basin – Comprises the non–Antelope Valley portion of Los Angeles County, Orange County, Riverside County and the non-desert portion of San Bernardino County.

SCAG Southern California Association of Governments – The metropolitan planning organization (MPO) for six counties including Imperial, Los Angeles, Orange, Riverside, San Bernardino and Ventura.

SCAQMD South Coast Air Quality Management District – The air pollution control agency for Orange County and major portions of Los Angeles, Riverside and San Bernardino Counties in Southern California.

SCCAB South Central Coast Air Basin – Comprises San Luis Obispo, Santa Barbara and Ventura Counties.

SCIG Southern California International Gateway, a proposed rail near-dock facility for the BNSF adjacent to the SPB ports.

SCRIFA Southern California Railroad Infrastructure Financing Authority.

Scrip A form of fare payment transferrable among transportation providers, often issued by Dial-A-Ride transit service providers to be used on taxis.

SDOH Social Determinants of Health – Includes the circumstances in which people are born, grow up, live, work, play and age. Economic opportunities, government policies and the built environment all play a role in shaping these circumstances and influencing public health outcomes.

SED Socioeconomic Data – Population, employment and housing forecast.

SFS Sustainable Freight Strategy – A new plan underway by ARB.

SGC The Strategic Growth Council is a state agency tasked with encouraging the development of sustainable communities.

SHA State Highway Account – The major state transportation account for highway purposes. Revenues include the state excise taxes on gasoline and diesel fuel and truck weight fees.

Shared Mobility Services Refers to a wide variety of new mobility services and encompasses bike share, car share, app-based transit services and ridesourcing. This term refers to the way in which these modes are offered as services brokered by a mobile application and each vehicle is shared amongst multiple users.

SHOPP State Highway Operation and Protection Program – A four-year capital improvement program for rehabilitation, safety and operational improvements on state highways.

SHSP Strategic Highway Safety Plan – A statewide, coordinated safety plan that provides a comprehensive framework for reducing fatalities and severe injuries to motorists, pedestrians, and bicyclists on all public roads. SHSP goals and objectives are data-driven and results are measured. Actions designed to achieve the objectives are developed by hundreds of safety stakeholders from the four E's of highway safety: engineering, education, enforcement and emergency medical services. In California, Caltrans coordinates the effort to develop the plan.

SIP State Implementation Plan – State air quality plan to ensure compliance with state and federal air quality standards. In order to be eligible for federal funding, projects must demonstrate conformity with the SIP.

Smart Growth Principles The following principles developed by the Smart Growth Network, a partnership of government, business and civic organizations created in 1996:
1. Mix land uses
2. Take advantage of compact building design
3. Create a range of housing opportunities and choices
4. Create walkable neighborhoods
5. Foster distinctive, attractive communities with a strong sense of place
6. Preserve open space, farmland, natural beauty and critical environmental areas
7. Strengthen and direct development towards existing communities
8. Provide a variety of transportation choices
9. Make development decisions predictable, fair and cost effective
10. Encourage community and stakeholder collaboration in development decisions

Social Equity Equal opportunity in a safe and healthy environment.

SOV Single-Occupant Vehicle – Privately operated vehicle that contains only one driver or occupant.

SOx Sulfur oxide – Any of several compounds of sulfur and oxygen, formed from burning fuels such as coal and oil.

SPB Ports San Pedro Bay Ports.

SRTS Safe Routes to School – Part of a nationwide/region-wide program to increase students walking or biking to school. Includes engineering, educational and enforcement activities. Funded through the State Active Transportation Program (ATP).

SSAB Salton Sea Air Basin – Comprises the Coachella Valley portion of Riverside County and all of Imperial County.

STA State Transit Assistance – State funding program for mass transit operations and capital projects. Current law requires that STA receive 50 percent of PTA revenues.

STIP State Transportation Improvement Program – A five-year capital outlay plan that includes the cost and schedule estimates for all transportation projects funded with any amount of state funds. The STIP is approved and adopted by the CTC and is the combined result of the ITIP and the RTIP.

STP Surface Transportation Program – Provides flexible funding that may be used by states and localities for projects on any federal-aid highway, bridge projects on any public road, transit capital projects and intracity and intercity bus terminals and facilities. A portion of funds reserved for rural areas may be spent on rural minor collectors.

Sustainability The practice of analyzing the impact of decisions, policies, strategies and development projects on the Economy, the Environment and Social Equity (commonly referred to as the three E's). In the 2008 Agency Strategic Plan, SCAG adopted the following definition of Sustainability as one of its core operational values: "We work with our partners and local governments to achieve a quality of life that provides resources for today's generation while preserving an improved quality of life for future generations."

TANN Traveler Advisory News Network – Provides real-time traffic and transportation information content to communications service providers and consumer media channels both nationally and internationally.

TAZ Traffic Analysis Zone – Zone system used in travel demand forecasting.

TC Transportation Committee – Committee used to study problems, programs and other matters which pertain to the regional issues of mobility, air quality, transportation control measures and communications.

TCM Transportation Control Measure – A project or program that is designed to reduce emissions or concentrations of air pollutants from transportation sources. TCMs are referenced in the State Implementation Plan (SIP) for the applicable air basin and have priority for programming and implementation ahead of non-TCMs.

TCWG Transportation Conformity Working Group – Forum used to support interagency coordination to help improve air quality and maintain transportation conformity.

TDA Transportation Development Act – State law enacted in 1971 that provided a 0.25 percent sales tax on all retail sales in each county for transit, bicycle and pedestrian purposes. In non-urban areas, funds may be used for streets and roads under certain conditions.

TDM Transportation Demand Management – Strategies that result in more efficient use of transportation resources, such as ridesharing, telecommuting, park-and-ride programs, pedestrian improvements and alternative work schedules.

TEA-21 Transportation Equity Act for the 21st Century – The predecessor to SAFETEA-LU, it was signed into federal law on June 9, 1998. TEA-21 authorized the federal surface transportation programs for highways, highway safety and transit for the six-year period of 1998–2003. TEA-21 builds upon the initiatives established in ISTEA.

TEU Twenty-Foot Equivalent Unit – A measure of shipping container capacity.

TIFIA Transportation Infrastructure Finance and Innovation Act of 1998 – Established a new federal credit program under which the U.S. DOT may provide three forms of credit assistance—secured (direct) loans, loan guarantees and standby lines of credit—for surface transportation projects of national or regional significance. The program's fundamental goal is to leverage federal funds by attracting substantial private and other non-federal co-investment in critical improvements to the nation's surface transportation system. Sponsors may include state departments of transportation, transit operators, special authorities, local governments and private entities.

TNC Transportation Network Companies – This is the technical term for ridesourcing companies used by the California Public Utilities Commission in order to create a new class of mobility provider distinguished from taxi companies and limousines.

TOD Transit-Oriented Development – A planning strategy that explicitly links land-use and transportation by focusing mixed housing, employment and commercial growth around bus and rail stations (usually within ½ mile). TODs can reduce the number and length of vehicle trips by encouraging more bicycle/pedestrian and transit use and can support transit investments by creating the density around stations to boost ridership.

TP&D Transportation Planning and Development Account – A state transit trust fund that is the funding source for the STA program.

TSP Transit Signal Priority – A set of operational improvements that use technology to facilitate the movement of transit vehicles and reduce their dwell time at traffic signals by holding green lights longer or shortening red lights. TSP may be implemented at individual intersections or across corridors or entire street systems. Objectives of TSP include improved schedule adherence and improved transit travel time efficiency while minimizing impacts to normal traffic operations.

Trantrak RTIP Database Management System.

TSWG Transportation Security Working Group – Advises the operating organizations on transportation safety matters associated with the transfer or shipment of hazardous materials.

TUMF Transportation Uniform Mitigation Fee – Ordinance enacted by the Riverside County Board of Supervisors and cities to impose a fee on new development to fund related transportation improvements.

TZEV Transitional Zero Emissions Vehicles – Terminology used by the Air Resources Board (ARB) to refer to Plug-in Hybrid Electric Vehicles, since these vehicles produce emissions when they are powered by the internal combustion engine.

Union Station Los Angeles Union Station is the main railway station in Los Angeles.

UPT Unlinked Passenger Trips – The number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.

UP Union Pacific Railroad.

Urban Areas Urban Areas in the SCAG region represent densely developed territory, and encompass residential, commercial and other non-residential urban land uses where population is concentrated over 2,500 people in a given locale.

Urban Growth Boundary A regional boundary that seeks to contain outward urban expansion by limiting development outside of the boundary, while focusing new growth within the boundary. Urban growth boundaries lead to the preservation of natural and agricultural lands, redevelopment and infill in existing communities and optimization of existing infrastructure and transportation investments.

U.S. DOT U.S. Department of Transportation – Federal agency responsible for the development of transportation policies and programs that contribute to providing fast, safe, efficient and convenient transportation at the lowest cost consistent with those and other national objectives, including the efficient use and conservation of the resources of the United States. U.S. DOT is comprised of ten operating administrations, including FHWA, FTA, FAA and FRA.

Value Pricing A user fee applied during peak demand periods on congested roadways to improve the reliability and efficiency of the transportation system and provide travelers with greater choices.

VCTC Ventura County Transportation Commission – Agency responsible for planning and funding countywide transportation improvements.

Vehicle Hours of Delay The travel time spent on the highway due to congestion. Delay is estimated as the difference between vehicle hours traveled at a specified free-flow speed and vehicle hours traveled at a congested speed.

VRH Vehicle Revenue Hours – The hours that a public transportation vehicle actually travels while in revenue service. Vehicle revenue hours include layover/recovery time, but exclude deadheading, operator training, vehicle maintenance testing and school bus and charter services.

VRM Vehicle Revenue Miles – The miles that a public transportation vehicle actually travels while in revenue service. Vehicle revenue miles include layover/recovery time, but exclude deadheading, operator training, vehicle maintenance testing and school bus and charter services.

VHDD Vehicle Hours of Daily Delay – Hours of delay attributed to congestion for vehicles each day.

VMT Vehicle Miles Traveled – On highways, a measurement of the total miles traveled by all vehicles in the area for a specified time period. It is calculated by the number of vehicles times the miles traveled in a given area or on a given highway during the time period. In transit, the number of vehicle miles operated on a given route or line or network during a specified time period.

VOC Volatile Organic Compounds – Organic gases emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products and other industrial sources. Ozone, the main component of smog, is formed from the reaction of VOCs and NOx in the presence of heat and sunlight.

ZEV Zero Emissions Vehicles – Vehicles that produce no tailpipe emissions of criteria pollutants. Generally, ZEVs feature electric powertrains. Technically, ZEVs are still responsible for some greenhouse gas (GHG) emissions, as the GHG content from the electricity generation must be accounted for.

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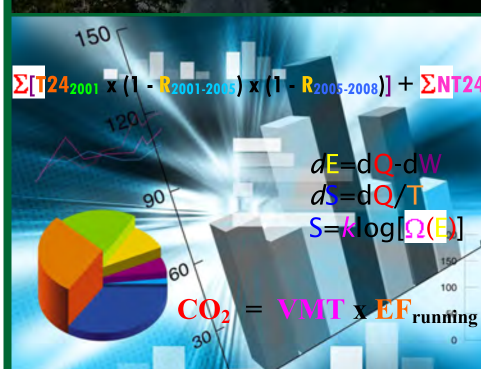

Quantifying Greenhouse Gas Mitigation Measures

A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures

August, 2010

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California Air Pollution Control Officers Association

with

Northeast States for Coordinated Air Use Management

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Disclaimer

The California Air Pollution Control Officers Association (CAPCOA) has prepared this report on quantifying greenhouse gas emissions from select mitigation strategies to provide a common platform of information and tools to support local governments.

This paper is intended as a resource, not a guidance document. It is not intended, and should not be interpreted, to dictate the manner in which a city or county chooses to address greenhouse gas emissions in the context of projects it reviews, or in the preparation of its General Plan.

This paper has been prepared at a time when California law and regulation, as well as accepted practice regarding how climate change should be addressed in government programs, is undergoing change. There is pending litigation that may have bearing on these decisions, as well as active legislation at the federal level. In the face of this uncertainty, local governments are working to understand the new expectations, and how best to meet them. This paper is provided as a resource to local policy and decision makers to enable them to make the best decisions they can during this period of uncertainty.

Finally, in order to provide context for the quantification methodologies it describes, this report reviews requirements, discusses policy options, and highlights methods, tools, and resources available; these reviews and discussions are not intended to provide legal advice and should not be construed as such. Questions of legal interpretation, or requests for legal advice, should be directed to the jurisdiction's counsel.

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Appendices

This report on *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures* was prepared by the California Air Pollution Control Officers Association with the Northeast States for Coordinated Air Use Management and the National Association of Clean Air Agencies, and with technical support from Environ and Fehr & Peers. It is primarily focused on the quantification of project-level mitigation of greenhouse gas emissions associated with land use, transportation, energy use, and other related project areas. The mitigation measures quantified in the Report generally correspond to measures previously discussed in CAPCOA's earlier reports: *CEQA and Climate Change*; and *Model Policies for Greenhouse Gases in General Plans*. The Report does not provide policy guidance or advocate any policy position related to greenhouse gas emission reduction.

The Report provides a discussion of background information on programs and other circumstances in which quantification of greenhouse gas emissions is important. This includes voluntary emission reduction efforts, project-level emission reduction efforts, reductions for regulatory compliance, and reductions for some form of credit. The information provided covers basic terms and concepts and again, does not endorse or provide guidance on any policy position.

Certain key concepts for quantification are covered in greater depth. These include baseline, business-as-usual, types of emission reductions, project scope, lifecycle analysis, accuracy and reliability, additionality, and verification.

In order to provide transparency and to enhance the understanding of underlying strengths and weaknesses, the Report includes a detailed explanation of the approaches and methods used in developing the quantification of the mitigation measures. There is a summary of baseline methods (which are discussed in greater detail in Appendix B) as well as a discussion of methods for the measures. This includes the selection process for the measures, the development of the quantification approaches, and limitations in the data used to derive the quantification.

The mitigation measures were broken into categories, and an overview is provided for each category. The overview discusses specific considerations in quantifying emissions for measures in the category, as well as project-specific data the user will need to provide. Where appropriate and where data are readily available, the user is directed to relevant data sources. In addition, some tables and other information are included in the appendices.

The mitigation measures are presented in Fact Sheets. An overview of the Fact Sheets is provided which outlines their organization and describes the layout of information. The Report also includes a step-by-step guide to using a Fact Sheet to quantify a project, and discusses the use of Fact Sheets outside of California. The Report also discusses the grouping of the measures, and outlines procedures and limitations for quantifying projects where measures are combined either within or across categories. These limitations are critical to ensure that emission reductions are appropriately quantified and are not double counted. As a general guide, approximate ranges of effectiveness are provided for each of the measures, and this is presented in tables at the end of Chapter 6. These ranges are for reference only and should not be used in lieu of the actual Fact Sheets; they do not provide accurate quantification on a project-specific basis.

The Fact Sheets themselves are presented in Chapter 7, which includes an index of the Fact Sheets and cross references each measure to measures described in CAPCOA's earlier reports: *CEQA and Climate Change*; and *Model Policies for Greenhouse Gases in General Plans*. Each Fact Sheet includes a description of the measure, assumptions and limitations in the quantification, a baseline methodology, and the quantification of the measure itself. There is also a sample project calculation, and a discussion of the data and studies used in the development of the quantification.

In the Appendices, there is a glossary of terms. The baseline methodology is fully explained, and there is additional supporting information for the transportation methods and the non-transportation methods. Finally, the Report includes select reference tables that the user may consult for select project-specific factors that are called for in some of the Fact Sheets.

Background

The California Air Pollution Control Officers Association (CAPCOA) prepared the report, *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures* (Quantification Report, or Report), in collaboration with the Northeast States for Coordinated Air Use Management (NESCAUM) and the National Association of Clean Air Agencies (NACAA), and with contract support from Environ, and Fehr & Peers, who performed the technical analysis. The Report provides methods for quantifying emission reductions from a specified list of mitigation measures, primarily focused on project-level mitigation. The emissions calculations include greenhouse gases (GHGs), particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NOx), sulfur dioxide (SO2), and reactive organic gases (ROG), as well as toxic air pollutants, where information is available.

The measures included in this Report were selected because they are frequently considered as mitigation for GHG impacts, and standardized methods for quantifying emissions from these projects were not previously available. Measures were screened on the basis of the feasibility of quantifying the emissions, the availability of robust and meaningful data upon which to base the quantification, and whether the measures (alone or in combination with other measures) would result in appreciable reductions in GHG emissions. CAPCOA does not mean to suggest that other measures should not be considered, or that they might not be effective or quantifiable; on the contrary, there are many options and approaches to mitigate emissions of GHGs. CAPCOA sought to provide a high quality quantification tool to local governments with the broadest applicability possible, given the resource limitations for the project. CAPCOA encourages local governments to be bold and creative as they approach the challenge of climate change, and does not intend this Report to limit the scope of measures considered for mitigation.

The majority of the measures in the Report have been discussed in CAPCOA's previous resource documents: *CEQA and Climate Change*, and *Model Policies for Greenhouse Gases in General Plans*. The measures in this Report are cross-referenced to those prior reports. The quantification methods provided here are largely project-level in nature; they can certainly inform planning decisions, however a complete planning-level analysis of mitigation strategies will entail additional quantification.

In developing the quantification methods, CAPCOA and its contractors conducted an extensive literature review. The goal of the Report was to provide accurate and reliable quantification methods that can be used throughout California and adapted for use outside of the state as well.

Intent and Audience

This document is intended to further support the efforts of local governments to address the impacts of GHG emissions in their environmental review of projects and in their planning efforts. Project proponents and others interested in quantifying mitigation measures will also find the document useful.

The guidance provided in this Report specifically addresses appropriate procedures for applying quantification methods to achieve accurate and reliable results. The Report includes background information on programs and concepts associated with the quantification of GHG emissions. The Report does not provide policy guidance on any of these issues, nor does it dictate how any jurisdiction should address questions of policy. Policy considerations are left to individual agencies and their governing boards. Rather, this Report is intended to support the creation of a standardized approach to quantifying mitigation measures, to allow emission reductions and measure effectiveness to be considered and compared on a common basis.

Because the quantification methods in this Report were developed to meet the highest standards for accuracy and reliability, CAPCOA believes they will be generally accepted for most quantification purposes. The decision to accept any quantification method rests with the reviewing agency, however. Further, while the Report discusses the quantification of GHG emissions for a variety of purposes, including the quantification of reductions for credit, using these methods does not guarantee that credit will be awarded.

Using the Document

Chapters 2 and 3 of this Report discuss programs and concepts associated with GHG quantification. They are intended to provide background information for those interested in the context in which reductions are being made. Chapter 4 discusses the underpinnings of the quantification methods and specifically addresses limitations in the data used as well as limitations in applying the methods; it is important for anyone using this Report to review Chapter 4. Chapter 5 provides an overview of the mitigation measure categories, including key considerations in the quantification of emission reductions in those categories. Chapter 6 explains how to use the fact sheets for each measure's quantification method, and also discusses the effectiveness of the measures and how combining measures changes the effectiveness.

Once the user understands the quantification context, and the limitations of the methods, the fact sheets can be used like recipes in a cookbook . In using the fact sheets, however, CAPCOA strongly advises the reader to pay careful attention to the assumptions and limitations set forth for each individual measure, and to make sure that these are respected and appropriately considered.

The fact sheets with the actual quantification methods for each individual measure are contained in Chapter 7. The baseline methods are explained in Appendix B. It is the responsibility of the user to ensure that all data inputs are provided as called for in the methods, and that the data are of appropriate quality.

CAPCOA will not be able to provide case-by-case review or adjustments for specific projects outside of the provision for project-specific data inputs that is part of each fact sheet. Questions about individual projects may be referred to your local air district.

As a final note, the methods contained in this document include generalized information about the measures themselves. This information includes emission factors, usage rates, and other data from various sources, most commonly published data from public agencies. The data were carefully reviewed to ensure they represent the best information available for this purpose. The use of generalized information allows the quantification methods to be used across a range of circumstances, including variations in geographical location, climate, and population density, among others.

Where good quality, project-specific data is available that provides a superior characterization of a particular project, it should be used instead of the more generalized data presented here. The methods provided for baseline and mitigated emissions scenarios allow for such substitution. The local agency reviewing the project should review the project-specific data, however, to ensure that it meets standards for data quality and will not result in an inappropriate under- or overestimation of project emissions or mitigation.

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Quantification Framework

The Quantification Report has been prepared to support a range of quantification needs. It is based on the premise that quantification of GHG emissions and reductions should rest on a foundation of clear assumptions, limits, and calculations. When these elements and the methods of applying them are transparent, a common "language" is created that allows us to talk about, compare, and evaluate GHGs with confidence that we are looking at "apples to apples."

For the purpose of this report, GHGs are the six gases identified in the Kyoto Protocol: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). GHGs are expressed in metric tons (MT) of CO_2e (carbon dioxide equivalents). Individual GHGs are converted to CO_2e by multiplying values by their global warming potential (GWP). Global warming potentials represent a ratio of a gas' heat trapping characteristics compared to CO_2, which has a global warming potential of 1.

As a general rule, the quantification methods in this report are only accurate to the degree that the project adheres to the assumptions, limitations, and other criteria specified for a given measure. Where specific data inputs are indicated for either the baseline or the project scenario calculations, those data must be provided for the calculations to be valid. Further, the quality of the data used will substantially impact the quality of the results achieved. For example, if a calculation method calls for a traffic count, the calculations can't be made without supplying a traffic count number. However, the number used could be a rough estimate, could be based on a small, one-time sample, or could be derived through a full traffic study over a representative period of time or times. Clearly, using a rough estimate for any of the data inputs will yield results that are less accurate than they would be if higher quality data inputs were provided.

This does not mean that rough estimates cannot be used. There will be times when the quantification does not need to be precise. In order to speak the common language, however, it is important to identify how precise your data inputs are. It is also important to give careful consideration to the intended use of the quantification, to make sure that the results you achieve will be sufficiently rigorous to support the conclusions you draw from them.

The quantification methods in this report rely on very specific assumptions and limitations for each mitigation measure. Unlike the discussion of data inputs, the measure assumptions and limits affect more than the precision of the calculations: they determine whether the calculation is valid at all. For example, there is a method for calculating GHG reductions for each percentage in improvement in building energy use beyond the performance standards in California's Title 24; that method states that the measure is specifically for electricity and natural gas use in residential and commercial buildings subject to Title 24. If the building is located outside of California, where Title 24 is not applicable, the method will not yield accurate results unless the baseline assumptions are adjusted to reflect the standards that actually apply. Further, the measure effectiveness is based on assumptions that certain other energy efficiency measures are also applied (such as third-party HVAC-commissioning); if those additional measures are not applied, the calculated reductions will not be accurate and will overestimate the reductions compared to what will actually be achieved.

There may be situations where you choose to apply a method even if the assumptions do not match the specific conditions of the project; while CAPCOA does not recommend this, if you do it, it is imperative that any deviations are clearly identified. While you may still be able to calculate a reduction for your measure, in many cases the error in your result will be so large that any conclusions you would draw from the analysis could be completely wrong.

Quantifying Measures for Different Purposes

There are several reasons that a person might implement measures to reduce GHG emissions. Some measures are implemented simply because it's a good thing to do. Knowing how many metric tons of GHG emissions were reduced might not be important in that case. There are other reasons for undertaking a project to reduce GHGs, however, and for some of these purposes quantification (and verification) become increasingly important, and sensitive. This chapter discusses the role of quantification, and to a lesser extent verification, in reductions undertaken for a range of reasons. These include: voluntary reductions, reductions undertaken specifically to mitigate current or future impacts, reductions for regulatory compliance, and reductions where some form of credit is being sought, including credits that may be traded on a credit exchange. The purpose for which reductions are quantified will determine the level of detail involved in the quantification, as well as the degree of verification needed to support the quantification. As stated previously, this discussion is provided for information purposes only; it should not be construed to advocate or endorse any particular policy position.

Voluntary Reductions

Voluntary reductions of GHG emissions are reductions that are not required for any reason, including a regulation, law, or other form of standard. Even when reductions are not mandatory, however, there may be reasons to quantify them. The project proponent may simply want to know how effective the project is. Examples of this would be when a project is undertaken in an educational setting, or to demonstrate the general feasibility of a concept, or promote an image of environmental responsibility. In such a case, the focus may be on implementing the project more than documenting exactly how many tons of CO_2e have been reduced, and a reasonable estimate might be sufficient. The project proponent may wish to track reductions to fulfill an organizational policy or commitment, or to establish a track record in GHG reductions. For these purposes, the quantification does not need to be precise, but it should still be based on sound principles and accepted methods.

When reductions are purely voluntary, they may be estimated using the methods contained in this document, even if all of the variables are not known, or if some of the assumptions are not fully supported by the specifics of the project. If the quantification is performed without the level of detail outlined in the method for a given measure (or specified for the baseline calculations), the results will be less accurate. The same is true if a method is used in a situation where the assumptions are not fully supported, or if the method is used outside the noted limitations. As one would expect, the greater the degree of variation from the conditions put forth in the fact sheets, the less accurate the quantification will be. Significant deviation can result in very large errors.

If there is any possibility that the project proponent may at some point wish to use the reductions to fulfill a future regulatory or mitigation requirement, or seek some form of credit for the reductions, the proponent should not deviate from the methods and should ensure that all necessary data are included, and all assumptions and limitations are appropriately addressed. Acceptance of the quantification methods in this Report to fulfill any requirement is solely at the discretion of the approving agency. Use of these methods does not guarantee that credit of any kind will be awarded for reductions made.

Reductions to Mitigate Current or Future Impacts

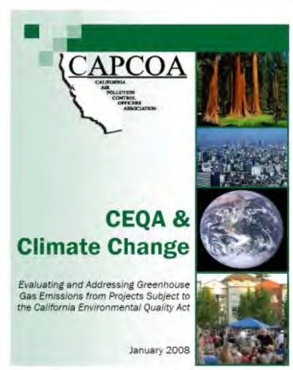
One of the most common reasons for quantifying emissions of GHG is to analyze and mitigate current or future impacts of specific actions or activities. This can include project-level impacts, such as those evaluated under the California Environmental Quality Act (CEQA), or plan-level impacts, such those resulting from the implementation of a General Plan or Climate Action Plan. Quantification of projects and mitigation under CEQA was the main focus in preparing this guidance document. Most of the measures quantified in the Report are project-level in nature. Many of these are also good examples of the kinds of policies and actions that would be included in a General Plan or a Climate Action Plan. The quantification methods provided here can be used to support conclusions about the effectiveness of different measures in a planning context; however, a full analysis of plan-level impacts will require consideration of additional factors, depending on the nature of the measure. Some of the measures have been specifically identified as General Plan measures, and a discussion is included about appropriate analysis of these measures, where study data exist to support such analysis.

Project-Level Mitigation: Existing environmental law and policy requires that environmental impacts of projects be evaluated and disclosed to the public, and where those impacts are potentially significant, that they be mitigated. At the federal level, the National Environmental Protection Act (NEPA) governs this evaluation. Many states have their own programs as well; in California, the California Environmental Quality Act, or CEQA, sets forth the requirements and the framework for the review.

The responsibility to evaluate impacts, to determine significance, and to define appropriate mitigation rests with the Lead Agency. This is typically a city or county with land-use decision-making authority, although other agencies can be Lead Agencies, depending on the nature of the project and the jurisdiction of the agency.

Guidance on CEQA and Climate Change: There are currently two resources for Lead Agencies on incorporating considerations of climate change into their CEQA processes. The first was prepared by CAPCOA, and the most recent is an amendment to the official CEQA Guidelines prepared by the California Natural Resources Agency (Resources Agency).

CAPCOA Guidance- In January of 2008, CAPCOA released a resource document, *"CEQA and Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to the California Environmental Quality Act,"* that discussed different approaches to determining whether GHG emissions from projects are significant under CEQA. It reviewed the models and other tools available at that time for conducting GHG analyses, and the document also contained a list of mitigation measures. A copy of the report is available at *http://www.capcoa.org*.



Resources Agency Guidance- Since the release of that report, the California Natural Resources Agency (Resources Agency) finalized its guidance on GHG emissions and CEQA in December of 2009. Under Senate Bill 97 (Chapter 148, Statutes of 2007), the Governor's Office of Planning and Research (OPR) was required to prepare amendments to the state's CEQA Guidelines addressing analysis and mitigation of the potential effects of GHG emissions in CEQA documents. The legislation required the Resources Agency to adopt the amended Guidelines by 2010.

The CEQA Guidelines Amendments adopted by the Resources Agency made material changes to 14 sections of the Guidelines. The changes include dealing with the determination of significance (principally in Public Resource Code Section 15064) and cumulative impacts, as well as areas such as the consultation process for the draft EIR, the statement of overriding considerations, the environmental setting, mitigation measures, and tiering and streamlining. Overall, the discussion of determining significance in

these amendments is consistent with the earlier report released by CAPCOA.

In the Final Statement of Reasons (SOR) for the adoption of the amendments to the CEQA Guidelines, the Resources Agency makes two points that are important with regard to quantification of GHG emissions from projects. First, it states that the Guidelines "appropriately focus on a project's potential incremental contribution of GHGs" and that the amendments "expressly incorporate the fair argument standard." [1] This sets the parameters for the analysis to be performed. The Resources Agency further states that the analysis for GHGs must be consistent with existing CEQA principles, which includes standards for the substantial evidence needed to support findings.

Second, the Final SOR specifically states that the amendments "interpret and make specific statutory CEQA provisions and case law … determining the significance of GHG emissions that may result from proposed projects."[2] In this context, they cite specific case law as well as CEQA Guidelines Section 15144 that require a lead agency to "meaningfully attempt to quantify the Project's potential impacts on GHG emissions and determine their significance."[3]

Complete copies of the 2009 CEQA Guidelines Amendments and the Final Statement of Reasons may be downloaded at: *http://ceres.ca.gov/ceqa/docs/*.

<u>Quantification of Projects</u>: Project level quantification, especially as it pertains to CEQA, was CAPCOA's main focus in developing this Report. The baseline conditions and quantification methods were selected to be consistent with the implementation of AB 32, as well as the Scoping Plan developed by ARB. The list of mitigation measures selected for the Report reflects the types of strategies that local governments and project proponents have shown interest in, and sought direction on quantifying. For the most part, they entail clearly delineated boundary conditions, and have been designed to be applicable across a range of circumstances.

This Quantification Report does not provide any policy guidance on what amount of GHG emissions would be significant. The determination of significance, including any thresholds, is the exclusive purview of the Lead Agency and its policy board. CAPCOA's Quantification Report provides methods to quantify emissions from specific types of mitigation projects or measures. It is based on a careful review of existing studies and determinations to develop rigorous quantification methods that meet the substantial evidence requirements of CEQA.

A project proponent or reviewer who wishes to use these methods to quantify emissions for the purpose of complying with CEQA must adhere to the assumptions and limitations

[1] California Natural Resources Agency: "Final Statement of Reasons for Regulatory Action: Amendments to the State CEQA Guidelines Addressing and Analysis and Mitigation of Greenhouse Gas Emissions Pursuant to SB 97," December, 2009; p 12.
[2] Ibid: p. 18.
[3] Ibid: p. 18.

specified in the methods for each project type. If these assumptions and limitations are not followed, the quantification will not be valid. Ultimately, the Lead Agency will have the responsibility to review and decide whether to allow any requests for deviations from the method, and to determine whether those deviations have a substantive impact on the results. Lead Agencies may contact their local air district for assistance in making such a review, but CAPCOA will not be in a position to provide any case-by-case review of changes to the quantification methods in this report.

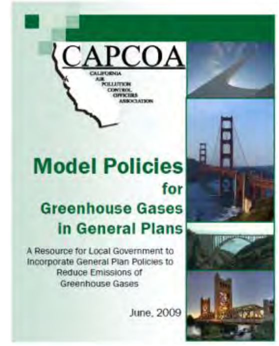
As stated previously, where good quality, project-specific data are available, they should be substituted for the more generalized data used in the baseline and mitigation emissions calculations. The quality of the data inputs can significantly affect the accuracy and reliability of the results. When quantification is performed for CEQA compliance, CAPCOA recommends that project-specific data be as robust as possible. We discourage the use of approximations or unsubstantiated numbers. In any case, CAPCOA strongly recommends that the source(s) and/or basis of all project-specific data supplied by the project proponent be clearly identified in the analysis, and the limitations of the data be discussed.

Plan-Level Mitigation: Cities and counties, as well as other entities, develop environmental planning documents. The most common are General Plans, which specify the blueprint for land-use, transportation, housing, growth, and resource management for cities, counties, and regions. These plans are periodically updated, and in recent updates, the California Attorney General has put jurisdictions on notice that their plans must consider climate change.

A stand-alone plan that considers climate change is a Climate Action Plan. Climate Action Plans can be developed for a school or company, for a city, county, region, or larger jurisdiction. A Climate Action Plan will typically identify a reduction target or commitment, and then set forth the complement of goals, policies, measures, and ordinances that will achieve the target. These policies and other strategies will typically include measures in transportation, land use, energy conservation, water conservation, and other elements.

<u>Guidance on Planning and Climate Change</u>: CAPCOA prepared a guidance document on GHGs and General Plans for local governments. There are also several important processes under way that will have a significant impact on the planning process in the coming years. These include the early implementation of Senate Bill 375 (Steinberg, Statutes of 2008); the development of new General Plan Guidelines; and statewide planning for adaptation to the impacts of climate change. They are described below.

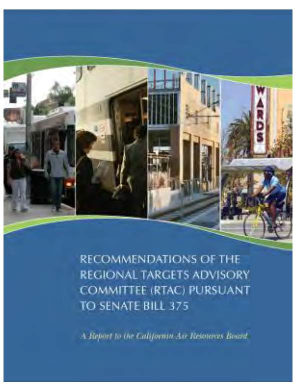
<u>CAPCOA Guidance for General Plans</u>- In June of 2009, CAPCOA released "*Model Policies for Greenhouse Gases in General Plans: A Resource for Local Government to Incorporate General Plan Policies to Reduce Emissions of Greenhouse Gases*." This document embodied a menu of GHG mitigation measures that could



be included in a General Plan or a Climate Action Plan. It was structured around the elements of a General Plan, provided model language that could be taken and dropped into a plan, and also provided a worksheet for evaluating which measures to use. The CAPCOA Model Policies document focused on strategies to reduce GHG emissions; it did not address climate change adaptation, which is an important, but separate consideration.

Senate Bill 375- Senate Bill 375 is considered a landmark piece of legislation that aligns regional land use, transportation, housing, and greenhouse gas reduction planning efforts. The bill requires the ARB to set greenhouse gas emission reduction targets for light trucks and passenger vehicles for 2020 and 2035. The 18 Metropolitan Planning Organizations (MPOs) are responsible for preparing Sustainable Communities Strategies and, if needed, Alternative Planning Strategies (APS), that will include a region's respective strategy for meeting the established targets. An APS is an alternative strategy that must show how the region would, if implemented, meet the target if the SCS does not.

To develop the targets, SB 375 called for a Regional Targets Advisory Committee (RTAC), which included representatives from the MPOs, cities and counties, air districts, elected officials, the business community, nongovernmental organizations, and experts in land use and transportation. The RTAC provided recommendations on the targets to ARB in a formal report in September, 2009. The report covers a range of important considerations in target setting and implementation. Target setting topics include: the use of empirical data and modeling; key underlying assumptions; best management practices; the base year, the metric, targets for 2020 and 2035; and both statewide and regional factors affecting transportation patterns. For implementation, the report considers housing and social equity issues; local government challenges in meeting the targets; funding and other support at the state and federal level; and a variety of other important considerations. A complete copy of the report may be downloaded at: *http://www.arb.ca.gov/cc/sb375/rtac/report/092909/finalreport.pdf*.



ARB staff released draft regional targets for 2020 for the four largest MPOs in June, 2010, along with placeholder targets for 2035. Placeholder targets were also issued for both 2020 and 2035 for MPOs in the San Joaquin Valley. An alternative approach to target setting was proposed for the remaining MPOs. As required by SB 375, ARB expects to formally adopt the final targets before the end of September, 2010. Additional information about the target setting process can be found at: *http://www.arb.ca.gov/cc/sb375/sb375.htm*.

For the four largest MPOs, the draft 2020 targets are expressed as a percent reduction in emissions based on the potential reductions from land use and transportation planning scenarios provided by the MPOs, with a proposed range for the targets between 5% and 10%[4]. This reduction excludes the expected emission reductions from Pavley GHG vehicle standards and low carbon fuel standard measures. Each of the four regions has its own placeholder targets for 2035, shown in Table 2-1, below.

Table 2-1: Draft Regional Targets for 2035

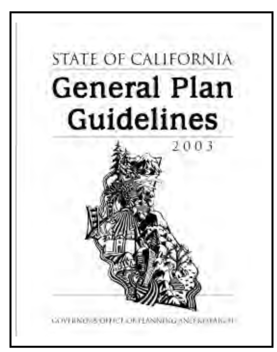
Regional MPO	Draft GHG Reduction Target
Metropolitan Planning Commission (MTC)	3-12%
Sacramento Area Council of Governments (SACOG)	13-17%
San Diego Association of Governments (SANDAG)	5-19%
Southern California Association of Governments (SCAG)	3-12%

Source: ARB: "Draft Regional Greenhouse Gas Emission Reduction Targets For Automobiles and Light Trucks Pursuant to Senate Bill 375" page 4.

The placeholder targets for the MPOs in the San Joaquin Valley range from 1-7% for both 2020 and 2035. Placeholder targets were provided in lieu of draft targets to allow the MPOs to provide additional information for ARB to consider before finalizing the targets. For the remaining six MPOs, ARB proposes to use the most current per-capita GHG emissions data, adjusted for the impacts of the recession, as the basis for setting individual regional targets in those areas.

In addition to serving on the RTAC, local districts will support the MPOs as they develop their strategies to meet their regional targets, and local cities and counties as they incorporate sustainable strategies into their own planning efforts. Two of the contractors who developed the quantification methods in this Quantification Report also served on the RTAC, and every effort has been made to ensure that work here will ultimately be compatible with, and useful in, the implementation of SB 375.

General Plan Guidelines- The Governor's Office of Planning and Research (OPR) provides technical assistance on land use planning and CEQA matters to local governments. In this effort, OPR is required to adopt and periodically revise advisory guidelines to assist local governments in the preparation of local general plans. Commonly referred to as the General Plan Guidelines, the most current edition was released in 2003.



In the 2003 edition, OPR included an overview of the General Plan statutory requirements, a review of CEQA's role in the general plan process, implementation techniques, and the General Plan's relationship to other statutory planning requirements. The 2003 Guidelines do not specifically address GHG emissions or climate change.

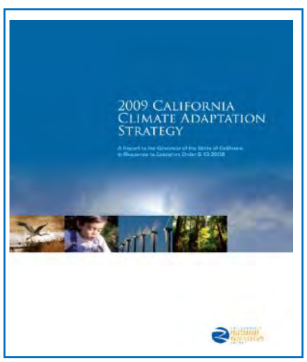
[4] ARB: "Draft Regional Greenhouse Gas Emission Reduction Targets For Automobiles and Light Trucks Pursuant to Senate Bill 375," June, 2010; page 4.

It is important to note that the General Plan Guidelines are advisory, not mandatory. Nevertheless, it is the state's only official document explaining California's legal requirements for general plans. The General Plan Guidelines are continually shaped to reflect current trends, changes in applicable laws, and incorporate additional statutory requirements. This includes anticipated effects from AB 32 and SB 375.

An update to the 2003 General Plan Guidelines has been in development and includes a Climate Change Supplement. This update is expected to be finalized by the end of 2010.

Adaptation- Adaptation has not received the same attention that has been given to steps that might prevent or mitigate the extent of climate change, however it is a topic that should not be ignored in General Plans. The overwhelming body of scientific studies point to a certain amount of change in our climate that is inevitable, even if we are aggressive and diligent in our efforts to prevent it. Many regions of the state (indeed, the nation) are projected to see substantial impacts on agriculture, climate dependant business (such as recreation and tourism), infrastructure, and habitat. Coastal areas will see a rise in sea level, currently projected to be between one and three meters by 2100. Wild fires are expected to increase in number, size, and severity. Stresses on the environment, combined with extreme weather events, are projected to increase the incidence and severity of a number of infectious diseases and other medical conditions. These and myriad other changes pose tremendous risks to people and our way of life.

For that reason, in December, 2009, a team of California state agencies released a report: "The 2009 Climate Adaptation Strategy." In it, the team states that 2.5 trillion dollars' worth of infrastructure in California is at risk from the various projected climate-related changes in our environment. The estimated cost of addressing the impacts on that infrastructure is about $3.9 billion, annually.[5] The report identifies a number of steps to be taken in the near term to appropriately plan for and address this threat. Highlights of the actions include: the formation of a Climate Adaptation Advisory Panel; new approaches to water management; revised land-use planning to avoid construction in highly vulnerable areas; evaluation of all state infrastructure projects to avoid exacerbating threats to infrastructure; and, more specific planning by emergency response agencies, public health agencies, and others to fortify existing communities and resources, and prepare for future stressors. For more information, the full report may be downloaded at: *http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF*.



Quantification for Planning Purposes: Quantification of the impacts of measures for planning purposes is a different exercise than quantification for a specific project. By its

[5] California Natural Resources Agency: "2009 Climate Adaptation Strategy" Dec. 2009; p. 5.

very nature, planning involves a future set of conditions about which less is known, and indeed knowable. The art and science of planning depend upon the interpretation of present conditions and trends, and the application of that interpretation to create a picture of future conditions. This document does not address detailed planning analysis in a comprehensive manner.

The majority of the measures described and quantified here are project-level measures; only a few are plan-level measures by design. That said, many of the project level measures are good examples of the implementation of planning-level policies that were described in the CAPCOA Model Policies report. The quantification of these measures will provide important and useful information for the planner to use in the context of quantifying anticipated effects in broader planning efforts.

In a planning context, it is especially important to be mindful of the interactions of different measures. A more detailed explanation is provided in Chapter 6, but the main concern is that certain measures do interact with each other, and their effects are not independent. This means that some measures will have little effect on their own, but in combination with other measures may have significant effect. The classic example of this is the bus shelter. A clean, well-lit, and comfortable bus shelter can enhance ridership on the buses stopping at that shelter and therefore reduce vehicle trips; but without the underlying bus service, the shelter itself does not reduce vehicle trips.

There are also instances where a measure is less effective in combination with other measures than it might be by itself. There are several reasons why this can occur. In some cases this happens because of a diminishing return for consecutive efforts. For example, there may be six good methods to increase ridership on a public transit line, any one of which might increase transit ridership by 20%. But implementing all of them will not necessarily increase ridership by 120%. In fact, for each successive method applied, it is likely that a lesser effect will be observed. Another example is where the measures are in some sense competing, as in a campaign to increase ridership on a commuter rail line at the same time that a new public transit bus line is established with overlapping service areas. Although the ridership campaign might be expected to cause 5% of drivers to switch to rail, some of those potential new riders might use the new bus service instead, making the ridership campaign less effective. At the same time, the new bus line might also be expected to reduce vehicle trips by 5%, but the actual reduction may be lower in reality if some of the ridership comes from those who would have been rail passengers and not from driving. Together, the ridership campaign for the rail line and the new bus line may only reduce vehicle trips by 7%, not the 10% predicted from the estimates of their independent effectiveness.[6]

These effects become more pronounced when considered in a city-wide, county-wide, or regional context. The interplay of land use decisions and transportation infrastructure development will be better assessed with more integrated computer modeling efforts. The quantification of some of the strategies at the individual, project level will provide

[6] Please note that the effectiveness estimates provided here are only for the purposes of illustration and should not be taken as actual quantification of such measures.

insight into how useful and appropriate the strategies will be in the planning effort, however. More detailed discussion of how to quantify combinations of measures is provided in Chapter 6.

Reductions for Regulatory Compliance

There are three basic types of regulations for which emissions quantification is likely to be required: command-and-control regulations, permitting, and participation in a cap-and-trade program. A discussion of each is provided for information purposes, as is a discussion of quantification for mandatory emissions reporting regulations. The quantification methods in this document are intended primarily for use in project-level mitigation. Regulatory programs are likely to have specific requirements for monitoring, reporting, and quantification, which may or may not allow the use of the methods in this Report.

Command and Control Regulations: Some local air districts have command-and-control regulations for GHGs already on the books. These include limitations on the use of certain chemicals that are active in the atmosphere, performance requirements for landfill gas collection, and for systems that use GHGs with high Global Warming Potential, as well as efficiency standards for specific equipment or processes. Under the umbrella of the Scoping Plan, the ARB is also developing command-and-control regulations for a number of source categories. Regulations already adopted include standards for various GHGs that have a high global warming potential, such as sulfur hexafluoride (SF_6) used in the electricity sector, semiconductors, and other operations; perfluorocarbons in semiconductor manufacturing; certain refrigerants; and materials used in consumer products. There are also GHG emission limits on light-duty vehicles, rules for port drayage trucks and other heavy-duty vehicles, as well as landfill methane control requirements, and the Low Carbon Fuel Standard. Additional rulemaking is currently underway.

For these types of regulations, compliance may not rest upon quantification of emissions or emissions reductions. In many cases, installation of a specific technology, substitution of materials, or implementation of inspection and maintenance programs meets the requirements of the rule, and is presumed to have a certain effectiveness in reducing emissions from a baseline level. When a focused regulation does require quantification of emissions, it will generally specify a method for testing emissions, where appropriate, or for calculating emissions from other measured parameters.

A related, but more flexible type of regulation for emission reductions is an overall emissions cap for facilities or operations. Under this approach, sometimes referred to as a “bubble,” the regulation calls for an overall reduction in emissions from a specified baseline, but the operator has the discretion to decide how to achieve those reductions. This is different from a cap-and-trade program (see below), in that there is no trading between facilities, or purchasing of credits to offset obligations. Because energy efficiency and other conservation projects are a likely strategy to meet a facility-wide GHG emission reduction requirement, the quantification of measures in this Report may be useful for compliance with such a cap. Of course, the caveats about assumptions and data inputs are also important here. Further, demonstration of compliance with this kind of limit will also involve verification of the emissions reductions, and is likely to include ongoing compliance tracking.

The regional targets of SB 375 are a type of emissions cap. It is important to note that the quantification presented in this Report may ultimately be useful in demonstrating reductions towards those targets. Although much of the work of implementing SB 375 will involve extensive land use and transportation modeling, the project level quantification in this Report may allow cities and counties to track their contribution towards their region's goal.

Permitting Programs: In addition to land-use permitting (discussed under "Project-level Mitigation" above), there may be requirements for operations to have permits to emit GHGs because GHGs are air pollutants. Federal air permitting requirements for stationary sources will become effective on January 1, 2011 (and will apply to applications that have not been acted upon prior to that date), under several federal permit programs, including Prevention of Significant Deterioration (PSD) and Title V. These programs are implemented by the local air districts. Applicability of these programs is based on annual potential to emit GHGs, with thresholds initially set between 75,000 and 100,000 tons per year, depending on the program, and decreasing over time, with final thresholds for smaller sources of GHG to be determined by a future federal rulemaking.

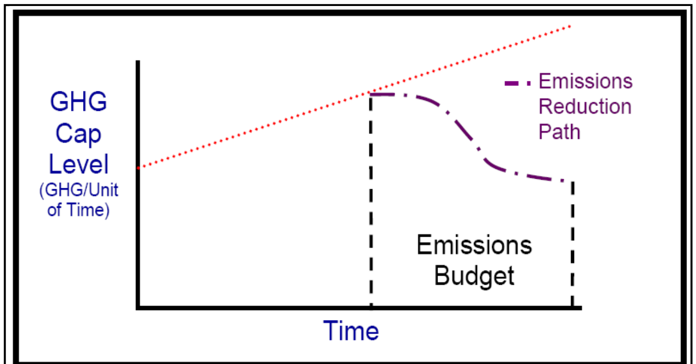
Because these permit programs are threshold-driven, quantification of emissions is an important element of compliance. At present, there is no specific federal guidance on quantifying GHG emissions pursuant to these programs, other than general guidelines for quantifying emissions of other regulated pollutants. This Quantification Report does not specifically address stationary source emissions, however some of the methods may be useful for certain elements of these programs, such as energy efficiency, water efficiency, and other associated measures of carbon use by a facility. The local air district with jurisdiction will be able to provide guidance on calculating emissions for a specific project, both for applicability and for compliance.

In addition, most permits require some form of verification, and ongoing demonstration on compliance. These obligations will be established as part of the permit.

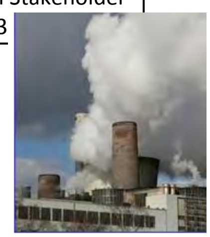
Cap-and-Trade: A cap-and-trade program is a specific type of emissions trading program. Emissions trading in general is discussed in the next section. A brief explanation of cap-and-trade programs is provided below as background information for interested readers. It is not necessary to understand cap and trade programs, or emissions trading in general, in order to use the quantification methods in this report.

Further, these quantification methods were not developed specifically for the purposes of complying with cap and trade requirements, or for emissions trading more generally.

A cap-and-trade regulation establishes "allowances" for carbon emissions, expressed as CO_2 equivalents, usually in tons, or metric tons. An emitter of carbon must hold enough allowances to cover the amount of carbon it actually emits. Allowances are obtained on a carbon exchange, or market. In some cases they may be allocated by the government to emitters. There is a "cap" placed on the amount of allowances available in the market, and the cap declines over time. Carbon emitters must either reduce their emissions or purchase allowances from someone else; this is the "trade" part of the program. In this way, the program should cause carbon to be reduced wherever the reduction costs are lowest. The ARB is developing a cap-and-trade program which they currently expect will be considered for Board approval before the end of 2010. Information about the developing ARB program can be obtained from the conceptual drafts released by staff. Legislation is also pending at the federal level that would establish cap-and-trade on a national scale, but the ultimate scope and content of the program is still unknown. The most recent ARB draft proposal may be downloaded at: *http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm*.



From ARB materials for AB 32 Program Design Technical Stakeholder Working Group Meeting, April 25, 2008, Figure 1, page 3



Although compliance with a cap-and-trade program is not likely to be a reason for quantifying GHG reductions today, it is likely to be one in the future. When that time comes, there will be several important considerations in deciding whether to use this Quantification Report in meeting those obligations.

Mandatory Reporting: The ARB currently has a Mandatory Reporting Rule for specified stationary sources with GHG emissions greater than 25,000 metric tons of CO_2e per year. This rule was established pursuant to the requirements of AB 32, and was intended to provide information to support the development of the Scoping Plan and its implementing regulations. At the time the Mandatory Reporting Rule was approved by the ARB Board, staff indicated that the Rule was not intended, nor did it include the level of detail necessary, to implement the cap-and-trade program (which, at that time, was not yet proposed). Applicable quantification protocols will be developed and approved by the ARB Board as part of its cap-and-trade regulation, as will a revised Mandatory Reporting Rule. More information about the ARB's Mandatory Reporting Rule may be obtained at *http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm*.

The U.S. EPA also has a Mandatory Reporting Rule. Under this rule, suppliers of fossil fuels or greenhouse gases that are used in industrial operations, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions are required to submit annual reports to EPA. The EPA rule does not currently specify quantification methods, and CAPCOA anticipates that any methods in this Report that would be applicable to affected reporters (e.g., building energy use) would be also be acceptable for use under the rule. Details on this rule can be found in 40 CFR Part 98, which was published in the Federal Register (*www.regulations.gov*) on October 30, 2009 under Docket ID No. EPA-HQ-OAR-2008-0508-2278.

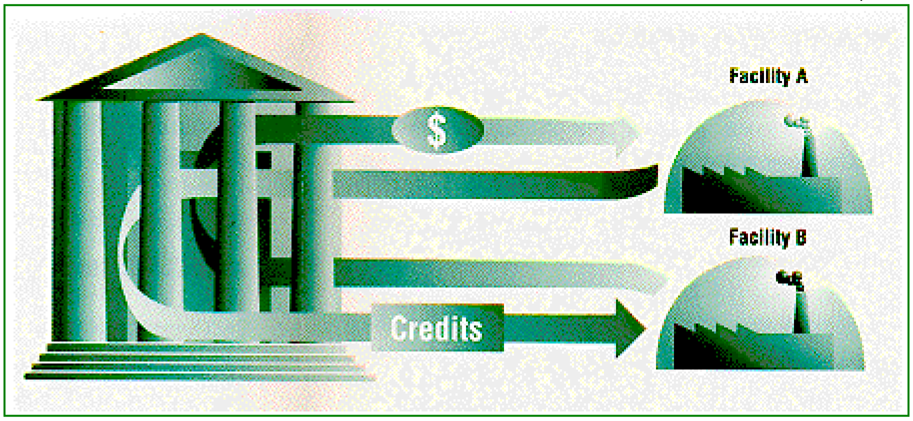
Reductions for Credit

There are several different ways to formally award credit for emission reductions. Emission reduction credits are used when the opportunity, desire, obligation, and the resources to implement reductions are not aligned. Sometimes an entity has the desire and opportunity to reduce emissions, but not the resources. Sometimes an entity is required to make reductions but has no viable project opportunities. Or funds may be available to implement project, but willing participants are needed. Systems are used to match up projects, proponents, funding, and, in some cases, compliance obligations, and the basis of the systems is emission reduction credits.

Concurrent Offsite Mitigation Projects: The simplest form of credit for emission reductions occurs when someone needs to reduce emissions to mitigate impacts (for example, under CEQA), but does not have a good opportunity within his or her own operation or project; but if a good opportunity is available at another operation the person who needs the reductions can fund that project in exchange for being able to take credit for the reduction. A variant of this can occur when a list of emission reduction projects that could be used for mitigation is maintained, and those projects are matched with people who need to implement mitigation. The key in this arrangement is that the project is directly funded by the person who needs mitigation, at whatever the cost the mitigation project ultimately has. The emission reductions occur, but are not traded as an independent commodity. The person who needs the mitigation remains obligated to ensure that the project is implemented and the emission reductions occur.

Mitigation Funds: Instead of matching the person needing mitigation with a project that is then directly funded by that person, it is also possible to collect the funding and then create the projects. In this case, funds are paid into a mitigation fund at a pre-established rate, and the operator of the fund is then obligated to find and implement emission reduction projects. The rate is typically set at a level (for example in dollars per ton needed) that is sufficient to implement an actual project to produce the emission reductions, based on data about actual project costs. As with concurrent offsite mitigation projects, the emission reductions here are not traded as an independent commodity, however a default rate is established. Under a mitigation fund, then, the person needing mitigation is considered to have provided it (that is, given “credit” for the reductions) at the point of paying into the mitigation fund. The obligation to ensure the emission reductions occur is transferred to the fund operator.

Emissions Trading: Emissions trading is a transaction that occurs between entities that make emission reductions which they don't need, and entities that desire emissions reductions but, for whatever reason, do not choose to make them. The emissions (or, more accurately, "credits" for the emission reductions) are treated as a commodity with independent value. The transaction occurs in some form of market, much as transactions occur between the grower of produce and the consumer in a local farmers market. The transaction, or trade, happens when a consumer believes that the product is worth the price being asked for it.



The obligation to ensure the emission reductions occur generally rests with the person selling the credits, and (to the extent an independent review has occurred) with whomever grants certification to the reduction project.

As explained above, a cap-and-trade program is a type of GHG trading market, but there are other types of emissions trading markets. An open GHG credit-based trading market does not have a cap, and participation is on a voluntary basis. In a credit-based market, credits are awarded for emission reductions, and may be purchased and sold as a commodity on an exchange. The credits are sometimes referred to as offsets, and they are generally tracked as tons, or metric tons, of pollutant reduced; in the case of GHGs, this is typically in the form of CO_2e. The important distinction between an open market and a cap-and-trade system is that the creation, buying, and selling of offsets is not restricted in an open market.

The following key terms and concepts are discussed to help the interested reader understand how credits are used in a trading market, It is not necessary to understand trading markets in order to use the quantification methods in this report, and the reader may proceed directly to Chapter 3.

Regulators and Exchanges: Some emissions trading markets are run by the government, while others are operated by independent, non-governmental entities. In government-run markets, such as the Regional Clean Air Incentives Market (RECLAIM) developed and administered by the South Coast Air Quality Management District, and U.S. EPA's Acid Rain program, a government agency establishes and implements the trading market. These markets are typically regulatory in nature, rather than voluntary, although some voluntary participation may be allowed. The Regional Greenhouse Gas Initiative (RGGI) implemented by ten Northeast and Mid-Atlantic states, and the

European Union Emission Trading Scheme (EU ETS) are other examples of regulatory markets.

Independent exchanges, such as the California Climate Action Registry (CCAR) and the Climate Registry (TCR), were established as independent, non-governmental operations. They offer a forum for entities to have emission reductions certified for credit, and for those credits to be bought and sold. These bodies develop their own structure and rules for participation. The nature of those rules determines the quality of the credits available on the exchange. Participation in the exchange is voluntary.

Standards for Credits: In order to be acceptable for credit under the AB 32 program, GHG emission reductions must be real, permanent, quantifiable, verifiable, enforceable, and additional. Historically, the federal Clean Air Act (CAA, or Act) has required emission reduction credits to be: real, permanent, quantifiable, enforceable, and surplus[7]. In this context, surplus means the reductions are not required by any law, regulation, permit condition, or other enforceable mechanism under the Act. California continued this concept in AB 32, requiring that any regulation adopted pursuant to AB 32 ensure that GHG reductions are "real, permanent, quantifiable, verifiable, and enforceable."[8]

The term "additional" comes from the Clean Development Mechanism in the Kyoto Protocol; it is essentially the same as "surplus" except that it is not restricted to any particular statute, and means that you cannot receive credit for any reductions that you were otherwise obligated to make. AB 32 requires its implementing regulations that include market-based compliance mechanisms to ensure that reductions are "in addition to any greenhouse gas emission reduction otherwise required by law or regulation, and any other greenhouse gas emission reduction that might otherwise occur."[9]

Protocols: Transactions to purchase emission reductions depend on the confidence the purchaser has in the value of reductions being purchased. Price is part of the concept of value that we can easily understand. The other, less tangible part of the concept of value is the quality of the emission reductions themselves. This is harder to understand because, unlike the produce at the farmer's market, we can't examine the product to determine its value. Not only are emission reductions invisible, they actually *didn't happen*. So to have confidence in their value, we need a reliable and accurate picture of what *would have happened*, as well as what *actually happened*.

Protocols are the formalized procedures for accounting for credits that ensure the credits are an accurate and reliable representation of emission reductions that actually occurred. Some protocols focus only on quantification of the reductions, while others also address documentation and verification. They can be developed and adopted by regulatory bodies, by the operators of exchanges, or by subject area experts. Some markets will require participants to use a specific protocol or set of protocols. Others

[7] 40 CFR Sections 51.493 and 51.852
[8] California HS&C: Section 35862(d)(1)
[9] Ibid, Section 35862(d)(2)

will allow participants to propose a protocol for developing and quantifying reductions. Failure to follow required protocols may prevent the project from receiving credit.

Holding and Using Credits: When credits are awarded for emission reduction projects, the owner of the credits is generally given a certificate of value. In this case, "value" means the corresponding emission reductions, not the price, which is determined by the market. The credits are registered with a bank where they are kept until the owner of the credits uses or sells them.

Credit Banks: Emission credit banks are similar to savings banks where money is deposited. The bank tracks credits, credit value, credit price, and transactions. It compiles data and issues reports. Banks are subject to accounting standards and requirements for transparency. It is important to note that not all credits can be banked. Credits or allowances that have a finite life do not retain their value beyond their life term.

Credit Life: Credits may have a specified life (for example, one year), or they may be permanent. The life of the credit may be dictated either by the nature of the reductions that generated it, or by the program in which it is being used. As discussed above, in California, AB 32 requires reductions for regulatory compliance to be permanent. In other markets, such as Kyoto's Clean Development Mechanism, there are both long term and short term credits.

Discounting Credit Value: Some regulatory structures require that credits be discounted, that is, the emission reduction value of the credit (not the price) is reduced to account for certain factors, or to enhance the liquidity of the market. In some cases, a portion of the credit value is surrendered or retired in the interest of environmental policy goals.

Offset Ratios: Offset ratios are a way to ensure an adequate margin of safety when credits are provided to offset impacts. A program may require that the amount of credits provided is greater than the anticipated emissions increases. If the program requires 10% extra credits, then the offset ratio is said to be "1.1 to 1."

The above discussion of emission reduction credits and trading is provided for information only, and should not be construed as endorsement of, or recommendation for, the use of credits or trading for the purposes of meeting GHG reduction obligations. CAPCOA does not make policy recommendations regarding credits or trading in this Report. Decisions about whether to allow the use of credits rests solely with the agency with jurisdiction over a project or program.

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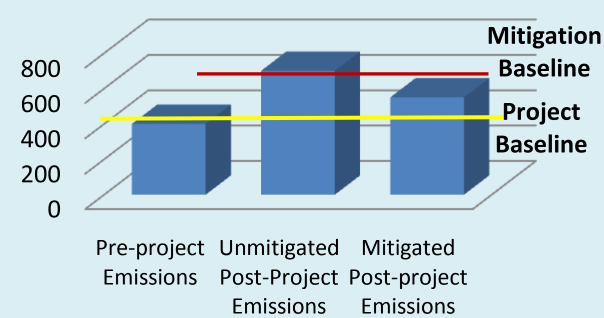
This chapter provides an overview of some key concepts that arise in considering quantification of GHG emission reduction projects. This discussion is provided so the reader understands the context in which these terms are used throughout this document. Here again, this discussion is not intended to endorse any policy position, nor does it provide any recommendations on thresholds of significance for GHG emissions. Policy decisions are left to individual agencies and their governing boards.

Baseline

An emissions baseline is the foundation of any estimate of the impacts of a project or of a mitigation measure. In its simplest form, it reflects the current level of emissions if those emissions do not vary. Usually, however, emissions do vary, typically because the activities or operations that cause the emissions change. Traffic patterns change with the time of day, ski areas are busiest in the winter, air conditioners run more in the summer, people drive less when fuel prices rise, and production of goods changes with the economy. To set a baseline, it is important to understand what factors affect the activity or operation in a way that will alter its emissions; then, the most appropriate scenario is selected and the emissions are adjusted to account for that scenario. Figure 3-1: Baseline illustrates the concept of baselines in project analysis.

Figure 3-1: Baseline



Regulatory programs that require calculation of emissions baselines generally specify the basis for the calculation. For example, a baseline scenario could be a three year average of actual emissions, or the worst case, or, as in CEQA, the program may call for an analysis to identify a representative set of conditions based on historical data.

In its proposed draft regulation for cap-and-trade, ARB defines baseline to mean "the scenario that reflects a conservative estimate of the business-as-usual performance or activities for the relevant type of activity or practice such that the baseline provides an adequate margin of safety to reasonably calculate the amount of GHG reductions in reference to such baseline."[1]

For this Quantification Report, CAPCOA selected a baseline period to correspond to the average GHG emissions from 2002 to 2004, inclusive. This is the emissions baseline period used by ARB in its Scoping Plan[2]. The baseline conditions used to quantify the

[1] ARB: "Preliminary Draft Regulation for a California Cap-and-Trade Program," Section 95802 (a)(2), Dec., 2009; page 5.
[2] ARB: "Climate Change Scoping Plan: a framework for change," Dec., 2008; page 11.

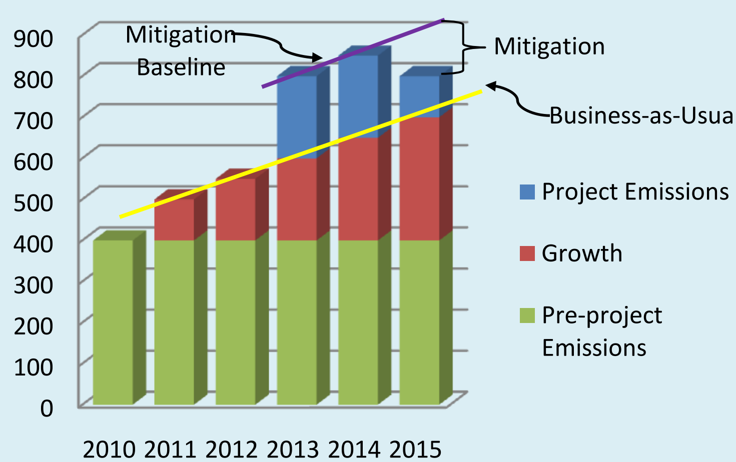
effectiveness of mitigation measures for this Quantification Report reflect the conditions that formed the basis for ARB's 2007 inventory of economic activity and GHG emissions. Those conditions and the associated quantification methods are explained in Appendix B to this Report. A copy of ARB's Scoping Plan may be downloaded at: *http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm*.

There may be circumstances in which a different set of baseline conditions is more appropriate. If a user wishes to adjust the baseline, CAPCOA recommends using the methods provided in the measure Fact Sheet, and in Appendix B, but substituting data inputs that better reflect the baseline conditions for the project under consideration. This ensures consistent methods are used so the comparison of baseline to project is an "apples-to-apples" comparison. So, for example, a user outside of California would substitute an emission factor for electricity generation that better represents the generation mix that is provided in the user's region. This alternative factor would be used in the baseline methods where electricity generation is part of the calculation, and would also be used in the quantification of emissions associated with the project.

It may also be appropriate to adjust the baseline conditions on a temporal basis if needed to account for changes over time. The ARB revises its emissions inventory information on a periodic basis. The most current inventory information was published in May of 2010, and covers the time period from 2000 to 2008. The information is available by category, with trends analysis, and with full documentation of data sources and methods. The updated emissions inventory information is available at: *http://www.arb.ca.gov/cc/inventory/data/data.htm*.

Business-as-Usual Scenario

Figure 3-2: Business-as-Usual



Not all baseline conditions occur in the present. In some cases, the baseline is a forecast of the conditions that are expected to exist at some time in the future, in the absence of interventions to change those future conditions. The forecasted baseline conditions are referred to as "business-as-usual" and are intended to reflect normal operation. For example, a town might currently have 20,000 residents, and be on a course to to add another 5,000 residents in low-density, planned development at the perimeter of its existing footprint over the next 10 years. The town could add an urban growth boundary that would change that anticipated development. In order to quantify the effect of adding the urban growth boundary, the business-as-usual growth scenario must first be calculated; that will form the baseline to compare to the growth scenario with the adopted boundary. Figure 3-2 illustrates the application of the "business-as-usual" concept to a project.

ARB defines business-as-usual to mean, "the normal course of business or activities for an entity or a project before the imposition of greenhouse gas emission reduction requirements or incentives."[3]

Mitigation Types

There are four general ways to create emission reductions for mitigation projects: (1) the operation or activity can be avoided so that emissions are not created in the first place; (2) the operation or activity can be changed so that it creates fewer emissions; (3) emission control technology can be added to the activity or operation that prevents the release of emissions that are created; and (4) emissions that have been released can be sequestered in the environment. Each of these is discussed below.

Avoided Emissions: When someone chooses to walk to the grocery store in lieu of driving, or turn off the lights, energy isn't needed to power the car or lights, and the emissions associated with that energy don't occur. In the case of walking instead of driving, the avoided emissions include the CO_2 and other pollutants that would have come from the tailpipe of the car. These are "direct" emissions that are being avoided, and they can be readily quantified to show the benefit associated with walking. When electricity isn't needed, it isn't generated; the avoided emissions are the CO_2 and other pollutants that are not emitted by the power plant. Because the emissions are not directly emitted where the light is being used, this type of emissions are referred to as "indirect" emissions; even though they are indirect, they can still be quantified to show the benefit of turning off the lights. There can be other benefits associated with avoided emissions as well. When you consider the walking scenario in a lifecycle sense, the avoided emissions can also include the energy that would have been used to extract, refine, transport, and dispense the fuel. The same is true when you use a reusable cloth bag instead of a disposable plastic bag to carry your purchases; energy is needed to extract and refine the petroleum that goes into the bag, to make and transport the bag, and then to dispose of the bag after it is used. These kinds of avoided emissions are much more difficult to fully quantify, however, and will not be included in the quantification approaches in this document. Even if we aren't quantifying the benefits, however, it is important to understand that avoided emissions can have positive effects both upstream and downstream, creating a ripple effect of further avoided emissions.

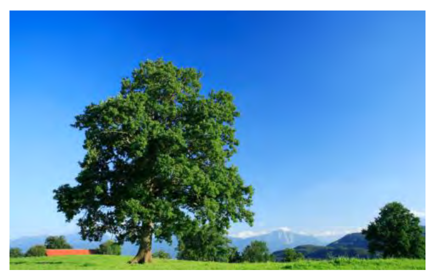
[3] ARB: "Preliminary Draft Regulation for a California Cap-and-Trade Program," Section 95802 (a)(18), Dec., 2009; page 7.

Fewer Created Emissions: If the activity or operation can't be avoided, sometimes it can be accomplished in a way that creates fewer emissions. This is usually associated with increased efficiency. So, for example, if walking to the store isn't an option, someone could choose to drive there in a more efficient vehicle, like a gas-electric hybrid powered car. The engine in the hybrid is able to drive more miles with less fuel consumed. Less fuel consumed equates to fewer emissions at the tailpipe. In the lighting example, using a more efficient light bulb is one way to reduce the indirect emissions, but a more efficient power plant would also do this.

Controlled Emissions: Once emissions are created, they are either released to the environment, or they are controlled with technology that captures and stores or destroys them. In the car example, the addition of a catalytic converter allows the tailpipe emissions to be collected after they are created, and destroyed before they are released. Note that the efficiency of the engine (discussed above), and the control of emissions after they leave it, are two distinct ways to reduce emissions. There are also emissions control technologies for power plants.

Sequestration of Emissions: Carbon emissions are "sequestered" by embedding the carbon in structure that will hold the emissions and keep them out of the atmosphere. Sequestration happens through biological, chemical, or physical processes.

<u>Biological Sequestration</u>: Trees and other vegetation biologically absorb carbon from the atmosphere and incorporate it into their biomass; the carbon becomes the solid form of the growing tree or plant. Many sequestration projects involve the planting of trees or vegetation to improve the uptake of carbon from the atmosphere. Enhanced farming practices may also achieve some sequestration through the use of CO_2 absorbing cover crops, improved grazing practices, and restoration of depleted land. Increased peat production in peat bogs is also method to biologically sequester carbon.



<u>Chemical Sequestration</u>: Oceans absorb CO_2, and it causes the oceans to become more acidic (which is detrimental to coral reefs and other sea life). Other chemical processes include reacting CO_2 through a process called mineral carbonation to form stable carbonate minerals that are normally found in the earth's crust.

<u>Physical Sequestration</u>: CO_2 can also be physically contained in a way that prevents its release to the atmosphere. This can involve injecting it deep into the ground, for example into depleted oil and gas reservoirs. It can also be injected into oil wells to push up the oil. Another approach is to embed it in cement through a newly developed process that causes cement to absorb CO_2 from the atmosphere while it is curing.

Measure or Project Scope

Just as good quantification requires careful and transparent consideration of the baseline or business-as-usual scenario, it also requires a complete and detailed characterization of the measure or project being undertaken. This is important because considerations of what is included in, and what is excluded from, the analysis can have a significant impact on results of the quantification.

Determining the appropriate scope for the analysis of a project or measure is not always as simple as it might appear. Take for example the installation of solar panels in a remote desert region that receives a lot of sun. The panels generate electricity without releasing GHG emissions, which offset more traditional generation of electricity that does emit GHGs. But the desert region may be prone to dust or sand storms, which would quickly obscure the glass panels and decrease their effectiveness. This decrease could be minimized if the panels were cleaned regularly. But the cleaning will require vehicles to come to the site, which takes energy and releases GHGs, and the cleaning activity itself may do so as well. If the site is truly remote, the emissions from those vehicle trips could be large. But what if there is another installation nearby: can the trip-related emissions be considered only in addition to those for the other site? Do you have to know if the cleaning for both sites can be accomplished in one trip? And what about the energy and materials needed to make the solar panels?

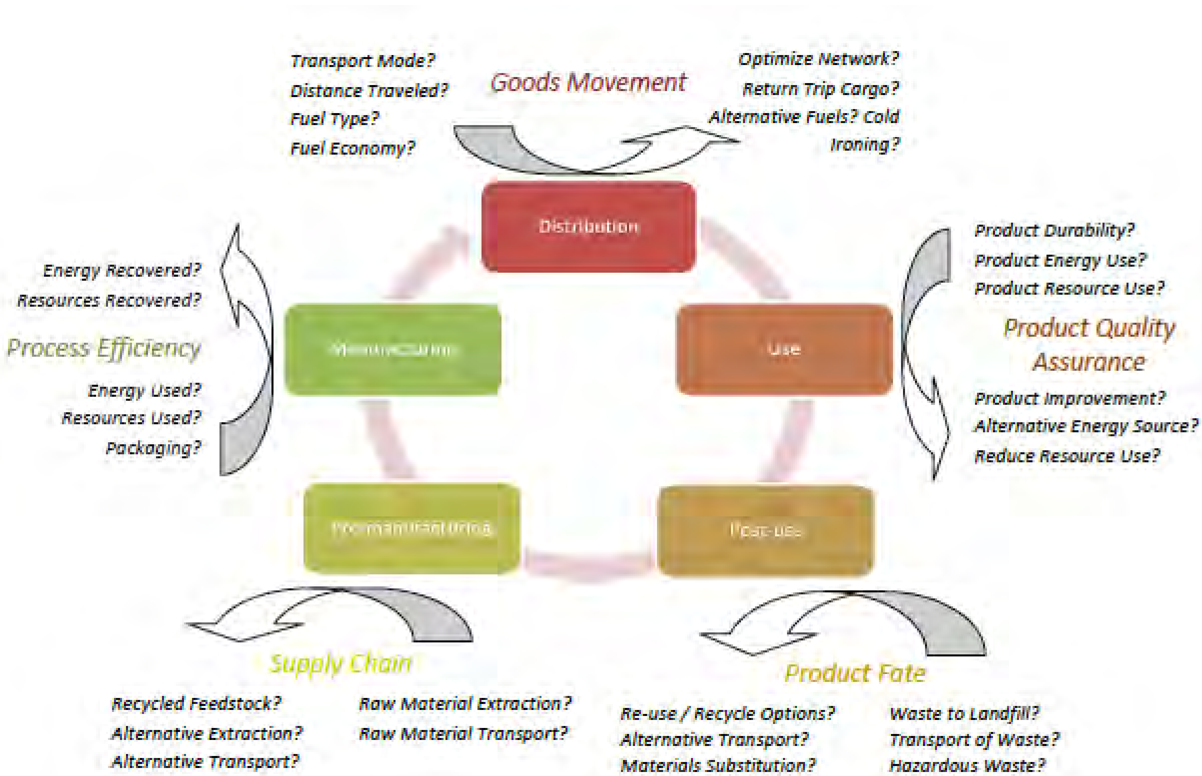
The methods in this Report generally include those reductions over which a project proponent can exercise direct control, as well as indirect emissions associated with electrical generation and the use of natural gas. CAPCOA does not include analysis of full lifecycle emissions in this Report, because of the complexity of the analysis involved and the lack of general standards for incorporating such considerations.

Lifecycle Analysis

Energy and materials are involved in the creation, processing, transport, and disposal of all of the products we use, from the tomatoes on our salads, to the computers we work with, the vehicles we drive (even if they are zero-emission vehicles), and the roadways we travel over. A lifecycle analysis attempts to identify and quantify the GHG emissions associated the energy and materials used at all stages of the product's life, from the gathering of raw materials, through the growing or fabrication, distribution, use, and the ultimate disposal at the end of the product's useful life.

This is a difficult and complicated undertaking; it is challenging to identify all of the inputs that are both necessary and meaningful for this sort of analysis. Even if the inputs can be identified, good data are not readily available to quantify emissions in most cases. Further, there is not yet agreement on methodological approaches to lifecycle analysis for most sectors (Figure 3-3: Lifecycle Analysis shows a basic schematic of some of these considerations.). For these reasons, as stated under the discussion of scope, above, CAPCOA does not include lifecycle analysis in this Report.

Figure 3-3: Lifecycle Analysis



Unfortunately, there are important mitigation projects or measures that cannot be quantified without a lifecycle analysis, and some of them are measures that are highly desirable or commonly encouraged. One example is the recycling and reuse of construction materials; it is intuitively obvious that recycling and reuse avoids both the embedded energy costs in the new material, as well as the energy and emissions associated with disposal. Another example is the push for reusable cloth grocery bags instead of disposable plastic ones, or reusable water bottles filled with tap water instead of disposable bottled water. For some of these measures, it is possible to do a limited lifecycle analysis, if the project scope is well defined and if the data are available. The Report provides a discussion of how to pursue an analysis in such cases, but otherwise identifies these kinds of measures as Best Management Practices.

It is important to note that Appendix F to the CEQA Guidelines Amendments approved in December of 2009 specifically state that a lead agency is not required to perform a project-level energy life-cycle analysis[4]. Because direct GHG emissions from electrical generation, and GHG emissions from electricity associated with water use (as well as other direct emissions associated with water treatment) are well defined and can be

[4] California Natural Resources Agency: Adopted Text of the CEQA Guidelines Amendments (Adopted December 30, 2009, Effective March 18, 2010), Appendix F.

accurately quantified, they are not considered to "lifecycle emissions" for the purposes of this Report, and they are included in these quantification methods.

Accuracy and Reliability

In an effort to standardize the creation of GHG inventories, and improve the quality of the information, the IPCC defines "good practice" for GHG emissions quantifications as those that "contain neither over- nor under-estimates so far as can be judged, and in which uncertainties are reduced as far as practicable."[5]

Part of the challenge in developing methods that meet this standard of good practice is assuring the accuracy of the methods. CAPCOA uses accuracy to mean the closeness of the agreement between the result of a measurement or calculation, and the true value, or a generally accepted reference value. When a method is accurate, it will, for a particular case, produce a quantification of emissions that is as close to the actual emissions as can practicably be done with information that is reasonably available.

To meet the good practice standard, the quantification methods must also be reliable, which is different from being accurate. A reliable method will yield accurate results across a range of different cases, not only in one particular case.

To some extent, the accuracy of the quantification is sacrificed to achieve reliability. This is because a method that can be applied across a range of scenarios must be generalized to some extent. So, for example, the transportation analyses do not, for the most part, differentiate between peak and off-peak vehicle trips, even though off-peak trips will have a lower emission impact because of the effects of congestion on travel time and engine performance. In order to fully address all of the factors that impact the emissions associated with vehicle trips in a specific project, a far more detailed and costly analysis would be needed, and it would not be readily applied to other situations. The methods contained in this Report have been developed to provide the best balance between accuracy and reliability, bearing in mind that ease of use is also important.

In order to ensure both the accuracy and the reliability of the quantification methods in this Report, each method is accompanied by a discussion of the assumptions and limitations of the method. Where either the assumptions are not met, or the limitations are exceeded, the method will not be accurate, and the error can be very large. Further, if the conditions of the project differ from the assumptions and limitations of the method, the quantification may no longer be applicable. It is possible to look at the underlying assumptions and calculation and make adjustments to the method so that it better reflects the conditions of a specific project. Doing this may preserve the accuracy to some extent, but the user is responsible for determining how best to accomplish this, and the reviewing agency will decide whether the results are still acceptable.

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[5] IPCC 2006, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds).Published: IGES, Japan. Page 1.6.

Additionality

In order for a project or measure that reduces emissions to count as mitigation of impacts, the reductions have to be "additional." Greenhouse gas emission reductions that are otherwise required by law or regulation would appropriately be considered part of the existing baseline. Thus, any resulting emission reduction cannot be construed as appropriate (or additional) for purposes of mitigation under CEQA. For example, in the draft regulation for cap-and-trade, ARB specifies that in order to be eligible for offset credit, "emission reductions must be in addition to any greenhouse gas reduction, avoidance or sequestration otherwise required by law or regulation, or any greenhouse gas reduction, avoidance or sequestration that would otherwise occur."[6] What this means in practice is that if there is a rule that requires, for example, increased energy efficiency in a new building, the project proponent cannot count that increased efficiency as a mitigation or credit unless the project goes beyond what the rule requires; and in that case, only the efficiency that is in excess of what is required can be counted. It also means that if there is a rule that requires a boiler to be replaced with one that releases fewer smog-forming pollutants, and the new boiler is more efficient and also releases less CO_2, the reduced CO_2 can't be counted as mitigation or credit, because the reductions were going to happen anyway. But if the boiler were replaced with a solar-powered water heater, the difference in emissions between a typical new boiler and the solar water heater could be counted.

From a practical standpoint, any reductions that are *not* additional have to be either included in the baseline or subtracted from the project, whichever is more appropriate. In preparing this Report, CAPCOA made determinations about requirements to include in or exclude from the baseline. A more complete discussion of those determinations is included in Appendix B.

Verification

Verification is the process by which we demonstrate that the emission reductions we have quantified for a project actually occurred. While not important for purely voluntary projects, verification in some form is a necessary step in most other circumstances. Verification is an important component in establishing the value of reductions that are made. It allows others to have confidence in the quality of the reductions. If the reductions are being made to satisfy an obligation to mitigate impacts, the agency with jurisdiction should be consulted to determine what standard of verification is needed. In some cases, independent, third-party verification is required. Not all regulatory programs specify third-party verification, however. For example, the U.S. EPA's Mandatory Reporting Rule relies instead on routine compliance verification through a permit system.

[6] ARB: "Preliminary Draft Regulation for a California Cap-and-Trade Program," Section 95802 (a)(4), Dec., 2009; page 6.

This chapter of the Report provides an explanation of how the quantification methods were developed, and the limitations of the sources used. There is also an overview of the presentation of the quantification methods in the Report. Finally this section discusses the limitations of the methods themselves, and how these limitations should be considered when applying the methods to actual mitigation projects.

General Emission Quantification Approach

The emission quantification methods in this Report are designed to provide GHG estimates using readily available, user-specified information for a source or activity. In general, GHG emissions associated with a given source or activity are estimated using data for a physical quantity or metric, on the underlying assumption that CO_2 emissions are directly proportional to that metric. For example, emissions related to vehicles are estimated using vehicle trips and mileage data. For sources of indirect emissions such as buildings, swimming pools, municipal lighting and water distribution, the metric is energy use as electricity or natural gas[1]. When site-specific energy use data are not available, energy use can be estimated using a physical metric such as the volume of water supplied, the size of building, and the number of lamps.

For each source metric there are emission factors that quantify the amount of emissions released as a result of the source or activity. These emission factors have been developed by various governmental agencies, public utilities and other entities though data analysis and numerical models. The factors are based on certain assumptions that define the typical or "baseline" emissions scenario. For example, emission factors for vehicles assume a particular type of fuel and driving speed, and emission factors for electricity use assume a certain mix of electricity generating methods. .

Individual GHGs are converted to carbon dioxide equivalent units by multiplying values by their global warming potential (GWP). The GWP values used in this report are based on the IPCC Second Assessment Report (SAR, 1996), even though more recent (and slightly different) GWP values were developed in the IPCC's Third Assessment Report (TAR, 2001) and Fourth Assessment Report (FAR, 2007). The values in the SAR were used in this Report because they are still used by international convention.

The general equation for emissions quantification is shown below for each GHG:

$$\text{GHG Emissions} = [\text{source metric}] \times [\text{emission factor}] \times [\text{GWP}]$$

Then, all GHGs are summed from an individual source.

$$\text{GHG Emissions}_{total} = \sum_{n=1}^{i} [\text{GHG Emissions}]_n$$

[1] Note that emissions from natural gas use are not always indirect in nature. For more discussion of direct and indirect emissions and types of mitigation, please see Chapter 3.

Where "source metric" and "emission factor" are defined as follows:

Source Metric: The "source metric" is the unit of measure of the source of the emissions. For example, for transportation sources, the metric is vehicle miles traveled; for building energy use, it is "energy intensity", that is, the energy demand per square foot of building space. Mitigation measures that involve source reduction are measures that reduce the source metric. This can include for example, reducing the miles traveled by a vehicle because the reduction in miles traveled will reduce the emissions generated from vehicle travel. Similarly, a reduction in dwelling unit electricity use by installing energy efficient appliances and lighting will reduce the emissions associated with total electricity assigned to dwelling units.

Emissions associated with source reduction measures are generally avoided emissions. As discussed in Chapter 3, there are often additional benefits to these kinds of reductions. Source reduction promotes efficient use and management of resources and utilities, in addition to avoiding emissions. Thus, source reduction can also result in a decreased need for downstream emissions control. From a quantification standpoint, for this type of measure, it is the "source metric" in the basic emissions equation (above) that changes.

Emission Factor: The "emission factor" is the rate at which emissions are generated per unit of source metric (see above). Reductions in the emission factor happen when fewer emissions are generated per unit of source metric, for example, a decrease in the amount emissions that are released per kilowatt hour, per gallon of water, etc. Such a decrease may apply if a carbon-neutral electricity source (e.g. from photovoltaics) is used in place of grid electricity, which has higher associated emissions; or if electricity is used instead of combustion fuel, such as with electric cars. Reductions can also occur if a fuel with lower GHG emissions is used in the place of one with higher GHG emissions. From a quantification standpoint, for this type of measure, it is the "emission factor" in the equation that changes.

For both kinds of measures, mitigated emissions are calculated using the same general equation, but the emissions will change based on whether the values change for the source metric or the emission factor. Several mitigation measures may apply to the same source, changing both the source metric and the emission factor, and the estimation of the overall impact of simultaneous measures must be carefully evaluated. In some cases the reductions are additive, but in others they must be evaluated sequentially. Other sets of mitigation measures may require additional analysis to avoid double-counting. Furthermore, not all types of mitigation measures will be feasible in all situations. Chapter 6 provides a detailed discussion of considerations in quantifying the combination of mitigation measures, as well as a set of rules to guard against over-estimation of reductions.

Quantification of Baseline Emissions

In order to ensure that similar assumptions and methodologies are being used to quantify both the baseline and project emissions, a consistent set of methodologies for determining the GHG emission baseline emissions was defined. This was the first step in establishing quantitative methods for assessing GHG mitigation reductions. The results of this effort are contained in Appendix B and should be utilized or considered when establishing baseline emission levels. This same set of methodologies was used to develop the quantification methods for each mitigation measure.

Quantification of Emission Reductions for Mitigation Measures

There is a wide array of mitigation measures that could reduce direct or indirect GHG emissions for a project; however, not all of them can be readily quantified with the information and tools currently available. Other measures may be individually quantifiable, but the quantification cannot be reliably extrapolated to other similar projects. The goal in developing this Quantification Report was to provide accurate and reliable methods that can be easily applied across a range of projects and settings. This section explains how the list of measures included in this guidance was developed, and how the measures are presented.

Screening of Mitigation Measures: An initial list of candidate measures was developed with about 75 types of greenhouse gas mitigation measures related to site design, land use, building components, parking measures, energy, solid waste management, etc. These were identified because they were commonly seen in land use permit applications or were measures that air districts have been frequently asked for guidance on. A literature review was done to identify potential additional measures.

Measures from this compiled list were screened based on the following criteria:

- Relevance to project-level CEQA analysis;
- Availability of empirical evidence or reliable research to credibly establish baselines and level of effectiveness; and
- Non-negligible level of effectiveness determined by credible research.

Measures or grouped measures that did not meet all three of these criteria were evaluated for the possibility of grouping measures with synergistic effects or describing as a Best Management Practice (BMP). Where measures were determined to be BMPs, the Report describes the relevant literature and, where applicable, provides methods that could be used if substantial evidence is available to support the reduction effectiveness. In addition some measures had substantial evidence of reductions when implemented at a general Plan (GP) level rather than a project level. These measures were retained as applicable for General Plans, only. Local Agencies may decide to provide incentives or allocate the General Plan level reductions to specific projects by weighting the overall effect by the number of projects to which the General Plan reduction would apply.

Information Sources and Their Limitations: The quantified effect that different mitigation measures have on source quantities or emission intensities must be based on substantial evidence and should be enforceable (to ensure that the commitments are adhered to) and verifiable (to confirm that the mitigation measures were implemented).

Examples of credible sources for supporting evidence include government agency-sponsored studies, peer-reviewed scientific literature, case studies, government-approved modeling software and widely adopted protocols. In order for the supporting evidence or data for a given mitigation measure to be deemed applicable, it must be based on similar or scalable assumptions and conditions in terms of period of study, physical scale, site-specific parameters, operating conditions, technology, population type, etc.

There are uncertainties associated with any type of estimation method. Some of these methods attempt to predict future behavior with respect to water and energy use using historical data and trends, which may not accurately reflect changes in behavior due to increasing awareness of resource conservation. Despite these uncertainties, the methods presented in Chapter 7 provide the best available estimations of GHG emissions and are therefore suitable for the project-level inventories.

Enforceable Reductions: As discussed in Chapter 2, emission reductions (whether as mitigation under CEQA, for regulatory purposes, or for trading) have to be enforceable. For that reason, in this Report the quantity of reductions or applicability of mitigation measures is limited to elements which the project proponent can control. Additional reductions in GHG emissions may be feasible in the broader sense and may occur; however, because the project proponent does not have control over these elements, those other reductions are not considered in the quantification methods here.

For instance, in the context of a building project, source reductions that rely on individual occupant behavior are generally not enforceable by the builder. A residential dwelling, when occupied, will contain a variety of electrical appliances. An individual occupant may decide to purchase energy efficient appliances and would therefore reduce energy use. This reduction in energy use is not enforceable, however, because the project proponent can't dictate individual occupants' purchases; these types of reductions are not counted in the methods in this Report. There may be some instances, however, where the project proponent is the occupant and would have the ability to enforce behavior. In these instances additional emission reductions not quantified in this document may be feasible and enforceable.

Some reductions in emissions are not enforceable when voluntary, but become enforceable when implemented as part of a regulatory scheme. Once regulations that result in emissions reductions are enacted, the project should be reviewed to determine how the requirements affect the baseline, and the reductions that can be quantified for mitigation credit.

When the emission reductions from a project are not enforceable, and therefore not quantified under these protocols, they may still have value for mitigation purposes and a qualitative analysis should be considered. Decisions about whether such reductions will be considered, and what sort of qualitative analysis is appropriate, are the responsibility of the agency reviewing the project.

Creation of Mitigation Measure Fact Sheets: Once the list of mitigation measures was determined, detailed Fact Sheets were developed for each mitigation measure. Each fact sheet presents a summary of the measure's applicability; the required calculation inputs from the actual project; the baseline emissions method; the mitigation calculation method and associated assumptions; a discussion of the calculation and an example calculation; and finally a summary of the preferred and alternative literature sources for measure efficacy. The fact sheets begin with a measure description. This description includes two critical components: (1) specific language regarding the measure implementation (which should be consistent with the implementation method for the actual project), and (2) a discussion of key support strategies that are assumed to also be in place for the reported range of effectiveness. Chapter 6 provides a discussion of the Fact Sheets and a brief description of their intended use. The Fact Sheets themselves are included in Chapter 7.

Quantification Methods

In this Report, emissions reductions are presented in terms of percentage reductions. For mitigation measures where the source metric is reduced, reductions were generally assessed based on a ratio comparison of a common "denominator" source metric for each source category in order to assist in the quantification of strategy impacts:

- Building Energy Use will utilize natural gas and electricity use.
- Water will utilize outdoor and indoor water use.
- Solid waste will utilize waste disposed.
- Mobile sources will utilize changes in vehicle miles travelled (VMT).

For mitigation measures involving emission factor reductions, a ratio comparing the mitigated and baseline emissions factor is utilized to quantify the emission reductions.

Because a ratio comparison is utilized, in most cases the reductions quantified for GHGs will also be the same reduction assessed for criteria pollutants and toxic air contaminants provided the reduction in emission factors also occurs for the other types of pollutants. This is not always the case and in some cases a reduction for one pollutant may result in an increase for another pollutant.

There is one exception to the quantitative approach described above, for off-road and on-road vehicles that affects the quantification of the emissions of ROGs. The underlying data and methods available to quantify these emissions were limited to running emissions (that is, emissions from the tailpipe while the engine is running). There are also evaporative emissions, however, which occur when pollutants evaporate from the fuel in the fuel tank and escape to the atmosphere. The evaporative emissions of most pollutants are very small when compared to the running emissions, but evaporative emissions of ROGs are not small compared to the running emissions. Because the underlying data and methods available did not address evaporative emissions, they are not part of the emission factor ratio and must be accounted for separately. Accordingly, an estimate of the ratio of running to evaporative emissions for ROGs was determined and used to adjust the reductions for ROGs from vehicles.

Limitations to Quantification of Emission Reductions for Mitigation Measures

In order to properly apply the quantification methods in this Report, it is important to understand the limitations of the methods. The following discusses the limitations of the underlying data and methods used to develop the quantification in this Report. A discussion of the limits on applying the methods in the Report is contained in Chapter 6. Further, the Fact Sheet for each individual measure identifies specific limitations and considerations that affect the application of that particular measure.

Prediction of Future Behavior: In order to assess the emissions associated with a project that does not yet exist, it is necessary to make assumptions regarding anticipated amounts of energy use, VMT, water use, etc, that will characterize the project once it occurs. These values may be based on estimates of source metrics from surveys of current values for those metrics, or from recent historical values. When such data are used, they are typically assumed to remain constant when applied to the project unless a there is a specific action (such as the application of a mitigation measure) that would alter the value(s). Although this is a commonly accepted practice, in reality, current behavior is not likely to remain constant over time in the way it is assumed. For instance, the occupant of a building determines the set point of thermostats, the duration of showers, and the usage of air conditioning, among other things. The project proponent will have little, if any, influence over these choices made by the future occupants.

Understanding the limits of these predictions, they are still the best basis for estimating future behavior. For this Report, quantification was based on current median behavior attributes. The limitations of the predictions can be minimized, however. Information about what influences behavior in specific circumstances is often available. Where data are available to show the relationship between external factors and the source metrics used to quantify a particular measure (such as fuel prices and VMT, for example), and more specific information is available about those external factors to predict future trends, that information could be used to further refine the quantification presented here. Again, the quality of the data used will substantially affect the accuracy and reliability of the results. It is also important to be aware of, and to minimize if possible, the error that can result from combining data from different sources (see below).

Combination of Data Sources: The quantification of some of the measures in this Report required the use of multiple sources of data. Any time data are derived from different sources there may be slight discrepancies the underlying in methodologies and data set characteristics; when the information between two data sets is combined, the discrepancies may affect the ultimate quantification of emissions, either over- or underestimating them. For example, some energy efficient appliances were not directly called out in the study of primary energy use based on end use. To obtain information on specific end uses, a secondary source was consulted that quantified energy use by end uses, and the values from this study were used to provide the detail where the end use data were lacking in the first study. It is not possible to determine the precise magnitude of the error that combining these two data sets induced in the final quantification, however every effort was made to minimize potential errors through thorough review of available data and exclusion of incompatible data sets.

There may be data sets available when considering a specific project that address the particulars of the project but are not generally applicable. Such case-specific data could be substituted for the more general data used to develop the quantifications in this Report. If such a substitution is considered, it is important to understand that it can result in an error in the quantification of the mitigation measure reductions because the methods used to derive the case-specific data may contain different assumptions that are not considered in, or are not consistent with the mitigation measure as characterized in the Fact Sheet. Anyone proposing the use of alternative underlying data for source metrics or emission factors must have a good understanding of the assumptions used in estimating the metrics/factors used in the baseline methodology and measure quantification for this Report. The discussion of sources and methods in the measure Fact Sheets as well as the baseline methodology in Appendix B should provide sufficient information to make this assessment.

Understanding these caveats, use of source-specific data is generally an improvement over that of generalized data, and where good quality source-specific data are available, they should be used. CAPCOA will not be able to review case-specific changes to the methods in this Report; however, the local air district may be able to provide assistance or recommendations. The decision to allow alterations to methods, including substitution of underlying data sets, rests with the agency reviewing the project.

Projects That Involve More Than One Mitigation Measure: Each mitigation measure was quantified using a specific set of underlying data and assumptions, and will provide the most accurate and reliable results when the project precisely matches the description of the measure, with all of its assumptions and limitations. In reality, projects may differ from the described measures, or may involve the application of more than one measure. In order to ensure that the resulting quantification is appropriate and accurate, specific procedures are provided in Chapter 6 for combining mitigation measures.

Lack of Detailed Information: The quantification methods provided in this report have been developed to allow them to be applied to a range of project conditions and still yield accurate and reliable results. In order to do this, the methods require data inputs that reflect the specific conditions of the project. Because the project has not yet been completed, however, certain information about the project will not be known and must be either estimated or assumed based on standard procedures. For example, at the time of the CEQA process a project proponent might know the number of residential dwelling units that will be in the project, but not know the actual square footage individual units will have. Similarly, while the project proponent may know a general type of non-residential land uses planned, these are often generalized categories such as retail and do not reflect the true diversity and range of source category parameters that would occur between the specific types of retail that the project eventually has. Nor can a project proponent predict specific appliances that will be in buildings or frequency of use. Further, most projects rely on generalized trip rate and trip lengths information that are not specific to the project; these estimates may over or underestimate the actual trip rates and trip lengths generated by the project. In each of these cases, estimates of future conditions are made based on accepted procedures and available data. This Report does not provide, or in any way alter, guidance on the level of detail required for the review or approval of any project. For the purposes of CEQA documents, the current CEQA guidelines address the information that is needed.[2]

The lack of precise and accurate data inputs limits the quality of the quantified project baseline and mitigated emissions, however. This limitation can be minimized to the extent the project proponent is able to provide better predictive data, or establish incentives, agreements, covenants, deeds, or other means of defining and restricting future uses to allow more precise estimates of the emissions associated with them. Some of these means of refining the data may also be creditable as mitigation of the project. The approval of any such enhancements of the data, or credit as mitigation, is at the discretion of the agency reviewing the project.

Use of Case Studies: One method of enhancing the data available for a project is the use of case studies. Case studies generally have detailed information regarding a particular effect. However, there are limitations of using this information to quantify emissions in other situations since adequate controls may not have been studied to separate out combined effects. There may be features or characteristics in the case-study that do not translate to the project and therefore may over or underestimate the GHG emission reductions. For the most part, case studies were not used as the primary source in the development of the quantification methods in this report. Where case studies were used to enhance underlying data, the studies were carefully reviewed to ensure that appropriate controls were used and the data meet the quality requirements of this Report.

[2] See: California Natural Resources Agency: 2007 CEQA Guidelines – Title 14 California Code of Regulations, Sections 15125, 15126.2, 15144, and 15146.

Extent Reductions Are Demonstrated in Practice: Some of the GHG mitigation measures in this Report are open-ended with regards to the amount of reductions that are theoretically possible. There are, however, practical limitations to the amount of reductions that can actually be achieved. These limitations can include the cost to implement the measure, physical constraints (e.g., roof space for photovoltaic panels), mainstream availability of technology, regulatory constraints, and other practical considerations. In applying the quantification methods for these types of measures, it is important to evaluate the reasonableness and practicability of the assumptions regarding these parameters.

Over time, some of these limitations may change. Implementation costs decrease as advanced technology is reaches mass production scale, for example, technological innovation can address physical constraints, and regulations change. The determination of feasibility for project assumptions should therefore be reconsidered for future applications based on the best available information at the time.

Biogenic CO_2 Emissions: This document did not address biogenic CO_2 emissions. Biogenic CO_2 emissions result from materials that are derived from living cells, as opposed to CO_2 emissions derived from fossil fuels, limestone, and other materials that have been transformed by geological processes. Biogenic CO_2 contains carbon that is present in organic materials that include, but are not limited to, wood, paper, vegetable oils, animal fat, and waste from food, animals, and vegetation (such as yard or forest waste). Biogenic CO_2 emissions are excluded from these GHG emissions quantification methods because they are the result of materials in the biological/physical carbon cycle, rather than the geological carbon cycle.

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Introduction

The mitigation measures quantified for this Report fall into general categories within which the quantification methods follow a common approach. The following sections summarize the select categories and subcategories of measures and discuss the quantification methods used for each one. In general, emission reductions are quantified (1) as a percentage of the baseline emissions; or (2) by calculating mitigated emissions and determining the change in emissions relative to the baseline case. More detailed explanation of the parameters and equations used to calculate the emission reductions for each individual measure are provided in the Fact Sheets in Chapter 7.

Building Energy Use

The emissions associated with building energy use come from power generation that provides the energy used to operate the building. Power is typically generated by a remote, central electricity generating plant, or onsite generation by fuel combustion. These emissions can be reduced by lowering the amount of electricity and natural gas required for building operations. This can be achieved by designing a more energy-efficient building structure and/or installing energy-efficient appliances. Replacing high-emitting energy generation with clean energy will also reduce emissions, and that type of mitigation is discussed in “On-site Energy Generation” below.

NREL.gov

As discussed in Chapter 3, this Report does not include a lifecycle analysis for GHG emissions. However, if a project proposes mitigation in the form of improved building energy use, a limited analysis of indirect emissions will be needed to quantify the associated reductions in GHG emissions. Emissions associated with energy use to light and heat buildings are, as stated previously, well-defined and not considered to be “lifecycle emissions” for the purposes of this Report. The quantification methods in this Report that deal with building energy use provide a specific method for conducting that analysis.

Emission reductions in this category are quantified as percentage reductions in specific baseline energy end uses, such as Title 24-regulated energy or household appliance energy use. The baseline values are determined using California-specific energy end use databases such as California Commercial End-Use Survey (CEUS) and Residential Appliance Saturation Study (RASS). The percentage reduction in Title-24 regulated energy is a project-specific input, whereas the percentage reductions in energy use for energy-efficient models of various household appliances can be obtained from literature sources (for example, through the Energy Star program).

Outdoor Water Use

Energy use associated with pumping, treating and conveying water generates indirect GHG emissions. The amount of energy required depends on both the volume of water and energy intensity associated with the water source. For example, it generally takes less energy to pump and convey water from a local source than to transport water across long distances. As a result, the GHG emission factor associated with locally-sourced water will also be lower. Indirect GHG emissions associated with water use can be decreased by reducing the water demand and/or by using a less energy-intensive water source. As discussed in Chapter 3, these emissions are well-defined and are not considered to be "lifecycle emissions" for the purposes of this report.

Outdoor water use at mixed-use developments is associated with irrigation for landscaping. The volume of water required for landscaping will depend on the areal extent of landscaping; the specific watering needs for the type of vegetation; and the water efficiency of the irrigation system. A reduction in outdoor water demand can be achieved by designing water-efficient landscapes that include plants with relatively low watering needs; minimizing areas of water-intensive turf; and installing smart irrigation systems to avoid excessive water use. Emission reductions associated with water-efficient design are quantified as the difference between mitigated and baseline values, which in turn are estimated using established models from government agencies or scientific literature. Emission reductions associated with smart irrigation systems and turf minimization are quantified as percentage reductions from the baseline. The implementation of gray water systems, where allowed, and the use of recycled water can also reduce emissions; however, it is important to consider the energy used to operate the gray water or water recycling system. These percentages are either taken from literature or estimated using site-specific data. The quantification methods in this Report include estimates of electricity use for recycled water systems, but not for gray water systems, because those emissions are generally more site specific.

As described previously, the energy use intensity for water supply will depend on the water source and its associated treatment and conveyance requirements. The typical or baseline scenario water source for Southern California is the State Water Project; however, other less-energy intensive supplies such as locally-treated recycled wastewater may instead be used to satisfy some of the project's non-potable water demand. Energy intensity values for different water sources can be obtained from California Energy Commission reports on water-related energy use, and are provided in Appendix E (Table E-2). Emissions associated with water use are estimated by multiplying the volume of water by the energy intensity value for the water source. The associated emission reduction is quantified by calculating emissions associated with water supplied by the lower impact water source (which can include the gray water or recycled water systems mentioned above), and subtracting it from the emissions associated with the same volume of water using the typical or baseline scenario water source.

Indoor Water Use

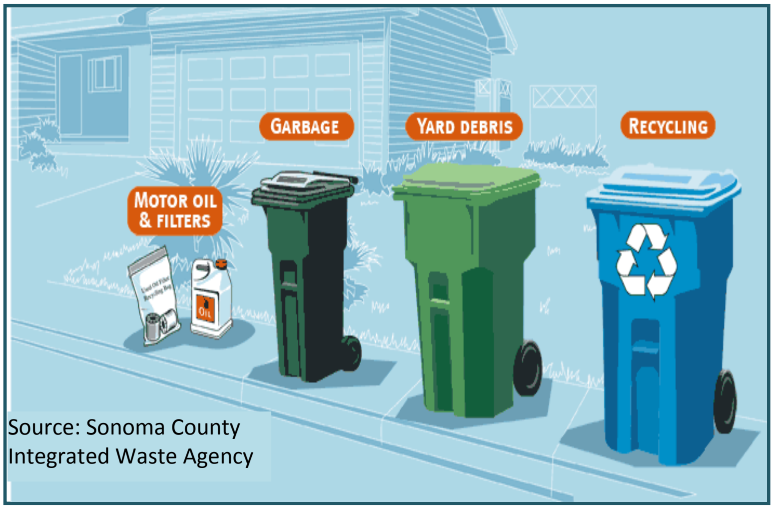
Similar to outdoor water use, indirect GHG emissions from indoor water use can be reduced by decreasing water demand or using a less energy-intensive water source. A project can reduce its indoor water demand relative to the baseline scenario by installing low-flow and high-efficiency water fixtures and appliances such as toilets, showerheads, faucets, clothes washers, and dishwashers.

Emission reductions associated with reduced water demand will be directly proportional to the decrease in demand. The total percentage reduction can be estimated by summing the reductions associated with each type of water-saving feature, which can be obtained from such sources as the California Green Building Standards Code or Energy Star standards. This total percentage would then be multiplied by the project's baseline demand, which should be available from the project's water assessment report. If the water assessment also has an estimate of mitigated water demand, which incorporates the reductions associated with water-saving features, then the reduction can be directly calculated as the difference between baseline and mitigated values.

Emission reductions associated with lower-impact water sources can be quantified as described above for outdoor water use.

Municipal Solid Waste

Solid waste generated at a site can directly produce GHG emissions via decomposition or incineration; it also generates vehicle-based emissions from trucks required to transport waste from its source to the waste handling facility. A reduction in the mass of municipal solid waste sent to landfills would lower emissions associated with its transport and treatment. This can be achieved by reducing the rate at which waste is generated, or by diverting material away from the landfill via on-site composting, reuse, or recycling operations (although direct and transport-related emissions associated with the alternate fates must be accounted for too).



Source: Sonoma County Integrated Waste Agency

Most methods to quantify municipal solid waste involve life-cycle assessments. The fact sheets describe the inventory emissions and the available tools that should be used if the Local Agency or project Applicant would like to quantify the benefits of a solid waste measure with respect to a reduction in life-cycle emissions.

Public Area and Traffic Signal Lighting

Energy use for lighting generates indirect GHG emissions. The amount of energy required for lighting depends in part on the number and energy needs of the lamps. Indirect emissions from lighting energy use can be reduced by installing energy-efficient lamps that maintain the same efficacy beyond what is required to meet any government standards. The replacement of existing, incandescent traffic signal lamps with light-emitting diode (LED) versions will reduce traffic light energy use relative to the baseline. New public lighting fixtures outfitted with energy-efficiency lamps will also use less electricity than the existing baseline energy use. However, because regulations require all new traffic lights to be LED-based, the methods in this Report do not quantify a reduction associated with LED traffic lights for new traffic intersections. Emissions reductions for lighting-based mitigation measures are quantified as percentages of the baseline emissions. The percentage reductions for energy-efficiency lighting are based on a survey of literature data.

Vegetation (including Trees)

As discussed in Chapter 3, vegetation incorporates carbon into its structure during its growth phase, and thereby can remove a finite amount of carbon from the atmosphere. The sequestration capacity of on-site vegetation is determined by the area available for vegetation, and the types of vegetation installed. A project can increase the area available for vegetation by converting previously developed land into vegetated open space. Conversions from one type of vegetated land to another may increase or decrease carbon sequestration, depending on the relative sequestration capacities of the land types. A third way to increase sequestration is by planting new trees on either developed or undeveloped land.

The increase in carbon sequestration capacity is determined by calculating the total sequestration capacity of converted land, new vegetated land and trees; and then subtracting the combined capacity of vegetated land or trees that are removed. Carbon sequestration capacities for different land types (e.g. cropland, forest land) and for different tree species classes are available from IPCC guidelines, and summarized in Table E-2, in Appendix E.

Construction Equipment

Construction equipment typically uses diesel fuel and releases emissions based on the amount of fuel combusted and emission factor of the equipment. Emissions can be reduced by using equipment that emits fewer pollutants for the same amount of work.

This is typically equipment powered through grid electricity or hybrid technology. The exclusive use of grid electricity eliminates the diesel emissions at the site but would increase indirect electricity emissions. However, grid-based emissions are typically small compared to the emissions from the diesel-fueled equipment (depending on the source of grid power). Hybrid-powered equipment would decrease but not completely eliminate fuel use. The electricity for hybrid equipment is self-generated unless the equipment has plug-in capability, so it would not increase grid-based electrical generation and the associated emissions there.

The emissions reductions in this category are determined by finding the difference between the estimated mitigation emissions and the baseline emissions for construction equipment. Emissions for the mitigated scenario may consist of direct emissions from combustion fuel use, and/or indirect emissions from grid electricity. These would be calculated using resources described previously, such as the OFFROAD database and literature-based methodologies and values.

Transportation

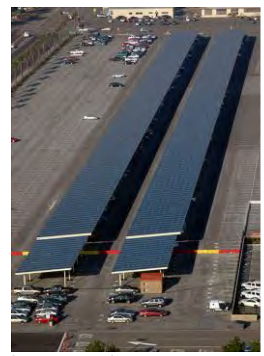
Transportation emissions can be reduced by improving the emissions profile of the vehicle fleet that travels the roads, or by reducing the vehicle miles traveled by the fleet. The majority of the measures quantified for this report focus on the reduction of VMT. This can be accomplished by optimizing the location and types of land uses in the project and its immediate vicinity, and by site enhancements to roads, and to bike and pedestrian networks to encourage the use of alternative modes of transportation. Mode shifts are also encouraged by implementing parking policies, transit system improvements, and trip reduction coordination or incentive programs.

The emission reductions in this category are determined by evaluating the elasticity of a measure relative to the amount of vehicle miles traveled that may be reduced as a result of the mitigation measure.

A few transportation measures in this Report are aimed at improving the emissions profile of the vehicle fleet. These measures promote alternative fuel, hybrid or electrical vehicles. The emission reductions in these measures are based on the improved emission factors and on changes to the assumed vehicle fleet mix.

On-Site Energy Generation

Different modes of energy generation have different GHG emission intensities. Fossil fuel-based generation emits GHG gases from combustion of the fuel, with the amount of emissions depending on the quantity and type of fuel used. Renewable energy generation, on the other hand, typically has significantly fewer emissions, and some types do not have any associated GHG emissions, such as photovoltaic systems and solar hot water heaters (excluding lifecycle emissions, as previously described in Chapter 3).



Solar Array at Coronado Naval Base

The emission reductions associated with using renewable non-emitting energy generated on-site are quantified as the emissions avoided because an equivalent amount of grid energy is not used. To calculate this, the energy generated by the on-site system(s) must be quantified, and then multiplied by the utility-specific emission factor for the type of energy (e.g. electricity, natural gas) being replaced. Energy generated on site is usually used for building operations; hence, it is generally considered a mitigation measure for building energy use.

Miscellaneous

The following miscellaneous mitigation measures are also discussed:

Loading Docks: A project applicant may elect to limit idling of engines beyond what is required by regulation at loading docks, or provide electrified loading docks. Electrified loading docks reduce the need for diesel auxiliary engines to run in order to keep refrigerated transportation units temperature controlled. The emission reduction is a comparison of the GHG emissions associated with the electricity compared to the diesel fuel combustion.

Off-site Mitigation: At the discretion of the reviewing agency, emission reductions may be created with offsite mitigation projects, as described in Chapter 2. If an off-site mitigation project is approved, the amount of emission reductions generated depends on the type of project implemented.

The numerical emission reductions would be quantified using the methods described for the different project categories above, with baseline values derived for the off-site location (instead of the project's baseline scenario). Once the numerical reductions have been estimated, they can be compared to the project's baseline emissions in order to determine the relative percentage reductions. Certain types of off-site projects may result in one-time emissions and others may result in a continuing stream of emissions reductions.

Carbon Sequestration: Emission reductions may be generated by implementing a carbon sequestration project. Carbon sequestration may be biological, chemical, or physical in nature, as described in Chapter 3. This Report does not address chemical or physical sequestration projects.

For biological sequestration, emission reductions are calculated as for vegetation projects (see above). The amount of the sequestration equals the amount of carbon removed by the vegetation.

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This chapter of the Report explains how the quantification of individual strategies is presented in Fact Sheets, how those fact sheets are designed and organized, and how to use them. This chapter also explains how and why mitigation measures have been grouped, and provides detailed discussion of how to apply the quantification methods when more than one strategy is being applied to the same project. A summary of the range of effectiveness for different measures is also provided for general information purposes, in table form, however it is very important that those generalized ranges NOT be used in place of the more specific quantification methods for the measure as detailed in the measure Fact Sheet. Finally, at the end of the Chapter there are step-by-step instructions on using the Fact Sheets, including an example.

Mitigation Strategies and Fact Sheets:

Accurate and reliable quantification depends on properly identifying the important variables that affect the emissions from an activity or source, and from changes to that activity or source. In order to provide a clear summary of those variables and usable instructions on how to find and apply the data needed, we have designed a Fact Sheet format to present each strategy or measure.

Types of Mitigation Strategies: There are three different types of mitigation strategies described in Chapter 7: Quantified measures, Best Management Practices, and General Plan strategies.

<u>Quantified Measures</u>: Quantified measures are fully quantified, project-level mitigation strategies. They are presented in categories where the nature of the underlying emissions sources are the same; the categories are discussed under "Organization of Fact Sheets" below. In addition, the measures may either stand alone, or be considered in connection with one or more other measures (that is, "grouped"). Groups of measures are always within a category; more detailed explanation is provided in "Grouping of Strategies" below. The majority of the strategies in this Report are fully Quantified Measures, and a strategy may be assumed to be of this type unless the Fact Sheet notes otherwise.

<u>Best Management Practices</u>: Several strategies are denoted as Best Management Practice (BMP). These measures are of two types. The first type of BMPs are quantifiable and describe methods that can be used to quantify the GHG mitigation reductions provided the project Applicant can provide substantial evidence supporting the values needed to quantify the reduction. These are listed as BMPs since there is not adequate literature at this time to generalize the mitigation measure reductions. However, the project Applicant may be able to provide the site specific information necessary to quantify a reduction. The second type of BMPs do not have methods for quantifying GHG mitigation reductions. These measures have preliminary evidence suggesting they will reduce GHG emissions if implemented, however, at this time adequate literature and methodologies are not available to quantify these reductions or

they involve life-cycle GHG emission benefits. The measures are encouraged to be implemented nonetheless. Local Agencies may decide to provide incentives to encourage implementation of these measures.

General Plan Strategies: The measures listed under the General Plan category are measures that will have the most benefit when implemented at a General Plan level, but are not quantifiable or applicable at the project specific level. While on a project basis some of these measures may not be quantifiable, at the General Plan level they may be quantified under the assumption that this will be implemented on a widespread basis. Local Agencies may decide to provide incentives or allocate the General Plan level reductions to specific projects by weighting the overall effect by the number of projects the General Plan reduction would apply to.

Introduction to the Fact Sheets: This Report presents the quantification of each mitigation measure in a Fact Sheet format. Each Fact Sheet includes: a detailed summary of each measure's applicability; the calculation inputs for the specific project; the baseline emissions method; the mitigation calculation method and associated assumptions; a discussion of the calculation and an example calculation; and finally a summary of the preferred and alternative literature sources for measure efficacy. The Fact Sheets are found in Chapter 7.

Layout of the Fact Sheets: Each Fact Sheet describes one mitigation measure. The mitigation measure has a unique number and is provided at the bottom of each page in that measure's Fact Sheet. This will assist the end user in determining where a mitigation measure fact sheet begins and ends while still preserving consecutive page numbers in the overall Report.

At the top of each Fact Sheet, the name of the measure category appears on the left, and the subcategory on the right. Cross-references to prior CAPCOA documents appear at the top left, below the category name. Specifically, measures labeled CEQA #: are from the *CAPCOA 2008 CEQA & Climate Change*[1] and measures labeled MP#: are from the *CAPCOA 2009 Model Policies for Greenhouse Gases in General Plans*[2]. This cross-referencing is also included in the list of measures at the beginning of Chapter 7, and is intended to allow the user to move easily between the documents. The measure number is at the bottom of the page, on the right-hand side.

The fact sheets begin with a measure description. This description includes two critical components:

(1) Specific language regarding the measure implementation – which should be consistent with the implementation method suggested by the project Applicant; and

[1] Available online at http://www.capcoa.org/wp-content/uploads/downloads/2010/05/CAPCOA-White-Paper.pdf
[2] Available online at http://www.capcoa.org/wp-content/uploads/downloads/2010/05/CAPCOA-ModelPolicies-6-12-09-915am.pdf

(2) A discussion of key support strategies that are required for the reported range of effectiveness.

Appendices with additional calculations and assumptions for some of the fact sheets are provided at the end of this document. Default assumptions should be carefully reviewed for project applicability. Appendix B details the methodologies that should be used to calculate baseline GHG emissions for a project.

Organization of the Fact Sheets – Categories and Subcategories: The Fact Sheets are organized by general emission category types as follows:

- Energy
- Transportation
- Water
- Landscape Equipment
- Solid Waste
- Vegetation
- Construction
- Miscellaneous Categories
- General Plans

Several of these main categories are split into subcategories, for ease of understanding how to properly address the effects of combining the measures. Strategies are organized into categories and subcategories where they affect similar types of emissions sources. As an example, the category of "Energy" includes measures that reduce emissions associated with energy generation and use. Within that category, there are subcategories of measures that address "Building Energy Use," "Alternative Energy," and "Lighting," each with one or more measures in it. The measures in the subcategory are closely related to each other.

Categories and subcategories for the measures are illustrated in Charts 6-1 and 6-2, below. Chart 6-1 shows all of the measure categories EXCEPT the Transportation category, including their subcategories; note that not all categories have subcategories. Measures in the Transportation category are shown in Chart 6-2. There are a number of subcategories associated with the Transportation category. As shown in Chart 6-2, the primary measures in each subcategory are indicated in bold type, and the measures shown in normal type are either support measures, or they are explicitly "grouped" measures.

It is important to note that subcategories are NOT the same as "grouped" measures / strategies. The grouping of strategies connotes a specific relationship, and is explained in the next section, below.

Chart 6-1: Non-Transportation Strategies Organization

Energy

BE – Building Energy
- **Exceed Title 24**
- **Install Energy Efficient Appliances**
- Install Programmable Thermostats Reduction: Grouped
- Obtain 3rd Party Commissioning Reduction: Grouped

AE – Alternative Energy
- **Onsite Renewable Energy**
- **Utilize Combined Heat & Power**
- **Establish Methane Recovery**

LE – Lighting
- **Install High Efficacy Lighting**
- **Limit Outdoor Lighting**
- Replace Traffic Lights with LED Reduction: Additional

Water

Adopt a Water Conservation Strategy

OR

WSW – Water Supply
- **Use Reclaimed Water**
- **Use Graywater**
- **Use Locally Sourced Water**

WUW – Water Use
- **Install Low-Flow Fixtures**
- **Design Water-Efficient Landscapes**
- **Use Water-Efficient Irrigation**
- **Reduce Turf**
- Plant Native or Drought-Resistant Vegetation

Area Landscaping

A – Landscaping Equipment
- **Prohibit gas Powered Landscape Equipment**
- Implement Lawnmower Exchange Program Reduction: Grouped
- Electric Yard Equipment Compatibility Reduction Grouped

Solid Waste

SW – Solid Waste
- Institute or Extend Recycling & Composting Services
- Recycle Demolished Construction Material

Vegetation

V – Vegetation
- **Plant Urban Trees**
- **New Vegetated Open Space**

Construction

C – Construction
- **Use Alternative Fuels for Construction Equipment**
- **Use Electric or Hybrid Construction Equipment**
- Limit Construction Equipment Idling
- Institute a Heavy-Duty Off-Road Vehicle Plan
- Implement a Construction Vehicle Inventory Tracking System

Miscellaneous

Misc – Miscellaneous
- **Establish Carbon Sequestration**
- **Establish Off-site Mitigation**
- **Implement an Innovative Strategy**
- Use Local and Sustainable Building Materials
- Require BMP in Agriculture and Animal Operations
- Require Environmentally Responsible Purchasing

General Plans

GP – General Plans
- Fund Incentives for Energy Efficiency
- Establish a Local Farmer's Market
- Establish Community Gardens
- Plant Urban Shade Trees
- Implement Strategies to Reduce Urban Heat-Island Effect

Note: Strategies in bold text are primary strategies with reported VMT reductions; non-bolded strategies are support or grouped strategies.

Chart 6-2: Transportation Strategies Organization

Transportation Measures (Five Subcategories) Global Maximum Reduction (all VMT):
urban = 75%; compact infill = 40%; suburban center or suburban with NEV = 20%; suburban = 15%

Global Cap for Road Pricing needs further study

Transportation Measures (Four Categories) Cross-Category Max Reduction (all VMT):
urban = 70%; compact infill = 35%; suburban center or suburban with NEV = 15%; suburban = 10%

Max Reduction = 15% overall; work VMT = 25%; school VMT = 65%;

Max Reduction = 25% (all VMT)

Land Use / Location Max Reduction: urban = 65%; compact infill = 30%; suburban center = 10%; suburban = 5%	Neighborhood / Site Enhancement Max Reduction: without NEV = 5%; with NEV = 15%	Parking Policy / Pricing Max Reduction = 20%	Transit System Improvements Max Reduction = 10%	Commute Trip Reduction (assumes mixed use) Max Reduction = 25% (work VMT)	Road Pricing Management Max Reduction = 25%	Vehicles
Density (30%)	Pedestrian Network (2%)	Parking Supply Limits (12.5%)	Network Expansion (8.2%)	CTR Program Required = 21% work VMT Voluntary = 6.2% work VMT	Cordon Pricing (22%)	Electrify Loading Docks
Design (21.3%)	Traffic Calming (1%)	Unbundled Parking Costs (13%)	Service Frequency / Speed (2.5%)	Transit Fare Subsidy (20% work VMT)	Traffic Flow Improvements (45% CO2)	Utilize Alternative Fueled Vehicles
Location Efficiency (65%)	NEV Network (14.4) <NEV Parking>	On-Street Market Pricing (5.5%)	Bus Rapid Transit (3.2%)	Employee Parking Cash-out (7.7% work VMT)	Required Contributions by Project	Utilize Electric or Hybrid Vehicles
Diversity (30%)	Car Share Program (0.7%)	Residential Area Parking Permits	Access Improvements	Workplace Parking Pricing (19.7% work VMT)		
Destination Accessibility (20%)	Bicycle Network <Lanes> <Parking> <Land Dedication for Trails>		Station Bike Parking	Alternative Work Schedules & Telecommute (5.5% work VMT)		
Transit Accessibility (25%)	Urban Non-Motorized Zones		Local Shuttles	CTR Marketing (5.5% work VMT)		
BMR Housing (1.2%)			Park & Ride Lots*	Employer-Sponsored Vanpool/Shuttle (13.4% work VMT)		
Orientation Toward Non-Auto Corridor				Ride Share Program (15% work VMT)		
Proximity to Bike Path				Bike Share Program		
				End of Trip Facilities		
				Preferential Parking Permit		
				School Pool (15.8% school VMT)		
				School Bus (6.3% school VMT)		

Note: Strategies in bold text are primary strategies with reported VMT reductions; non-bolded strategies are support or grouped strategies.

Grouping of Strategies

Strategies noted as “grouped” are separately documented in individual Fact Sheets but must be paired with other strategies within the category. When these “grouped” strategies are implemented together, the combination will result in either an enhancement to the primary strategy by improving its effectiveness or a non-negligible reduction in effectiveness that would not occur without the combination.

Rules for Combining Strategies or Measures

Mitigation measures or strategies are frequently implemented together with other measures. Often, combining measures can lead to better emission reductions than implementing a single measure by itself. Unfortunately, the effects of combining the measures are not always as straightforward as they might at first appear. When more and more measures are implemented to mitigate a particular source of emissions, the benefit of each additional measure diminishes. If it didn’t, some odd results would occur. For example, if there were a series of measures that each, independently, was predicted to reduce emissions from a source by 10%, and if the effect of each measure was independent of the others, then implementing ten measures would reduce all of the emissions; and what would happen with the eleventh measure? Would the combination reduce 110% of the emissions? No. In fact, each successive measure is slightly less effective than predicted when implemented on its own.

On the other hand, some measures enhance the performance of a primary measure when they are combined. This Report includes a set of rules that govern different ways of combining measures. The rules depend on whether the measures are in the *same* category, or different categories. Remember, the categories include: Energy, Transportation, Water, Landscape Equipment, Solid Waste, Vegetation, Construction, Miscellaneous Categories, and General Plans.

Combinations <u>Between</u> Categories: The following procedures must be followed when combining mitigation measures that fall in separate categories. In order to determine the overall reduction in GHG emissions compared to the baseline emissions, the relative magnitude of emissions between the source categories needs to be considered. To do this, the user should determine the percent contribution made by each individual category to the overall baseline GHG emissions. This percent contribution by a category should be multiplied by the reduction percentages from mitigation measures in that category to determine the scaled GHG emission reductions from the measures in that category. This is done for each category to be combined. The scaled GHG emissions for each category can then be added together to give a total GHG reduction for the combined measures in all of the categories.

For example, consider a project whose total GHG emissions come from the following categories: transportation (50%), building energy use (40%), water (6%), and other (4%). This project implements a transportation mitigation measure that results in a 10% reduction in VMT. The project also implements mitigation measures that result in a 30% reduction in water usage. The overall reduction in GHG emissions is as follows:

Reduction from Transportation: 0.50 x 0.10 = 0.5 or 5%
Reduction from Water: 0.06 x 0.30 = 0.018 or 1.8%

Total Reduction: 5% + 1.8% = 6.8%

This example illustrates the importance of the magnitude of a source category and its influence on the overall GHG emission reductions.

The percent contributions from source categories will vary from project to project. In a commercial-only project it may not be unusual for transportation emissions to represent greater than 75% of all GHG emissions whereas for a residential or mixed use project, transportation emissions would be below 50%.

Combinations Within Categories: The following procedures must be followed when combining mitigation measures that fall within the same category.

Non-Transportation Combinations: When combining non-transportation subcategories, the total amount of reductions for that category should not exceed 100% except for categories that would result in additional excess capacity that can be used by others, but which the project wants to take credit for (subject to approval of the reviewing agency). This may include alternative energy generation systems tied into the grid, vegetation measures, and excess graywater or recycled water generated by the project and used by others. These excess emission reductions may be used to offset other categories of emissions, with approval of the agency reviewing the project. In these cases of excess capacity, the quantified amounts of excess emissions must be carefully verified to ensure that any credit allowed for these additional reductions is truly surplus.

Category Maximum- Each category has a maximum allowable reduction for the combination of measures in that category. It is intended to ensure that emissions are not double counted when measures within the category are combined. Effectiveness levels for multiple strategies within a subcategory (as denoted by a column in the appropriate chart, above) may be multiplied to determine a combined effectiveness level up to a maximum level. This should be done first to mitigation measures that are a source reduction followed by those that are a reduction to emission factors. Since the combination of mitigation measures and independence of mitigation measures are both complicated, this Report recommends that mitigation measure reductions within a category be multiplied unless a project applicant can provide substantial evidence indicating that emission reductions are independent of one another. This will take the following form:

GHG emission reduction for category = 1-[(1-A) x (1-B) x (1-C)]

Where:

A, B and C = Individual mitigation measure reduction percentages for the strategies to be combined in a given category.

Global Maximum- A separate maximum, referred to as a global maximum level, is also provided for a combination across subcategories. Effectiveness levels for multiple strategies across categories may also be multiplied to determine a combined effectiveness level up to global maximum level.

For example, consider a project that is combining 3 mitigation strategies from the water category. This project will install low-flow fixtures (measure WUW-1), use water-efficient irrigation (measure WUW-4, and reduce turf (measure WUW-5). Reductions from these measures will be:

- low-flow fixtures 20% or 0.20 (A)
- water efficient irrigation 10% or 0.10 (B)
- turf reductions 20% or 0.20 (C)

To combine measures within a category, the reductions would be
= 1-[(1-A) x (1-B) x (1-C)]
= 1-[(1-.20) x (1-.10) x (1-.20)]
= 1-[(0.8) x (0.9) x (.8)]
= 1-0.576 = 0.424
= 42.4%

Transportation Combinations: The interactions between the various categories of transportation-related mitigation measures is complex and sometimes counter-intuitive. Combining these measures can have a substantive impact on the quantification of the associated emission reductions. In order to safeguard the accuracy and reliability of the methods, while maintaining their ease of use, the following rules have been developed and should be followed when combining transportation-related mitigation measures. The rules are presented by sub-category, and reference Chart 6-2 Transportation Strategies Organization. The maximum reduction values also reflect the highest reduction levels justified by the literature. The chart indicates maximum reductions for individual mitigation measures just below the measure name.

Cross-Category Maximum- A cross-category maximum is provided for any combination of land use, neighborhood enhancements, parking, and transit strategies (columns A-D in Chart 6-1, with the maximum shown in the top row). The total project VMT reduction across these categories should be capped at these levels based on empirical evidence.[3] Caps are provided for the location/development type of the project. VMT reductions may be multiplied across the four categories up to this maximum. These include:

- Urban: 70% VMT
- Compact Infill: 35%
- Suburban Center (or Suburban with NEV): 15%
- Suburban: 10% (note that projects with this level of reduction must include a diverse land use mix, workforce housing, and project-specific transit; limited empirical evidence is available)

(See blue box, pp. 58-59.)

[3] As reported by Holtzclaw, et al for the State of California.

As used in this Report, location settings are defined as follows:

Urban: A project located within the central city and may be characterized by multi-family housing, located near office and retail. Downtown Oakland and the Nob Hill neighborhood in San Francisco are examples of the typical urban area represented in this category. The urban maximum reduction is derived from the average of the percentage difference in per capita VMT versus the California statewide average (assumed analogous to an ITE baseline) for the following locations:

Location	Percent Reduction from Statewide VMT/Capita
Central Berkeley	-48%
San Francisco	-49%
Pacific Heights (SF)	-79%
North Beach (SF)	-82%
Mission District (SF)	-75%
Nob Hill (SF)	-63%
Downtown Oakland	-61%

The average reflects a range of 48% less VMT/capita (Central Berkeley) to 82% less VMT/capita (North Beach, San Francisco) compared to the statewide average. The urban locations listed above have the following characteristics:

- Location relative to the regional core: these locations are within the CBD or less than five miles from the CBD (downtown Oakland and downtown San Francisco).
- Ratio or relationship between jobs and housing: jobs-rich (jobs/housing ratio greater than 1.5)
- Density character
  - typical building heights in stories: six stories or (much) higher
  - typical street pattern: grid
  - typical setbacks: minimal
  - parking supply: constrained on and off street
  - parking prices: high to the highest in the region
- Transit availability: high quality rail service and/or comprehensive bus service at 10 minute headways or less in peak hours

Compact infill: A project located on an existing site within the central city or inner-ring suburb with high-frequency transit service. Examples may be community redevelopment areas, reusing abandoned sites, intensification of land use at established transit stations, or converting underutilized or older industrial buildings. Albany and the Fairfax area of Los Angeles are examples of typical compact infill area as used here. The compact infill maximum reduction is derived from the average of the percentage difference in per capita VMT versus the California statewide average for the following locations:

Location	Percent Reduction from Statewide VMT/Capita
Franklin Park, Hollywood	-22%
Albany	-25%
Fairfax Area, Los Angeles	-29%
Hayward	-42%

The average reflects a range of 22% less VMT/capita (Franklin Park, Hollywood) to 42% less VMT/capita (Hayward) compared to the statewide average. The compact infill locations listed above have the following characteristics:

- Location relative to the regional core: these locations are typically 5 to 15 miles outside a regional CBD
- Ratio or relationship between jobs and housing: balanced (jobs/housing ratio ranging from 0.9 to 1.2)
- Density character
  - typical building heights in stories: two to four stories
  - typical street pattern: grid
  - typical setbacks: 0 to 20 feet
  - parking supply: constrained
  - parking prices: low to moderate
- Transit availability: rail service within two miles, or bus service at 15 minute peak headways or less

As used in this Report, additional location settings are defined as follows:

Suburban Center: A project typically involving a cluster of multi-use development within dispersed, low-density, automobile dependent land use patterns (a suburb). The center may be an historic downtown of a smaller community that has become surrounded by its region's suburban growth pattern in the latter half of the 20th Century. The suburban center serves the population of the suburb with office, retail and housing which is denser than the surrounding suburb. The suburban center maximum reduction is derived from the average of the percentage difference in per capita VMT versus the California statewide average for the following locations:

Location	Percent Reduction from Statewide VMT/Capita
Sebastopol	0%
San Rafael (Downtown)	-10%
San Mateo	-17%

The average reflects a range of 0% less VMT/capita (Sebastopol) to 17% less VMT/capita (San Mateo) compared to the statewide average. The suburban center locations listed above have the following characteristics:

- Location relative to the regional core: these locations are typically 20 miles or more from a regional CBD
- Ratio or relationship between jobs and housing: balanced
- Density character
  - typical building heights in stories: two stories
  - typical street pattern: grid
  - typical setbacks: 0 to 20 feet
  - parking supply: somewhat constrained on street; typically ample off-street
  - parking prices: low (if priced at all)
- Transit availability: bus service at 20-30 minute headways and/or a commuter rail station

While all three locations in this category reflect a suburban "downtown," San Mateo is served by regional rail (Caltrain) and the other locations are served by bus transit only. Sebastopol is located more than 50 miles from downtown San Francisco, the nearest urban center. San Rafael and San Mateo are located 20 miles from downtown San Francisco.

Suburban: A project characterized by dispersed, low-density, single-use, automobile dependent land use patterns, usually outside of the central city (a suburb). Suburbs typically have the following characteristics:

- Location relative to the regional core: these locations are typically 20 miles or more from a regional CBD
- Ratio or relationship between jobs and housing: jobs poor
- Density character
  - typical building heights in stories: one to two stories
  - typical street pattern: curvilinear (cul-de-sac based)
  - typical setbacks: parking is generally placed between the street and office or retail buildings; large-lot residential is common
  - parking supply: ample, largely surface lot-based
  - parking prices: none
- Transit availability: limited bus service, with peak headways 30 minutes or more

The maximum reduction provided for this category assumes that regardless of the measures implemented, the project's distance from transit, density, design, and lack of mixed use destinations will keep the effect of any strategies to a minimum.

Global Maximum- A global maximum is provided for any combination of land use, neighborhood enhancements, parking, transit, and commute trip reduction strategies (the first five columns in the organization chart). This excludes reductions from road-pricing measurements which are discussed separately below. The total project VMT reduction across these categories, which can be combined through multiplication, should be capped at these levels based on empirical evidence.[4] Maximums are provided for the location/development type of the project. The Global Maximum values can be found in the top row of Chart 6-2.

These include:

- Urban: 75% VMT
- Compact Infill: 40% VMT
- Suburban Center (or Suburban with NEV): 20%
- Suburban: 15% (limited empirical evidence available)

Specific Rules for Subcategories within Transportation- Because of the unique interactions of measures within the Transportation Category, each subcategory has additional rules or criteria for combining measures.

❖ Land Use/Location Strategies – Maximum Reduction Factors: Land use measures apply to a project area with a radius of ½ mile. If the project area under review is greater than this, the study area should be divided into subareas of radii of ½ mile, with subarea boundaries determined by natural "clusters" of integrated land uses within a common walkshed. If the project study area is smaller than ½ mile in radius, other land uses within a ½ mile radius of the key destination point in the study area (i.e. train station or employment center) should be included in design, density, and diversity calculations. Land use measures are capped based on empirical evidence for location setting types as follows:[5]

  - Urban: 65% VMT
  - Compact Infill: 30% VMT
  - Suburban Center: 10% VMT
  - Suburban: 5% VMT

❖ Neighborhood/Site Enhancements Strategies – Maximum Reduction Factors: The neighborhood/site enhancements category is capped at 12.7% VMT reduction (with Neighborhood Electric Vehicles (NEVs)) and 5% without NEVs based on empirical evidence (for NEVs) and the multiplied combination of the non-NEV measures.

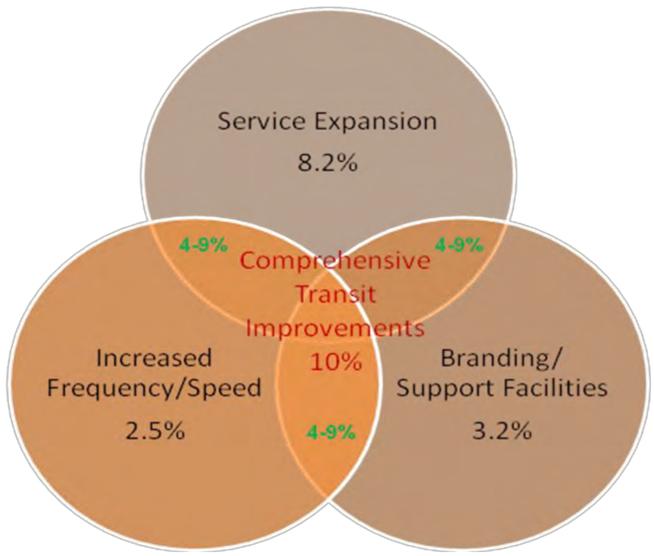
❖ Parking Strategies – Maximum Reduction Factors: Parking strategies should be implemented in one of two combinations:

  - Limited (reduced) off-street supply ratios plus residential permit parking and priced on-street parking (to limit spillover), or
  - Unbundled parking plus residential permit parking and priced on-street parking (to limit spillover).

[4] As reported by Holtzclaw, et al for the State of California. Note that CTR strategies must be converted to overall VMT reductions (from work-trip VMT reductions) before being combined with strategies in other categories.
[5] As reported for California locations in Holtzclaw, et al. "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles, and San Francisco." *Transportation Planning and Techno*logy, 2002, Vol. 25, pp. 1–27.

Note: The reduction maximum of 20% VMT reflects the combined (multiplied) effect of unbundled parking and priced on-street parking.

- Transit System Strategies – Maximum Reduction Factors: The 10% VMT reduction maximum for transit system improvements reflects the combined (multiplied) effect of network expansion and service frequency/speed enhancements. A comprehensive transit improvement would receive this type of reduction, as shown in the center overlap in the Venn diagram, below.



- Commuter Trip Reductions (CTR) Strategies – Maximum Reduction Factors: The most effective commute trip reduction measures combine incentives, disincentives, and mandatory monitoring, often through a transportation demand management (TDM) ordinance. Incentives encourage a particular action, for example parking cash-out, where the employee receives a monetary incentive for not driving to work, but is not punished for maintaining status quo. Disincentives establish a penalty for a status quo action. An example is workplace parking pricing, where the employee is now monetarily penalized for driving to work. The 25% maximum for work-related VMT applies to comprehensive CTR programs. TDM strategies that include only incentives, only disincentives, and/or no mandatory monitoring, should have a lower total VMT reduction than those with a comprehensive approach. Support strategies to strengthen CTR programs include guaranteed-ride-home, taxi vouchers, and message boards/marketing materials. A 25% reduction in work-related VMT is assumed equivalent to a 15% reduction in overall project VMT for the purpose of the global maximum; this can be adjusted for project-specific land use mixes.

  Two school-related VMT reduction measures are also provided in this category. The maximum reduction for these measures should be 65% of school-related VMT based on the literature.

- Road Pricing/Management Strategies – Maximum Reduction Factors: Cordon pricing is the only strategy in this category with an expected VMT reduction potential. Other forms of road pricing would be applied at a corridor or region-wide level rather than as mitigation applied to an individual development project. No domestic case studies are available for cordon pricing, but international studies suggest a VMT reduction maximum of 25%. A separate, detailed, and project-specific study should be conducted for any project where road pricing is proposed as a VMT reduction measure.

Additional Rules for Transportation Measures- There are also restrictions on the application of measures in rural applications, and application to baseline, as follows:

- Rural Application: Few empirical studies are available to suggest appropriate VMT reduction caps for strategies implemented in rural areas. Strategies likely to have the largest VMT reduction in rural areas include vanpools, telecommute or alternative work schedules, and master planned communities (with design and land use diversity to encourage intra-community travel). NEV networks may also be appropriate for larger scale developments. Because of the limited empirical data in the rural context, project-specific VMT reduction estimates should be calculated.

- Baseline Application: As discussed in previous sections of this report, VMT reductions should be applied to a baseline VMT expected for the project, based on the Institute of Transportation Engineers' 8th Edition *Trip Generation Manual* and associated typical trip distance for each land use type. Where trip generation rates and project VMT provided by the project Applicant are derived from another source, the VMT reductions must be adjusted to reflect any "discounts" already applied.

Range of Effectiveness of Mitigation Measures

The following charts provide the range of effectiveness for the quantified mitigation measures. Each chart shows one category of measures, with subcategories identified. The charts also show the basis for the quantification, and indicate applicable groupings. IMPORTANT: these ranges are approximate and should NOT be used in lieu of the specific quantification method provided in the fact sheet for each measure. Restrictions on combining measures must be observed.

Table 6-1: Energy Category

Energy						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Building Energy Use	BE-1	Buildings exceed Title 24 Building Envelope Energy Efficiency Standards by X% (X is equal to the percentage improvement selected for the project			For a 10% improvement over 2008 Title 24: Non-Residential electricity use: 0.2-5.5%; natural gas use: 0.7-10% Residential electricity use: 0.3-2.6%; natural gas use: 7.5-9.1%	
	BE-2	Install Programmable Thermostat Timers	x		BMP	
	BE-3	Obtain Third-party HVAC Commissioning and Verification of Energy Savings	x	BE-1	BMP	
	BE-4	Install Energy Efficient Appliances			Residential building: 2-4% Grocery Stores: 17-22%	Appliance Electricity Use
	BE-5	Install Energy Efficient Boilers			1.2-18.4%	Fuel Use
Alternative Energy Generation	AE-1	Establish Onsite Renewable Energy Systems-Generic			0-100%	
	AE-2	Establish Onsite Renewable Energy Systems-Solar Power			0-100%	
	AE-3	Establish Onsite Renewable Energy Systems-Wind Power			0-100%	
	AE-4	Utilize a Combined Heat and Power System			0-46%	
	AE-5	Establish Methane Recovery in Landfills			73-77%	
	AE-6	Establish Methane Recovery in Wastewater Treatment Plants			95-97%	
Lighting	LE-1	Install Higher Efficacy Public Street and Area Lighting			16-40%	Outdoor Lighting Electricity Use
	LE-2	Limit Outdoor Lighting Requirements	x		BMP	
	LE-3	Replace Traffic Lights with LED Traffic Lights			90%	Traffic Light Electricity Use

Table 6-2: Transportation Category

Transportation						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Land Use / Location	LUT-1	Increase Density			1.5-30.0%	VMT
	LUT-2	Increase Location Efficiency			10-65%	VMT
	LUT-3	Increase Diversity of Urban and Suburban Developments (Mixed Use)			9-30%	VMT
	LUT-4	Incr. Destination Accessibility			6.7-20%	VMT
	LUT-5	Increase Transit Accessibility			0.5-24.6%	VMT
	LUT-6	Integrate Affordable and Below Market Rate Housing			0.04-1.20%	VMT
	LUT-7	Orient Project Toward Non-Auto Corridor			NA	
	LUT-8	Locate Project near Bike Path/Bike Lane			NA	
	LUT-9	Improve Design of Development			3.0-21.3%	VMT
Neighborhood / Site Design	SDT-1	Provide Pedestrian Network Improvements			0-2%	VMT
	SDT-2	Traffic Calming Measures			0.25-1.00%	VMT
	SDT-3	Implement a Neighborhood Electric Vehicle (NEV) Network			0.5-12.7%	VMT
	SDT-4	Urban Non-Motorized Zones		SDT-1	NA	
	SDT-5	Incorporate Bike Lane Street Design (on-site)		LUT-9	NA	
	SDT-6	Provide Bike Parking in Non-Residential Projects		LUT-9	NA	
	SDT-7	Provide Bike Parking in Multi-Unit Residential Projects		LUT-9	NA	
	SDT-8	Provide EV Parking		SDT-3	NA	
	SDT-9	Dedicate Land for Bike Trails		LUT-9	NA	
Parking Policy / Pricing	PDT-1	Limit Parking Supply			5-12.5%	
	PDT-2	Unbundle Parking Costs from Property Cost			2.6-13%	
	PDT-3	Implement Market Price Public Parking (On-Street)			2.8-5.5%	
	PDT-4	Require Residential Area Parking Permits		PDT-1, 2 & 3	NA	

Transportation - continued						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Trip Reduction Programs	TRT-1	Implement Voluntary CTR Programs			1.0-6.2%	Commute VMT
	TRT-2	Implement Mandatory CTR Programs – Required Implementation/Monitoring			4.2-21.0%	Commute VMT
	TRT-3	Provide Ride-Sharing Programs			1-15%	Commute VMT
	TRT-4	Implement Subsidized or Discounted Transit Prog.			0.3-20.0%	Commute VMT
	TRT-5	Provide End of Trip Facilities		TRT-1, 2 & 3	NA	
	TRT-6	Telecommuting and Alternative Work Schedules			0.07-5.50%	Commute VMT
	TRT-7	Implement Commute Trip Reduction Marketing			0.8-4.0%	Commute VMT
	TRT-8	Implement Preferential Parking Permit Program		TRT-1, 2 & 3	NA	
	TRT-9	Implement Car-Sharing Program			0.4-0.7%	VMT
	TRT-10	Implement School Pool Program			7.2-15.8%	School VMT
	TRT-11	Provide Employer-Sponsored Vanpool/Shuttle			0.3-13.4%	Commute VMT
	TRT-12	Implement Bike-Sharing Program		SDT-5, LUT-9	NA	
	TRT-13	Implement School Bus Program			38-63%	School VMT
	TRT-14	Price Workplace Parking			0.1-19.7%	Commute VMT
	TRT-15	Implement Employee Parking "Cash-Out"			0.6-7.7%	Commute VMT

Transportation - continued						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Transit System Improvements	TST-1	Provide a Bus Rapid Transit System			0.02-3.2%	VMT
	TST-2	Implement Transit Access Improvements		TST-3, TST-4	NA	
	TST-3	Expand Transit Network			0.1-8.2%	VMT
	TST-4	Increase Transit Service Frequency/Speed			0.02-2.5%	VMT
	TST-5	Provide Bike Parking Near Transit		TST-3, TST-4	NA	
	TST-6	Provide Local Shuttles		TST-3, TST-4	NA	
Road Pricing / Management	RPT-1	Implement Area or Cordon Pricing			7.9-22.0%	VMT
	RPT-2	Improve Traffic Flow			0-45%	VMT
	RPT-3	Require Project Contributions to Transportation Infrastructure Improvement Projects		RPT-2, TST-1 to 6	NA	
	RPT-4	Install Park-and-Ride Lots		RPT-1, TRT-11, TRT-3, TST-1 to 6	NA	
Vehicles	VT-1	Electrify Loading Docks and/or Require Idling-Reduction Systems			26-71%	Truck Idling Time
	VT-2	Utilize Alternative Fueled Vehicles			Varies	
	VT-3	Utilize Electric or Hybrid Vehicles			0.4-20.3%	Fuel Use

Table 6-3: Water Category

Water						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Water Supply	WSW-1	Use Reclaimed Water			up to 40% for Northern Californiaup to 81% for Southern California	Outdoor Water Use
	WSW-2	Use Gray Water			0-100%	Outdoor Water Use
	WSW-3	Use Locally-Sourced Water Supply			0-60% for Northern and Central California; 11-75% for Southern California	Indoor and Outdoor Water Use
Water Use	WUW-1	Install Low-Flow Water Fixtures.			Residential: 20% Non-Residential: 17-31%	Indoor Water Use
	WUW-2	Adopt a Water Conservation Strategy.			varies	
	WUW-3	Design Water-Efficient Landscapes			0-70%	Outdoor Water Use
	WUW-4	Use Water-Efficient Landscape Irrigation Systems			6.1%	Outdoor Water Use
	WUW-5	Reduce Turf in Landscapes and Lawns			varies	
	WUW-6	Plant Native or Drought-Resistant Trees and Vegetation			BMP	

Table 6-4: Area Landscaping

Area Landscaping						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Area Landscaping	A-1	Prohibit Gas Powered Landscape Equipment.			LADWP: 2.5-46.5% PG&E: 64.1-80.3% SCE: 49.5-72.0% SDGE: 38.5-66.3% SMUD: 56.3-76.0%	Fuel Use
	A-2	Implement Lawnmower Exchange Program			BMP	
	A-3	Electric Yard Equipment Compatibility		A-1 or A-2	BMP	

Table 6-5: Solid Waste Category

Solid Waste						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Solid Waste	SW-1	Institute or Extend Recycling and Composting Services			BMP	
	SW-2	Recycle Demolished Construction Material			BMP	

Table 6-6: Vegetation Category

Vegetation						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Vegetation	V-1	Urban Tree Planting		GP-4	varies	
	V-2	Create new vegetated open space.			varies	

Table 6-7: Construction Category

Construction						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Construction	C-1	Use Alternative Fuels for Construction Equipment			0-22%	Fuel Use
	C-2	Use Electric and Hybrid Construction Equipment			2.5-80%	Fuel Use
	C-3	Limit Construction Equipment Idling beyond Regulation Requirements			varies	
	C-4	Institute a Heavy-Duty Off-Road Vehicle Plan		Any C	BMP	
	C-5	Implement a Vehicle Inventory Tracking System		Any C	BMP	

Table 6-8: Miscellaneous Category

Miscellaneous						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
Miscellaneous	Misc-1	Establish a Carbon Sequestration Project			varies	
	Misc-2	Establish Off-Site Mitigation			varies	
	Misc-3	Use Local and Sustainable Building Materials	x		BMP	
	Misc-4	Require Best Management Practices in Agriculture and Animal Operations	x		BMP	
	Misc-5	Require Environmentally Responsible Purchasing	x		BMP	
	Misc-6	Implement an Innovative Strategy for GHG Mitigation	x		BMP	

Table 6-9: General Plans

General Plan Strategies						
Category	Measure Number	Strategy	BMP	Grouped With #	Range of Effectiveness	
					Percent Reduction in GHG Emissions	Basis
General Plans	GP-1	Fund Incentives for Energy Efficiency	x		BMP	
	GP-2	Establish a Local Farmer's Market	x		BMP	
	GP-3	Establish Community Gardens	x		BMP	
	GP-4	Plant Urban Shade Trees	x	V-1	BMP	
	GP-5	Implement Strategies to Reduce Urban Heat-Island Effect	x		BMP	

Applicability of Quantification Fact Sheets Outside of California

In order to apply the quantification methods in this Report to projects located outside of California, the assumptions and methods in the baseline methodology and in the Fact Sheets should be reviewed prior to applying them. First, evaluate the basis for use metrics and emission factors for applicability outside of California. The Report references various sources for use metrics and emission factors; if these are California-specific, the method should be evaluated to determine if these same use metrics and emission factors are applicable to the project area. If they are not applicable, factors appropriate for the project area should be substituted in the baseline and project methods. Key factors to consider are climate zone[6], precipitation, building standards, end-user behavior, and transportation environment (land use and transportation characteristics). Use metrics likely to vary outside of California include:

- Building Energy Use
- Water Use
- Vehicle Trip Lengths and Vehicle Miles Traveled
- Building Standards
- Waste Disposal Rates
- Landscape Equipment Annual Usage

Emission factors relate the use metric to carbon intensity to estimate GHG emissions. Depending on the type of emission factor, these values may or may not change based on location. For instance, the emission factor for combustion of a specific amount of fuel does not typically change; however the engine mix may change by location, and fuel use by those engines may be different. Other emission factors are regionally dependent and alternative sources should be investigated. Emission factors likely to vary outside of California include:

- Electricity associated with water and wastewater supply and treatment
- Carbon intensity of electricity supplied
- Fleet and model year distribution of vehicles which influences emission factors

The user should be able to adjust the methodologies to: (1) calculate the baseline for a given mitigation measure; and then (2) incorporate the appropriate data and assumptions into the calculations for the emission mitigation associated with the measure.

There is at least one mitigation measure that will not be applicable outside of California unless adjustments are made by substituting location-specific factors in the baseline methodology: the improvement beyond Title 24 (BE-1) is not applicable outside of California since buildings outside California would be subject to different building codes. The project Applicant may be able to estimate a baseline energy use for building envelope systems under other building standards and estimate the change in energy use for improvements to building envelope systems using building energy software or literature surveys.

[6] Climate zones are specific geographic areas of similar climatic characteristics, including temperature, weather, and other factors which affect building energy use. The California Energy Commission identified 16 Forecasting Climate Zones (FCZs) within California.

How to Use a Fact Sheet to Quantify a Project

This section provides step-by-step instructions and an example regarding how a fact sheet can be used. After choosing the appropriate fact sheet(s), follow these general steps. Steps may need to be adjusted for different types of fact sheets.

Step 1: Does this fact sheet apply?
Carefully read the measure's description and applicability to ensure that you are using the correct fact sheet.

Step 2: Is the measure "grouped"?
Check Tables 6-1 to 6-9 to see if the measure is "grouped" with other measures. If it is, then all measures in the group must be implemented together.

Step 3: Review defaults
Review the default assumptions in the fact sheet.

Step 4: Data inputs
Determine the type of data and data sources necessary. Refer to Appendix B and other suggested documents.

Step 5: Calculate baseline emissions
Calculate baseline emissions using formulas provided in the fact sheet.

Step 6: Percent reductions
If applicable, calculate the percent reduction for the specific action in the measure.

Step 7: Quantify reductions
Quantify emission reductions for a particular mitigation measure using the provided formula.

Step 8: Grouped measures
If you are using a mitigation measure that is grouped with another measure, refer to Tables 6-1 to 6-9 and complete the calculations for all measures that are grouped together for a particular mitigation strategy.

Step 9: Multiple measures
See Chapter 6 for how to combine reductions from multiple measures.

IMPORTANT: Clearly document information such as data sources, data used, and calculations.

Example:

The following is an example calculation for a building project that will use Fact Sheet 2.1.1 - *Exceed Title 24 Building Envelope Energy Efficiency Standards by X%*. In this example, a large office building is being built, and it will be designed to do 10% more than Title 24 standards for both electricity and natural gas.

- **Step 1 – Does this fact sheet apply?**
  The project and fact sheet have been reviewed, and YES, this fact sheet is appropriate to use to estimate reductions from the project.

- **Step 2 - Is the measure "grouped"?**
  NO, this is a measure that does not have to be done with other measures.

- **Step 3 – Review defaults**
  Default assumptions and emission factors have been reviewed and used, as appropriate.

- **Steps 4 – Data inputs**
  The table below shows the data needed for the example, the sample data input, and the source of the sample data. Make sure the data use the units specified in the equation. *

Data for Fact Sheet 2.1.1 Example

Data Needed	Input	Source of Data
Project type	Commercial land use = Large Office	User Input
Size	100,000 sq. ft	User Input
Climate Zone	1	From Figure BE 1.1
Electricity $Intensity_{baseline}$	8.32 kWh/SF/yr	From Fact Sheet 2.1.1
Utility Provider	PG&E	User Input
Emission $Factor_{Electricity}$	2.08E-4 MT CO_2e/kWh	Fact Sheet 2.1.1
Natural Gas $Intensity_{baseline}$	18.16 kBTU/SF/yr	From Fact Sheet 2.1.1
Emission $Factor_{NaturalGas}$	5.32E-5 MT CO_2e/therm	From Fact Sheet 2.1.1
% Reduction Commitment	10% over 2008 Title 24 Standards	User Input

- **Step 5 – Calculate baseline emissions**
  Once all necessary information has been obtained, use the equation provided to determine the baseline emissions. Round results to the nearest MT.

⇨ GHG Emissions $Baseline_{Electicity}$ = Electricity $Intensity_{Baseline}$ x Size x Emission $Factor_{Electricity}$

= 8.32 kWh/SF/yr x 100,000 SF x (2.08E-4 MT CO_2e/kWh)
= **173 MT CO_2e/yr [Baseline GHG Emissions for Electricity]**

⇨ GHG Emissions $Baseline_{Natural\ Gas}$ = Natural Gas $Intensity_{Baseline}$ x Size x Emission $Factor_{NaturalGas}$

= 18.16 kBTU/SF/yr x 100,000 SF x (5.32E-5 MT CO_2e/kBTU)
= **97 MT CO_2e/yr [Baseline GHG Emissions for Natural Gas]**

⇨ GHG $Emissions_{Baseline}$ = GHG Emissions $Baseline_{Electricity}$ + GHG Emissions $Baseline_{Natural\ Gas}$

= 173 MT CO_2e/yr + 97 MT CO_2e/yr
= 270 MT CO_2e/yr

- **Step 6 – Percent reductions**

Now calculate the percent GHG emission reduction based on the stated improvement goal. In this example the goal is a 10% reduction over Title 24 Energy Efficiency Standards. See Table BE-1.1 for data used for this step.

- $Reduction_{Electricity}$ from 1% over 2008 Title 24 Standards = 0.20%
  $Reduction_{NaturalGas}$ from 1% over 2008 Title 24 Standards = 1.00%

From Table BE-1.1

- Multiply the Percent Factor from Table BE-1.1 by the Percent Reduction Commitment (10% for this example)

Reduction in GHG emissions from electricity generation:

= 0.20% x 10
= 2%

Reduction Percentage X 10% goal

Reduction in GHG emissions from natural gas combustion:

= 1% x 10
= 10%

Reduction Percentage X 10% goal

- **Step 7 – Quantify reductions**
  Using the percent reductions, the emission reductions can be calculated, as shown below.

- Total Building GHG emissions = GHG Emissions $Baseline_{Electricity.}$ x ($Reduction_{Electricity}$) + GHG Emissions $Baseline_{NaturalGas}$ x ($Reduction_{NaturalGas}$)

= 173 MT CO_2e/yr x $(\frac{100\%-2\%}{100})$ + 97 MT CO_2e/yr x $(\frac{100\%-10\%}{100})$
= **257 MT CO_2e/yr**

Net reductions are the difference between the baseline emissions and the emissions calculated above for what will occur with this strategy implemented.

- Net reductions = Baseline – Total Building GHG Emissions

= 270 MT CO_2e/yr - 257 MT CO_2e/yr
= **13 MT CO_2e/yr**

This shows that a 10% improvement in energy consumption over 2008 Title 24 Standards from electricity and natural gas will result in a GHG reduction of 13 MT CO_2e/yr.

- **Step 8 – Grouped measures**
  In this example, the measure is not grouped. For grouped measures, refer to Tables 6-1 to 6-9 in Chapter 6 for how to combine reductions.

- **Step 9 – Multiple measures**
  See "Rules for Combining Strategies or Measures" section in Chapter 6 for how to add reductions from multiple measures

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1.0 Introduction

Chapter 7 is made up of a series of Fact Sheets. Each sheet summarizes the quantification methodology for a specific mitigation measure. As described in Chapter 6, the measures are grouped into Categories, and, in some cases, into subcategories. For information about the development of the Fact Sheets, please see Chapter 4. For a discussion of specific quantification issues in select measure categories or subcategories, please refer to Chapter 5. Chapter 6 provides a detailed explanation of the organization and layout of the Fact Sheets, including rules that govern the quantification of measures that have been, or will be, implemented in combination.

In order to facilitate navigation through, and the use of, the Fact Sheets, they have been color coded to reflect the Category the measure is in, and if applicable, the subcategory. The color scheme is shown in Charts 6-1 and 6-2, and also in Table 7-1 (below).

The colored bar at the top of each Fact Sheet corresponds to the Category color as shown in Charts 6-1 and 6-2, and in Table 7-1; the Category name is shown in the colored bar at the left hand margin. The second colored bar, immediately below the first one, shows the name of the subcategory, if any, and corresponds to subcategory color in those charts and tables. The subcategory name appears at the right hand margin.

At the left hand margin, below the Category name, is a cross-reference to the corresponding measure in the previous two CAPCOA reports (*CEQA and GHG*; and *Model Polices for GHG in General Plans*). The term “MP#” refers to a measure in the Model Policies document. The term CEQA# refers to a measure in the CEQA and GHG report.

At the bottom of the page is a colored bar that corresponds to the Category, and, where applicable, there is a colored box at the right hand margin, contiguous with the colored bar. This color of the box corresponds to the subcategory, where applicable. The box contains the measure number.

The layout of information in each Fact Sheet is covered in detail in Chapter 6.

Table 7-1, below, provides an index and cross-reference for the measure Fact Sheets. It is color-coded, as explained above, and may be used as a key to more quickly and easily navigate through the Fact Sheets

Table 7-1: Measure Index & Cross Reference

Section	Category	Page #	Measure #	BMP	MP #	CEQA #
2.0	**Energy**	**85**				
2.1	Building Energy Use	85				
2.1.1	Buildings Exceed Title 24 Building Envelope Energy Efficiency Standards By X%	85	BE-1		EE-2	MM-E6
2.1.2	Install Programmable Thermostat Timers	99	BE-2	x	EE-2	-
2.1.3	Obtain Third-party HVAC Commissioning and Verification of Energy Savings	101	BE-3	x	EE-2	-
2.1.4	Install Energy Efficient Appliances	103	BE-4		EE-2.1.6	MM E-19
2.1.5	Install Energy Efficient Boilers	111	BE-5		-	-
2.2	Lighting	115				
2.2.1	Install Higher Efficacy Public Street and Area Lighting	115	LE-1		EE-2.1.5	-
2.2.2	Limit Outdoor Lighting Requirements	119	LE-2	x	EE-2.3	
2.2.3	Replace Traffic Lights with LED Traffic Lights	122	LE-3		EE-2.1.5	-
2.3	Alternative Energy Generation	125				
2.3.1	Establish Onsite Renewable Energy Systems-Generic	125	AE-1		AE-2.1	MM E-5
2.3.2	Establish Onsite Renewable Energy Systems-Solar Power	128	AE-2		AE-2.1	MM E-5
2.3.3	Establish Onsite Renewable Energy Systems-Wind Power	132	AE-3		AE-2.1	MM E-5
2.3.4	Utilize a Combined Heat and Power System	135	AE-4		AE-2	-
2.3.5	Establish Methane Recovery in Landfills	143	AE-5		WRD-1	-
2.3.6	Establish Methane Recovery in Wastewater Treatment Plants	149	AE-6			
3.0	**Transportation**	**155**				
3.1	Land Use/Location	155				
3.1.1	Increase Density	155	LUT-1		LU-1.5 & LU-2.1.8	MM D-1 & D-4
3.1.2	Increase Location Efficiency	159	LUT-2		LU-3.3	-
3.1.3	Increase Diversity of Urban and Suburban Developments (Mixed Use)	162	LUT-3		LU-2	MM D-9 & D-4
3.1.4	Increase Destination Accessibility	167	LUT-4		LU-2.1.4	MM D-3
3.1.5	Increase Transit Accessibility	171	LUT-5		LU-1,LU-4	MM D-2
3.1.6	Integrate Affordable and Below Market Rate Housing	176	LUT-6		LU-2.1.8	MM D-7
3.1.7	Orient Project Toward Non-Auto Corridor	179	LUT-7		LU-4.2	LUT-3
3.1.8	Locate Project near Bike Path/Bike Lane	181	LUT-8		-	LUT-4
3.1.9	Improve Design of Development	182	LUT-9		-	-
3.2	Neighborhood/Site Enhancements	186				
3.2.1	Provide Pedestrian Network Improvements	186	SDT-1		LU-4	MM-T-6
3.2.2	Provide Traffic Calming Measures	190	SDT-2		LU-1.6	MM-T-8
3.2.3	Implement a Neighborhood Electric Vehicle (NEV) Network	194	SDT-3		TR-6	MM-D-6
3.2.4	Create Urban Non-Motorized Zones	198	SDT-4		LU-3.2.1 & 4.1.4	SDT-1
3.2.5	Incorporate Bike Lane Street Design (on-site)	200	SDT-5		TR-4.1	LUT-9
3.2.6	Provide Bike Parking in Non-Residential Projects	202	SDT-6		TR-4.1	MM T-1
3.2.7	Provide Bike Parking with Multi-Unit Residential Projects	204	SDT-7		TR-4.1.2	MM T-3
3.2.8	Provide Electric Vehicle Parking	205	SDT-8		TR-5.4	MM T-17 & E-11
3.2.9	Dedicate Land for Bike Trails	206	SDT-9		TR-4.1	LUT-9
3.3	Parking Policy/Pricing	207				
3.3.1	Limit Parking Supply	207	PDT-1		LU-1.7 & LU-2.1.1.4	-
3.3.2	Unbundle Parking Costs from Property Cost	210	PDT-2		LU-1.7	-
3.3.3	Implement Market Price Public Parking (On-Street)	213	PDT-3		-	-
3.3.4	Require Residential Area Parking Permits	217	PDT-4		-	PDT-1, PDT-2, PDT-3

Section	Category	Page #	Measure #	BMP	MP #	CEQA #
3.4	Commute Trip Reduction Programs	218				
3.4.1	Implement Commute Trip Reduction Program - Voluntary	218	TRT-1		-	-
3.4.2	Implement Commute Trip Reduction Program – Required Implementation/Monitoring	223	TRT-2		MO-3.1	T-19
3.4.3	Provide Ride-Sharing Programs	227	TRT-3		MO-3.1	-
3.4.4	Implement Subsidized or Discounted Transit Program	230	TRT-4		MO-3.1	-
3.4.5	Provide End of Trip Facilities	234	TRT-5		MO-3.2	TRT-1, TRT-2, TRT-3
3.4.6	Encourage Telecommuting and Alternative Work Schedules	236	TRT-6		TR-3.5	-
3.4.7	Implement Commute Trip Reduction Marketing	240	TRT-7		-	-
3.4.8	Implement Preferential Parking Permit Program	244	TRT-8		TR-3.1	TRT-1, TRT-2, TRT-3
3.4.9	Implement Car-Sharing Program	245	TRT-9		-	-
3.4.10	Implement a School Pool Program	250	TRT-10		-	-
3.4.11	Provide Employer-Sponsored Vanpool/Shuttle	253	TRT-11		MO-3.1	-
3.4.12	Implement Bike-Sharing Programs	256	TRT-12		-	SDT-5, LUT-9
3.4.13	Implement School Bus Program	258	TRT-13		TR-3.4	-
3.4.14	Price Workplace Parking	261	TRT-14		-	-
3.4.15	Implement Employee Parking "Cash-Out"	266	TRT-15		TR-5.3	MM T-9
3.5	Transit System Improvements	270				
3.5.1	Provide a Bus Rapid Transit System	270	TST-1		-	MS-G3
3.5.2	Implement Transit Access Improvements	275	TST-2		LU-3.4.3	TST-3, TST-4
3.5.3	Expand Transit Network	276	TST-3		-	MS-G3
3.5.4	Increase Transit Service Frequency/Speed	280	TST-4		-	MS-G3
3.5.5	Provide Bike Parking Near Transit	285	TST-5		TR-4.1.4	TST-3, TST-4
3.5.6	Provide Local Shuttles	286	TST-6			TST-3, TST-4
3.6	Road Pricing/Management	287				
3.6.1	Implement Area or Cordon Pricing	287	RPT-1		TR-3.6	-
3.6.2	Improve Traffic Flow	291	RPT-2		TR-2.1, TR-2.2	-
3.6.3	Required Project Contributions to Transportation Infrastructure Improvement Projects	297	RPT-3		-	RPT-2, TST-1 to 6
3.6.4	Install Park-and-Ride Lots	298	RPT-4		TR-1	RPT-1, TRT-11, TRT-3, TST-1 to 6
3.7	Vehicles	300				
3.7.1	Electrify Loading Docks and/or Require Idling-Reduction Systems	300	VT-1		TR-6	-
3.7.2	Utilize Alternative Fueled Vehicles	304	VT-2		-	MM T-21
3.7.3	Utilize Electric or Hybrid Vehicles	309	VT-3		-	MM T-20
4.0	**Water**	**332**				
4.1	Water Supply	332				
4.1.1	Use Reclaimed Water	332	WSW-1		COS-1.3	MS-G-8
4.1.2	Use Gray Water	336	WSW-2		COS-2.3	-
4.1.3	Use Locally Sourced Water Supply	341	WSW-3		-	-
4.2	Water Use	347				
4.2.1	Install Low-Flow Water Fixtures	347	WUW-1		EE-2.1.6; COS 2.2	MM-E23
4.2.2	Adopt a Water Conservation Strategy	362	WUW-2		COS-1.	MS-G-8
4.2.3	Design Water-Efficient Landscapes	365	WUW-3		COS-2.1	-
4.2.4	Use Water-Efficient Landscape Irrigation Systems	372	WUW-4		COS-3.1	MS-G-8
4.2.5	Reduce Turf in Landscapes and Lawns	376	WUW-5		-	-
4.2.6	Plant Native or Drought-Resistant Trees and Vegetation	381	WUW-6	x	COS-3.1	MM D-16

2.0 Energy

2.1 Building Energy Use

To determine overall reductions, the ratio of building energy associated GHG emissions to the other project categories needs to be determined. This percent contribution to the total is multiplied by the percentage reduction.

2.1.1 Buildings Exceed Title 24 Building Envelope Energy Efficiency Standards By X%[1]

(X is equal to the percentage improvement selected by Applicant such as 5%, 10%, or 20%)

Range of Effectiveness:

For a 10% improvement beyond Title 24 the range of effectiveness is:

	Electricity	Natural Gas
Non-residential	0.2 – 5.5%	0.7 – 10%
Residential	0.3 – 2.6%	7.5 – 9.1%

This is dependent on building type and climate zones.

Measure Description:

Greenhouse gases (GHGs) are emitted as a result of activities in residential and commercial buildings when electricity and natural gas are used as energy sources. New California buildings must be designed to meet the building energy efficiency standards of Title 24, also known as the California Building Standards Code. Title 24 Part 6 regulates energy uses including space heating and cooling, hot water heating, and ventilation[2]. By committing to a percent improvement over Title 24, a development reduces its energy use and resulting GHG emissions.

[1] Compliance with Title 24 is determined from the total daily valuation (TDV) of energy use in the built-environment (on a per square foot per year basis). TDV energy use is a parameter that reflects the burden that a building imposes on an electricity supply system. In general, there is a larger electricity demand and, hence, stress on the supply system during the day (peak times) than at night (off peak). Since a TDV analysis requires significant knowledge about the actual building which is not typically available during the CEQA process, the estimate of the energy and GHG savings from an improvement over Title 24 energy use from a TDV basis is proportional to the actual energy use.

[2] Hardwired lighting is part of Title 24 part 6. However, it is not part of the building envelope energy use and therefore not considered as part of this mitigation measure.

The energy use of a building is dependent on the building type, size and climate zone it is located in.

The *California Commercial Energy Use Survey* (CEUS) and *Residential Appliance Saturation Survey* (RASS) datasets can be used for these calculations since the data is scalable size and available for several land use categories in different climate zones in California.

The Title 24 standards have been updated twice (in 2005 and 2008) since some of these data were compiled. The California Energy Commission (CEC) has published reports estimating the percentage deductions in energy use resulting from these new standards. Based on CEC's discussion on average savings for Title 24 improvements, these CEC savings percentages by end user can be used to account for reductions in electricity and natural gas use due to updates to Title 24. Since energy use for each different system type (i.e., heating, cooling, water heating, and ventilation) as well as appliances is defined, this method will also easily allow for application of mitigation measures aimed at reducing the energy use of these devices in a prescriptive manner.

Measure Applicability:

- Electricity and natural gas use in residential and commercial buildings subject to California's Title 24 building requirements.
- This measure is part of a grouped measure. To ensure the measure effectiveness, this measure also requires third-party HVAC commissioning and verification of energy savings such as including the results from an alternative compliance model indicating the energy savings.

Inputs:

The following information needs to be provided by the Project Applicant:

- Square footage of non-residential buildings
- Number of dwelling units
- Building/Housing Type
- Climate Zone[3]
- Total electricity demand (KWh) per dwelling unit or per square feet
- % reduction commitment (over 2008 Title 24 standards)

Baseline Method:

The baseline GHG emissions from electricity and natural gas usage (reflecting 2008 Title 24 standards with no energy-efficient appliances) are calculated as follows:

[3] See Figure BE-1.1.

GHG Emissions Baseline$_{Electricity}$ = Electricity Intensity$_{baseline}$ x Size x Emission Factor$_{Electricity}$

GHG Emissions Baseline$_{NaturalGas}$ = Natural Gas Intensity$_{baseline}$ x Size x Emission Factor$_{NaturalGas}$

Where:

Electricity Intensity$_{baseline}$ = Total electricity demand (kWh) per dwelling unit or per square foot; provided by applicant and adjusted for 2008 Title 24 standards (calculated based on CEUS and RASS)[4]

Natural Gas Intensity$_{baseline}$ = Total natural gas demand (kBTU or therms) per dwelling unit or per square foot; provided by applicant and adjusted for 2008 Title 24 standards (calculated based on CEUS and RASS)[5]

Emission Factor$_{Electricity}$ = Carbon intensity of local utility (CO_2e/kWh)[6]

Emission Factor$_{NaturalGas}$ = Carbon intensity of natural gas use (CO_2e/kBTU or CO_2e/therm)[7]

Size = Number of dwelling units or square footage of commercial land uses

Mitigation Method:

GHG reduction % $_{Mitigated\_Electricity}$ = Reduction$_{Electricity}$ x Reduction Commitment

GHG reduction % $_{Mitigated\_NaturalGas}$ = Reduction$_{NaturalGas}$ x Reduction Commitment

Where:

Reduction = Applicable reduction based on climate zone, building type, and energy type from Tables BE-1.1 and BE-1.2

Reduction Commitment = Project's reduction commitment beyond 2008 Title 24 standards (expressed as a whole number)

This should be done for each individual building type. If the project involves multiple building types or only a percentage of buildings will have reductions the total for all buildings needs to be determined. This percentage should be applied as follows and summed over all buildings types:

---

4 See Appendix B for baseline inventory calculation methodologies to assist in determining these values.
5 See Appendix B for baseline inventory calculation methodologies to assist in determining these values.
6 Ibid.
7 Ibid.

$$\sum_i (Reduction \times Commitment)\left(\frac{buildingGHG_i}{TotalGHG_i}\right)(\%BuildingType)$$

$buildingGHG_i$	=	GHG emissions for specific building type for either electricity or natural gas
$TotalGHG_i$	=	Total GHG emissions for all buildings for either electricity or natural gas
i	=	electricity or natural gas
%BuildingType	=	portion of building(s) of this type

Tables BE-1.1 and BE-1.2 tabulate the percent reductions from building energy use for each land use type in the various climate zones in California. There is one table for residential land uses and another for non-residential land uses. There is a column for electricity reductions and another for natural gas reductions.

Assumptions:

See Figure BE-1.1 below for a map showing the 16 Climate Zones. Data for some Climate Zones is not presented in the CEUS and RASS studies. However, data from similar Climate Zones is representative and can be used as follows:

For non-residential building types:

Climate Zone 9 should be used for Climate Zone 11.
Climate Zone 9 should be used for Climate Zone 12.
Climate Zone 1 should be used for Climate Zone 14.
Climate Zone 10 should be used for Climate Zone 15.

For residential building types:

Climate Zone 2 should be used for Climate Zone 6.
Climate Zone 1 should be used for Climate Zone 14.
Climate Zone 10 should be used for Climate Zone 15.

Data based upon the following references:

- CEC. 2009. Residential Compliance Manual for California's 2008 Energy Efficiency Standards. Available online at: http://www.energy.ca.gov/title24/2008standards/residential_manual.html
- CEC. 2009. Nonresidential Compliance Manual for California's 2008 Energy Efficiency Standards. Available online at: http://www.energy.ca.gov/title24/2008standards/nonresidential_manual.html
- CEC. 2004. Residential Appliance Saturation Survey. Available online at: http://www.energy.ca.gov/appliances/rass/

- CEC. 2006. Commercial End-Use Survey. Available online at: http://www.energy.ca.gov/ceus/

Emission Reduction Ranges and Variables:

[Refer to Attached Tables BE-1.1 and BE-1.2 for climate zone and land use specific percentages]

This information uses 2008 Title 24 information. To adjust to 2005 Title 24, see Table BE-1.3.

Pollutant	Category Emissions Reductions
CO_2e	See Tables BE-1.1 and BE-1.2 for percentage reductions for every 1% improvement over 2008 Title 24.
PM	See Tables BE-1.1 and BE-1.2 for percentage reduction from natural gas. There is no reduction for electricity.
CO	See Tables BE-1.1 and BE-1.2 for percentage reduction from natural gas. There is no reduction for electricity.
SO_2	See Tables BE-1.1 and BE-1.2 for percentage reduction from natural gas. There is no reduction for electricity.
NOx	See Tables BE-1.1 and BE-1.2 for percentage reduction from natural gas. There is no reduction for electricity.

Discussion:

If the applicant selects to commit beyond requirements for 2008 Title 24 standards, the applicant would reduce the amount of GHG emissions associated with electricity generation and natural gas combustion.

Example:

Commercial land use = Large Office

Square footage = 100,000 sq. ft.

Climate Zone = 1

Utility Provider = PG&E

% Reduction Commitment = 10% over 2008 Title 24 Standards

Electricity $Intensity_{baseline}$ = 8.32 kWh/SF/yr (adjusted to reflect 2008 Title 24 standards)

Emission $Factor_{Electricity}$ = 2.08E-4 MT CO_2e/kWh

Electricity Emissions$_{baseline}$ = 8.32 kWh/SF/yr x 100,000 SF x (2.08E-4 MT CO_2e/kWh)
= 173 MT CO_2e/yr

Natural Gas Intensity$_{baseline}$ = 18.16 kBTU/SF/yr (adjusted to reflect 2008 Title 24 standards)

Emission Factor$_{NaturalGas}$ = 5.32E-5 MT CO_2e/therm

Natural Gas Emissions$_{baseline}$= 18.16 kBTU/SF/yr x 100,000 SF x (5.32E-5 MT CO_2e/kBTU)
= 97 MT CO_2e/yr

GHG emissions$_{baseline}$ = 173 MT CO_2e/yr + 97 MT CO_2e/yr
= 270 MT CO_2e/yr

From Table BE-1.1:

Reduction$_{Electricity}$ from 1% over 2008 Title 24 Standards = 0.20%
Reduction$_{NaturalGas}$ from 1% over 2008 Title 24 Standards = 1.00%

Reduction in GHG emissions from electricity generation: 0.20% x 10 = 2%
Reduction in GHG emissions from natural gas combustion: 1% x 10 = 10%
Mitigated Building GHG emissions = 173 MT CO_2e/yr x (100% - 2%) + 97 MT CO_2e/yr x (100% - 10%) = 257 CO_2e/yr

Preferred Literature:

GHG reductions from a percent improvement over Title 24 can be quantified by calculating baseline energy usage using methodologies based on the California Energy Commission (CEC)'s Residential Appliance Saturation Survey (RASS) and Commercial End-Use Survey (CEUS), or an applicable Alternative Calculation Method (ACM). RASS and CEUS data are based on CEC Forecasting Climate Zones (FCZs); therefore, differences in project energy usage due to different climates are accounted for. The percent improvement is applied to Title 24 built environment energy uses, and overall GHG emissions are calculated using local utility emission factors. This methodology allows the Project Applicant flexibility in choosing which specific measures it will pursue to achieve the percent reductions (for example, installing higher quality building insulation, or installing a more efficient water heating system), while still making the mitigation commitment at the time of California Environmental Quality Act (CEQA) analysis.

Alternative Literature:

Alternatively, a Project Applicant could use the "prescriptive package" approach to demonstrate compliance with Title 24. Using this approach, the Project Applicant would commit to specific design elements above Title 24 prescriptive package requirements at the time of CEQA analysis, such as using solar water heating or improved insulation. Rather than calculating an overall percent reduction in GHG emissions based on an overall baseline value as presented above, the prescriptive approach requires the Project Applicant to break down building energy use by end-use. The Project Applicant would need to provide substantial evidence supporting the GHG reductions attributable to mitigation measures for each end-use. There are several references for quantifying GHG reductions from prescriptive measures. One example of a prescriptive measure is installing tankless or on-demand water heaters. These systems use a gas burner or electric element to heat water as needed and therefore do not use energy to store heated water. According to the U.S. Department of Energy (USDOE), typical tankless water heaters can be 24-34% more energy efficient than conventional storage tank water heaters [1]. Another example of a prescriptive measure is installing geothermal (ground-source or water-source) heat pumps. This measure takes advantage of the fact that the temperature beneath the ground surface is relatively constant. Fluid circulating through underground pipe loops is either heated or cooled and the heat is either upgraded or reduced in the heat pump depending on whether the building requires heating or cooling [2]. United States Environmental Protection Agency (USEPA) reports that ENERGY STAR - qualified geothermal heat pump systems are 30-45% more efficient than conventional heat pumps [3].

Alternative Literature References:

[1] USDOE. Energy Savers: Demand (Tankless or Instantaneous) Water Heaters. Accessed February 2010. Available online at: http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820

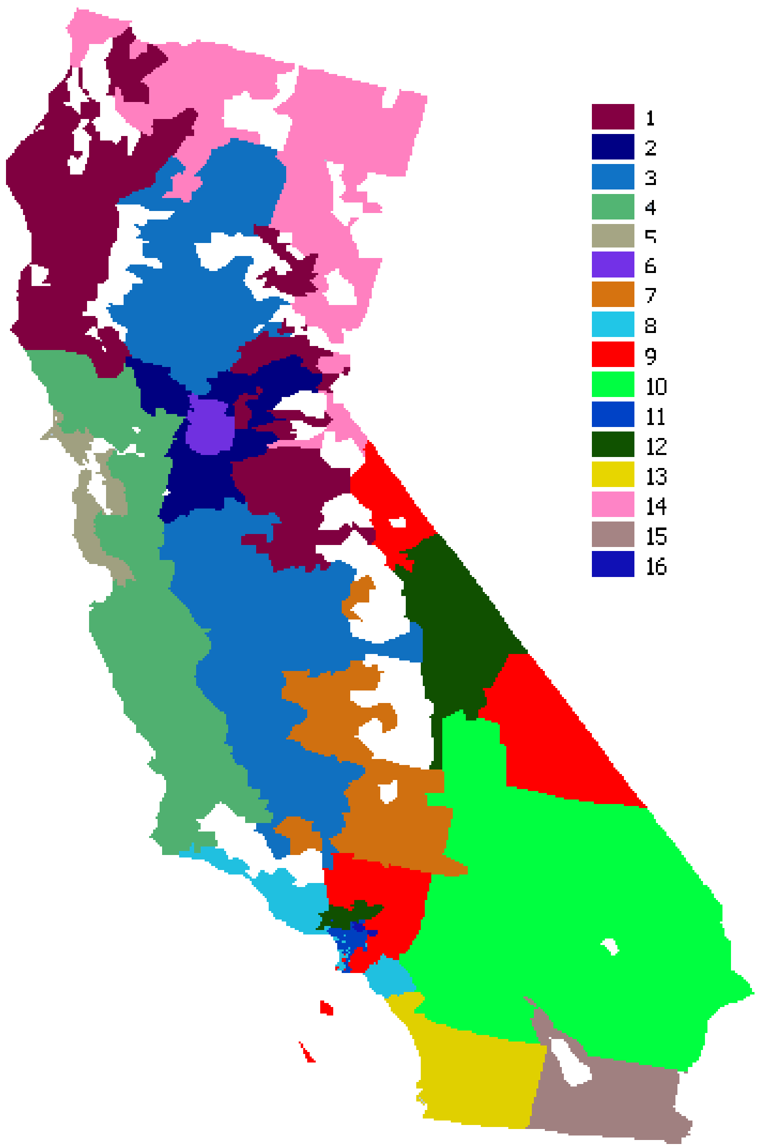
[2] CEC. Consumer Energy Center: Geothermal or Ground Source Heat Pumps. Accessed February 2010. Available online at: http://www.consumerenergycenter.org/home/heating_cooling/geothermal.html

[3] USEPA. ENERGY STAR: Heat Pumps, Geothermal. Accessed February 2010. Available online at: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=HP

Other Literature Reviewed:

None

Figure BE-1.1
CEC Forecast Climate Zones[8,9]



[8] Adapted from Figure 2 of CEC. 2004. Residential Appliance Saturation Survey. Available online at: http://www.energy.ca.gov/appliances/rass/
[9] White spaces represent national parks and forests.

Table BE-1.1
Non-Residential
Reduction for 1% Improvement over 2008 Title 24

Climate Zone	Building Types	Reduction	
		Electricity	Natural Gas
1	All Commercial	0.22%	0.76%
	All Office	0.36%	1.00%
	All Warehouses	0.02%	0.00%
	College	0.28%	1.00%
	Grocery	0.08%	0.96%
	Health	0.33%	1.00%
	Large Office	0.20%	1.00%
	Lodging	0.30%	1.00%
	Miscellaneous	0.16%	0.91%
	Refrigerated Warehouse	0.02%	0.00%
	Restaurant	0.19%	0.25%
	Retail	0.40%	1.00%
	School	0.26%	0.94%
	Small Office	0.37%	1.00%
	Unrefrigerated Warehouse	0.00%	0.00%
2	All Commercial	0.24%	0.86%
	All Office	0.35%	0.97%
	All Warehouses	0.07%	1.00%
	College	0.45%	1.00%
	Grocery	0.17%	1.00%
	Health	0.35%	0.72%
	Large Office	0.31%	1.00%
	Lodging	0.30%	0.99%
	Miscellaneous	0.22%	1.00%
	Refrigerated Warehouse	0.02%	1.00%
	Restaurant	0.22%	0.38%
	Retail	0.36%	0.97%
	School	0.36%	0.96%
	Small Office	0.38%	0.96%
	Unrefrigerated Warehouse	0.12%	1.00%
3	All Commercial	0.26%	0.66%
	All Office	0.32%	0.98%
	All Warehouses	0.03%	0.95%
	College	0.28%	0.94%
	Grocery	0.14%	0.53%
	Health	0.43%	0.82%
	Large Office	0.34%	0.97%
	Lodging	0.55%	0.73%

Climate Zone	Building Types	Reduction	
		Electricity	Natural Gas
	Miscellaneous	0.25%	0.82%
	Refrigerated Warehouse	0.02%	1.00%
	Restaurant	0.26%	0.18%
	Retail	0.29%	0.81%
	School	0.33%	0.93%
	Small Office	0.30%	1.00%
	Unrefrigerated Warehouse	0.13%	0.94%
4	All Commercial	0.27%	0.71%
	All Office	0.38%	1.00%
	All Warehouses	0.06%	0.77%
	College	0.37%	0.87%
	Grocery	0.12%	0.75%
	Health	0.45%	0.85%
	Large Office	0.41%	1.00%
	Lodging	0.30%	0.90%
	Miscellaneous	0.20%	0.76%
	Refrigerated Warehouse	0.02%	0.20%
	Restaurant	0.18%	0.30%
	Retail	0.29%	1.00%
	School	0.32%	0.95%
	Small Office	0.30%	1.00%
	Unrefrigerated Warehouse	0.10%	0.98%
5	All Commercial	0.26%	0.72%
	All Office	0.36%	0.95%
	All Warehouses	0.06%	0.46%
	College	0.44%	0.98%
	Grocery	0.09%	0.67%
	Health	0.40%	0.84%
	Large Office	0.37%	0.94%
	Lodging	0.29%	0.81%
	Miscellaneous	0.18%	0.73%
	Refrigerated Warehouse	0.04%	0.29%
	Restaurant	0.11%	0.25%
	Retail	0.24%	0.85%
	School	0.16%	0.91%
	Small Office	0.29%	1.00%
	Unrefrigerated Warehouse	0.07%	0.85%
6	All Commercial	0.31%	0.73%
	All Office	0.38%	0.95%
	All Warehouses	0.07%	0.86%
	College	0.43%	0.99%

Climate Zone	Building Types	Reduction	
		Electricity	Natural Gas
	Grocery	0.16%	0.64%
	Health	0.46%	0.86%
	Large Office	0.39%	0.94%
	Lodging	0.40%	0.86%
	Miscellaneous	0.25%	0.66%
	Refrigerated Warehouse	0.03%	0.58%
	Restaurant	0.24%	0.35%
	Retail	0.31%	0.83%
	School	0.31%	0.96%
	Small Office	0.34%	1.00%
	Unrefrigerated Warehouse	0.09%	1.00%
7	All Commercial	0.25%	0.88%
	All Office	0.32%	0.94%
	All Warehouses	0.02%	0.64%
	College	0.25%	0.99%
	Grocery	0.12%	0.90%
	Health	0.32%	0.93%
	Large Office	0.34%	1.00%
	Lodging	0.41%	0.94%
	Miscellaneous	0.18%	0.99%
	Refrigerated Warehouse	0.02%	0.64%
	Restaurant	0.27%	0.19%
	Retail	0.34%	0.99%
	School	0.29%	0.96%
	Small Office	0.31%	0.91%
	Unrefrigerated Warehouse	0.00%	0.00%
8	All Commercial	0.30%	0.62%
	All Office	0.37%	0.94%
	All Warehouses	0.12%	0.99%
	College	0.43%	0.67%
	Grocery	0.14%	0.50%
	Health	0.45%	0.85%
	Large Office	0.38%	0.94%
	Lodging	0.34%	0.86%
	Miscellaneous	0.22%	0.68%
	Refrigerated Warehouse	0.02%	0.93%
	Restaurant	0.27%	0.31%
	Retail	0.28%	0.49%
	School	0.33%	0.92%
	Small Office	0.33%	0.96%
	Unrefrigerated Warehouse	0.16%	0.99%

Climate Zone	Building Types	Reduction	
		Electricity	Natural Gas
9	All Commercial	0.28%	0.60%
	All Office	0.39%	0.96%
	All Warehouses	0.13%	0.95%
	College	0.33%	0.98%
	Grocery	0.14%	0.46%
	Health	0.44%	0.85%
	Large Office	0.43%	0.98%
	Lodging	0.37%	0.84%
	Miscellaneous	0.23%	0.76%
	Refrigerated Warehouse	0.03%	0.91%
	Restaurant	0.21%	0.19%
	Retail	0.32%	0.71%
	School	0.32%	0.90%
	Small Office	0.31%	0.94%
	Unrefrigerated Warehouse	0.18%	0.96%
10	All Commercial	0.30%	0.61%
	All Office	0.35%	1.00%
	All Warehouses	0.11%	0.58%
	College	0.27%	1.00%
	Grocery	0.19%	0.67%
	Health	0.46%	0.92%
	Large Office	0.34%	1.00%
	Lodging	0.39%	0.92%
	Miscellaneous	0.24%	0.49%
	Refrigerated Warehouse	0.03%	0.07%
	Restaurant	0.29%	0.29%
	Retail	0.36%	0.87%
	School	0.37%	0.80%
	Small Office	0.36%	1.00%
	Unrefrigerated Warehouse	0.15%	0.98%
13	All Commercial	0.29%	0.66%
	All Office	0.38%	0.80%
	All Warehouses	0.19%	0.95%
	College	0.33%	0.86%
	Grocery	0.11%	0.40%
	Health	0.39%	0.88%
	Large Office	0.41%	0.80%
	Lodging	0.40%	0.82%
	Miscellaneous	0.17%	0.39%

Climate Zone	Building Types	Reduction	
		Electricity	Natural Gas
	Refrigerated Warehouse	0.07%	1.00%
	Restaurant	0.24%	0.21%
	Retail	0.28%	0.53%
	School	0.31%	0.92%
	Small Office	0.32%	0.76%
	Unrefrigerated Warehouse	0.26%	0.93%

Table BE-1.2
Residential
Reduction for 1% Improvement over 2008 Title 24

Climate Zone	Housing	Reduction	
		Electricity	Natural Gas
1	Multi	0.24%	0.86%
	Single	0.17%	0.87%
	Townhome	0.22%	0.87%
2	Multi	0.15%	0.89%
	Single	0.14%	0.91%
	Townhome	0.11%	0.89%
3	Multi	0.23%	0.90%
	Single	0.18%	0.91%
	Townhome	0.16%	0.90%
4	Multi	0.12%	0.88%
	Single	0.09%	0.91%
	Townhome	0.09%	0.90%
5	Multi	0.09%	0.88%
	Single	0.04%	0.91%
	Townhome	0.05%	0.90%
7	Multi	0.25%	0.87%
	Single	0.16%	0.88%
	Townhome	0.18%	0.85%
8	Multi	0.09%	0.77%
	Single	0.07%	0.82%
	Townhome	0.07%	0.80%
9	Multi	0.08%	0.77%
	Single	0.11%	0.82%
	Townhome	0.09%	0.80%
10	Multi	0.26%	0.80%
	Single	0.18%	0.83%
	Townhome	0.22%	0.81%

11	Multi	0.05%	0.77%
	Single	0.05%	0.83%
	Townhome	0.03%	0.81%
12	Multi	0.15%	0.75%
	Single	0.15%	0.83%
	Townhome	0.13%	0.80%
13	Multi	0.09%	0.79%
	Single	0.06%	0.83%
	Townhome	0.05%	0.81%

2.1.2 Install Programmable Thermostat Timers

Range of Effectiveness:

Best Management Practice influences building energy use for heating and cooling.

Measure Description:

Programmable thermostat timers allow users to easily control when the HVAC system will heat or cool a certain space, thereby saving energy. Because most commercial buildings already have timed HVAC systems, this mitigation measure focuses on residential programmable thermostats.

The DOE reports [1] that residents can save around 10% on heating and cooling bills per year by lowering the thermostat by 10-15 degrees for eight hours[10]. This can be accomplished using an automatic timer or programmable thermostat, such that the heat is reduced while the residents are at work or otherwise out of the house. The energy savings from a programmable thermostat, however, depend on the user. Some users preset the thermostat to heat the house before they come home, thereby increasing energy usage, while others use it to avoid heating the house when they are not home or asleep. Because of the large variability in individual occupant behavior and because it is unclear whether programmable thermostats systematically reduce energy use, this measure cannot be reasonably quantified. This mitigation measure should be incorporated as a Best Management Practice to allow for educated occupants to have the most efficient means at controlling their heating and cooling energy use. In order to take quantitative credit for this mitigation measure, the Project Applicant would need to provide detailed and substantial evidence supporting a reduction in energy use and associated GHG emissions.

Measure Applicability:

- Electricity use in residential dwellings.
- Best Management Practice only.

Assumptions:

Data based upon the following references:

[1] USDOE. Energy Savers: Thermostats and Control Systems. Available online at: http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720

[10] Such a large drop in thermostat temperatures may not be applicable in parts of California; more applicable may be the raising of the thermostat for airconditioned spaces.

Emission Reduction Ranges and Variables:

This is a best management practice and therefore at this time there is no quantifiable reduction. Check with local agencies for guidance on any allowed reductions associated with implementation of best management practices.

If substantial evidence was provided, the GHG reductions would equal the percent savings in total electricity or natural gas. The total reduction would be:

GHG reduction = (% thermostat reduce heat/cool energy use) x
(% end use heat/cool of total energy use)

Preferred Literature:

The DOE reports [1] that residents can save approximately 10% on heating and cooling bills per year by lowering the thermostat by 10-15 degrees for eight hours. This can be accomplished using an automatic timer or programmable thermostat, such that the heat is reduced while the residents are at work or otherwise out of the house. The energy savings from a programmable thermostat, however, depend on the user. Some users preset the thermostat to heat the house before they come home, thereby increasing energy usage, while others use it to avoid heating the house when they are not home or asleep.

Alternative Literature:

None

Other Literature Reviewed:

Pacific Northwest National Laboratory. 2007. GridWise Demonstration Project Fast Facts. Available online at: http://gridwise.pnl.gov/docs/pnnl_gridwiseoverview.pdf.

2.1.3 Obtain Third-party HVAC Commissioning and Verification of Energy Savings

Range of Effectiveness:

Not applicable on its own. This measure enhances effectiveness of BE-1.

Measure Description:

Ensuring the proper installation and construction of energy reduction features is essential to achieving high thermal efficiency in a house. In practice, HVAC systems commonly do not operate at the designed efficiency due to errors in installation or adjustments. A Project Applicant can obtain HVAC commissioning and third-party verification of energy savings in thermal efficiency components including HVAC systems, insulation, windows, and water heating.

This measure is required to be grouped with measure "Exceed Title 24 Energy Efficiency Standards by X% (BE-1).

Measure Applicability:

- This measure is part of a grouped measure. This measure also requires third-party HVAC commissioning and verification of energy savings.
- Buildings subject to California's Title 24 building requirements.

Preferred Literature:

While Title 24 requires that a home's ducts be tested for leaks whenever the central air conditioner or furnace is installed or replaced, a third-party verifier such as the California Home Energy Efficiency Rating Service (CHEERS) and ENERGY STAR Home Energy Rating Service (HERS) can ensure that ducts were properly sealed [1-3]. These certified raters can also verify other energy efficiency measures, such as HVAC controls, insulation performance, and the air-tightness of the building envelope. Furthermore, these raters can analyze a home and make climate-specific recommendations for further improving the home's energy efficiency. Since this mitigation measure ensures that the building envelope systems are properly installed and sealed, there is no quantifiable reduction for this measure. It is recommended as a Best Management Practice grouped with the Title 24 improvement mitigation measure.

Alternative Literature:

None

Literature References:

[1] California Home Energy Efficiency Rating Services. What is CHEERS? Available online at: http://www.cheers.org/Home/Overview/tabid/124/Default.aspx. Accessed March 2010.

[2] USEPA. ENERGY STAR: Features of ENERGY STAR Qualified New Homes. Available online at: http://www.energystar.gov/index.cfm?c=new_homes.nh_features. Accessed March 2010.

[3] USEPA. ENERGY STAR: Independent Inspection and Testing. Available online at: http://www.energystar.gov/ia/new_homes/features/HERSrater_062906.pdf. Accessed March 2010.

2.1.4 Install Energy Efficient Appliances

Range of Effectiveness:

Residential 2-4% GHG emissions from electricity use. Grocery Stores: 17-22% of GHG emissions from electricity use.

Measure Description:

Using energy-efficient appliances reduces a building's energy consumption as well as the associated GHG emissions from natural gas combustion and electricity production. To take credit for this mitigation measure, the Project Applicant (or contracted builder) would need to ensure that energy efficient appliances are installed. For residential dwellings, typical builder-supplied appliances include refrigerators and dishwashers. Clothes washers and ceiling fans would be applicable if the builder supplied them. For commercial land uses, energy-efficient refrigerators have been evaluated for grocery stores. See Mitigation Method section on how project applicant may quantify additional building types and appliances.

The energy use of a building is dependent on the building type, size and climate zone it is located in. The *California Commercial Energy Use Survey* (CEUS) and *Residential Appliance Saturation Survey* (RASS) datasets for this calculation since the data is scalable by size and available for several land use categories in different climate zones in California. Typical reductions for energy-efficient appliances can be found in the *Energy Star and Other Climate Protection Partnerships 2008 Annual Report* or subsequent Annual Reports. ENERGY STAR refrigerators, clothes washers, dishwashers, and ceiling fans use 15%, 25%, 40%, and 50% less electricity than standard appliances, respectively.

RASS does not specify a ceiling fan end-use; rather, electricity use from ceiling fans is accounted for in the Miscellaneous category which includes interior lighting, attic fans, and other miscellaneous plug-in loads. Since the electricity usage of ceiling fans alone is not specified, a value from the National Renewable Energy Laboratory (NREL) Building American Research Benchmark Definition (BARBD) is used. BARBD reports that the average energy use per ceiling fan is 84.1 kWh per year. In this mitigation measure, it is assumed that each multi-family, single-family, and townhome residence has one ceiling fan. The electricity savings shown here is based on installing an ENERGY STAR ceiling fan and does not account for an occupant's decreased use of cooling devices such as air conditioners. For ceiling fans, the 50% reduction was applied to 84.1 kWh of the electricity attributed to the Miscellaneous RASS category.

Measure Applicability:

- Electricity use in residential dwellings and commercial grocery stores.
- This mitigation measure applies only when appliance installation can be specified as part of the Project.

Inputs:

The following information needs to be provided by the Project Applicant:

- Number of dwelling units and/or size of grocery store
- Climate Zone
- Housing Type (if residential)
- Utility provider
- Total natural gas demand (kBTU or therms) per dwelling unit or per square foot
- Types of energy efficient appliances to be installed (refrigerator, dishwasher, or clothes washer for residential land uses and refrigerators for grocery stores)

Baseline Method:

$$\text{GHG emissions} = \text{Electricity Intensity}_{baseline} \times \text{Size} \times \text{Emission Factor}_{Electricity} + \text{Natural Gas Intensity}_{baseline} \times \text{Size} \times \text{Emission Factor}_{NaturalGas}$$

Where:

GHG emissions = MT CO_2e (reflecting 2008 Title 24 standards with no energy-efficient appliances)

Electricity $\text{Intensity}_{baseline}$ = Total electricity demand (kWh) per dwelling unit or per square foot; provided by applicant and adjusted for 2008 Title 24 standards[11]

Natural Gas $\text{Intensity}_{baseline}$ = Total natural gas demand (kBTU or therms) per dwelling unit or per square foot; provided by applicant and adjusted for 2008 Title 24 standards[12]

Emission $\text{Factor}_{Electricity}$ = Carbon intensity of local utility (CO2e/kWh)[13]

Emission $\text{Factor}_{NaturalGas}$ = Carbon intensity of natural gas use (CO_2e/kBTU or CO_2e/therm)[14]

Size = Number of dwelling units or square footage of commercial land uses

Mitigation Method:

$$\text{GHG emissions}_{mitigated} = \text{Electricity Emissions}_{baseline} \times (1-(\text{Sum of Reductions})) +$$

[11] See Appendix B for baseline inventory calculation methodologies to assist in determining these values.
[12] Ibid
[13] Ibid.
[14] Ibid.

Natural Gas $Emissions_{baseline}$

Where:

Electricity $Emissions_{baseline}$	=	Emissions due to electricity generation, adjusted for 2008 Title 24 Standards (calculated based on CEUS and RASS)
Sum of Reductions	=	Applicable reduction based on energy efficient appliances installed (expressed as a decimal)
Natural Gas $Emissions_{baseline}$	=	Emissions due to natural gas combustion, adjusted for 2008 Title 24 Standards (calculated based on CEUS and RASS)
Building GHG reduction Percentage	=	[GHG emissions mitigated/GHG emissions baseline]

Tables BE-4.1 and BE-4.2 tabulate the percent reductions from installing specific ENERGY STAR appliances for each land use type in the various climate zones in California. There is one table for residential land uses and another for non-residential land uses. This will only result in reductions associated with electricity use and does not apply to natural gas since there are no major Energy Star appliances that use natural gas. The energy efficient heating, cooling, and water heating systems that may use natural gas are included in improvements over Title 24 (see measure BE-1).

For other building types and energy efficient appliances, the reductions similar to those in the tables can be quantified as follows:

$$\text{Reduction} = (\text{Appliance End Use \%}) \times (1 - \text{efficiency})$$

Where:

Appliance End Use %	=	portion of energy for this appliance compared to total electricity use
Efficiency	=	percent reduction in energy use for efficient appliance compared to standard.

Assumptions:

Data for some Climate Zones is not presented in the CEUS and RASS studies. However, data from similar Climate Zones is representative and can be used as follows:

For non-residential building types:
Climate Zone 9 should be used for Climate Zone 11.
Climate Zone 9 should be used for Climate Zone 12.

Climate Zone 1 should be used for Climate Zone 14.
Climate Zone 10 should be used for Climate Zone 15.
For residential building types:
Climate Zone 2 should be used for Climate Zone 6.
Climate Zone 1 should be used for Climate Zone 14.
Climate Zone 10 should be used for Climate Zone 15.

Data based upon the following references:

[1] USEPA. 2008. ENERGY STAR 2008 Annual Report. Available online at: http://www.epa.gov/cpd/annualreports/annualreports.htm

[2] CEC. 2004. Residential Appliance Saturation Survey. Available online at: http://www.energy.ca.gov/appliances/rass/

[3] CEC. 2006. Commercial End-Use Survey. Available online at: http://www.energy.ca.gov/ceus/

[4] NREL. 2010. Building America Research Benchmark Definition. Available online at: http://www.nrel.gov/docs/fy10osti/47246.pdf

Emission Reduction Ranges and Variables:

[Refer to Attached Tables BE-4.1 and BE-4.2 for climate zone and land use specific percentages]

If more than one type of appliance is considered the percentage for each appliance should be added together.

Pollutant	Category Emissions Reductions
CO_2e	See Tables BE-4.1 and BE-4.2 for percentage reductions.
PM	Not Quantified[15]
CO	Not Quantified
SO_2	Not Quantified
NOx	Not Quantified

Discussion:

If the applicant commits to installing energy efficient appliances, the applicant would reduce the amount of GHG emissions associated with electricity generation because

[15] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

more energy efficient appliances will require less electricity to run. This reduces GHG emissions from power plants.

Example:

Housing Type = Single Family Home

Number of Dwelling Units = 100

Climate Zone = 1

Utility Provider = PG&E

Energy efficient appliances to be installed = refrigerator and dishwasher

Electricity Intensity$_{baseline}$	=	7,196 kWh/DU/yr (adjusted to reflect 2008 Title 24 standards)
Emission Factor$_{Electricity}$	=	2.08E-4 MT /kWh
Electricity Emissions$_{baseline}$	=	7,196 kWh/DU/yr x 100 DU x (2.08E-4 MT CO_2e/kWh)
	=	150 MT CO_2e/yr
Natural Gas Intensity$_{baseline}$	=	365 therms/DU/yr (adjusted to reflect 2008 Title 24 standards)
Emission Factor$_{NaturalGas}$	=	5.32E-3 MT CO_2e/kBTU
Natural Gas Emissions$_{baseline}$	=	365 therm/DU/yr x 100 DU x (5.32E-3 MT CO_2e/therm)
	=	194 MT CO_2e/yr
GHG emissions$_{baseline}$	=	150 MT CO_2e/yr + 194 MT CO_2e/yr
	=	344 MT CO_2e/yr

Sum of Reductions associated with electricity generation from Table BE-4.2 = 2.05%
Reductions associated with natural gas combustion = 0%

GHG emissions$_{mitigated}$ = 150*(1-.0205) + 194

= 341

Building GHG reduction = 1 - 341 / 344 = 0.9%

Preferred Literature:

The USEPA ENERGY STAR Program has identified energy efficient residential and consumer appliances including air conditioners, refrigerators, freezers, clothes washers, dishwashers, fryers, steamers, and vending machines. The ENERGY STAR Annual Report presents the average percent energy savings from using an ENERGY STAR-qualified appliance instead of a standard appliance. GHG emissions reductions are calculated based on local utility emission factors and the baseline appliance energy use derived from the CEC RASS and CEUS methodologies. RASS and CEUS data are climate-specific; therefore, differences in project energy usage due to different climates are accounted for.

Alternative Literature:

None

Other Literature Reviewed:

None

Table BE-4.1
Non-Residential
Reduction for ENERGY STAR Refrigerators in Grocery Stores

Climate Zone	Electricity Reduction
1	20%
2	17%
3	18%
4	21%
5	22%
6	19%
7	18%
8	19%
9	20%
10	18%
13	21%

Table BE-4.2
Residential
Reduction for ENERGY STAR Appliances

Climate Zone	Housing	Refrigerator[1,3]	Clothes Washer[1,3]	Dishwasher[1,3]	Ceiling Fan[2,3]
		Total Electricity Reduction			
1	Multi	2.59%	0.03%	0.10%	1.01%
	Single	1.72%	0.50%	0.12%	0.58%
	Townhome	2.28%	0.28%	0.11%	0.83%
2	Multi	2.86%	0.03%	0.11%	1.12%
	Single	1.79%	0.53%	0.13%	0.61%
	Townhome	2.61%	0.32%	0.13%	0.96%
3	Multi	2.62%	0.03%	0.10%	1.02%
	Single	1.69%	0.50%	0.12%	0.58%
	Townhome	2.44%	0.30%	0.12%	0.89%
4	Multi	2.97%	0.03%	0.12%	1.16%
	Single	1.90%	0.56%	0.14%	0.65%
	Townhome	2.64%	0.33%	0.13%	0.97%
5	Multi	3.07%	0.03%	0.12%	1.20%
	Single	1.99%	0.58%	0.14%	0.68%
	Townhome	2.78%	0.35%	0.14%	1.02%
7	Multi	2.54%	0.03%	0.10%	0.99%
	Single	1.74%	0.51%	0.12%	0.59%
	Townhome	2.39%	0.30%	0.12%	0.88%
8	Multi	3.08%	0.03%	0.12%	1.20%
	Single	1.94%	0.57%	0.14%	0.66%
	Townhome	2.71%	0.34%	0.14%	0.99%
9	Multi	3.13%	0.03%	0.12%	1.22%
	Single	1.85%	0.54%	0.13%	0.63%
	Townhome	2.65%	0.33%	0.13%	0.97%
10	Multi	2.52%	0.03%	0.10%	0.98%
	Single	1.71%	0.50%	0.12%	0.58%
	Townhome	2.27%	0.28%	0.11%	0.83%
11	Multi	3.21%	0.03%	0.13%	1.25%
	Single	1.97%	0.58%	0.14%	0.67%
	Townhome	2.83%	0.35%	0.14%	1.04%
12	Multi	2.89%	0.03%	0.11%	1.13%
	Single	1.76%	0.51%	0.13%	0.60%
	Townhome	2.53%	0.32%	0.13%	0.93%
13	Multi	3.09%	0.03%	0.12%	1.21%
	Single	1.95%	0.57%	0.14%	0.66%
	Townhome	2.76%	0.34%	0.14%	1.01%

Notes:

1. Percent reductions are based on the saturation values presented in RASS. The Project Applicant may use project-specific saturation values (i.e. if 100% of homes have clothes washers, then saturation = 1).

Notes:

2. CEC's RASS does not specify a ceiling fan end-use; rather, electricity use from ceiling fans is accounted for in the Miscellaneous category, which includes interior lighting, attic fans, and other miscellaneous plug-in loads. Since the electricity usage of ceiling fans alone is not specified, a value from NREL's BARBD was used. BARBD reports that the average energy use per ceiling fan is 84.1 kWh per year. In this table, it is assumed that each multi-family, single-family, and townhome residence has one ceiling fan. The electricity savings shown here is based on installing an ENERGY STAR ceiling fan and does not account for an occupant's decreased use of cooling devices such as air conditioners.

3. Total electricity reduction is based on installing ENERGY STAR appliances instead of standard appliances. ENERGY STAR refrigerators, clothes washers, dishwashers, and ceiling fans use 15%, 25%, 40%, and 50% less electricity than standard appliances, respectively. For ceiling fans, the 50% reduction was applied to 84.1 kWh of the electricity attributed to the Miscellaneous RASS category.

Abbreviations:

BARBD - Building America Research Benchmark Definition
CEC - California Energy Commission
NREL - National Renewable Energy Laboratory
RASS - Residential Appliance Saturation Survey
USEPA - United States Environmental Protection Agency

Sources:

CEC. 2004. Residential Appliance Saturation Survey. Available online at: http://www.energy.ca.gov/appliances/rass/

NREL. 2010. Building America Research Benchmark Definition. Available online at: http://www.nrel.gov/docs/fy10osti/47246.pdf

USEPA. 2008. ENERGY STAR 2008 Annual Report. Available online at: http://www.epa.gov/cpd/annualreports/annualreports.htm

2.1.5 Install Energy Efficient Boilers

Range of Effectiveness: 1.2-18.4% of boiler GHG emissions

Measure Description:

Boilers are used in many non-residential and multi-family housing buildings to provide space heating or steam or facility operations. Boilers combust natural gas to produce steam which can be used directly or as a method to heat a building space. Boilers represent 12% of installed building heating equipment for commercial and other buildings. Boiler efficiencies are regulated and commonly presented as annualized fuel utilization efficiency (AFUE), a ratio of the total useful heat delivered to the heat value from the annual amount of fuel consumed. Improving boiler efficiency decreases natural gas consumption for the same amount of energy output, thus reducing GHG emissions.

Only natural gas boilers are considered under this mitigation measure. The Project Applicant would only need to provide the annual natural gas consumptions to calculate the baseline emissions using heat content and carbon intensity factors from CCAR [3]. To determine the emission reduction, boiler efficiency is also needed, and should be obtainable from manufacturer specifications. The Consortium for Energy Efficiency (CEE) reports that the rate of high efficiency boilers (≥ 85%) has gone from 5-15% of sales in 2002 to 50%-60% of sales in 2007 [2]. The CEE study also noted that technical improvements can be made to existing boiler types to improve efficiency to 88%. Efficiency can be further enhanced to up to 98% using the condensing boiler.

A range of efficiencies from the CEE study has been presented for reference, but to take credit for this mitigation measure, the Project Applicant would also need to provide evidence from manufacturers supporting the higher efficiency from a retrofit or new boiler.

Measure Applicability:

- Natural Gas Boilers

Inputs:

The following information needs to be provided by the Project Applicant:

- Natural gas consumption of boiler
- Original or baseline efficiency of boiler
- Improved efficiency of boiler

Baseline Method:

$$\text{Emission} = \text{Consumption} \times HC \times EF \times C$$

Where:

Emission = MT CO_2e
Consumption = Natural gas consumption (ft^3)
HC = Natural gas heat content = 1,029 BTU/ft^3 (CCAR 2009)
EF = Natural gas carbon intensity factor = 0.1173 lbs CO_2e/kBTU (CCAR 2009)
C = Unit conversion factor

In this case, C = 4.54×10^{-7} kBTU x MT/BTU/lbs

Mitigation Method:

The GHG emission from a boiler with improved efficiency is:

$$\text{Mitigated GHG Emission} = \text{Consumption} \times \frac{E_O}{E_I} \times HC \times EF \times C$$

Where:

Emission = MT CO_2e
Consumption = Natural gas consumption (ft^3)
E_O = Original efficiency of boiler
E_I = Improved efficiency of boiler
HC = Natural gas heat content = 1,029 BTU/ft^3 (CCAR 2009)
EF = Natural gas carbon intensity factor = 0.1173 lbs CO_2e/kBTU (CCAR 2009)
C = Unit conversion factor

Emission Reduction Ranges and Variables:

Percentage of emissions reduction using a boiler with improved efficiency for all pollutants are the same and is calculated as follows:

$$\text{Reduction} = 1 - \frac{E_O}{E_I}$$

Where:

E_O = Original efficiency of boiler
E_I = Improved efficiency of boiler

Technology	Range of Efficiencies	Range of Emission Reduction
Atmospheric	80 – 84%	-
Fan assisted, non-condensing	85 – 88%	1.2% – 9.1%
Fan assisted, condensing	88 – 98%	4.5% – 18.4%

Discussion:

Boiler efficiency is included in product specification from manufacturer. ENERGY STAR boilers require minimum efficiency of 85%. The Consortium for Energy Efficiency (CEE) reports natural efficiency breakpoints of 85-88% for fan assisted, non-condensing commercial boilers, and 88-98% for fan assisted, condensing boilers.

Assumptions:

Data based upon the following references:

- California Climate Action Registry 2009. General Reporting Protocol, Version 3.1. Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf
- Energy Star. Boilers key Product Criteria. Available at: http://www.energystar.gov/index.cfm?c=boilers.pr_crit_boilers
- Science Applications International Corporation 2009. Prepared for California Climate Action Registry. Development of Issue Papers for GHG Reduction Project Types: Boiler Efficiency Projects. Available at: http://www.climateactionreserve.org/wp-content/uploads/2009/03/future-protocol-development_boiler-efficiency.pdf

Preferred Literature:

Boilers represent 12% of installed building heating equipment. Boiler efficiencies are regulated and commonly presented as annualized fuel utilization efficiency (AFUE), a ratio of the total useful heat delivered to the heat value from the annual amount of fuel consumed. The Climate Action Registry (CAR) Boiler Efficiency Projects estimated potential annual CO_2e emission reductions of 22,673,929 and 6,584,231 MT for commercial and residential boilers, respectively, from boiler efficiency improvement from 77% to 83% [1]. The Consortium for Energy Efficiency (CEE) reports that the rate of high efficiency boilers (≥ 85%) has gone from 5-15% of sales in 2002 to 50%-60% of sales in 2007 [2]. The CEE study also noted that technical improvements can be made to existing boiler types to improve efficiency to 88%. Efficiency can be further enhanced to up to 98% using the condensing boiler.

Only natural gas boilers are considered under this mitigation measure. The Project Applicant would only need to provide the annual natural gas consumptions to calculate the baseline emissions using heat content and carbon intensity factors from CCAR [3]. To determine the emission reduction, boiler efficiency is also needed, and should be obtainable from manufacturer specifications. A range of efficiencies from the CEE study has been presented for reference, but to take credit for this mitigation measure, the Project Applicant would also need to provide evidence from manufacturers supporting the higher efficiency from a retrofit or new boiler.

Alternative Literature:

None

Notes:

[1] Science Applications International Corporation 2009. Prepared for Climate Action Registry (CAR). Development of Issue Papers for GHG Reduction Project Types: Boiler Efficiency Projects. Available at: http://www.climateactionreserve.org/wp-content/uploads/2009/03/future-protocol-development_boiler-efficiency.pdf

[2] Consortium of Energy Efficiency (CEE) Winter Program Meeting 2008. Market Characterization of Commercial Gas Boilers.

[3] CCAR 2009. General Reporting Protocol, Version 3.1. Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

Other Literature Reviewed:

None

2.2 Lighting

2.2.1 Install Higher Efficacy Public Street and Area Lighting

Range of Effectiveness:

16-40% of outdoor lighting

Measure Description:

Lighting sources contribute to GHG emissions indirectly, via the production of the electricity that powers these lights. Public street and area lighting includes streetlights, pedestrian pathway lights, area lighting for parks and parking lots, and outdoor lighting around public buildings. Lighting design should consider the amount of light required for the area intended to be lit. Lumens are the measure of the amount of light perceived by the human eye. Different light fixtures have different efficacies or the amount of lumens produced per watt of power supplied. This is different than efficiency, and it is important that lighting improvements are based on maintaining the appropriate lumens per area when applying this measure. Installing more efficacious lamps will use less electricity while producing the same amount of light, and therefore reduces the associated indirect GHG emissions.

Measure Applicability:

- Public street and area lighting

Inputs:

The following information needs to be provided by the Project Applicant:

- Number of lighting heads (for baseline only)
- Power rating of public street and area lights
- Carbon intensity of local utility (for baseline only)

Baseline Method:

$$\text{GHG emissions} = \text{Heads} \times \text{Hours} \times \text{Days} \times \text{Power}_{baseline} \times \text{Utility}$$

Where:

GHG emissions	=	MT CO_2e/yr
Heads	=	Number of public street and area lighting heads. Provided by Applicant.
Hours	=	Hours of operation per day (12).
Days	=	Days of operation per year (365).
$\text{Power}_{baseline}$	=	Power rating of public street and area lights (kW).
Utility	=	Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

The minimum reduction in annual energy cost associated with higher efficacy street lighting systems is 16%. Note that a 16% reduction in power rating and GHG emissions is the estimated minimum percent reduction associated with installing higher efficacy public street and area lighting. NYSERDA reports that a 16% reduction is expected for installing metal halide post top lights as opposed to typical mercury cobrahead lights. The percent reduction is expected to increase to 35% for installing metal halide cobrahead or metal halide cutoff lights, and 40% for installing high pressure sodium cutoff lights. For lights operating with a single local utility district, the 16% energy cost reduction is equivalent to a 16% reduction in power rating because the energy cost comparison assumes an equal number of lighting heads and equal operation times. As all other variables remain equal between the baseline and mitigated scenarios, the reduction in GHG emissions is in turn 16%. Therefore, the reduction in GHG emissions associated with installing higher efficacy public street and area lighting is:

$$\text{GHG emission reduction} = \frac{Power_{baseline} - Power_{mitigated}}{Power_{baseline}} = 16\%$$

Where:

GHG emission reduction	=	Percentage reduction in GHG emissions for public street and area lighting.
$Power_{baseline}$	=	Power rating of public street and area lights (kW).
$Power_{mitigated}$	=	Power rating of public street and area lights (kW).

If different types of lampheads result in less heads needing to be installed, the reduction will be as follows:

$$\frac{Head_{baseline} \times Power_{baseline} - Head_{mitigated} \times Power_{mitigated}}{Head_{baseline} \times Power_{baseline}}$$

Where:

$Head_{baseline}$	=	the number of heads in the baseline scenario
$Power_{baseline}$	=	the number of heads in the mitigated scenario

As it can be seen by this equation, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Note that a 16% reduction in power rating and GHG emissions is the estimated minimum percent reduction associated with installing higher efficacy public street and area lighting. NYSERDA reports that a 16% reduction is expected for installing metal halide post top lights as opposed to typical mercury cobrahead lights. The percent reduction is expected to increase to 35% for installing metal halide cobrahead or metal halide cutoff lights, and 40% for installing high pressure sodium cutoff lights.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	16% for installing metal halide post top lights; 35% for installing metal halide cobrahead or cutoff lights; 40% for installing high pressure sodium cutoff lights
All other pollutants	Not Quantified[16]

Discussion:

If the applicant uses public street and area lighting, they would calculate baseline emissions as described in the baseline methodologies section. If the applicant then selects to mitigate public street and area lighting by committing to higher efficacy options, the applicant would reduce the amount of GHG emissions associated with public street and area lighting by 16%.

GHG Emissions Reduced = 16%

Assumptions:

Data based upon the following reference:

[1] New York State Energy Research and Development Authority (NYSERDA). 2002. NYSERDA How-to Guide to Effective Energy-Efficient Street Lighting for Municipal Elected/Appointed Officials.

Preferred Literature:

The New York State Energy Research and Development Authority (NYSERDA)'s 2002 How-to Guide to Effective Energy-Efficient Street Lighting reports a minimum reduction in electricity demand of 16% due to the installation of energy-efficient street lights such as metal halide and high-pressure sodium models (see page 4).

Alternative Literature:

None

Other Literature Reviewed:

[16] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

[2] The University of Rochester. Light-Emitting Diode (LED), Organic Light-Emitting Diode (OLED), and laser research for lighting applications. Homepage available online at: http://www.rochester.edu/research/sciences.html. Accessed February 2010.

[3] Chittenden County Regional Planning Commission. 1996. Outdoor Lighting Manual for Vermont Municipalities.

2.2.2 Limit Outdoor Lighting Requirements

Range of Effectiveness:

Best Management Practice, but may be quantified.

Measure Description:

Lighting sources contribute to GHG emissions indirectly, via the production of the electricity that powers these lights. When the operational hours of a light are reduced, GHG emissions are reduced. Strategies for reducing the operational hours of lights include programming lights in public facilities (parks, swimming pools, or recreational centers) to turn off after-hours, or installing motion sensors on pedestrian pathways. Since literature guidance for quantifying these reductions does not exist, this mitigation measure would be employed as a Best Management Practice. In order to take credit for this mitigation measure, the Project Applicant would need to provide detailed and substantial documentation of the reduction in operational hours of lights.

Measure Applicability:

- Outdoor lighting
- Best Management Practice unless Project Applicant supplies substantial evidence.

Inputs:

The following information needs to be provided by the Project Applicant:

- Number of outdoor lights
- Power rating of outdoor lights
- Carbon intensity of local utility (for baseline only)
- Limited hours of operation of outdoor lights

Baseline Method:

$$\text{GHG emissions} = \text{Heads} \times \text{Hours} \times \text{Power}_{baseline} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e/yr
Heads = Number of outdoor lighting heads. Provided by Applicant.
Hours = Annual hours of operation (4,280)[17].
$\text{Power}_{baseline}$ = Power rating of outdoor lights (kW).
Utility = Carbon intensity of Local Utility (CO_2e/kWh)

[17] Estimated based on the annual number of dark hours (hours between sunset and sunrise) for Los Angeles, California.

Mitigation Method:

Limiting the hours of operation of outdoor lights in turn limits the indirect GHG emissions associated with their electricity usage. Therefore, the reduction in GHG emissions associated with limiting outdoor lighting is:

$$\text{GHG emission reduction} = \frac{Hours_{baseline} - Hours_{limited}}{Hours_{baseline}}$$

Where:

GHG emission reduction	=	Percentage reduction in GHG emissions for outdoor lighting.
$Hours_{baseline}$	=	Annual hours of operation (4,280).
$Hours_{limited}$	=	Limited hours of operation per day. Provided by Applicant.

As it can be seen by this equation, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

This is a best management practice measure unless the Project Applicant supplies substantial evidence justifying a reduction in hours of operation. Check with local agencies for guidance on any allowed reductions associated with implementation of best management practices.

Pollutant	Category Emissions Reductions
CO_2e	0 to 100%
All other pollutants	Not Quantified[18]

Discussion:

If the applicant uses outdoor lighting, they would calculate baseline emissions as described in the baseline methodologies document. If the applicant then selects to mitigate outdoor lighting by limiting operation to 10 hours per day, the applicant would reduce the amount of GHG emissions associated with outdoor lighting by 20%.

$$\text{GHG Emissions Reduced} = \frac{12-10}{10} = 0.20 \text{ or } 20\%$$

Assumptions:

[18] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

None

Preferred Literature:

None

Other Literature Reviewed:

None

2.2.3 Replace Traffic Lights with LED Traffic Lights

Range of Effectiveness:

90% of emissions associated with existing traffic lights.

Measure Description:

Lighting sources contribute to GHG emissions indirectly, via the production of the electricity that powers these lights. Installing higher efficiency traffic lights reduces energy demand and associated GHG emissions. As high efficiency light-emitting diodes (LEDs), which consume about 90% less energy than traditional incandescent traffic lights while still providing adequate light or lumens when viewed, are currently required to meet minimum federal efficiency standards for new traffic lights. Project Applicants may take credit only if they are retrofitting existing incandescent traffic lights.

Measure Applicability:

- Traffic lighting – retrofitting incandescent traffic lights

Inputs:

The following information needs to be provided by the Project Applicant:

- Number of incandescent traffic lights being retrofitted
- Power rating of incandescent traffic lights being retrofitted
- Carbon intensity of local utility (for baseline only)

Baseline Method:

$$\text{GHG emissions} = \text{Lights} \times \text{Hours} \times \text{Days} \times \text{Power}_{baseline} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e/yr

Lights = Number of incandescent traffic lights being retrofitted. Provided by Applicant.

Hours = Hours of operation per day (24).

Days = Days of operation per year (365).

$\text{Power}_{baseline}$ = Power rating of incandescent traffic lights being retrofitted (kW).

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

Traffic lights using LEDs consume about 90% less power than traditional incandescent traffic lights. Therefore, the reduction in GHG emissions associated with replacing incandescent traffic lights with LED-based traffic lights is:

$$\text{GHG emission reduction} = \frac{Power_{baseline} - Power_{mitigated}}{Power_{baseline}} = 90\%$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for traffic lighting.

$Power_{baseline}$ = Power rating of incandescent traffic lights (kW).

$Power_{mitigated}$ = Power rating of LED traffic lights (kW).

As it can be seen by this equation, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	90%
All other pollutants	Not Quantified[19]

Discussion:

If the applicant uses traffic lights, they would calculate baseline emissions as described in the baseline methodologies document. If the applicant then selects to mitigate traffic lights by committing to replacing all existing incandescent traffic lights with LED traffic lights, the applicant would reduce the amount of GHG emissions associated with traffic lights in an existing area by 90%.

GHG Emissions Reduced = 90%

Assumptions:

Data based upon the following references:

[1] USDOE. 2004. NREL. State Energy Program Case Studies: California Says "Go" to Energy-Saving Traffic Lights. Available online at: http://www.nrel.gov/docs/fy04osti/35551.pdf

[2] USEPA. ENERGY STAR: Traffic Signals. Available online at: http://www.energystar.gov/index.cfm?c=traffic.pr_traffic_signals. Accessed February 2010.

[19] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

Preferred Literature:

NREL reports that traffic lights based on light-emitting diodes (LEDs) consume about 90% less power than traditional incandescent traffic lights. All traffic lights manufactured on or after January 1, 2006 must meet minimum federal efficiency standards, which are consistent with ENERGY STAR specifications for LED traffic lights.

Alternative Literature:

None

Other Literature Reviewed:

[3] The University of Rochester. LED, OLED, and laser research for lighting applications. Homepage available online at: http://www.rochester.edu/research/sciences.html. Accessed February 2010.

2.3 Alternative Energy Generation

2.3.1 Establish Onsite Renewable or Carbon-Neutral Energy Systems-Generic

Range of Effectiveness:

0-100% of emissions associated with electricity use. Note some systems could increase energy use.

Measure Description:

Using electricity generated from renewable or carbon-neutral power systems displaces electricity demand which would ordinarily be supplied by the local utility. Different sources of electricity generation that local utilities use have varying carbon intensities. Renewable energy systems such as fuel cells may have GHG emissions associated with them. Carbon-neutral power systems, such as photovoltaic panels, do not emit GHGs and will be less carbon intense than the local utility. This mitigation measure describes a method to calculate GHG emission reductions from displacing utility electricity with electricity generated from an on-site power system, which may incorporate technology which has not yet been established at the time this document was written.

Measure Applicability:

- Electricity use

Inputs:

The following information needs to be provided by the Project Applicant:

- Total annual electricity demand (kWh)
- Annual amount of electricity to be provided by the on-site power system (kWh) or percent of total electricity demand to be provided by the on-site power system (%)
- Carbon intensity of local utility and on-site power system if not carbon neutral

Baseline Method:

$$\text{GHG emissions} = \text{Electricity}_{baseline} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$\text{Electricity}_{baseline}$ = Total electricity demand (kWh)
Provided by Applicant

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

If the total amount of electricity to be provided by the carbon-neutral power system is known, then the GHG emission reduction is equivalent to the ratio of electricity from the carbon-neutral power system to the total electricity demand:

$$\text{GHG emission reduction} = \frac{\text{Electricity}_{\text{carbon-neutral}}}{\text{Electricity}_{\text{baseline}}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for electricity use

$\text{Electricity}_{\text{carbon-neutral}}$ = Electricity to be provided by the carbon-neutral power system (kWh)

$\text{Electricity}_{\text{baseline}}$ = Total electricity demand (kWh)

If the percent of total electricity demand to be provided by the carbon-neutral power system is known, then the GHG emission reduction is equivalent to that percentage.

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions for carbon neutral systems.

If the total amount of electricity to be provided by a renewable energy system that is not carbon neutral, then the GHG emission reduction is equivalent to the following equation:

$$\text{GHG emission reduction} = \frac{\text{Electricity}_{\text{renewable}}}{\text{Electricity}_{\text{baseline}}} \times \frac{(\text{Utility} - \text{Renewable})}{\text{Utility}}$$

Where

$\text{Electricity}_{\text{renewable}}$ = Electricity provided by renewable power system (kWh)

Renewable = Carbon intensity of renewable system (CO_2e/kWh)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Up to 100%, assuming all electricity demand is provided by a carbon-neutral power system
All other pollutants	Not Quantified[20], [21]

Discussion:

[20] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

[21] Assumes that the onsite carbon-neutral system displaces electricity use only.

If a project's total electricity demand is 10,000 kWh, and 1,000 kWh of that is provided by the carbon-neutral system, then the GHG emission reduction is 10%

$$\text{GHG Emission Reduced} = \frac{1{,}000}{10{,}000} = 0.10 \text{ or } 10\%$$

If a project instead uses a renewable system with carbon intensity of 500 CO_2e/kWh and the local utility is 100 CO_2e/kWh, then the GHG emission reduction is 5%.

$$\text{GHG Emission Reduced} = \frac{1{,}000}{10{,}000} \times \frac{(1{,}000 - 500)}{1{,}000} = 0.05 \text{ or } 5\%$$

2.3.2 Establish Onsite Renewable Energy Systems-Solar Power

Range of Effectiveness: 0-100% of GHG emissions associated with electricity use.

Measure Description:

Using electricity generated from photovoltaic (PV) systems displaces electricity demand which would ordinarily be supplied by the local utility. Since zero GHG emissions are associated with electricity generation from PV systems[22], the GHG emissions reductions from this mitigation measure are equivalent to the emissions that would have been produced had electricity been supplied by the local utility.

Measure Applicability:

- Electricity use

Inputs:

The following information needs to be provided by the Project Applicant:

- Total electricity demand (kWh)
- Amount of electricity to be provided by the PV system (kWh) or percent of total electricity demand to be provided by the PV system (%)

Baseline Method:

$$\text{GHG emissions} = \text{Electricity}_{baseline} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$\text{Electricity}_{baseline}$ = Total electricity demand (kWh) Provided by Applicant

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

If the total amount of electricity to be provided by the PV system is known, then the GHG emission reduction is equivalent to the ratio of electricity from the PV system to the total electricity demand:

$$\text{GHG emission reduction} = \frac{\text{Electricity}_{PV}}{\text{Electricity}_{baseline}}$$

[22] This mitigation measure does not account for GHG emissions associated with the embodied energy of PV systems.

Where:

GHG emission reduction	=	Percentage reduction in GHG emissions for electricity use
$Electricity_{PV}$	=	Electricity to be provided by PV system (kWh)
$Electricity_{baseline}$	=	Total electricity demand (kWh)

If the percent of total electricity demand to be provided by the PV system is known, then the GHG emission reduction is equivalent to that percentage.

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

The amount of electricity generated by a PV system depends on the size and type of the PV system and the location of the project. The Project Applicant can use a publically-available solar calculator, such as California's Public Utilities and Energy Commissions Go Solar Clean Power Estimator[23], to estimate the size of the PV system needed to generate the desired amount of electricity. The only input required for this calculator is the location (zip code). Estimates of the amount of electricity that can be generated from 1.5, 3, 5, and 10 kW PV systems in cities around California are shown in Table AE-2.1 below.

Since there is a range of PV system efficiencies, the local agency may consider checking the type of PV efficiency assumed to ensure the system that is installed meets this capacity.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Up to 100%, assuming all electricity demand is provided by a PV system. Percent reduction would scale down linearly as the percent of electricity provided by a PV system decreases.
All other pollutants	Not Quantified[24]

Discussion:

If a project's total electricity demand is 10,000 kWh, and 1,000 kWh of that is provided by a PV system, then the GHG emission reduction is 10%

[23] Available online at http://gosolarcalifornia.cleanpowerestimator.com/gosolarcalifornia.htm.
[24] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

$$\text{GHG Emission Reduced} = \frac{1{,}000}{10{,}000} = 0.10 \text{ or } 10\%$$

Assumptions:

The data in Table AE-2.1 was generated from California's Public Utilities and Energy Commissions Go Solar Clean Power Estimator, a publically-available solar calculator which the Project Applicant can use to estimate the PV system size needed to generate the desired amount of electricity. It is available online at: http://gosolarcalifornia.cleanpowerestimator.com/gosolarcalifornia.htm.

Other publically-available solar calculators include:

- USDOE. NREL: PVWatts Calculator. Available online at: http://www.nrel.gov/rredc/pvwatts/.
- SolarEstimate.Org. Solar & Wind Estimator. Available online at: http://www.solar-estimate.org/index.php?page=solar-calculator.
- SharpUSA. Solar Calculator. Available online at: http://sharpusa.cleanpowerestimator.com/sharpusa.htm.

Preferred Literature:

None

Other Literature Reviewed:

None

Table AE-2.1
Estimated Electricity Generation from Typical PV Systems

Location			Annual kWh Generated		
Air District	**Major City**	**Zip Code**	**3 kW PV System**	**5 kW PV System**	**10 kW PV System**
Amador County	Ione	95640	4,857	8,094	16,189
Antelope Valley	Lancaster	93534	5,034	8,390	16,781
Bay Area	San Francisco	94101	4,926	8,218	16,436
Butte County	Chico	95926	4,857	8,094	16,189
Calaveras County	Rancho Calaveras	95252	4,857	8,094	16,189
Colusa County	Colusa	95932	4,857	8,094	16,189
El Dorado County	South Lake Tahoe	96150	5,275	8,792	17,584
Feather River	Yuba City	95991	4,857	8,094	16,189
Glenn County	Orland	95963	4,857	8,094	16,189
Great Basin Unified	Bishop	93514	5,507	9,179	18,358
Imperial County	El Centro	92243	5,117	8,528	17,056
Kern County	Bakersfield	93301	5,082	8,470	16,939
Lake County	Lakeport	95453	4,857	8,094	16,189
Lassen County	Susanville	96130	5,275	8,792	17,584
Mariposa County	Mariposa	95338	5,065	8,441	16,882
Mendocino County	Ukiah	95482	4,926	8,218	16,436
Modoc County	Alturas	96101	5,275	8,792	17,584
Mojave Desert	Victorville	92392	5,885	9,808	19,617
Monterey Bay Unified	Monterey	93940	4,926	8,218	16,436
North Coast Unified	Eureka	95501	4,081	6,801	13,602
Northern Sierra	Grass Valley	95949	4,857	8,094	16,189
Northern Sonoma County	Healdsburg	95448	4,931	8,218	16,436
Placer County	Roseville	95678	4,857	8,094	16,189
Sacramento Metro	Sacramento	95864	4,857	8,094	16,189
San Diego County	San Diego	92182	5,102	8,528	17,056
San Joaquin Valley Unified	Fresno	93650	5,065	8,441	16,882
San Luis Obispo County	San Luis Obispo	93405	5,320	8,932	17,865
Santa Barbara County	Santa Barbara	93101	5,320	8,932	17,865
Shasta County	Redding	96001	4,081	6,801	13,602
Siskiyou County	Yreka	96097	4,363	7,271	14,543
South Coast	Los Angeles	90071	5,034	8,390	16,781
Tehama County	Red Bluff	96080	4,857	8,094	16,189
Tuolumne County	Sonora	95370	4,857	8,094	16,189
Ventura County	Oxnard	93030	5,034	8,390	16,781
Yolo-Solano	Davis	95616	4,857	8,094	16,189

2.3.3 Establish Onsite Renewable Energy Systems-Wind Power

Range of Effectiveness: 0-100% of GHG emissions associated with electricity use.

Measure Description:

Using electricity generated from wind power systems displaces electricity demand which would ordinarily be supplied by the local utility. Since zero GHG emissions are associated with electricity generation from wind turbines[25], the GHG emissions reductions from this mitigation measure are equivalent to the emissions that would have been produced had electricity been supplied by the local utility.

Measure Applicability:

- Electricity use

Inputs:

The following information needs to be provided by the Project Applicant:

- Total electricity demand (kWh)
- Amount of electricity to be provided by the wind power system (kWh) or percent of total electricity demand to be provided by the wind power system (%)

Baseline Method:

$$\text{GHG emissions} = \text{Electricity}_{baseline} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$\text{Electricity}_{baseline}$ = Total electricity demand (kWh) Provided by Applicant

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

The GHG emission reduction is equivalent to the ratio of electricity from the wind power system to the total electricity demand:

$$\text{GHG emission reduction} = \frac{\text{Electricity}_{wind}}{\text{Electricity}_{baseline}}$$

---

[25] This mitigation measure does not account for GHG emissions associated with the embodied energy of wind turbines.

Where:

GHG emission reduction	=	Percentage reduction in GHG emissions for electricity use
$Electricity_{wind}$	=	Electricity to be provided by wind power system (kWh)
$Electricity_{baseline}$	=	Total electricity demand (kWh)

If the percent of total electricity demand to be provided by the wind power system is known, then the GHG emission reduction is equivalent to that percentage.

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Up to 100%, assuming all electricity demand is provided by a wind power system. Percent reduction would scale down linearly as the percent of electricity provided by a wind power system decreases.
All other pollutants	None[26]

Discussion:

If a project's total electricity demand is 10,000 kWh, and 1,000 kWh of that is provided by a wind system, then the GHG emission reduction is 10%

$$\text{GHG Emission Reduced} = \frac{1{,}000}{10{,}000} = 0.10 \text{ or } 10\%$$

Assumptions:

None

Preferred Literature:

None

[26] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

Other Literature Reviewed:

None

2.3.4 Utilize a Combined Heat and Power System

Range of Effectiveness: 0-46% of GHG emissions associated with electricity use.

Measure Description:

For the same level of power output, combined heat and power (CHP) systems utilize less input energy than traditional separate heat and power (SHP) generation, resulting in fewer CO_2 emissions. In traditional SHP systems, heat created as a by-product is wasted by being released into the environment. In contrast, CHP systems harvest the thermal energy and use it to heat onsite or nearby processes, thus reducing the amount of natural gas or other fuel that would otherwise need to be combusted to heat those processes. In addition CHP systems lower the demand for grid electricity, thereby displacing the CO_2 emissions associated with the production of grid electricity.

This mitigation measure describes how to estimate CO_2 emissions savings (in MT per year) from utilizing a CHP system to supply energy demands which would otherwise be provided by separate heat and power systems (e.g. grid electricity for electricity demand and boilers for thermal demand). CO_2 emissions savings are quantified using the USEPA CHP Emission Calculator which allows users to estimate the CO_2 emissions savings associated with displaced electricity and thermal production from five CHP technologies: microturbine, fuel cell, reciprocating engine, combustion turbine, and backpressure steam turbine. The first three technologies have electricity generation capacities on a scale appropriate for residential neighborhoods, planned communities, and mixed-use and commercial developments. Combustion turbines and backpressure steam turbines are more appropriate for industrial processes or very large commercial developments. The user has the option to input project-specific data such as specific fuels, duct burner operation, cooling demand, and boiler efficiencies.

Table AE-4.1 provides examples of expected CO_2 savings for microturbines, fuel cells, and reciprocating engines of a range of electricity generating capacities for the five major California utilities (Southern California Edison (SCE), Los Angeles Department of Water and Power (LADWP), San Diego Gas and Electric (SDGE), Pacific Gas and Electric (PGE), and the Sacramento Municipal Utility District (SMUD). Default values provided by the USEPA CHP Calculator were used wherever possible (see the Assumptions section below). The magnitude of CO_2 reductions depends on the baseline power sources. For thermal demand, the baseline is assumed to be a new boiler with 80% efficiency. For electricity demand, the baseline is the carbon intensity of the local utility, which varies by utility. For reference, Table AE-4.2 provides the 2006 carbon intensity of delivered electricity for the five utilities. As shown in Table AE-4.1, certain CHP systems may not be appropriate for certain locations, especially in Northern California where PGE and SMUD have relatively low carbon intensities.

Measure Applicability:

- Grid electricity use
- Natural gas combustion

Inputs:

The following information needs to be provided by the Project Applicant:

- Expected CHP technology (microturbine, fuel cell, or reciprocating engine)
- Expected electricity demand

Baseline Method:

GHG emissions = CO_2 emissions displaced

Where:

GHG emissions	=	MT CO_2e
CO_2 emissions displaced	=	MT CO_2 from separate heat and power system Provided in Table AE-4.1 or calculated using USEPA CHP Calculator

Here it is assumed that all GHG emissions produced from fuel combustion and electricity generation are CO_2 emissions.

Mitigation Method:

GHG emission reduction = Percent Reduction in CO_2 emissions

Provided in Table A E-4.1 or calculated using USEPA CHP Calculator

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Up to 100%, assuming all electricity demand is provided by a CHP system. Percent reduction would scale down linearly as the percent of electricity provided by a CHP system decreases.
All other pollutants	0-70%[27] Depends on CHP technology, electricity generating capacity, sulfur content of fuel, and displaced thermal generation technology. Reductions in CO_2 may produce increases in SO_2 and/or NOx, or vice versa.

[27] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

Discussion:

Assume a project is located in SCE's service area and has an expected electricity demand of 100 kW. Using Table AE-4:

- A 100 kW microturbine will generate more CO_2 emissions than a separate heat and power system of equivalent power capacity.
- A 100 kW fuel cell will generate about the same CO_2 emissions than a separate heat and power system of equivalent power capacity.
- A 100 kW reciprocating engine will generate 14% less CO_2 emissions as a separate heat and power system of equivalent power capacity.

Therefore, the Project Applicant should choose the reciprocating engine. This system would generate 568 MT CO_2 compared to 657 MT CO_2 from the separate heat and power system.

Assumptions:

Table AE-4.1 was prepared using the 2009 USEPA CHP Calculator, a publically-available tool found online at: http://www.epa.gov/chp/basic/calculator.html. The following defaults and assumptions were made to generate the data in Table AE-4.1:

- The range of electricity generating capacity shown in Table AE-4.1 is based on the normal range for the technology (as per Calculator default)
- Operates 8,760 hours per year
- Provides heat only (no cooling)
- Combusts natural gas fuel (116.7 CO_2/MMBtu emission rate and 1,020 Btu/scf HHV as per Calculator defaults)
- No supplementary duct burner
- Assumes 8% transmission loss for displaced electricity

Table AE-4.2 was prepared using data from the California Climate Action Registry (CCAR) Power/Utility Protocol (PUP) public reports for reporting year 2006. These PUP reports are available online at: https://www.climateregistry.org/CARROT/public/reports.aspx.

Preferred Literature:

The USEPA CHP Emissions Calculator compares the anticipated emissions from a CHP system to the emissions from SHP systems. The Calculator was developed by the U.S. Department of Energy's Distributed Energy Program, Oak Ridge National Laboratory, and the U.S. Environmental Protection Agency's CHP Partnership. Users can choose from five different CHP technologies (microturbine, fuel cell, reciprocating engine, combustion turbine, and backpressure steam turbine) and compare their performance to a number of different SHP systems (e.g. local electricity utility and existing or new gas boiler, fuel oil boiler, or heat bump). Additionally, users have the option to refine the analysis with project-specific inputs such as the cooling demand and additional duct burning. Details such as the cooling efficiency of the displaced cooling system must be known to perform more detailed analysis. The calculator can be used to estimate expected reductions in CO_2, SO_2, and NOx emissions as well as fuel usage.

Alternative Literature:

The USEPA Combined Heat and Power Partnership Catalog of CHP Technologies presents performance details of six CHP technologies: gas turbine, microturbine, spark and compression ignition reciprocating engines, steam turbine, and fuel cell. Table I of the Introduction presents the equations necessary to calculate the percent fuel savings from using a CHP system instead of traditional separate heat and power generation. Subsequent chapters describe performance details of each of the CHP technologies, including estimated CO_2 emissions. The GHG emissions reductions associated with this mitigation measure are the change in emissions from using a CHP system rather than a SHP system in a building. The USEPA CHP Calculator methodologies are based in part on this Catalog of CHP Technologies document.

Other Literature Reviewed:

None

Table AE-4.1
Estimated CO_2 Emissions Savings from CHP Systems in California[1,2]

Utility	CHP Technology	Electricity Generating Capacity	Electric Efficiency	Power to Heat Ratio	CO_2 Emissions from CHP	CO_2 Emissions Displaced	Percent Reduction in CO_2 Emissions[3]
		(kW)	(% HHV)	--	(MT/year)	(MT/year)	(%)
SCE	Microturbine	30	24%	0.51	200	200	0%
		50	24%	0.51	334	333	0%
		100	26%	0.7	607	559	-9%
		250	26%	0.92	1517	1229	-23%
	Fuel Cell	5	30%	0.79	26	26	0%
		100	30%	0.79	527	527	0%
		1000	43%	1.95	3679	3783	3%
		2000	46%	1.92	6884	7597	9%
	Reciprocating Engine (Rich Burn)	55	30%	0.63	290	325	11%
		100	28%	0.52	568	657	14%
		1000	29%	0.64	5514	5859	6%
		1200	28%	0.63	6759	7052	4%
LADWP	Microturbine	30	24%	0.51	200	277	28%
		50	24%	0.51	334	462	28%
		100	26%	0.7	607	817	26%
		250	26%	0.92	1517	1875	19%
	Fuel Cell	5	30%	0.79	26	39	33%
		100	30%	0.79	527	786	33%
		1000	43%	1.95	3679	6366	42%
		2000	46%	1.92	6884	12762	46%
	Reciprocating Engine (Rich Burn)	55	30%	0.63	290	466	38%
		100	28%	0.52	568	915	38%
		1000	29%	0.64	5514	8441	35%
		1200	28%	0.63	6759	10188	34%
SDGE	Microturbine	30	24%	0.51	200	218	8%
		50	24%	0.51	334	363	8%
		100	26%	0.7	607	620	2%
		250	26%	0.92	1517	1381	-10%
	Fuel Cell	5	30%	0.79	26	30	12%
		100	30%	0.79	527	588	10%
		1000	43%	1.95	3679	4387	16%
		2000	46%	1.92	6884	8806	22%

Utility	CHP Technology	Electricity Generating Capacity	Electric Efficiency	Power to Heat Ratio	CO_2 Emissions from CHP	CO_2 Emissions Displaced	Percent Reduction in CO_2 Emissions[3]
		(kW)	(% HHV)	--	(MT/year)	(MT/year)	(%)
	Reciprocating Engine (Rich Burn)	55	30%	0.63	290	358	19%
		100	28%	0.52	568	717	21%
		1000	29%	0.64	5514	6463	15%
		1200	28%	0.63	6759	7814	14%
PGE	Microturbine	30	24%	0.51	200	175	-15%
		50	24%	0.51	334	293	-14%
		100	26%	0.7	607	479	-27%
		250	26%	0.92	1517	1030	-47%
	Fuel Cell	5	30%	0.79	26	23	-16%
		100	30%	0.79	527	447	-18%
		1000	43%	1.95	3679	2984	-23%
		2000	46%	1.92	6884	5999	-15%
	Reciprocating Engine (Rich Burn)	55	30%	0.63	290	280	-4%
		100	28%	0.52	568	577	2%
		1000	29%	0.64	5514	5059	-9%
		1200	28%	0.63	6759	6130	-10%
SMUD	Microturbine	30	24%	0.51	200	188	-7%
		50	24%	0.51	334	314	-6%
		100	26%	0.7	607	522	-16%
		250	26%	0.92	1517	1137	-33%
	Fuel Cell	5	30%	0.79	26	24	-7%
		100	30%	0.79	527	490	-8%
		1000	43%	1.95	3679	3411	-8%
		2000	46%	1.92	6884	6855	0%
	Reciprocating Engine (Rich Burn)	55	30%	0.63	290	304	4%
		100	28%	0.52	568	620	8%
		1000	29%	0.64	5514	5487	0%
		1200	28%	0.63	6759	6643	-2%

Abbreviations:

CHP - combined heat and power
CO_2 - carbon dioxide
HHV - higher heating value
kW - kilowatt
LADWP - Los Angeles Department of Water and Power

PGE - Pacific Gas and Electric
SCE - Southern California Edison
SDGE - San Diego Gas and Electric
SMUD - Sacramento Municipal Utility District
USEPA - United State Environmental Protection Agency

Notes:
1. All data in this table generated using the USEPA CHP Calculator using utility-specific CO_2 intensity factors (see Table B). The following defaults and assumptions for the CHP system were used:
- electricity generating capacity based on normal range for the technology (as per Calculator default)
- operate 8,760 hours per year
- heating only (no cooling)
- natural gas fuel (116.7 CO_2/MMBtu emission rate and 1,020 Btu/scf HHV as per Calculator defaults)
- no duct burner
- assumed 8% transmission loss for displaced electricity

2. All CHP systems were compared to a baseline separate heat and power system consisting of a "new gas boiler" (assumed 80% efficiency as per Calculator default) and the local utility CO_2 intensity factor as provided in Table B.
3. A negative value indicates that the proposed CHP system is expected to generate more CO_2 emissions than the baseline separate heat and power system.

Source:
USEPA. 2009. CHP Emissions Calculator. Available online at: http://www.epa.gov/chp/basic/calculator.html. Accessed April 2010.

Table AE-4.2
Carbon Intensity of California Utilities

Utility	Total From All Generation Sources[1]		
	Electricity	CO_2 Emissions	CO_2 intensity factor
	(MWh)	(MT)	(lb/MWh)
SCE	82,776,309	24,077,133	641
LADWP	29,029,883	16,308,526	1,239
SDGE	19,108,166	6,767,326	781
PGE	79,211,982	16,377,172	456
SMUD	15,133,569	3,811,571	555
eGRID National Average (default in USEPA CHP Calculator)[2,3]			540
eGRID National Fossil Fuel Average (default in USEPA CHP Calculator)[2,4]			1,076

Abbreviations:
CHP - combined heat and power
CO_2 - carbon dioxide
eGRID - Emissions and Generation Resource Integrated Database
LADWP - Los Angeles Department of Water and Power
lb - pound
MWh - megawatt-hour
PGE - Pacific Gas and Electric
SCE - Southern California Edison
SDGE - San Diego Gas and Electric
SMUD - Sacramento Municipal Utility District
USEPA - United State Environmental Protection Agency

Notes:
1. Total electricity and CO_2 emissions reported by the utility in the California Climate Action Registry Power/Utility Protocol (PUP) Reports for reporting year 2006. PUP Reports available online at: https://www.climateregistry.org/CARROT/public/reports.aspx.
2. eGRID is a comprehensive inventory of environmental attributes of electricity generation (such as the carbon intensity of power generation), compiled from data from three federal agencies: EPA, the Energy Information Administration (EIA), and the Federal Energy Regulatory Commission (FERC). The USEPA CHP Calculator provides default 2005 eGRID carbon intensities for the U.S. and California. For more information, see: http://www.epa.gov/rdee/energy-resources/egrid/index.html.
3. eGRID National Average represents the national average carbon intensity for electricity generation from all power sources (hydropower, nuclear, renewables, and fossil fuels including oil, natural gas, and coal).
4. eGRID National Fossil Fuel Average represents the national average carbon intensity for electricity generation from fossil fuel sources only (oil, natural gas, and coal).

2.3.5 Establish Methane Recovery in Landfills

Range of Effectiveness: 73-77% reduction in GHG emissions from landfills without methane recovery

Measure Description:

One of the U.S.'s largest sources of methane emissions is from the decomposition of waste in landfills. Methane (CH_4) is a potent GHG and has a global warming potential (GWP) over 20 times that of CO_2. Capturing methane in landfills and combusting it to generate electricity for on-site energy needs reduces GHG emissions in two ways: it reduces direct methane emissions, and it displaces electricity demand and the associated indirect GHG emissions from electricity production.

Measure Applicability:

- Electricity from utility
- Note: this mitigation measure does not include energy generation from burning municipal solid waste.

Inputs:

The following information needs to be provided by the Project Applicant:

- Amount of mixed solid waste (short tons)

Baseline Method:

In landfills without landfill gas recovery systems, greenhouse gases are emitted directly to the atmosphere.

$$CO_2e_{baseline} = MSW \times LFM \times (44/12)$$

Where

$CO_2e_{baseline}$	=	Amount of CO_2e generated from landfilling mixed solid waste (MT)
MSW	=	Amount of mixed solid waste (short tons) Provided by Applicant
LFM	=	Landfill methane generated from mixed solid waste 0.580 MTCE / short ton MSW
(44/12)	=	Conversion from MTCE to MT CO_2e

Mitigation Method:

Mitigation Option 1 – Methane is captured and flared

USEPA assumes that 10% of the landfill CH4 generated is either converted by bacteria or chemically oxidized to CO_2. The remaining 90% remains as CH4 and is either captured and flared[28] or released directly to the atmosphere as fugitive CH_4 emissions. Assume a 99% combustion conversion efficiency.

$$CO_2e_{Mit1} = MSW \times LFM \times 1/(12/44 \times 21) \times [(CO_{2oxidation} + CO_{2flare}) \times 1 + (CH_{4fugitive} + CH_{4unflare}) \times 21]$$

Where

CO_2e_{Mit1}	=	Amount of CO_2e from flaring landfill methane (MT)
MSW	=	Amount of mixed solid waste (short tons) Provided by Applicant
LFM	=	MTCE[29] methane generated per short ton MSW 0.580 MTCE / short ton MSW
1/(12/44 x 21)	=	Conversion from MTCE to MT CH_4
$CO_{2oxidation}$	=	Contribution from CO_2 generated from chemical or biological oxidation. 0.10
CO_{2flare}	=	Contribution from CO_2 generated from the flaring of methane. (1-0.10) x 0.75 x 0.99 = 0.66825
1	=	Global warming potential of CO_2, used to convert from CO_2 to CO_2e
$CH_{4fugitive}$	=	Contribution from CH_4 which remains unoxidized to CO_2 and is not captured for flaring, and therefore is released directly to the atmosphere. (1-0.10) x (1-0.75) = 0.225

[28] Seek local agency guidance on whether to include CO_{2flare} emissions. USEPA and IPCC consider these emissions to be biogenic; therefore, the emissions are not included in USEPA and IPCC greenhouse gas emissions inventories.
[29] MTCE = metric MTMTMTMT carbon equivalent. The MTCE equivalent of 1 MT of a greenhouse gas is (12/44) multiplied by the greenhouse gas global warming potential.

$CH_{4unflare}$ = Contribution from CH_4 which remains unoxidized and is captured for flaring, but remains unconverted due to incomplete combustion.
(1-0.10) x 0.75 x (1-0.99) = 0.00675

21 = Global warming potential of CH_4, used to convert from CH_4 to CO_2e

Therefore:

CO_2e_{Mit1} = MSW x 0.580 x 1/(12/44 x 21) x [(0.76825 x 1) + (0.23175 x 21)]

CO_2eMit1 = MSW x 0.571

And then the percent reduction in GHG emissions from Mitigation Option 1 is:

$$\text{GHG reduction}_{Mit1} = \frac{CO_2e_{baseline} - CO_2e_{Mit1}}{CO_2e_{baseline}}$$

GHG reduction$_{Mit1}$ = 73%

As shown from this equation, the percent reduction in greenhouse gas emissions does not depend on the amount of mixed solid waste in the landfill.

Mitigation Option 2 – Methane is captured and combusted for cogeneration

If a cogeneration system is used to generate electricity from the combusted methane, the following equation is used to calculate the amount of electricity generated:

Electricity = MSW x LFM x 1/(12/44 x 21) x Combust x Density x 10^6 x HHV x ECF x EFF x

Where

Electricity = Amount of electricity generated from combustion of methane (kWh)

LFM = MTCE methane generated per short ton MSW
0.580 MTCE / short ton MSW

1/(12/44 x 21) = Conversion from MTCE to MT CH_4

Combust = Fraction of CH_4 captured and combusted for cogeneration

(1-0.10) x 0.75 = 0.675; assumes 10% of methane is oxidized prior to capture and 75% capture efficiency

Density = Density of CH_4
0.05 ft^3 CH_4 / gram CH_4

10^6 = Conversion from grams to MT

HHV = Heating value of CH4
1,012 BTU / ft^3 CH_4

ECF = Energy conversion factor
0.00009 kWh/BTU

EFF = Efficiency Factor
0.85; USEPA assumes a 15% system efficiency loss to account for system down-time

Therefore:

Electricity = MSW x 265

Since this amount of electricity is generated on-site and no longer needs to be supplied by the local electricity utility, the indirect CO_2e emissions associated with that utility electricity generation are also avoided:

$$CO_2e_{displaced} = \text{Electricity} \times \text{Utility}$$

Where

Utility = Carbon intensity of Local Utility (MT CO_2e/kWh) from table below

Power Utility	Carbon-Intensity (lbs CO_2e/MWh)
LADW&P	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

Therefore:

$$\mathbf{CO_2e_{Mit2} = CO_2e_{Mit1} - CO_2e_{displaced}}$$

And then the percent reduction in GHG emissions from Mitigation 2 is:

$$\text{GHG reduction}_{Mit2} = \frac{CO_2e_{baseline} - (CO_2e_{Mit1} - CO_2e_{displaced})}{CO_2e_{baseline}}$$

$$\textbf{GHG reductionMit2} = \frac{1.556 + (265 \times \text{Utility})}{2.127}$$

As shown from these equations, the percent reduction in GHG emissions does not depend on the amount of mixed solid waste in the landfill.

Note that further reductions could be achieved if the heat generated from combustion and cogeneration were recovered and used to displace thermal energy that otherwise would have been generated from a separate heat system, such as a boiler. The magnitude of reductions depends on the system being displaced, including the boiler efficiency and the heating value of the fuel as compared to the heating value of methane. To take credit for this additional reduction, the Project Applicant would need to quantify displaced GHG emissions using the baseline document and the Mitigation Measure BE-5, Install Energy Efficient Boilers.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	73-77%
All other pollutants	Not Quantified[30]

Discussion:

In Southern California Edison's service area, a landfill which captures and flares methane achieves a 73% reduction in GHG emissions compared to a landfill without a methane recovery system. A landfill which captures and combusts methane for cogeneration achieves a 77% reduction in GHG emissions compared to a landfill without a methane recovery system:

$$\text{GHG reduction Mit2} = \frac{1.556 + (265 \times 2.909 \times 10^{-4})}{2.127} = 77\%$$

Assumptions:

[30] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

Data based upon the following reference:

- USEPA. 2006. Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Ed. Available online at: http://www.epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf

Preferred Literature:

Section 6 of USEPA's Solid Waste Management and Greenhouse Gases report presents methodology for calculating greenhouse gas emissions associated with three different landfill management systems: landfills which do not capture landfill gas, landfills which recover methane and flare it, and landfills which recover methane and combust it for cogeneration. Column (b) of Exhibit 6-6 shows methane generation factors for various types of landfill waste in MTCE per short ton of waste. For this analysis, the value for mixed solid waste is used. Section 6.2 provides USEPA defaults for percent of methane chemically or biologically oxidized to CO_2 (10%) and the efficiency of methane capture systems (75%). Exhibit 6-7 provides USEPA defaults used for calculating the amount of electricity generated from methane combustion and cogeneration.

Alternative Literature:

None

Other Literature Reviewed:

- CAR. 2009. Landfill Project Protocol: Collecting and Destroying Methane from Landfills. Version 3.0. Available online at: http://www.climateactionreserve.org/how/protocols/adopted/landfill/current-landfill-project-protocol/
- CalRecycle (CIWMB). Climate Change and Solid Waste Management: Draft Final Report and Draft GHG Calculator Tool. Available online at: http://www.calrecycle.ca.gov/Climate/Organics/LifeCycle/default.htm. Accessed February 2010.
- CARB. 2008. Local Government Operations Protocol. Version 1.0. Available online at: http://www.arb.ca.gov/cc/protocols/localgov/pubs/final_lgo_protocol_2008-09-25.pdf
- American Carbon Registry. Standards. Available online at: http://www.americancarbonregistry.org/carbon-accounting/standards/?searchterm=landfill. Accessed February 2010.

2.3.6 Establish Methane Recovery in Wastewater Treatment Plants

Range of Effectiveness: 95-97% reduction in GHG emissions from wastewater treatment plants without recovery.

Measure Description:

Methane (CH_4) is a potent GHG and has a global warming potential (GWP) over 20 times that of CO_2. Capturing methane from wastewater treatment (WWT) plants and combusting it to generate electricity for on-site energy needs reduces GHG emissions in two ways: it reduces direct methane emissions, and it displaces electricity demand and the associated indirect GHG emissions from electricity production.

Measure Applicability:

- Electricity from utility

Inputs:

The following information needs to be provided by the Project Applicant:

- Liters of wastewater

Baseline Method:

Centralized wastewater treatment facilities may use anaerobic or facultative lagoons or anaerobic digesters to treat wastewater. The methane emissions expected from anaerobic or facultative lagoons is calculated using the following equation from the California Air Resources Board (CARB)'s Local Government Reporting Protocol:

$$CO_2e_{baseline} = \text{Wastewater} \times BOD_5 \text{ load} \times 10^{-6} \times Bo \times MCF_{anaerobic} \times 10^{-3} \times 21$$

Where

$CO_2e_{baseline}$	=	Amount of CO_2e generated from wastewater treatment (MT)
Wastewater	=	Volume of wastewater (liters) Provided by Applicant
BOD_5 load	=	Concentration of BOD_5 in wastewater 200 mg / liter wastewater
10^{-6}	=	Conversion from mg to kg
Bo	=	Maximum CH_4-producing capacity for domestic wastewater 0.6 kg CH_4 / kg BOD_5 removed
$MCF_{anaerobic}$	=	CH_4 correction factor for anaerobic systems 0.8
10^{-3}	=	Conversion from kg to MT

21 = Global warming potential of CH_4, used to convert from CH_4 to CO_2e

Therefore:

$$\mathbf{CO_2e_{baseline} = Wastewater \times 2.02 \times 10^{-6}}$$

Mitigation Method:

Mitigation Option 1 – Methane is captured and flared

Anaerobic digesters produce methane-rich biogas which can be combusted and converted to CO_2.[31] Inherent inefficiencies in the system results in incomplete combustion of the biogas, which results in remaining methane emissions:

$$CO_2e_{Mit1} = \text{Wastewater} \times 0.2642 \times \text{Digester Gas} \times FCH_4 \times (CH_4\text{unflare} + CO_2\text{flare})$$

Where

CO_2e_{Mit1}	=	Amount of CO_2e generated from flaring methane from wastewater treatment plant (MT)
Wastewater	=	Volume of wastewater (liters) Provided by Applicant
0.2642	=	Conversion from liters to gallons
Digester Gas	=	Volume of biogas generated per volume of wastewater treated ft^3 biogas / gallon wastewater 0.01
F_{CH4}	=	Fraction of CH_4 in biogas 0.65
$CH_{4unflare}$	=	Contribution from CH_4 which is captured for flaring, but remains unconverted due to incomplete combustion $CH_{4unflare} = \rho_{CH4} \times (1\text{-}DE) \times 0.0283 \times 10^{-6} \times 21 = 3.93 \times 10^{-6}$
ρ_{CH4}	=	Density of CH4 at standard conditions 662 g/m^3
DE	=	CH_4 destruction efficiency 0.99
0.0283	=	Conversion factor from ft^3 to m^3
10^{-6}	=	Conversion factor from g to MT
21	=	Global warming potential of CH_4, used to convert from CH_4 to CO_2e
CO_2flare	=	Contribution from CO_2 generated from the flaring of methane
CO_2flare	=	EF / 2204.623 x 1= 5.44×10^{-5}
EF	=	Emission factor for methane combustion

[31] Seek local agency guidance on whether to include CO_2 combustion emissions. USEPA and IPCC consider these emissions to be biogenic; therefore, the emissions are not included in USEPA and IPCC greenhouse gas emissions inventories.

		0.120 lb CO_2/ft^3 CH_4
2204.623	=	Conversion factor from lb to MT
1	=	Global warming potential of CO_2, used to convert from CO_2 to CO_2e

Therefore:

$$\mathbf{CO_2e_{Mit1} = Wastewater \times 1.00 \times 10^{-7}}$$

And then the percent reduction in GHG emissions from Mitigation Option 1 is:

$$\text{GHG reduction}_{Mit1} = \frac{CO_2e_{baseline} - CO_2e_{Mit1}}{CO_2e_{baseline}}$$

GHG reduction$_{Mit1}$ = 95%

As shown from this equation, the percent reduction in greenhouse gas emissions does not depend on the amount of wastewater being treated.

Mitigation Option 2 – Methane is captured and combusted for cogeneration

If a cogeneration system is used to generate electricity from the combusted biogas, the following equation is used to calculate the amount of electricity generated:

$$\text{Electricity} = \text{Wastewater} \times 0.2642 \times \text{Digester Gas} \times F_{CH4} \times HHV_{CH4} \times ECF \times EFF$$

Where:

Electricity	=	Amount of electricity generated from combustion of methane (kWh)
Wastewater	=	Volume of wastewater (liters) Provided by Applicant
0.2642	=	Conversion from liters to gallons
Digester Gas	=	Volume of biogas generated per volume of wastewater treated 0.01 ft^3 biogas / gallon wastewater
F_{CH4}	=	Fraction of CH_4 in biogas 0.65
HHV	=	Heating value of methane 1,012 BTU / ft^3 CH_4
ECF	=	Energy conversion factor 0.00009 kWh/BTU
EFF	=	Efficiency Factor 0.85; USEPA assumes a 15% system efficiency loss to account for system down-time

Therefore:

$$\text{Electricity} = \text{Wastewater} \times 1.33 \times 10^{-4}$$

Since this amount of electricity is generated on-site and no longer needs to be supplied by the local electricity utility, the indirect CO_2e emissions associated with that utility electricity generation are also avoided:

$$CO_2e_{displaced} = \text{Electricity} \times \text{Utility}$$

Where

Utility = Carbon intensity of Local Utility (MT CO_2e/kWh) from table below

Power Utility	Carbon-Intensity (lbs CO_2e/MWh)
LADW&P	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

Therefore:

$$\mathbf{CO_2e_{Mit2} = CO_2e_{Mit1} - CO_2e_{displaced}}$$

And then the percent reduction in GHG emissions from Mitigation 2 is:

$$\text{GHG reduction}_{Mit2} = \frac{CO2e_{baseline} - (CO2e_{Mit1} - CO2e_{displaced})}{CO2e_{baseline}}$$

$$\textbf{GHG reductionMit2} = \frac{1.92 \times 10^{-6} + (1.33 \times 10^{-4} \times \text{Utility})}{2.02 \times 10^{-6}}$$

As shown from these equations, the percent reduction in GHG emissions does not depend on the amount of wastewater being treated.

Note that further reductions could be achieved if the heat generated from combustion and cogeneration were recovered and used to displace thermal energy that otherwise would have been generated from a separate heat system, such as a boiler. The magnitude of reductions depends on the system being displaced, including the boiler efficiency and the heating value of the fuel as compared to the heating value of methane. To take credit for this additional reduction, the Project Applicant would need to quantify displaced GHG emissions using the baseline document and the Mitigation Measure BE-5, Install Energy Efficient Boilers.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	95-97%
All other pollutants	Not Quantified[32]

Discussion:

In Southern California Edison's service area, a WWT plant which captures and flares methane achieves a 95% reduction in GHG emissions compared to a WWT plant without a methane recovery system. A WWT plant which captures and combusts methane for cogeneration achieves a 97% reduction in GHG emissions compared to a landfill without a methane recovery system:

$$\text{GHG reduction Mit2} = \frac{1.92\times10^{-6} + \left(1.33\times10^{-4}\times 2.909\times10^{-4}\right)}{2.02\times10^{-6}} = 97\%$$

Assumptions:

Data based upon the following references:

- CARB. 2008. Local Government Operations Protocol. Chapter 10: Wastewater Treatment Facilities. Available online at: http://www.arb.ca.gov/cc/protocols/localgov/pubs/final_lgo_protocol_2008-09-25.pdf
- USEPA. 2008. Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2006. Chapter 8: Waste. Available online at: http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf
- USEPA. 2006. Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 3rd Ed. Available online at: http://www.epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf

Preferred Literature: Chapter 10 of CARB's Local Government Operations Protocol (LGOP) provides the methodology for calculating methane emissions from wastewater treatment. Centralized wastewater treatment facilities may use anaerobic or facultative lagoons or anaerobic digesters to treat wastewater. Equation 10.3 of the LGOP calculates methane emissions from anaerobic or facultative lagoons. Equation 10.1 of the LGOP calculates the methane emissions remaining due to incomplete combustion of anaerobic digester gas. Default values for the amount of digester gas produced per volume of wastewater and the fraction of methane in digester gas are taken from the 2008 USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks. Exhibit 6-7 of

[32] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

USEPA's Solid Waste Management and Greenhouse Gases report provides the methodology for calculating the amount of electricity generated from methane combustion and cogeneration.

Alternative Literature:

None

Other Literature Reviewed:

None

3.0 Transportation

3.1 Land Use/Location

3.1.1 Increase Density

Range of Effectiveness: 0.8 – 30.0% vehicle miles traveled (VMT) reduction and therefore a 0.8 – 30.0% reduction in GHG emissions.

Measure Description:

Designing the Project with increased densities, where allowed by the General Plan and/or Zoning Ordinance reduces GHG emissions associated with traffic in several ways. Density is usually measured in terms of persons, jobs, or dwellings per unit area. Increased densities affect the distance people travel and provide greater options for the mode of travel they choose. This strategy also provides a foundation for implementation of many other strategies which would benefit from increased densities. For example, transit ridership increases with density, which justifies enhanced transit service.

The reductions in GHG emissions are quantified based on reductions to VMT. The relationship between density and VMT is described by its elasticity. According to a recent study published by Brownstone, et al. in 2009, the elasticity between density and VMT is 0.12. Default densities are based on the typical suburban densities in North America which reflects the characteristics of the ITE Trip Generation Manual data used in the baseline estimates.

Measure Applicability:

- Urban and suburban context
    - Negligible impact in a rural context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Number of housing units per acre or jobs per job acre

Mitigation Method:

% VMT Reduction = A * B [not to exceed 30%]

Where:

A = Percentage increase in housing units per acre or jobs per job acre[33] = (number of housing units per acre or jobs per job acre – number of housing units per acre or jobs per job acre for typical ITE development) / (number of housing units per acre or jobs per job acre for typical ITE development) For small and medium sites (less than ½ mile in radius) the calculation of housing and jobs per acre should be performed for the development site as a whole, so that the analysis does not erroneously attribute trip reduction benefits to measures that simply shift jobs and housing within the site with no overall increase in site density. For larger sites, the analysis should address the development as several ½-mile-radius sites, so that shifts from one area to another would increase the density of the receiving area but reduce the density of the donating area, resulting in trip generation rate decreases and increases, respectively, which cancel one another.

B = Elasticity of VMT with respect to density (from literature)

Detail:

- A: [not to exceed 500% increase]
    - If housing: (Number of housing units per acre – 7.6) / 7.6 (See Appendix C for detail)
    - If jobs: (Number of jobs per acre – 20) / 20 (See Appendix C for detail)
- B: 0.07 (Boarnet and Handy 2010)

Assumptions:

Data based upon the following references:

- Boarnet, Marlon and Handy, Susan. 2010. "DRAFT Policy Brief on the Impacts of Residential Density Based on a Review of the Empirical Literature." http://arb.ca.gov/cc/sb375/policies/policies.htm; Table 1.

[33] This value should be checked first to see if it exceeds 500% in which case A = 500%.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[34]
CO_2e	1.5-30% of running
PM	1.5-30% of running
CO	1.5-30% of running
NOx	1.5-30% of running
SO_2	1.5-30% of running
ROG	0.9-18% of total

Discussion:

The VMT reductions for this strategy are based on changes in density versus the typical suburban residential and employment densities in North America (referred to as "ITE densities"). These densities are used as a baseline to mirror those densities reflected in the ITE Trip Generation Manual, which is the baseline method for determining VMT.

There are two separate maxima noted in the fact sheet: a cap of 500% on the allowable percentage increase of housing units or jobs per acre (variable A) and a cap of 30% on % VMT reduction. The rationale for the 500% cap is that there are diminishing returns to any change in environment. For example, it is reasonably doubtful that increasing residential density by a factor of six instead of five would produce any additional change in travel behavior. The purpose for the 30% cap is to limit the influence of any single environmental factor (such as density). This emphasizes that community designs that implement multiple land use strategies (such as density, design, diversity, etc.) will show more of a reduction than relying on improvements from a single land use factor.

Example:

Sample calculations are provided below for housing:

Low Range % VMT Reduction (8.5 housing units per acre)

$$= (8.5 - 7.6) / 7.6 * 0.07 = 0.8\%$$

High Range % VMT Reduction (60 housing units per acre)

$$= \frac{60 - 7.6}{7.6} = 6.9 \text{ or } 690\% \quad \text{Since greater than 500\%, set to 500\%}$$

$$= 500\% \times 0.07 = 0.35 \text{ or } 35\% \quad \text{Since greater than 30\%, set to 30\%}$$

[34] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Sample calculations are provided below for jobs:

Low Range % VMT Reduction (25 jobs per acre)
= (25 – 20) / 20 *0.12 = 3%

High Range % VMT Reduction (100 jobs per acre)

$$= \frac{100 - 20}{20} = 4 \text{ or } 400\%$$

=400% x 0.12 = 0.48 or 48% Since greater than 30%, set to 30%

Preferred Literature:

- -0.07 = elasticity of VMT with respect to density

Boarnet and Handy's detailed review of existing literature highlighted three individual studies that used the best available methods for analyzing data for individual households. These studies provided the following elasticities: -0.12 - Brownstone (2009), -0.07 – Bento (2005), and -0.08 – Fang (2008). To maintain a conservative estimate of the impacts of this strategy, the lower elasticity of -0.07 is used in the calculations.

Alternative Literature:

- -0.05 to -0.25 = elasticity of VMT with respect to density

The *TRB Special Report 298* literature suggests that doubling neighborhood density across a metropolitan area might lower household VMT by about 5 to 12 percent, and perhaps by as much as 25 percent, if coupled with higher employment concentrations, significant public transit improvements, mixed uses, and other supportive demand management measures.

Alternative Literature References:

TRB, 2009. *Driving and the Built Environment*, Transportation Research Board Special Report 298. http://onlinepubs.trb.org/Onlinepubs/sr/sr298.pdf . Accessed March 2010. (p. 4)

Other Literature Reviewed:

None

3.1.2 Increase Location Efficiency

Range of Effectiveness: 10-65% vehicle miles traveled (VMT) reduction and therefore 10-65% reduction in GHG emissions

Measure Description:

This measure is not intended as a separate strategy but rather a documentation of empirical data to justify the "cap" for all land use/location strategies. The location of the Project relative to the type of urban landscape such as being located in an urban area, infill, or suburban center influences the amount of VMT compared to the statewide average. This is referred to as the location of efficiency since there are synergistic benefits to these urban landscapes.

To receive the maximum reduction for this location efficiency, the project will be located in an urban area/ downtown central business district. Projects located on brownfield sites/infill areas receive a lower, but still significant VMT reduction. Finally, projects in suburban centers also receive a reduction for their efficient location. Reductions are based on the typical VMT of a specific geographic area relative to the average VMT statewide.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled
$EF_{running}$ = emission factor for running emissions

Inputs:

- No inputs are needed. VMT reduction ranges are based on the geographic location of the project within the region.

Mitigation Method:

% VMT reduction =

- Urban: 65% (representing VMT reductions for the average urban area in California versus the statewide average VMT)
- Compact Infill: 30% (representing VMT reductions for the average compact infill area in California versus the statewide average VMT)
- Suburban Center: 10% (representing VMT reductions for the average suburban center in California versus the statewide average VMT)

Assumptions:

Data based upon the following references:

- Holtzclaw, et al. 2002. "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles, and Chicago." *Transportation Planning and Technology*, Vol. 25, pp. 1–27.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[35]
CO_2e	10-65% of running
PM	10-65% of running
CO	10-65% of running
NOx	10-65% of running
SO_2	10-65% of running
ROG	6-39% of total

Discussion:

Example:

N/A – no calculations needed

Alternative Literature:

- 13-72% reduction in VMT for infill projects

Preferred Literature:

Holtzclaw, et al., [1] studied relationships between auto ownership and mileage per car and neighborhood urban design and socio-economic characteristics in the Chicago, Los

[35] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Angeles, and San Francisco metro areas. In all three regions, average annual vehicle miles traveled is a function of density, income, household size, and public transit, as well as pedestrian and bicycle orientation (to a lesser extent). The annual VMT for each neighborhood was reviewed to determine empirical VMT reduction "caps" for this report. These location-based caps represent the average and maximum reductions that would likely be expected in urban, infill, suburban center, and suburban locations.

Growing Cooler looked at 10 studies which have considered the effects of regional location on travel and emissions generated by individual developments. The studies differ in methodology and context but they tend to yield the same conclusion: infill locations generate substantially lower VMT per capita than do greenfield locations, ranging from 13 - 72% lower VMT.

Literature References:

[1] Holtzclaw, et al. 2002. "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles, and Chicago." *Transportation Planning and Technology*, Vol. 25, pp. 1–27.

[2] Ewing, et al, 2008. Growing Cooler – The Evidence on Urban Development and Climate Change. Urban Land Institute. (p.88, Figure 4-30)

Other Literature Reviewed:

None

3.1.3 Increase Diversity of Urban and Suburban Developments (Mixed Use)

Range of Effectiveness: 9-30% vehicle miles traveled (VMT) reduction and therefore 9-30% reduction in GHG emissions.

Measure Description:

Having different types of land uses near one another can decrease VMT since trips between land use types are shorter and may be accommodated by non-auto modes of transport. For example when residential areas are in the same neighborhood as retail and office buildings, a resident does not need to travel outside of the neighborhood to meet his/her trip needs. A description of diverse uses for urban and suburban areas is provided below.

Urban:

The urban project will be predominantly characterized by properties on which various uses, such as office, commercial, institutional, and residential, are combined in a single building or on a single site in an integrated development project with functional interrelationships and a coherent physical design. The mixed-use development should encourage walking and other non-auto modes of transport from residential to office/commercial/institutional locations (and vice versa). The residential units should be within ¼-mile of parks, schools, or other civic uses. The project should minimize the need for external trips by including services/facilities for day care, banking/ATM, restaurants, vehicle refueling, and shopping.

Suburban:

The suburban project will have at least three of the following on site and/or offsite within ¼-mile: Residential Development, Retail Development, Park, Open Space, or Office. The mixed-use development should encourage walking and other non-auto modes of transport from residential to office/commercial locations (and vice versa). The project should minimize the need for external trips by including services/facilities for day care, banking/ATM, restaurants, vehicle refueling, and shopping.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context (unless the project is a master-planned community)
- Appropriate for mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of each land use type in the project (to calculate land use index)

Mitigation Method:

% VMT Reduction = Land Use * B [not to exceed 30%]

Where

Land Use = Percentage increase in land use index versus single use development

= (land use index – 0.15)/0.15 (see Appendix C for detail)

Land use index = -a / ln(6) (from [2])

$$a = \sum_{i=1}^{6} a_i \times \ln(a_i)$$

a_i = building floor area of land use i / total square feet of area considered

- a_1 = single family residential
- a_2 = multifamily residential
- a_3 = commercial
- a_4 = industrial
- a_5 = institutional
- a_6 = park

if land use is not present and a_i is equal to 0, set a_i equal to 0.01

B = elasticity of VMT with respect to land use index (0.09 from [1]) not to exceed 500% increase

Assumptions:

Data based upon the following references:

[1] Ewing, R., and Cervero, R., "Travel and the Built Environment - A Meta-Analysis." *Journal of the American Planning Association*, <to be published> (2010). Table 4.

[2] Song, Y., and Knaap, G., “Measuring the effects of mixed land uses on housing values.” *Regional Science and Urban Economics 34 (2004) 663-680.* (p. 669) http://urban.csuohio.edu/~sugie/papers/RSUE/RSUE2005_Measuring%20the%20effects%20of%20mixed%20land%20use.pdf

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[36]
CO_2e	9-30% of running
PM	9-30% of running
CO	9-30% of running
NOx	9-30% of running
SO_2	9-30% of running
ROG	5.4-18% of total

Discussion:

In the above calculation, a land use index of 0.15 is used as a baseline representing a development with a single land use (see Appendix C for calculations).

There are two separate maxima noted in the fact sheet: a cap of 500% on the allowable percentage increase of land use index (variable A) and a cap of 30% on % VMT reduction. The rationale for the 500% cap is that there are diminishing returns to any change in environment. For example, it is reasonably doubtful that increasing the land use index by a factor of six instead of five would produce any additional change in travel behavior. The purpose for the 30% cap is to limit the influence of any single environmental factor (such as diversity). This emphasizes that community designs that implement multiple land use strategies (such as density, design, diversity, etc.) will show more of a reduction than relying on improvements from a single land use factor.

[36] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Example:

Sample calculations are provided below:

90% single family homes, 10% commercial

- Land use index = -[0.9*ln(0.9)+ 0.1*ln(0.1)+ 4*0.01*ln(0.01)] / ln(6) = 0.3
- Low Range % VMT Reduction = (0.3 – 0.15)/0.15 *0.09 = 9%

1/6 single family, 1/6 multi-family, 1/6 commercial, 1/6 industrial, 1/6 institutional, 1/6 parks

- Land use index = -[6*0.17*ln(0.17)] / ln(6) = 1
- High Range % VMT Reduction (land use index = 1)
- Land use = (1-0.15)/0.15 = 5.6 or 566%. Since this is greater than 500%, set to 500%.
- % VMT Reduction = (5 x 0.09) = 0.45 or 45%. Since this is greater than 30%, set to 30%.

Preferred Literature:

- -0.09 = elasticity of VMT with respect to land use index

The land use (or entropy) index measurement looks at the mix of land uses of a development. An index of 0 indicates a single land use while 1 indicates a full mix of uses. Ewing's [1] synthesis looked at a total of 10 studies, where none controlled for self-selection[37]. The weighted average elasticity of VMT with respect to the land use mix index is -0.09. The methodology for calculating the land use index is described in Song and Knaap [2].

Alternative Literature:

- Vehicle trip reduction = [1 - (ABS(1.5*h-e) / (1.5*h+e)) - 0.25] / 0.25*0.03

Where :
h = study area housing units, and
e = study area employment.

Nelson\Nygaard's report [3] describes a calculation adapted from Criterion and Fehr & Peers [4]. The formula assumes an "ideal" housing balance of 1.5 jobs per household and a baseline diversity of 0.25. The maximum trip reduction with this method is 9%.

[37] Self selection occurs when residents or employers that favor travel by non-auto modes choose locations where this type of travel is possible. They are therefore more inclined to take advantage of the available options than a typical resident or employee might otherwise be.

Alternative Literature References:

[3] Nelson\Nygaard, 2005. Crediting Low-Traffic Developments (p.12). http://www.montgomeryplanning.org/transportation/documents/TripGenerationAnalysisUsingURBEMIS.pdf

[4] Criteron Planner/Engineers and Fehr & Peers Associates (2001). Index 4D Method. *A Quick-Response Method of Estimating Travel Impacts from Land-Use Changes*. Technical Memorandum prepared for US EPA, October 2001.

Other Literature Reviewed:

None

3.1.4 Increase Destination Accessibility

Range of Effectiveness: 6.7 – 20% vehicle miles traveled (VMT) reduction and therefore 6.7-20% reduction in GHG emissions.

Measure Description:

The project will be located in an area with high accessibility to destinations. Destination accessibility is measured in terms of the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones. The location of the project also increases the potential for pedestrians to walk and bike to these destinations and therefore reduces the VMT.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Distance to downtown or major job center

Mitigation Method:

% VMT Reduction = Center Distance * B [not to exceed 30%]

Where

Center Distance = Percentage decrease in distance to downtown or major job center versus typical ITE suburban development = (distance to downtown/job center for typical ITE development – distance to downtown/job center for project) / (distance to downtown/job center for typical ITE development)

Center Distance = 12 - Distance to downtown/job center for project) / 12
See Appendix C for detail

B = Elasticity of VMT with respect to distance to downtown or major job center (0.20 from [1])

Assumptions:

Data based upon the following references:

[1] Ewing, R., and Cervero, R., "Travel and the Built Environment - A Meta-Analysis." Journal of the American Planning Association, <to be published> (2010). Table 4.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[38]
CO_2e	6.7 – 20% of running
PM	6.7 – 20% of running
CO	6.7 – 20% of running
NOx	6.7 – 20% of running
SO_2	6.7 – 20% of running
ROG	4 – 12% of total

Discussion:

The VMT reductions for this strategy are based on changes in distance to key destinations versus the standard suburban distance in North America. This distance is used as a baseline to mirror the distance to destinations reflected in the land uses for the ITE Trip Generation Manual, which is the baseline method for determining VMT.

The purpose for the 30% cap on % VMT reduction is to limit the influence of any single environmental factor (such as destination accessibility). This emphasizes that community designs that implement multiple land use strategies (such as density,

[38] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

design, diversity, destination, etc.) will show more of a reduction than relying on improvements from a single land use factor.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (8 miles to downtown/job center) =
  $\frac{12-8}{12} \times 0.20 = 6.7\%$
- High Range % VMT Reduction (0.1 miles to downtown/job center) =
  $\frac{12-0.1}{12} \times 0.20 = 20.0\%$

Preferred Literature:

- -0.20 = elasticity of VMT with respect to job accessibility by auto
- -0.20 = elasticity of VMT with respect to distance to downtown

The Ewing and Cervero report [1] finds that VMT is strongly related to measures of accessibility to destinations. The weighted average elasticity of VMT with respect to job accessibility by auto is -0.20 (looking at five total studies). The weighted average elasticity of VMT with respect to distance to downtown is -0.22 (looking at four total studies, of which one controls for self selection[39]).

Alternative Literature:

- 10-30% reduction in vehicle trips

The VTPI literature [2] suggests a 10-30% reduction in vehicle trips for “smart growth” development practices that result in more compact, accessible, multi-modal communities where travel distances are shorter, people have more travel options, and it is possible to walk and bicycle more.

Alternative Literature References:

[2] Litman, T., 2009. “Win-Win Emission Reduction Strategies.” Victoria Transport Policy Institute (VTPI). Website: http://www.vtpi.org/wwclimate.pdf. Accessed March 2010. (p. 7, Table 3)

[39] Self selection occurs when residents or employers that favor travel by non-auto modes choose locations where this type of travel is possible. They are therefore more inclined to take advantage of the available options than a typical resident or employee might otherwise be.

Other Literature Reviewed:

None

3.1.5 Increase Transit Accessibility

Range of Effectiveness: 0.5 – 24.6% VMT reduction and therefore 0.5-24.6% reduction in GHG emissions.[40]

Measure Description:

Locating a project with high density near transit will facilitate the use of transit by people traveling to or from the Project site. The use of transit results in a mode shift and therefore reduced VMT. A project with a residential/commercial center designed around a rail or bus station, is called a transit-oriented development (TOD). The project description should include, at a minimum, the following design features:

- A transit station/stop with high-quality, high-frequency bus service located within a 5-10 minute walk (or roughly ¼ mile from stop to edge of development), and/or
    - A rail station located within a 20 minute walk (or roughly ½ mile from station to edge of development)
- Fast, frequent, and reliable transit service connecting to a high percentage of regional destinations
- Neighborhood designed for walking and cycling

In addition to the features listed above, the following strategies may also be implemented to provide an added benefit beyond what is documented in the literature:

- Mixed use development [LUT-3]
- Traffic calmed streets with good connectivity [SDT-2]
- Parking management strategies such as unbundled parking, maximum parking requirements, market pricing implemented to reduce amount of land dedicated to vehicle parking [see PPT-1 through PPT-7]

Measure Applicability:

- Urban and suburban context
- Appropriate in a rural context if development site is adjacent to a commuter rail station with convenient rail service to a major employment center
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Baseline Method:

---

[40] Transit vehicles may also result in increases in emissions that are associated with electricity production or fuel use. The Project Applicant should consider these potential additional emissions when estimating mitigation for these measures.

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:
The following information needs to be provided by the Project Applicant:

- Distance to transit station in project

Mitigation Method:

% VMT = Transit * B [not to exceed 30%]

Where

Transit = Increase in transit mode share = % transit mode share for project - % transit mode share for typical ITE development (1.3% as described in Appendix C)
% transit mode share for project (see Table)

Distance to transit	Transit mode share calculation equation (where x = distance of project to transit)
0 – 0.5 miles	-50*x + 38
0.5 to 3 miles	-4.4*x + 15.2
> 3 miles	no impact
Source: Lund et al, 2004; Fehr & Peers 2010 (see Appendix C for calculation detail)	

B = adjustments from transit ridership increase to VMT (0.67, see Appendix C for detail)

Assumptions:
Data based upon the following references:

[1] Lund, H. and R. Cervero, and R. Willson (2004). *Travel Characteristics of Transit-Oriented Development in California*. (p. 79, Table 5-25)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[41]
CO_2e	0.5 – 24.6% of running
PM	0.5 – 24.6% of running
CO	0.5 – 24.6% of running
NOx	0.5 – 24.6% of running
SO_2	0.5 – 24.6% of running
ROG	0.3 – 14.8% of total

Discussion:

The purpose for the 30% cap on % VMT reduction is to limit the influence of any single environmental factor (such as transit accessibility). This emphasizes that community designs that implement multiple land use strategies (such as density, design, diversity, transit accessibility, etc.) will show more of a reduction than relying on improvements from a single land use factor.

Example:

Sample calculations are provided below for a rail station:

- Low Range % VMT Reduction (3 miles from station) = [(-4.4*3+15.2) – 1.3%] * 0.67 = 0.5%
- High Range % VMT Reduction (0 miles from station) = [(-50*0+38) – 1.3%] * 0.67 = 24.6%

Preferred Literature:

- 13 to 38% transit mode share (residents in TODs with ½ mile of rail station)
- 5 to 13% transit mode share (residents in TODs from ½ mile to 3 miles of rail station)

The *Travel Characteristics* report [1] surveyed TODs and surrounding areas in San Diego, Los Angeles, San Jose, Sacramento, and Bay Area regions. Survey sites are all located in non-central business district locations, are within walking distance of a transit station with rail service headways of 15 minutes or less, and were intentionally developed as TODs.

[41] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Alternative Literature:

Alternate:

- -0.05 = elasticity of VMT with respect to distance to nearest transit stop

Ewing and Cervero's meta-analysis [2] provides this weighted average elasticity based on six total studies, of which one controls for self-selection. The report does not provide the range of distances where this elasticity is valid.

Alternate:

- 5.9 – 13.3% reduction in VMT

The Bailey, et al. 2008 report [3] predicted a reduction of household daily VMT of 5.8 miles for a location next to a rail station and 2.6 miles for a location next to a bus station. Using the report's estimate of 43.75 daily average miles driven, the estimated reduction in VMT for rail accessibility is 13.3% (5.8/43.75) and for bus accessibility is 5.9% (2.6/43.75).

Alternate:

- 15% reduction in vehicle trips
- 2 to 5 times higher transit mode share

TCRP Report 128 [4] concludes that transit-oriented developments, compared to typical developments represented by the *ITE Trip Generation Manual*, have 47% lower vehicle trip rates and have 2 to 5 times higher transit mode share. *TCRP Report 128* notes that the *ITE Trip Generation Manual* shows 6.67 daily trips per unit while detailed counts of 17 residential TODs resulted in 3.55 trips per unit (a 47% reduction in vehicle trips). This study looks at mid-rise and high-rise apartments at the residential TOD sites. A more conservative comparison would be to look at the *ITE Trip Generation Manual* rates for high-rise apartments, 4.2 trips per unit. This results in a 15% reduction in vehicle trips.

Alternative Literature References:

[2] Ewing, R., and Cervero, R., "Travel and the Built Environment - A Meta-Analysis." *Journal of the American Planning Association*, <to be published> (2010). Table 4.

[3] Bailey, L., Mokhtarian, P.L., & Little, A. (2008). "The Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction." ICF International. (Table 4 and 5)

[4] TCRP, 2008. *TCRP Report 128 - Effects of TOD on Housing, Parking, and Travel.* http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_128.pdf (p. 11, 69).

Other Literature Reviewed:

None

3.1.6 Integrate Affordable and Below Market Rate Housing

Range of Effectiveness: 0.04 – 1.20% vehicle miles traveled (VMT) reduction and therefore 0.04-1.20% reduction in GHG emissions.

Measure Description:

Income has a statistically significant effect on the probability that a commuter will take transit or walk to work [4]. BMR housing provides greater opportunity for lower income families to live closer to jobs centers and achieve jobs/housing match near transit. It also addresses to some degree the risk that new transit oriented development would displace lower income families. This strategy potentially encourages building a greater percentage of smaller units that allow a greater number of families to be accommodated on infill and transit-oriented development sites within a given building footprint and height limit. Lower income families tend to have lower levels of auto ownership, allowing buildings to be designed with less parking which, in some cases, represents the difference between a project being economically viable or not.

Residential development projects of five or more dwelling units will provide a deed-restricted low-income housing component on-site.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context unless transit availability and proximity to jobs/services are existing characteristics
- Appropriate for residential and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of units in project that are deed-restricted BMR housing

Mitigation Method:

% VMT Reduction = 4% * Percentage of units in project that are deed-restricted BMR housing [1]

Assumptions:

Data based upon the following references:

[1] Nelson\Nygaard, 2005. Crediting Low-Traffic Developments (p.15). http://www.montgomeryplanning.org/transportation/documents/TripGenerationAnalysisUsingURBEMIS.pdf

Criteron Planner/Engineers and Fehr & Peers Associates (2001). Index 4D Method. *A Quick-Response Method of Estimating Travel Impacts from Land-Use Changes*. Technical Memorandum prepared for US EPA, October 2001.

Holtzclaw, John; Clear, Robert; Dittmar, Hank; Goldstein, David; and Haas, Peter (2002), "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles and San Francisco", *Transportation Planning and Technology*, 25 (1): 1-27.

All trips affected are assumed average trip lengths to convert from percentage vehicle trip reduction to VMT reduction (%VT = %VMT)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[42]
CO_2e	0.04 – 1.20% of running
PM	0.04 – 1.20% of running
CO	0.04 – 1.20% of running
NOx	0.04 – 1.20% of running
SO_2	0.04 – 1.20% of running
ROG	0.024 – 0.72% of total

Discussion:

At a low range, 1% BMR housing is assumed. At a medium range, 15% is assumed (based on the requirements of the San Francisco BMR Program[5]). At a high range, the San Francisco program is doubled to reach 30% BMR. Higher percentages of BMR are possible, though not discussed in the literature or calculated.

[42] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction = 4% * 1% = 0.04%
- High Range % VMT Reduction = 4% * 30% = 1.20%

Preferred Literature:

Nelson\Nygaard [1] provides a 4% reduction in vehicle trips for each deed-restricted BMR unit. This is calculated from Holtzclaw [3], with the following assumptions: 12,000 average annual VMT per vehicle, $33,000 median per capita income (2002 figures per CA State Department of Finance), and average income in BMR units 25% below median. With a coefficient of -0.0565 (estimate for VMT/vehicle as a function of $/capita) from [3], the VMT reduction is 0.0565*33,000*0.25/12,000 = 4%.

Alternative Literature:

- 50% greater transit school trips than higher income households

Fehr & Peers [6] developed Direct Ridership Models to predict the Bay Area Rapid Transit (BART) ridership activity. One of the objectives of this assessment was to understand the land use and system access factors that influence commute period versus off-peak travel on BART. The analysis focused on the Metropolitan Transportation Commission 2000 Bay Area Travel Survey [7], using the data on household travel behavior to extrapolate relationships between household characteristics and BART mode choice. The study found that regardless of distance from BART, lower income households generate at least 50% higher BART use for school trips than higher income households. More research would be needed to provide more applicable information regarding other types of transit throughout the state.

Other Literature Reviewed:

[4] Bento, Antonio M., Maureen L. Cropper, Ahmed Mushfiq Mobarak, and Katja Vinha. 2005. “The Effects of Urban Spatial Structure on Travel Demand in the United States.” *The Review of Economics and Statistics* 87,3: 466-478. (cited in Measure Description section)

[5] San Francisco BMR Program: http://www.ci.sf.ca.us/site/moh_page.asp?id=48083 (p.1) (cited in Discussion section).

[6] Fehr & Peers. *Access BART*. 2006.

[7] BATS. 2000. 2000 Bay Area Travel Survey.

3.1.7 Orient Project Toward Non-Auto Corridor

Range of Effectiveness: Grouped strategy. [See LUT-3]

Measure Description:

A project that is designed around an existing or planned transit, bicycle, or pedestrian corridor encourages alternative mode use. For this measure, the project is oriented towards a planned or existing transit, bicycle, or pedestrian corridor. Setback distance is minimized.

The benefits of Orientation toward Non-Auto Corridor have not been sufficiently quantified in the existing literature. This measure is most effective when applied in combination of multiple design elements that encourage this use. There is not sufficient evidence that this measure results in non-negligible trip reduction unless combined with measures described elsewhere in this report, including neighborhood design, density and diversity of development, transit accessibility and pedestrian and bicycle network improvements. Therefore, the trip reduction percentages presented below should be used only as reasonableness checks. They may be used to assess whether, when applied to projects oriented toward non-auto corridors, analysis of all of those other development design factors presented in this report produce trip reductions at least as great as the percentages listed below.

Measure Applicability:

- Urban or suburban context; may be applicable in a master-planned rural community
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

- 0.25 – 0.5% reduction in vehicle miles traveled (VMT)

The Sacramento Metropolitan Air Quality Management District (SMAQMD) Recommended Guidance for Land Use Emission Reductions attributes 0.5% reduction for a project oriented towards an *existing* corridor. A 0.25% reduction is attributed for a project oriented towards a *planned* corridor. The planned transit, bicycle, or pedestrian corridor must be in a General Plan, Community Plan, or similar plan.

Alternate:

- 0.5% reduction in VMT per 1% improvement in transit frequency
- 0.5% reduction in VMT per 10% increase in transit ridership

The *Center for Clean Air Policy (CCAP) Guidebook* [2] attributes a 0.5 % reduction per 1% improvement in transit frequency. Based on a case study presented in the CCAP report, a 10% increase in transit ridership would result in a 0.5% reduction. (This information is based on a TIAX review for SMAQMD).

The sources cited above reflect existing guidance rather than empirical studies.

Alternative Literature References:

[1] Sacramento Metropolitan Air Quality Management District (SMAQMD). "Recommended Guidance for Land Use Emission Reductions." http://www.airquality.org/ceqa/GuidanceLUEmissionReductions.pdf

[2] Center for Clean Air Policy (CCAP). *Transportation Emission Guidebook*. http://www.ccap.org/safe/guidebook/guide_complete.html
TIAX Results of 2005 Literature Search Conducted by TIAX on behalf of SMAQMD

Other Literature Reviewed:

None

3.1.8 Locate Project near Bike Path/Bike Lane

Range of Effectiveness: Grouped strategy. [See LUT-4]

Measure Description:

A Project that is designed around an existing or planned bicycle facility encourages alternative mode use. The project will be located within 1/2 mile of an existing Class I path or Class II bike lane. The project design should include a comparable network that connects the project uses to the existing offsite facilities.

This measure is most effective when applied in combination of multiple design elements that encourage this use. Refer to Increase Destination Accessibility (LUT-4) strategy. The benefits of Proximity to Bike Path/Bike Lane are small as a standalone strategy. The strategy should be grouped with the Increase Destination Accessibility strategy to increase the opportunities for multi-modal travel.

Measure Applicability:

- Urban or suburban context; may be applicable in a rural master planned community
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

- 0.625% reduction in vehicle miles traveled (VMT)

As a rule of thumb, the *Center for Clean Air Policy (CCAP) Guidebook* [1] attributes a 1% to 5% reduction associated with comprehensive bicycle programs. Based on the CCAP guidebook, the TIAX report allots 2.5% reduction for all bicycle-related measures and a 1/4 of that for this measure alone. (This information is based on a TIAX review for SMAQMD).

Alternative Literature References:

[1] Center for Clean Air Policy (CCAP). *Transportation Emission Guidebook*. http://www.ccap.org/safe/guidebook/guide_complete.html; TIAX Results of 2005 Literature Search Conducted by TIAX on behalf of SMAQMD.

Other Literature Reviewed:

None

3.1.9 Improve Design of Development

Range of Effectiveness: 3.0 – 21.3% vehicle miles traveled (VMT) reduction and therefore 3.0-21.3% reduction in GHG emissions.

Measure Description:

The project will include improved design elements to enhance walkability and connectivity. Improved street network characteristics within a neighborhood include street accessibility, usually measured in terms of average block size, proportion of four-way intersections, or number of intersections per square mile. Design is also measured in terms of sidewalk coverage, building setbacks, street widths, pedestrian crossings, presence of street trees, and a host of other physical variables that differentiate pedestrian-oriented environments from auto-oriented environments.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Number of intersections per square mile

Mitigation Method:

$$\% \text{ VMT Reduction} = \text{Intersections} * B$$

Where

Intersections = Percentage increase in intersections versus a typical ITE suburban development

$$= \frac{\text{Intersections per square mile of project} - \text{Intersections per square mile of typical ITE suburban development}}{\text{Intersections per square mile of typical ITE suburban development}}$$

$$= \frac{\text{Intersections per square mile of project} - 36}{36}$$

See Appendix C for detail [not to exceed 500% increase]

B = Elasticity of VMT with respect to percentage of intersections (0.12 from [1])

Assumptions:

Data based upon the following references:

[1] Ewing, R., and Cervero, R., "Travel and the Built Environment - A Meta-Analysis." *Journal of the American Planning Association*, <to be published> (2010). Table 4.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[43]
CO_2e	3.0 – 21.3% of running
PM	3.0 – 21.3% of running
CO	3.0 – 21.3% of running
NOx	3.0 – 21.3% of running
SO_2	3.0 – 21.3% of running
ROG	1.8 – 12.8% of total

Discussion:

The VMT reductions for this strategy are based on changes in intersection density versus the standard suburban intersection density in North America. This standard density is used as a baseline to mirror the density reflected in the *ITE Trip Generation Manual*, which is the baseline method for determining VMT.

The calculations in the Example section look at a low and high range of intersection densities. The low range is simply a slightly higher density than the typical ITE

[43] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

development. The high range uses an average intersection density of mixed use/transit-oriented development sites (TOD Site surveys in the Bay Area for *Candlestick-Hunters Point Phase II TIA,* Fehr & Peers, 2009).

There are two separate maxima noted in the fact sheet: a cap of 500% on the allowable percentage increase of intersections per square mile (variable A) and a cap of 30% on % VMT reduction. The rationale for the 500% cap is that there are diminishing returns to any change in environment. For example, it is reasonably doubtful that increasing intersection density by a factor of six instead of five would produce any additional change in travel behavior. The purpose for the 30% cap is to limit the influence of any single environmental factor (such as design). This emphasizes that community designs that implement multiple land use strategies (such as density, design, diversity, etc.) will show more of a reduction than relying on improvements from a single land use factor.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (45 intersections per square mile) = (45 – 36) / 36 * 0.12 = 3.0%
- High Range % VMT Reduction (100 intersections per square mile) = (100 – 36) / 36 * 0.12 = 21.3%

Preferred Literature:

- -0.12 = elasticity of VMT with respect to design (intersection/street density)
- -0.12 = elasticity of VMT with respect to design (% of 4-way intersections)

Ewing and Cervero's [1] synthesis showed a strong relationship of VMT to design elements, second only to destination accessibility. The weighted average elasticity of VMT to intersection/street density was -0.12 (looking at six studies). The weighted average elasticity of VMT to percentage of 4-way intersections was -0.12 (looking at four studies, of which one controlled for self-selection[44]).

Alternative Literature:

Alternate:

- 2-19% reduction in VMT

[44] Self selection occurs when residents or employers that favor travel by non-auto modes choose locations where this type of travel is possible. They are therefore more inclined to take advantage of the available options than a typical resident or employee might otherwise be.

Growing Cooler [2] looked at various reports which studied the effect of site design on VMT, showing a range of 2-19% reduction in VMT. In each case, alternative development plans for the same site were compared to a baseline or trend plan. Results suggest that VMT and CO_2 per capita decline as site density increases as well as the mix of jobs, housing, and retail uses become more balanced. *Growing Cooler* notes that the limited number of studies, differences in assumptions and methodologies, and variability of results make it difficult to generalize.

Alternate:

- 3 – 17% shift in mode share from auto to non-auto

The Marshall and Garrick paper [3] analyzes the differences in mode shares for grid and non-grid ("tree") neighborhoods. For a city with a tributary tree street network, a neighborhood with a tree network had auto mode share of 92% while a neighborhood with a grid network had auto mode share of 89% (3% difference). For a city with a tributary radial street network, a tree neighborhood had auto mode share of 97% while a grid neighborhood had auto mode share of 84% (13% difference). For a city with a grid network, a tree neighborhood had auto mode share of 95% while a grid neighborhood had auto mode share of 78% (17% difference). The research is based on 24 California cities with populations between 30,000 and 100,000.

Alternative Literature References:

[2] Ewing, et al, 2008. Growing Cooler – The Evidence on Urban Development and Climate Change. Urban Land Institute.

[3] Marshall and Garrick, 2009. "The Effect of Street Network Design on Walking and Biking." Submitted to the 89th Annual Meeting of Transportation Research Board, January 2010. (Table 3)

Other Literature Reviewed:

None

3.2 Neighborhood/Site Enhancements

3.2.1 Provide Pedestrian Network Improvements

Range of Effectiveness: 0 - 2% vehicle miles traveled (VMT) reduction and therefore 0 - 2% reduction in GHG emissions.

Measure Description:

Providing a pedestrian access network to link areas of the Project site encourages people to walk instead of drive. This mode shift results in people driving less and thus a reduction in VMT. The project will provide a pedestrian access network that internally links all uses and connects to all existing or planned external streets and pedestrian facilities contiguous with the project site. The project will minimize barriers to pedestrian access and interconnectivity. Physical barriers such as walls, landscaping, and slopes that impede pedestrian circulation will be eliminated.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects
- Reduction benefit only occurs if the project has both pedestrian network improvements on site and connections to the larger off-site network.

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The project applicant must provide information regarding pedestrian access and connectivity within the project and to/from off-site destinations.

Mitigation Method:

Estimated VMT Reduction	Extent of Pedestrian Accommodations	Context
2%	Within Project Site and Connecting Off-Site	Urban/Suburban
1%	Within Project Site	Urban/Suburban
< 1%	Within Project Site and Connecting Off-Site	Rural

Assumptions:

Data based upon the following references:

- Center for Clean Air Policy (CCAP) Transportation Emission Guidebook. http://www.ccap.org/safe/guidebook/guide_complete.html (accessed March 2010)
- 1000 Friends of Oregon (1997) "Making the Connections: A Summary of the LUTRAQ Project" (p. 16): http://www.onethousandfriendsoforegon.org/resources/lut_vol7.html

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[45]
CO_2e	0 - 2% of running
PM	0 - 2% of running
CO	0 - 2% of running
NOx	0 - 2% of running
SO_2	0 - 2% of running
ROG	0 – 1.2% of total

Discussion:

As detailed in the preferred literature section below, the lower range of 1 – 2% VMT reduction was pulled from the literature to provide a conservative estimate of reduction potential. The literature does not speak directly to a rural context, but an assumption was made that the benefits will likely be lower than a suburban/urban context.

Example:

N/A – calculations are not needed.

Preferred Literature:

[45] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

- 1 - 2% reduction in VMT

The Center for Clean Air Policy (CCAP) attributes a 1% reduction in VMT from pedestrian-oriented design assuming this creates a 5% decrease in automobile mode share (e.g. auto split shifts from 95% to 90%). This mode split is based on the Portland Regional Land Use Transportation and Air Quality (LUTRAQ) project. The LUTRAQ analysis also provides the high end of 10% reduction in VMT. This 10% assumes the following features:

– Compact, mixed-use communities
– Interconnected street network
– Narrower roadways and shorter block lengths
– Sidewalks
– Accessibility to transit and transit shelters
– Traffic calming measures and street trees
– Parks and public spaces

Other strategies (development density, diversity, design, transit accessibility, traffic calming) are intended to account for the effects of many of the measures in the above list. Therefore, the assumed effectiveness of the Pedestrian Network measure should utilize the lower end of the 1 - 10% reduction range. If the pedestrian improvements are being combined with a significant number of the companion strategies, trip reductions for those strategies should be applied as well, based on the values given specifically for those strategies in other sections of this report. Based upon these findings, and drawing upon recommendations presented in the alternate literature below, the recommended VMT reduction attributable to pedestrian network improvements, above and beyond the benefits of other measures in the above bullet list, should be 1% for comprehensive pedestrian accommodations within the development plan or project itself, or 2% for comprehensive internal accommodations and external accommodations connecting to off-site destinations.

Alternative Literature:

Alternate:

- Walking is three times more common with enhanced pedestrian infrastructure
- 58% increase in non-auto mode share for work trips

The Nelson\Nygaard [1] report for the City of Santa Monica Land Use and Circulation Element EIR summarized studies looking at pedestrian environments. These studies have found a direct connection between non-auto forms of travel and a high quality pedestrian environment. Walking is three times more common with communities that have pedestrian friendly streets compared to less pedestrian friendly communities. Non-auto mode share for work trips is 49% in a pedestrian friendly community, compared to 31% in an auto-oriented community. Non-auto mode share for non-work trips is 15%, compared to 4% in an auto-oriented community. However, these effects also depend upon other aspects of the pedestrian friendliness being present, which are accounted for separately in this report through land use strategy mitigation measures such as density and urban design.

Alternate:

- 0.5% - 2.0% reduction in VMT

The Sacramento Metropolitan Air Quality Management District (SMAQMD) Recommended Guidance for Land Use Emission Reductions [2] attributes 1% reduction for a project connecting to *existing* external streets and pedestrian facilities. A 0.5% reduction is attributed to connecting to *planned* external streets and pedestrian facilities (which must be included in a pedestrian master plan or equivalent). Minimizing pedestrian barriers attribute an additional 1% reduction in VMT. These recommendations are generally in line with the recommended discounts derived from the preferred literature above.

Preferred and Alternative Literature Notes:

[1] Nelson\Nygaard, 2010. City of Santa Monica Land Use and Circulation Element EIR Report, Appendix – Santa Monica Luce Trip Reduction Impacts Analysis (p.401). http://www.shapethefuture2025.net/

Nelson\Nygaard looked at the following studies: Anne Vernez Moudon, Paul Hess, Mary Catherine Snyder and Kiril Stanilov (2003), Effects of Site Design on Pedestrian Travel in Mixed Use, Medium-Density Environments, http://www.wsdot.wa.gov/research/reports/fullreports/432.1.pdf; Robert Cervero and Carolyn Radisch (1995), Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods, http://www.uctc.net/papers/281.pdf;

[2] Sacramento Metropolitan Air Quality Management District (SMAQMD) Recommended Guidance for Land Use Emission Reductions. (p. 11) http://www.airquality.org/ceqa/GuidanceLUEmissionReductions.pdf

Other Literature Reviewed:

None

3.2.2 Provide Traffic Calming Measures

Range of Effectiveness: 0.25 – 1.00% vehicle miles traveled (VMT) reduction and therefore 0.25 – 1.00% reduction in GHG emissions.

Measure Description:

Providing traffic calming measures encourages people to walk or bike instead of using a vehicle. This mode shift will result in a decrease in VMT. Project design will include pedestrian/bicycle safety and traffic calming measures in excess of jurisdiction requirements. Roadways will be designed to reduce motor vehicle speeds and encourage pedestrian and bicycle trips with traffic calming features. Traffic calming features may include: marked crosswalks, count-down signal timers, curb extensions, speed tables, raised crosswalks, raised intersections, median islands, tight corner radii, roundabouts or mini-circles, on-street parking, planter strips with street trees, chicanes/chokers, and others.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of streets within project with traffic calming improvements
- Percentage of intersections within project with traffic calming improvements

Mitigation Method:

		% of streets with improvements			
		25%	*50%*	*75%*	*100%*
		% VMT Reduction			
% of intersections with improvements	*25%*	**0.25%**	**0.25%**	**0.5%**	**0.5%**
	50%	**0.25%**	**0.5%**	**0.5%**	**0.75%**
	75%	**0.5%**	**0.5%**	**0.75%**	**0.75%**
	100%	**0.5%**	**0.75%**	**0.75%**	**1%**

Assumptions:

Data based upon the following references:

[1] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.*(p. B-25) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendices_Complete_102209.pdf

[2] Sacramento Metropolitan Air Quality Management District (SMAQMD) *Recommended Guidance for Land Use Emission Reductions.* (p.13) http://www.airquality.org/ceqa/GuidanceLUEmissionReductions.pdf

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[46]
CO_2e	0.25 – 1.00% of running
PM	0.25 – 1.00% of running
CO	0.25 – 1.00% of running
NOx	0.25 – 1.00% of running
SO_2	0.25 – 1.00% of running
ROG	0.15 – 0.6% of total

Discussion:

The table above allows the Project Applicant to choose a range of street and intersection improvements to determine an appropriate VMT reduction estimate. The Applicant will look at the rows on the left and choose the percent of intersections within

[46] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

the project which will have traffic calming improvements. Then, the Applicant will look at the columns along the top and choose the percent of streets within the project which will have traffic calming improvements. The intersection cell of the row and column selected in the matrix is the VMT reduction estimate.

Though the literature provides some difference between a suburban and urban context, the difference is small and thus a conservative estimate was used to be applied to all contexts. Rural context is not specifically discussed in the literature but is assumed to have similar impacts.

For a low range, a project is assumed to have 25% of its streets with traffic calming improvements and 25% of its intersections with traffic calming improvements. For a high range, 100% of streets and intersections are assumed to have traffic calming improvements

Example:

N/A - No calculations needed.

Preferred Literature:

- -0.03 = elasticity of VMT with respect to a pedestrian environment factor (PEF)
- 1.5% - 2.0% reduction in suburban VMT
- 0.5% - 0.6% reduction in urban VMT

Moving Cooler [1] looked at Ewing's synthesis elasticity from the Smart Growth INDEX model (-0.03) to estimate VMT reduction for a suburban and urban location. The estimated reduction in VMT came from looking at the difference between the VMT results for Moving Cooler's strategy of pedestrian accessibility only compared to an aggressive strategy of pedestrian accessibility and traffic calming.

The Sacramento Metropolitan Air Quality Management District (SMAQMD) *Recommended Guidance for Land Use Emission Reductions* [2] attributes 0.25 – 1% of VMT reductions to traffic calming measures. The table above illustrates the range of VMT reductions based on the percent of streets and intersections with traffic calming measures implemented. This range of reductions is recommended because it is generally consistent with the effectiveness ranges presented in the other preferred literature for situations in which the effects of traffic calming are distinguished from the other measures often found to co-exist with calming, and because it provides graduated effectiveness estimates depending on the degree to which calming is implemented.

Alternative Literature:

None

Alternative Literature References:

None

Other Literature Reviewed:

None

3.2.3 Implement a Neighborhood Electric Vehicle (NEV) Network

Range of Effectiveness: 0.5-12.7% vehicle miles traveled (VMT) reduction since Neighborhood Electric Vehicles (NEVs) would result in a mode shift and therefore reduce the traditional vehicle VMT and GHG emissions[47]. Range depends on the available NEV network and support facilities, NEV ownership levels, and the degree of shift from traditional

Measure Description:

The project will create local "light" vehicle networks, such as NEV networks. NEVs are classified in the California Vehicle Code as a "low speed vehicle". They are electric powered and must conform to applicable federal automobile safety standards. NEVs offer an alternative to traditional vehicle trips and can legally be used on roadways with speed limits of 35 MPH or less (unless specifically restricted). They are ideal for short trips up to 30 miles in length. To create an NEV network, the project will implement the necessary infrastructure, including NEV parking, charging facilities, striping, signage, and educational tools. NEV routes will be implemented throughout the project and will double as bicycle routes.

Measure Applicability:

- Urban, suburban, and rural context
- Small citywide or large multi-use developments
- Appropriate for mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

[47] Transit vehicles may also result in increases in emissions that are associated with electricity production or fuel use. The Project Applicant should consider these potential additional emissions when estimating mitigation for these measures.

Inputs:

The following information needs to be provided by the Project Applicant:

- low vs. high penetration

Mitigation Method:

% VMT reduction = Pop * Number * NEV

Where

Penetration = Number of NEVs per household (0.04 to 1.0 from [1])
NEV = VMT reduction rate per household (12.7% from [2])

Assumptions:

Data based upon the following reference:

[1] City of Lincoln, MHM Engineers & Surveyors, *Neighborhood Electric Vehicle Transportation Program Final Report*, Issued 04/05/05
[2] City of Lincoln, *A Report to the California Legislature as required by Assembly Bill 2353, Neighborhood Electric Vehicle Transportation Plan Evaluation,* January 1, 2008.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[48]
CO_2e	0.5 – 12.7% of running
PM	0.5 – 12.7% of running
CO	0.5 – 12.7%of running
NOx	0.5 – 12.7% of running
SO_2	0.5 – 12.7% of running
ROG	0.3 – 7.6% of total

Discussion:

The estimated number of NEVs per household may vary based on what the project estimates as a penetration rate for implementing an NEV network. Adjust according to project characteristics. The estimated reduction in VMT is for non-NEV miles traveled. The calculations below assume that NEV miles traveled replace regular vehicle travel.

▪ [48] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

This may not be the case and the project should consider applying an appropriate discount rate on what percentage of VMT is actually replaced by NEV travel..

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (low penetration) = 0.04 * 12.7% = 0.5%
- High Range % VMT Reduction (high penetration) = 1.0 * 12.7% = 12.7%

Preferred Literature:

- 12.7% reduction in VMT per household
- Penetration rates: 0.04 to 1 NEV / household

The NEV Transportation Program plans to implement the following strategies: charging facilities, striping, signage, parking, education on NEV safety, and NEV/bicycle lines throughout the community. . One estimate of current NEV ownership reported roughly 600 NEVs in the city of Lincoln in 2008[49]. With current estimated households of ~13,500[50], a low estimate of NEV penetration would be 0.04 NEV per household. A high NEV penetration can be estimated at 1 NEV per household. The 2007 survey of NEV users in Lincoln revealed an average use of about 3,500 miles per year [2]. With an estimated annual 27,500 VMT/household[51], this results in a 12.7% reduction in VMT per household.

Alternative Literature:

- 0.5% VMT reduction for neighborhoods with internal NEV connections
- 1% VMT reduction for internal and external connections to surrounding neighborhoods
- 1.5% VMT reduction for internal NEV connections and connections to other existing NEV networks serving all other types of uses.

The Sacramento Metropolitan Air Quality Management District (SMAQMD) Recommended Guidance for Land Use Emission Reductions notes that current studies show NEVs do not replace gas-fueled vehicles as the primary vehicle. For the purpose

[49] Lincoln, California: A NEV-Friendly Community, Bennett Engineering, the City of Lincoln, and LincolnNEV, August 28, 2008 - http://electrickmotorsports.com/news.php

[50] SACOG Housing Estimates Statistics (http://www.sacog.org/about/advocacy/pdf/fact-sheets/HousingStats.pdf). Linearly interpolated 2008 household numbers between 2005 and 2035 projections.

[51] SACOG SACSim forecasts for VMT per household at 75.4 daily VMT per household * 365 days = 27521 annual VMT per household

of providing incentives for developers to promote NEV use, a project will receive the above listed VMT reductions for implementation.

Alternative Literature Reference:

[1] Sacramento Metropolitan Air Quality Management District (SMAQMD) Recommended Guidance for Land Use Emission Reductions. (p. 21) http://www.airquality.org/ceqa/GuidanceLUEmissionReductions.pdf

Other Literature Reviewed:

None

3.2.4 Create Urban Non-Motorized Zones

Range of Effectiveness: Grouped strategy. [See SDT-1]

Measure Description:

The project, if located in a central business district (CBD) or major activity center, will convert a percentage of its roadway miles to transit malls, linear parks, or other non-motorized zones. These features encourage non-motorized travel and thus a reduction in VMT.

This measure is most effective when applied with multiple design elements that encourage this use. Refer to Pedestrian Network Improvements (SDT-1) strategy for ranges of effectiveness in this category. The benefits of Urban Non-Motorized Zones alone have not been shown to be significant.

Measure Applicability:

- Urban context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

- 0.01 – 0.2% annual Vehicle Miles Traveled (VMT) reduction

Moving Cooler [1] assumes 2 – 6% of U.S. CBDs/activity centers will convert to non-motorized zones for the purpose of calculating the potential impact. At full implementation, this would result in a range of CBD/activity center annual VMT reduction of 0.07-0.2% and metro VMT reduction of 0.01-0.03%.

Alternate:

Pucher, Dill, and Handy (2010) [2] note several international case studies of urban non-motorized zones. In Bologna, Italy, vehicle traffic declined by 50%, and 8% of those arriving in the CBD came by bicycle after the conversion. In Lubeck, Germany, of those who used to drive, 12% switched to transit, walking, or bicycling with the conversion. In Aachen, Germany, car travel declined from 44% to 36%, but bicycling stayed constant at 3%

Notes:

No literature was identified that quantifies the benefits of this strategy at a smaller scale.

Alternative Literature References:

[1] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

[2] Pucher J., Dill, J., and Handy, S. *Infrastructure, Programs and Policies to Increase Bicycling: An International Review.* February 2010. *Preventive Medicine 50 (2010) S106–S125.* http://policy.rutgers.edu/faculty/pucher/Pucher_Dill_Handy10.pdf

Other Literature Reviewed:

None

3.2.5 Incorporate Bike Lane Street Design (on-site)

Range of Effectiveness: Grouped strategy. [See LUT-9]

Measure Description:

The project will incorporate bicycle lanes, routes, and shared-use paths into street systems, new subdivisions, and large developments. These on-street bike accommodations will be created to provide a continuous network of routes, facilitated with markings and signage. These improvements can help reduce peak-hour vehicle trips by making commuting by bike easier and more convenient for more people. In addition, improved bicycle facilities can increase access to and from transit hubs, thereby expanding the "catchment area" of the transit stop or station and increasing ridership. Bicycle access can also reduce parking pressure on heavily-used and/or heavily-subsidized feeder bus lines and auto-oriented park-and-ride facilities.

Refer to Improve Design of Development (LUT-9) strategy for overall effectiveness levels. The benefits of Bike Lane Street Design are small and should be grouped with the Improve Design of Development strategy to strengthen street network characteristics and enhance multi-modal environments.

Measure Applicability:

- Urban and suburban context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

- 1% increase in share of workers commuting by bicycle (for each additional mile of bike lanes per square mile)

Dill and Carr (2003) [1] showed that each additional mile of Type 2 bike lanes per square mile is associated with a 1% increase in the share of workers commuting by bicycle. Note that increasing by 1 mile is significant compared to the current average of 0.34 miles per square mile. Also, an increase in 1% in share of bicycle commuters would double the number of bicycle commuters in many areas with low existing bicycle mode share.

Alternate:

- 0.05 – 0.14% annual greenhouse gas (GHG) reduction
- 258 – 830% increase in bicycle community

Moving Cooler [2], based off of a national baseline, estimates 0.05% annual reduction in GHG emissions and 258% increase in bicycle commuting assuming 2 miles of bicycle lanes per square mile in areas with density > 2,000 persons per square mile. For 4 miles of bicycle lanes, estimates 0.09% GHG reductions and 449% increase in bicycle commuting. For 8 miles of bicycle lanes, estimates 0.14% GHG reductions and 830% increase in bicycle commuting. Companion strategies assumed include bicycle parking at commercial destinations, busses fitted with bicycle carriers, bike accessible rapid transit lines, education, bicycle stations, end-trip facilities, and signage.

Alternate:

- 0.075% increase in bicycle commuting with each mile of bikeway per 100,000 residents

A before-and-after study by Nelson and Allen (1997) [3] of bicycle facility implementation found that each mile of bikeway per 100,000 residents increases bicycle commuting 0.075%, all else being equal.

Alternative Literature References:

[1] Dill, Jennifer and Theresa Carr (2003). "Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Tem, Commuters Will Use Them – Another Look." *TRB 2003 Annual Meeting CD-ROM*.

[2] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

[3] Nelson, Arthur and David Allen (1997). "If You Build Them, Commuters Will Use Them; Cross-Sectional Analysis of Commuters and Bicycle Facilities." *Transportation Research Record 1578.*

Other Literature Reviewed:

None

3.2.6 Provide Bike Parking in Non-Residential Projects

Range of Effectiveness: Grouped strategy. [See LUT-9]

Measure Description:

A non-residential project will provide short-term and long-term bicycle parking facilities to meet peak season maximum demand. Refer to Improve Design of Development (LUT-9) strategy for overall effectiveness ranges. Bike Parking in Non-Residential Projects has minimal impacts as a standalone strategy and should be grouped with the Improve Design of Development strategy to encourage bicycling by providing strengthened street network characteristics and bicycle facilities.

Measure Applicability:

- Urban, suburban, and rural contexts
- Appropriate for retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

- 0.625% reduction in Vehicle Miles Traveled (VMT)

As a rule of thumb, the Center for Clean Air Policy (CCAP) guidebook [1] attributes a 1% to 5% reduction in VMT to the use of bicycles, which reflects the assumption that their use is typically for shorter trips. Based on the *CCAP Guidebook*, the TIAX report allots 2.5% reduction for all bicycle-related measures and a quarter of that for this bicycle parking alone. (This information is based on a TIAX review for Sacramento Metropolitan Air Quality Management District (SMAQMD).)

Alternate:

- 0.05 – 0.14% annual greenhouse gas (GHG) reduction
- 258 – 830% increase in bicycle community

Moving Cooler [2], based off of a national baseline, estimates 0.05% annual reduction in GHG emissions and 258% increase in bicycle commuting assuming 2 miles of bicycle lanes per square mile in areas with density > 2,000 persons per square mile. For 4 miles of bicycle lanes, *Moving Cooler* estimates 0.09% GHG reductions and 449% increase in bicycle commuting. For 8 miles of bicycle lanes, *Moving Cooler* estimates 0.14% GHG reductions and 830% increase in bicycle commuting. Companion strategies assumed include bicycle parking at commercial destinations, busses fitted with bicycle carriers, bike accessible rapid transit lines, education, bicycle stations, end-trip facilities, and signage.

Alternative Literature References:

[1]*Center For Clean Air Policy (CCAP) Transportation Emission Guidebook*. http://www.ccap.org/safe/guidebook/guide_complete.html; Based on results of 2005 literature search conducted by TIAX on behalf of SMAQMD.

[2] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

Other Literature Reviewed:

None

3.2.7 Provide Bike Parking with Multi-Unit Residential Projects

Range of Effectiveness: Grouped strategy. [See LUT-9]

Measure Description:

Long-term bicycle parking will be provided at apartment complexes or condominiums without garages. Refer to Improve Design of Development (LUT-9) strategy for effectiveness ranges in this category. The benefits of Bike Parking with Multi-Unit Residential Projects have no quantified impacts and should be grouped with the Improve Design of Development strategy to encourage bicycling by providing strengthened street network characteristics and bicycle facilities.

Measure Applicability:

- Urban, suburban, or rural contexts
- Appropriate for residential projects

Alternative Literature:

No literature was identified that specifically looks at the quantitative impact of including bicycle parking at multi-unit residential sites.

Alternative Literature References:

None

Other Literature Reviewed:

None

3.2.8 Provide Electric Vehicle Parking

Range of Effectiveness: Grouped strategy. [See SDT-3]

Measure Description:

This project will implement accessible electric vehicle parking. The project will provide conductive/inductive electric vehicle charging stations and signage prohibiting parking for non-electric vehicles. Refer to Neighborhood Electric Vehicle Network (SDT-3) strategy for effectiveness ranges in this category. The benefits of Electric Vehicle Parking may be quantified when grouped with the use of electric vehicles and or Neighborhood Electric Vehicle Network.

Measure Applicability:

- Urban or suburban contexts
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

No literature was identified that specifically looks at the quantitative impact of implementing electric vehicle parking.

Alternative Literature References:

None

Other Literature Reviewed:

None

3.2.9 Dedicate Land for Bike Trails

Range of Effectiveness: Grouped strategy. [See LUT-9]

Measure Description:

Larger projects may be required to provide for, contribute to, or dedicate land for the provision of off-site bicycle trails linking the project to designated bicycle commuting routes in accordance with an adopted citywide or countywide bikeway plan.

Refer to Improve Design of Development (LUT-9**)** strategy for ranges of effectiveness in this category. The benefits of Land Dedication for Bike Trails have not been quantified and should be grouped with the Improve Design of Development strategy to strengthen street network characteristics and improve connectivity to off-site bicycle networks.

Measure Applicability:

- Urban, suburban, or rural contexts
- Appropriate for large residential, retail, office, mixed use, and industrial projects

Alternative Literature:

No literature was identified that specifically looks at the quantitative impact of implementing land dedication for bike trails.

Alternative Literature References:

None

Other Literature Reviewed:

None

3.3 Parking Policy/Pricing

3.3.1 Limit Parking Supply

Range of Effectiveness: 5 – 12.5% vehicle miles travelled (VMT) reduction and therefore 5 – 12.5% reduction in GHG emissions.

Measure Description:

The project will change parking requirements and types of supply within the project site to encourage "smart growth" development and alternative transportation choices by project residents and employees. This will be accomplished in a multi-faceted strategy:

- Elimination (or reduction) of minimum parking requirements[52]
- Creation of maximum parking requirements
- Provision of shared parking

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects
- Reduction can be counted only if spillover parking is controlled (via residential permits and on-street market rate parking) [See PPT-5 and PPT-7]

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled
$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- ITE parking generation rate for project site
- Actual parking provision rate for project site

[52] This may require changes to local ordinances and regulations.

Mitigation Method:

$$\% \text{ VMT Reduction} = \frac{\text{Actual parking provision} - \text{ITE parking generation rate}}{\text{ITE parking generation rate}} \times 0.5$$

Assumptions:

Data based upon the following references:

[1] Nelson\Nygaard, 2005. Crediting Low-Traffic Developments (p. 16) http://www.montgomeryplanning.org/transportation/documents/TripGenerationAnalysisUsingURBEMIS.pdf

All trips affected are assumed average trip lengths to convert from percentage vehicle trip reduction to VMT reduction (% vehicle trips = %VMT).

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[53]
CO_2e	5 – 12.5% of running
PM	5 – 12.5% of running
CO	5 – 12.5% of running
NOx	5 – 12.5% of running
SO_2	5 – 12.5% of running
ROG	3 – 7.5% of total

Discussion:

The literature suggests that a 50% reduction in conventional parking provision rates (per ITE rates) should serve as a typical ceiling for the reduction calculation. The upper range of VMT reduction will vary based on the size of the development (total number of spaces provided). ITE rates are used as baseline conditions to measure the effectiveness of this strategy.

Though not specifically documented in the literature, the degree of effectiveness of this measure will vary based on the level of urbanization of the project and surrounding areas, level of existing transit service, level of existing pedestrian and bicycle networks and other factors which would complement the shift away from single-occupant vehicle travel.

[53] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis.

Example:

If the ITE parking generation rate for the project is 100 spaces, for a low range a 5% reduction in spaces is assumed. For a high range a 25% reduction in spaces is assumed.

- Low range % VMT Reduction = [(100 - 95)/100] * 0.5 = 2.5%
- High range % VMT Reduction = [(100 - 75)/100] * 0.5 = 12.5%

Preferred Literature:

To develop this model, Nelson\Nygaard [1] used the Institute of Transportation Engineers' *Parking Generation* handbook as the baseline figure for parking supply. This is assumed to be unconstrained demand. Trip reduction should only be credited if measures are implemented to control for spillover parking in and around the project, such as residential parking permits, metered parking, or time-limited parking.

Alternative Literature:

- 100% increase in transit ridership
- 100% increase in transit mode share

According to *TCRP Report 95, Chapter 18* [2], the central business district of Portland, Oregon implemented a maximum parking ratio of 1 space per 1,000 square feet of new buildings and implemented surface lot restrictions which limited conditions where buildings could be razed for parking. A "before and after" study was not conducted specifically for the maximum parking requirements and data comes from various surveys and published reports. Based on rough estimates the approximate parking ratio of 3.4 per 1,000 square feet in 1973 (for entire downtown) had been reduce to 1.5 by 1990. Transit mode share increased from 20% to 40%. The increases in transit ridership and mode share are not solely from maximum parking requirements. Other companion strategies, such as market parking pricing and high fuel costs, were in place.

Alternative Literature Sources:

[1] TCRP Report 95, Chapter 18: Parking Management and Supply: Traveler Response to *Transportation System Changes*. (p. 18-6) http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c18.pdf

Other Literature Reviewed:

None

3.3.2 Unbundle Parking Costs from Property Cost

Range of Effectiveness: 2.6 – 13% vehicles miles traveled (VMT) reduction and therefore 2.6 – 13% reduction in GHG emissions.

Measure Description:

This project will unbundle parking costs from property costs. Unbundling separates parking from property costs, requiring those who wish to purchase parking spaces to do so at an additional cost from the property cost. This removes the burden from those who do not wish to utilize a parking space. Parking will be priced separately from home rents/purchase prices or office leases. An assumption is made that the parking costs are passed through to the vehicle owners/drivers utilizing the parking spaces.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects
- Complementary strategy includes Workplace Parking Pricing. Though not required, implementing workplace parking pricing ensures the market signal from unbundling parking is transferred to the employee.

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Monthly parking cost for project site

Mitigation Method:

% Reduction in VMT = Change in vehicle cost * elasticity * A

Where:

- -0.4 = elasticity of vehicle ownership with respect to total vehicle costs (lower end per VTPI)
- Change in vehicle cost = monthly parking cost * (12 / $4,000), with $4,000 representing the annual vehicle cost per VTPI [1]
- A: 85% = adjustment from vehicle ownership to VMT (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] Victoria Transport Policy Institute, *Parking Requirement Impacts on Housing Affordability;* http://www.vtpi.org/park-hou.pdf; January 2009; accessed March 2010. (Annual/monthly parking fees estimated by VTPI in 2009) (p. 8, Table 3)

- For the elasticity of vehicle ownership, VTPI cites Phil Goodwin, Joyce Dargay and Mark Hanly (2003), *Elasticities Of Road Traffic And Fuel Consumption With Respect To Price And Income: A Review*, ESRC Transport Studies Unit, University College London (www.transport.ucl.ac.uk), commissioned by the UK Department of the Environment, Transport and the Regions (now UK Department for Transport); J.O. Jansson (1989), “Car Demand Modeling and Forecasting,” *Journal of Transport Economics and Policy*, May 1989, pp. 125-129; Stephen Glaister and Dan Graham (2000), *The Effect of Fuel Prices on Motorists*, AA Motoring Policy Unit (www.theaa.com) and the UK Petroleum Industry Association (http://195.167.162.28/policyviews/pdf/effect_fuel_prices.pdf); and Thomas F. Golob (1989), “The Casual Influences of Income and Car Ownership on Trip Generation by Mode”, *Journal of Transportation Economics and Policy*, May 1989, pp. 141-162

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[54]
CO_2e	2.6 – 13% of running
PM	2.6 – 13% of running
CO	2.6 – 13% of running

[54] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

NOx	2.6 – 13% of running
SO_2	2.6 – 13% of running
ROG	1.6 – 7.8% of total

Discussion:

As discussed in the preferred literature section, monthly parking costs typically range from $25 to $125. The lower end of the elasticity range provided by VTPI is used here to be conservative.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction = $25* 12 / $4000 * 0.4 * 85% = 2.6%
- High Range % VMT Reduction = $125* 12 / $4000 * 0.4 * 85%= 12.8%

Preferred Literature:

- -0.4 to -1.0 = elasticity of vehicle ownership with respect to total vehicle costs

The above elasticity comes from a synthesis of literature. As noted in the VTPI report [1], a 10% increase in total vehicle costs (operating costs, maintenance, fuel, parking, etc.) reduces vehicle ownership between 4% and 10%. The report, estimating $4,000 in annual costs per vehicle, calculated vehicle ownership reductions from residential parking pricing.

Vehicle Ownership Reductions from Residential Parking Pricing

Annual (Monthly) Parking Fee	-0.4 Elasticity	-0.7 Elasticity	-1.0 Elasticity
$300 ($25)	4%	6%	8%
$600 ($50)	8%	11%	15%
$900 ($75)	11%	17%	23%
$1,200 ($100)	15%	23%	30%
$1,500 ($125)	19%	28%	38%

Alternative Literature:

None

Alternative Literature Notes:

None

Other Literature Reviewed:

None

3.3.3 Implement Market Price Public Parking (On-Street)

Range of Effectiveness: 2.8 – 5.5% vehicle miles traveled (VMT) reduction and therefore 2.8 – 5.5% reduction in GHG emissions.

Measure Description:

This project and city in which it is located will implement a pricing strategy for parking by pricing all central business district/employment center/retail center on-street parking. It will be priced to encourage "park once" behavior. The benefit of this measure above that of paid parking at the project only is that it deters parking spillover from project-supplied parking to other public parking nearby, which undermine the vehicle miles traveled (VMT) benefits of project pricing. It may also generate sufficient area-wide mode shifts to justify increased transit service to the area.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context
- Appropriate for retail, office, and mixed-use projects
- Applicable in a specific or general plan context only
- Reduction can be counted only if spillover parking is controlled (via residential permits)
- Study conducted in a downtown area, and thus should be applied carefully if project is not in a central business/activity center

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Location of project site: low density suburb, suburban center, or urban location

- Percent increase in on-street parking prices (minimum 25% needed)

Mitigation Method:

% VMT Reduction = Park$ * B

Where:

Park$ = Percent increase in on-street parking prices (minimum of 25% increase [1])

B = Elasticity of VMT with respect to parking price (0.11, from [2])

Assumptions:

Data based upon the following references:

[1] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (p. B-10)

Moving Cooler's parking pricing analysis cited Victoria Transport Policy Institute, *How Prices and Other Factors Affect Travel Behavior* (http://www.vtpi.org/tdm/tdm11.htm#_Toc161022578). The VTPI paper summarized the elasticities found in the Hensher and King paper. David A. Hensher and Jenny King (2001), "Parking Demand and Responsiveness to Supply, Price and Location in Sydney Central Business District," *Transportation Research A*, Vol. 35, No. 3 (www.elsevier.com/locate/tra), March 2001, pp. 177-196.

[2] J. Peter Clinch and J. Andrew Kelly (2003), *Temporal Variance Of Revealed Preference On-Street Parking Price Elasticity*, Department of Environmental Studies, University College Dublin (www.environmentaleconomics.net). (p. 2) http://www.ucd.ie/gpep/research/workingpapers/2004/04-02.pdf As referenced in VTPI: http://www.vtpi.org/tdm/tdm11.htm#_Toc161022578

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[55]
CO_2e	2.8 – 5.5% of running

[55] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

PM	2.8 – 5.5% of running
CO	2.8 – 5.5% of running
NOx	2.8 – 5.5% of running
SO_2	2.8 – 5.5% of running
ROG	1.7 – 3.3% of total

Discussion:

The range of parking price increases should be a minimum of 25% and a maximum of 50%. The minimum is based on Moving Cooler [1] discussions which state that a less than 25% increase would not be a sufficient amount to reduce VMT. The case study [2] looked at a 50% price increase, and thus no conclusions can be made on the elasticities above a 50% increase. This strategy may certainly be implemented at a higher price increase, but VMT reductions should be capped at results from a 50% increase to be conservative.

Example:

Assuming a baseline on-street parking price of $1, sample calculations are provided below:

- Low Range % VMT Reduction (25% increase) = ($1.25 - $1)/$1 * 0.11 = 2.8%
- High Range % VMT Reduction (50% increase) = ($1.50 - $1)/$1 * 0.11 = 5.5%

Preferred Literature:

- -0.11 parking demand elasticity with respect to parking prices

The Clinch & Kelly study [2] of parking meters looked at the impacts of a 50% price increase in the cost of on-street parking. The case study location was a central on-street parking area with a 3-hour time limit and a mix of business and non-business uses. The study concluded the parking increases resulted in an estimated average price elasticity of demand of -0.11, while factoring in parking duration results in an elasticity of -0.2 (cost increases also affect the amount of time cars are parked). Though this study is international (Dublin, Ireland), it represents a solid study of parking meter price increases and provides a conservative estimate of elasticity compared to the alternate literature.

Alternative Literature:

Alternate:

- -0.19 shopper parking elasticity with respect to parking price
- -0.48 commuter parking elasticity with respect to parking price

The *TCRP 95 Chapter 13* [3] report looked at a case study of the city of San Francisco implementing a parking tax on all public and private off-street parking (in 1970). Based on the number of cars parked, the report estimated parking price elasticities of -0.19 to -0.48, an average over a three year period.

Alternate:

- -0.15 VMT elasticity with respect to parking prices (for low density regions)
- -0.47 VMT elasticity with respect to parking prices (for high density regions)

The Moving Cooler analysis assumes a 25 percent increase in on-street parking fees is a starting point sufficient to reduce VMT. Using the elasticities stated above, Moving Cooler estimates an annual percent VMT reduction from 0.42% - 1.14% for a range of regions from a large low density region to a small high density region. The calculations assume that pricing occurs at the urban central business district/employment cent/retail center, one-fourth of all person trips are commute based trips, and approximately 15% of commute trips are to the CBD or regional activity centers.

Alternative Literature References:

[3] TCRP Report 95. *Chapter 13: Parking Pricing and Fees - Traveler Response to Transportation System Changes.* http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c13.pdf. (p.13-42)

Other Literature Reviewed:

None

3.3.4 Require Residential Area Parking Permits

Range of Effectiveness: Grouped strategy. (See PPT-1, PPT-2, and PPT-3)

Measure Description:

This project will require the purchase of residential parking permits (RPPs) for long-term use of on-street parking in residential areas. Permits reduce the impact of spillover parking in residential areas adjacent to commercial areas, transit stations, or other locations where parking may be limited and/or priced. Refer to Parking Supply Limitations (PPT-1), Unbundle Parking Costs from Property Cost (PPT-2), or Market Rate Parking Pricing (PPT-3) strategies for the ranges of effectiveness in these categories. The benefits of Residential Area Parking Permits strategy should be combined with any or all of the above mentioned strategies, as providing RPPs are a key complementary strategy to other parking strategies.

Measure Applicability:

- Urban context
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

- -0.45 = elasticity of vehicle miles traveled (VMT) with respect to price
- 0.08% greenhouse gas (GHG) reduction
- 0.09-0.36% VMT reduction

Moving Cooler [1] suggested residential parking permits of $100-$200 annually. This mitigation would impact home-based trips, which are reported to represent approximately 60% of all urban trips. The range of VMT reductions can be attributed to the type of urban area. VMT reductions for $100 annual permits are 0.09% for large, high-density; 0.12% for large, low-density; 0.12% for medium, high-density; 0.18% for medium, low-density; 0.18% for small, high-density; and 0.12% for small, low-density. VMT reductions for $200 annual permits are 0.18% for large, high-density; 0.24% for large, low-density; 0.24% for medium, high-density; 0.36% for medium, low-density; 0.36% for small, high-density; and 0.24% for small, low-density.

Alternative Literature References:

[1] Cambridge Systematics. Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Technical Appendices. Prepared for the Urban Land Institute. http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

3.4 Commute Trip Reduction Programs

3.4.1 Implement Commute Trip Reduction Program - Voluntary

Commute Trip Reduction Program – Voluntary, is a multi-strategy program that encompasses a combination of individual measures described in sections 3.4.3 through 3.4.9. It is presented as a means of preventing double-counting of reductions for individual measures that are included in this strategy. It does so by setting a maximum level of reductions that should be permitted for a combined set of strategies within a voluntary program.

Range of Effectiveness: 1.0 – 6.2% commute vehicle miles traveled (VMT) Reduction and therefore 1.0 – 6.2% reduction in commute trip GHG emissions.

Measure Description:

The project will implement a voluntary Commute Trip Reduction (CTR) program with employers to discourage single-occupancy vehicle trips and encourage alternative modes of transportation such as carpooling, taking transit, walking, and biking. The main difference between a voluntary and a required program is:

- Monitoring and reporting is not required
- No established performance standards (i.e. no trip reduction requirements)

The CTR program will provide employees with assistance in using alternative modes of travel, and provide both "carrots" and "sticks" to encourage employees. The CTR program should include all of the following to apply the effectiveness reported by the literature:

- Carpooling encouragement
- Ride-matching assistance
- Preferential carpool parking
- Flexible work schedules for carpools
- Half time transportation coordinator
- Vanpool assistance
- Bicycle end-trip facilities (parking, showers and lockers)

Other strategies may also be included as part of a voluntary CTR program, though they are not included in the reductions estimation and thus are not incorporated in the estimated VMT reductions. These include: new employee orientation of trip reduction and alternative mode options, event promotions and publications, flexible work schedule for all employees, transit subsidies, parking cash-out or priced parking, shuttles, emergency ride home, and improved on-site amenities.

TRT-1 Commute Trip Reduction

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context, unless large employers exist, and suite of strategies implemented are relevant in rural settings
- Appropriate for retail, office, industrial and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of employees eligible
- Location of project site: low density suburb, suburban center, or urban location

Mitigation Method:

$$\% \text{ VMT Reduction} = A * B$$

Where

A = % reduction in commute VMT (from [1])
B = % employees eligible

Detail:

- A: 5.2% (low density suburb), 5.4% (suburban center), 6.2% (urban) annual reduction in commute VMT (from [1])

Assumptions:

Data based upon the following references:

- Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (Table 5.13) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[56]
CO_2e	1.0 – 6.2% of running
PM	1.0 – 6.2% of running
CO	1.0 – 6.2% of running
NOx	1.0 – 6.2% of running
SO_2	1.0 – 6.2% of running
ROG	0.6 –3.7% of total

Discussion:

This set of strategies typically serves as a complement to the more effective workplace CTR strategies such as pricing and parking cash out.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (low density suburb and 20% eligible) = 5.2% * 0.2 = 1.0%
- High Range % VMT Reduction (urban and 100% eligible) = 6.2% * 1 = 6.2%

Preferred Literature:

- 5.2 - 6.2% commute VMT reduction

Moving Cooler assumes the employer support program will include: carpooling, ride-matching, preferential carpool parking, flexible work schedules for carpools, a half-time transportation coordinator, vanpool assistance, bicycle parking, showers, and locker facilities. The report assigns 5.2% reduction to large metropolitan areas, 5.4% to medium metropolitan areas, and 6.2% to small metropolitan areas.

[56] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Alternative Literature:

Alternate:

- 15-19% reduction in commute vehicle trips

TCRP 95 Draft Chapter 19 [2] looked at a sample of 82 Transportation Demand Management (TDM) programs. Low support TDM programs had a 15% reduction, medium support programs 15.9%, and high support 19%. Low support programs had little employer effort. These programs may include rideshare matching, distribution of transit flyers, but have little employer involvement. With medium support programs, employers were involved with providing information regarding commute options and programs, a transportation coordinator (even if part-time), and assistance for ridesharing and transit pass purchases. With high support programs, the employer was providing most of the possible strategies. The sample of programs should not be construed as a random sample and probably represent above average results.

Alternate:

- 4.16 – 4.76% reduction in commute VMT

The Herzog study [3] compared a group of employees, who were eligible for comprehensive commuter benefits (with financial incentives, services such as guaranteed ride home and carpool matching, and informational campaigns) and general marketing information, to a reference group of employees not eligible for commuter benefits. The study showed a 4.79% reduction in VMT, assuming 75% of the carpoolers were traveling to the same worksite. There was a 4.16% reduction in VMT, assuming only 50% of carpoolers were traveling to the same worksite.

Alternate:

- 8.5% reduction in vehicle commute trips

Employer survey results [4] showed that employees at the surveyed companies made 8.5% fewer vehicle trips to work than had been found in the baseline surveys conducted by large employers under the area's trip reduction regulation (i.e. comparing voluntary program with a mandatory regulation). This implied that the 8.5% reduction is a conservative estimate as it is compared to another trip reduction strategy, rather than comparing to a baseline with no reduction strategies implemented. Another survey also showed that 68% of commuters drove alone to work when their employer did not encourage trip reduction. It revealed that with employer encouragement, the drive-alone rate fell 5 percentage points to 63%.

This strategy assumes a companion strategy of employer encouragement. The literature did not specify what commute options each employer provided as part of the program. Options provided may have ranged from simply providing public transit information to implementing a full TDM program with parking cash out, flex hours, emergency ride home, etc. This San Francisco Bay Area survey worked to determine the extent and impact of the emissions saved through voluntary trip reduction efforts (www.cleanairpartnership.com). It identified 454 employment sites with voluntary trip reduction programs and conducted a selected random survey of the more than 400,000 employees at those sites. The study concluded that employer encouragement makes a significant difference in employees' commute choices.

Alternative Literature References:

[2] Pratt, Dick. Personal Communication Regarding the Draft of TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies.

[3] Herzog, Erik, Stacey Bricka, Lucie Audette, and Jeffra Rockwell. 2006. "Do Employee Commuter Benefits Reduce Vehicle Emissions and Fuel Consumption? Results of Fall 2004 Survey of Best Workplaces for Commuters." *Transportation Research Record 1956*, 34-41. (Table 8)

[4] Transportation Demand Management Institute of the Association for Commuter Transportation. *TDM Case Studies and Commuter Testimonials*. Prepared for the US EPA. 1997. (p. 25-28) http://www.epa.gov/OMS/stateresources/rellinks/docs/tdmcases.pdf

Other Literature Reviewed:

None

3.4.2 Implement Commute Trip Reduction Program – Required Implementation/Monitoring

Commute Trip Reduction Program – Required, is a multi-strategy program that encompasses a combination of individual measures described in sections 3.4.3 through 3.4.9. It is presented as a means of preventing double-counting of reductions for individual measures that are included in this strategy. It does so by setting a maximum level of reduction that should be permitted for a combined set of strategies within a program that is contractually required of the development sponsors and managers and accompanied by a regular performance monitoring and reporting program.

Range of Effectiveness: 4.2 – 21.0% commute vehicle miles traveled (VMT) reduction and therefore 4.2 – 21.0% reduction in commute trip GHG emissions.

Measure Description:

The jurisdiction will implement a Commute Trip Reduction (CTR) ordinance. The intent of the ordinance will be to reduce drive-alone travel mode share and encourage alternative modes of travel. The critical components of this strategy are:

- Established performance standards (e.g. trip reduction requirements)
- Required implementation
- Regular monitoring and reporting

Regular monitoring and reporting will be required to assess the project's status in meeting the ordinance goals. The project should use existing ordinances, such as those in the cities of Tucson, Arizona and South San Francisco, California, as examples of successful CTR ordinance implementations. The City of Tucson requires employers with 100+ employees to participate in the program. An Alternative Mode Usage (AMU) goal and VMT reduction goal is established and each year the goal is increased. Employers persuade employees to commute via an alternative mode of transportation at least one day a week (including carpooling, vanpooling, transit, walking, bicycling, telecommuting, compressed work week, or alternatively fueled vehicle). The Transportation Demand Management (TDM) Ordinance in South San Francisco requires all non-residential developments that produce 100 average daily vehicle trips or more to meet a 35% non-drive-alone peak hour requirement with fees assessed for non-compliance. Employers have established significant CTR programs as a result.

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context, unless large employers exist, and suite of strategies implemented are relevant in rural settings
- Jurisdiction level only
- Strategies in this case study calculations included:

- Parking cash out
- Employer sponsored shuttles to transit station
- Employer sponsored bus servicing the Bay Area
- Transit subsidies

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of employees eligible

Mitigation Method:

$$\% \text{ VMT Reduction} = A * B$$

Where

A = % shift in vehicle mode share of commute trips (from [1])
B = % employees eligible
C = Adjustment from vehicle mode share to commute VMT

Detail:

- A: 21% reduction in vehicle mode share (from [1])
- C: 1.0 (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] Nelson/Nygaard (2008). *South San Francisco Mode Share and Parking Report for Genentech, Inc.*(p. 8)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[57]
CO_2e	4.2 – 21.0% of running
PM	4.2 – 21.0% of running
CO	4.2 – 21.0% of running
NOx	4.2 – 21.0% of running
SO_2	4.2 – 21.0% of running
ROG	2.5 – 12.6% of total

Discussion:

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (20% eligibility) = 21% * 20% = 4.2%
- High Range % VMT Reduction (100% eligibility) = 21% * 100% = 21%

Preferred Literature:

- 21% reduction in vehicle mode share

Genentech, in South San Francisco [1], achieved a 34% non-single-occupancy vehicle (non-SOV) mode share (66% SOV) in 2008. Since 2006 when SOV mode share was 74% (26% non-SOV), there has been a reduction of over 10% in drive alone share. Carpool share was 12% in 2008, compared to 11.57% in 2006. Genentech has a significant TDM program including parking cash out ($4/day), express GenenBus service around the Bay Area, free shuttles to Bay Area Rapid Transit (BART) and Caltrain, and transit subsidies. The Genentech campus surveyed for this study is a large, single-tenant campus. Taking an average transit mode share in a suburban development of 1.3% (NHTS,

[57] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001_Stw Travel Survey WkdayRpt.pdf (SCAG, SANDAG, Fresno County)), this is an estimated decrease from 98.7% to 78% vehicle mode share (66% SOV + 12% carpool), a 21% reduction in vehicle mode share.

Alternative Literature:

Alternate:

- 10.7% average annual increase in use of non-SOV commute modes

For the City of Tucson [2], use of alternative commute modes increased 64.3% between 1989 and 1995. Employers integrated several key activities into their TDM plans: disseminating information, developing company policies to support TDM, investing in facility enhancements, conducting promotional campaigns, and offering subsidies or incentives to encourage AMU.

Alternative Literature References:

[2] Transportation Demand Management Institute of the Association for Commuter Transportation. *TDM Case Studies and Commuter Testimonials*. Prepared for the US EPA. 1997. (p. 17-19) http://www.epa.gov/OMS/stateresources/rellinks/docs/tdmcases.pdf

Other Literature Reviewed:

None

3.4.3 Provide Ride-Sharing Programs

Range of Effectiveness: 1 – 15% commute vehicle miles traveled (VMT) reduction and therefore 1 - 15% reduction in commute trip GHG emissions.

Measure Description:

Increasing the vehicle occupancy by ride sharing will result in fewer cars driving the same trip, and thus a decrease in VMT. The project will include a ride-sharing program as well as a permanent transportation management association membership and funding requirement. Funding may be provided by Community Facilities, District, or County Service Area, or other non-revocable funding mechanism. The project will promote ride-sharing programs through a multi-faceted approach such as:

- Designating a certain percentage of parking spaces for ride sharing vehicles
- Designating adequate passenger loading and unloading and waiting areas for ride-sharing vehicles
- Providing a web site or message board for coordinating rides

Measure Applicability:

- Urban and suburban context
- Negligible impact in many rural contexts, but can be effective when a large employer in a rural area draws from a workforce in an urban or suburban area, such as when a major employer moves from an urban location to a rural location.
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of employees eligible

- Location of project site: low density suburb, suburban center, or urban location

Mitigation Method:

% VMT Reduction = Commute * Employee

Where

Commute = % reduction in commute VMT (from [1])
Employee = % employees eligible

Detail:

- Commute: 5% (low density suburb), 10% (suburban center), 15% (urban) annual reduction in commute VMT (from [1])

Assumptions:

Data based upon the following references:

[1] VTPI. *TDM Encyclopedia*. http://www.vtpi.org/tdm/tdm34.htm; Accessed 3/5/2010.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[58]
CO_2e	1 – 15% of running
PM	1 – 15% of running
CO	1 – 15% of running
NOx	1 – 15% of running
SO_2	1 – 15% of running
ROG	0.6 – 9% of total

Discussion:

This strategy is often part of Commute Trip Reduction (CTR) Program, another strategy documented separately (see TRT-1 and TRT-2). The Project Applicant should take care not to double count the impacts.

Example:

Sample calculations are provided below:

[58] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

- Low Range % VMT Reduction (low density suburb and 20% eligible) = 5% * 20% = 1%
- High Range % VMT Reduction (urban and 100% eligible) = 15% * 1 = 15%

Preferred Literature:

- 5 – 15% reduction of commute VMT

The *Transportation Demand Management (TDM) Encyclopedia* notes that because rideshare passengers tend to have relatively long commutes, mileage reductions can be relatively large with rideshare. If ridesharing reduces 5% of commute trips it may reduce 10% of vehicle miles because the trips that are reduced are twice as long as average. Rideshare programs can reduce up to 8.3% of commute VMT, up to 3.6% of total regional VMT, and up to 1.8% of regional vehicle trips (Apogee, 1994; TDM Resource Center, 1996). Another study notes that ridesharing programs typically attract 5-15% of commute trips if they offer only information and encouragement, and 10-30% if they also offer financial incentives such as parking cash out or vanpool subsidies (York and Fabricatore, 2001).

Alternative Literature:

- Up to 1% reduction in VMT (if combined with two other strategies)

Per the Nelson\Nygaard report [2], ride-sharing would fall under the category of a minor TDM program strategy. The report allows a 1% reduction in VMT for projects with at least three minor strategies.

Alternative Literature References:

[2] Nelson\Nygaard, 2005. *Crediting Low-Traffic Developments* (p.12). http://www.montgomeryplanning.org/transportation/documents/TripGenerationAnalysisUsingURBEMIS.pdf

Criteron Planner/Engineers and Fehr & Peers Associates (2001). Index 4D Method. *A Quick-Response Method of Estimating Travel Impacts from Land-Use Changes*. Technical Memorandum prepared for US EPA, October 2001.

Other Literature Reviewed:

None

3.4.4 Implement Subsidized or Discounted Transit Program

Range of Effectiveness: 0.3 – 20.0% commute vehicle miles traveled (VMT) reduction and therefore a 0.3 – 20.0% reduction in commute trip GHG emissions.

Measure Description:

This project will provide subsidized/discounted daily or monthly public transit passes. The project may also provide free transfers between all shuttles and transit to participants. These passes can be partially or wholly subsidized by the employer, school, or development. Many entities use revenue from parking to offset the cost of such a project.

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of project employees eligible
- Transit subsidy amount
- Location of project site: low density suburb, suburban center, or urban location

Mitigation Method:

$$\% \text{ VMT Reduction} = A * B * C$$

Where

A = % reduction in commute vehicle trips (VT) (from [1])

B = % employees eligible

C = Adjustment from commute VT to commute VMT

Detail:

- A:

	Daily Transit Subsidy			
	$0.75	$1.49	$2.98	$5.96
Worksite Setting	**% Reduction in Commute VT**			
Low density suburb	**1.5%**	**3.3%**	**7.9%**	**20.0%***
Suburban center	**3.4%**	**7.3%**	**16.4%**	**20.0%***
Urban location	**6.2%**	**12.9%**	**20.0%***	**20.0%***
* Discounts greater than 20% will be capped, as they exceed levels recommended by TCRP 95 Draft Chapter 19 and other literature.				

- C: 1.0 (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] Nelson\Nygaard, 2010. *City of Santa Monica Land Use and Circulation Element EIR Report, Appendix – Santa Monica Luce Trip Reduction Impacts Analysis* (p.401).

[2] Nelson\Nygaard used the following literature sources: VTPI, Todd Litman, *Transportation Elasticities, http://www.vtpi.org/elasticities.pdf*. Comsis Corporation (1993), *Implementing Effective Travel Demand Management Measures: Inventory of Measures and Synthesis of Experience*, USDOT and Institute of Transportation Engineers (www.ite.org); www.bts.gov/ntl/DOCS/474.html.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[59]
CO_2e	0.3 - 20% of running
PM	0.3 - 20% of running
CO	0.3 - 20% of running
NOx	0.3 - 20% of running
SO_2	0.3 - 20% of running
ROG	0. 18 - 12% of total

[59] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Discussion:

This strategy is often part of a Commute Trip Reduction (CTR), another strategy documented separately (see TRT-1 and TRT-2). The Project Applicant should take care not to double count the impacts.

The literature evaluates this strategy in relation to the employer, but keep in mind that this strategy can also be implemented by a school or the development as a whole.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction ($0.75, low density suburb, 20% eligible) = 1.5% * 20% = 0.3%
- High Range % VMT Reduction ($5.96, urban, 100% eligible) = 20% * 100% = 20%

Preferred Literature:

Commute Vehicle Trip Reduction	**Daily Transit Subsidy**			
Worksite Setting	**$0.75**	**$1.49**	**$2.98**	**$5.96**
Low density suburb, rideshare oriented	0.1%	0.2%	0.6%	1.9%
Low density suburb, mode neutral	1.5%	3.3%	7.9%	21.7%*
Low density suburb, transit oriented	2.0%	4.2%	9.9%	23.2%*
Activity center, rideshare oriented	1.1%	2.4%	5.8%	16.5%
Activity center, mode neutral	3.4%	7.3%	16.4%	38.7%*
Activity center, transit oriented	5.2%	10.9%	23.5%*	49.7%*
Regional CBD/Corridor, rideshare oriented	2.2%	4.7%	10.9%	28.3%*
Regional CBD/Corridor, mode neutral	6.2%	12.9%	26.9%*	54.3%*
Regional CBD/Corridor, transit oriented	9.1%	18.1%	35.5%*	64.0%*

* Discounts greater than 20% will be capped, as they exceed levels recommended by *TCRP 95 Draft Chapter 19* and other literature.

Nelson\Nygaard (2010) updated a commute trip reduction table from VTPI Transportation Elasticities to account for inflation since the data was compiled. Data regarding commute vehicle trip reductions was originally from a study conducted by Comsis Corporation and the Institute of Transportation Engineers (ITE).

Alternative Literature:

Alternate:

- 2.4-30.4% commute vehicle trip reduction (VTR)

TCRP 95 Draft Chapter 19 [2] indicates transit subsidies in areas with good transit and restricted parking have a commute VTR of 30.4%; good transit but free parking, a commute VTR of 7.6%; free parking and limited transit 2.4%. Programs with transit subsidies have an average commute VTR of 20.6% compared with an average commute VTR of 13.1% for sites with non-transit fare subsidies.

Alternate:

- 0.03-0.12% annual greenhouse gas (GHG) reduction

Moving Cooler [3] assumed price elasticities of -0.15, -0.2, and -0.3 for lower fares 25%, 33%, and 50%, respectively. *Moving Cooler* assumes average vehicle occupancy of 1.43 and a VMT/trip of 5.12.

Alternative Literature References:

[2] Pratt, Dick. Personal Communication Regarding the Draft of TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies.

[3] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (Table D.3) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

Other Literature Reviewed:

None

3.4.5 Provide End of Trip Facilities

Range of Effectiveness: Grouped strategy (see TRT-1 through TRT-3)

Measure Description:

Non-residential projects will provide "end-of-trip" facilities for bicycle riders including showers, secure bicycle lockers, and changing spaces. End-of-trip facilities encourage the use of bicycling as a viable form of travel to destinations, especially to work. End-of-trip facilities provide the added convenience and security needed to encourage bicycle commuting.

End-of-trip facilities have minimal impacts when implemented alone. This strategy's effectiveness in reducing vehicle miles traveled (VMT) depends heavily on the suite of other transit, pedestrian/bicycle, and demand management measures offered. End-of-trip facilities should be grouped with Commute Trip Reduction (CTR) Programs (TRT-1 through TRT-2).

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

- 22% increase in bicycle mode share

The bicycle study documents a multivariate analysis of UK National Travel Survey (Wardman et al. 2007) which found significant impacts on bicycling to work. Compared to base bicycle mode share of 5.8% for work trips, outdoor parking would raise the share to 6.3%, indoor secure parking to 6.6%, and indoor parking plus showers to 7.1%. This results in an estimate 22% increase in bicycle mode share ((7.1%-5.8%)/5.8% = 22%). This suggests that such end of trip facilities have an important impact on the decision to bicycle to work. However, these effects represent reductions in VMT no greater than 0.02% (see Appendix C for calculation detail).

Alternate:

- 2 - 5% reduction in commute vehicle trips

The *Transportation Demand Management (TDM) Encyclopedia*, citing Ewing (1993), documents Sacramento's TDM ordinance. The City allows developers to claim trip reduction credits for worksite showers and lockers of 5% in central business districts, 2% within 660 feet of a transit station, and 2% elsewhere.

Alternate:

- 0.625% reduction in VMT

The *Center for Clean Air Policy (CCAP) Guidebook* attributes a 1% to 5% reduction associated with the use of bicycles, which reflects the assumption that their use is typically for shorter trips. Based on the *CCAP Guidebook*, a 2.5% reduction is allocated for all bicycle-related measures and a 1/4 of that for this measure alone. (This information is based on a TIAX review for SMAQMD).

Alternative Literature References:

[1] Pucher J., Dill, J., and Handy, S. *Infrastructure, Programs and Policies to Increase Bicycling: An International Review.* February 2010. (Table 2, pg. S111) http://policy.rutgers.edu/faculty/pucher/Pucher_Dill_Handy10.pdf

[2] Victoria Transportation Policy Institute (VTPI). *TDM Encyclopedia,* http://www.vtpi.org/tdm/tdm9.htm; accessed 3/4/2010; last update 1/25/2010). VTPI citing: Reid Ewing (1993), "TDM, Growth Management, and the Other Four Out of Five Trips," *Transportation Quarterly*, Vol. 47, No. 3, Summer 1993, pp. 343-366.

[3] Center for Clean Air Policy (CCAP), *CCAP Transportation Emission Guidebook*. http://www.ccap.org/safe/guidebook/guide_complete.html; TIAX Results of 2005 Literature Search Conducted by TIAX on behalf of SMAQMD

Other Literature Reviewed:

None

3.4.6 Encourage Telecommuting and Alternative Work Schedules

Range of Effectiveness: 0.07 – 5.50% commute vehicle miles traveled (VMT) reduction and therefore 0.07 – 5.50% reduction in commute trip GHG emissions.

Measure Description:

Encouraging telecommuting and alternative work schedules reduces the number of commute trips and therefore VMT traveled by employees. Alternative work schedules could take the form of staggered starting times, flexible schedules, or compressed work weeks.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for retail, office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of employees participating (1 – 25%)
- Strategy implemented: 9-day/80-hour work week, 4-day/40-hour work week, or 1.5 days of telecommuting

Mitigation Method:

% Commute VMT Reduction = Commute

Where

Commute = % reduction in commute VMT (See table below)

	Employee Participation				
	1%	**3%**	**5%**	**10%**	**25%**
	% Reduction in Commute VMT				
9-day/80-hour work week	0.07%	0.21%	0.35%	0.70%	1.75%
4-day/40-hour work week	0.15%	0.45%	0.75%	1.50%	3.75%
telecommuting 1.5 days	0.22%	0.66%	1.10%	2.20%	5.5%

Source: Moving Cooler Technical Appendices, Fehr & Peers

Notes: The percentages from Moving Cooler incorporate a discount of 25% for rebound effects. The percentages beyond 1% employee participation are linearly extrapolated.

Assumptions:

Data based upon the following references:

[1] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (p. B-54) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[60]
CO_2e	0.07 – 5.50% of running
PM	0.07 – 5.50% of running
CO	0.07 – 5.50% of running
NOx	0.07 – 5.50% of running
SO_2	0.07 – 5.50% of running
ROG	0.04 – 3.3% of total

Discussion:

This strategy is often part of a Commute Trip Reduction Program, another strategy documented separately (see TRT-1 and TRT-2). The Project Applicant should take care not to double count the impacts.

The employee participation rate should be capped at a maximum of 25%. *Moving Cooler* [1] notes that roughly 50% of a typical workforce could participate in alternative

▪ [60] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

work schedules (based on job requirements) and roughly 50% of those would choose to participate.

The 25% discount for rebound effects is maintained to provide a conservative estimate and support the literature results. The project may consider removing this discount from their calculations if deemed appropriate.

Example:

N/A – no calculations are needed.

Preferred Literature:

- 0.07% - 0.22% reduction in commuting VMT

Moving Cooler [1] estimates that if 1% of employees were to participate in a 9 day/80 hour compressed work week, commuting VMT would be reduced by 0.07%. If 1% of employees were to participate in a 4 day/40 hour compressed work week, commuting VMT would reduce by 0.15%; and 1% of employees participating in telecommuting 1.5 days per week would reduce commuting VMT by 0.22%. These percentages incorporate a discounting of 25% to account for rebound effects (i.e., travel for other purposes during the day while not at the work site). The percentages beyond 1% employee participation are linearly extrapolated (see table above).

Alternative Literature:

Alternate:

- 9-10% reduction in VMT for participating employees

As documented in *TCRP 95 Draft Chapter 19* [2], a Denver federal employer's implementation of compressed work week resulted in a 14-15% reduction in VMT for participating employees. This is equivalent to the 0.15% reduction for each 1% participation cited in the preferred literature above. In the Denver example, there was a 65% participation rate out of a total of 9,000 employees. *TCRP 95* states that the compressed work week experiment has no adverse effect on ride-sharing or transit use. Flexible hours have been shown to work best in the presence of medium or low transit availability.

Alternate:

- 0.5 vehicle trips reduced per employee per week
- 13 – 20 VMT reduced per employee per week

As documented in *TCRP 95 Draft Chapter 19* [2], a study of compressed work week for 2,600 Southern California employees resulted in an average reduction of 0.5 trips per week (per participating employee). Participating employees also reduced their VMT by 13-20 miles per week. This translates to a reduction of between 5% and 10% in commute VMT, and so is lower than the 15% reduction cited for Denver government employees.

Alternative Literature References:

[2] Pratt, Dick. Personal Communication Regarding the Draft of TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies.

Other Literature Reviewed:

None

3.4.7 Implement Commute Trip Reduction Marketing

Range of Effectiveness: 0.8 – 4.0% commute vehicle miles traveled (VMT) reduction and therefore 0.8 – 4.0% reduction in commute trip GHG emissions.

Measure Description:

The project will implement marketing strategies to reduce commute trips. Information sharing and marketing are important components to successful commute trip reduction strategies. Implementing commute trip reduction strategies without a complementary marketing strategy will result in lower VMT reductions. Marketing strategies may include:

- New employee orientation of trip reduction and alternative mode options
- Event promotions
- Publications

CTR marketing is often part of a CTR program, voluntary or mandatory. CTR marketing is discussed separately here to emphasis the importance of not only providing employees with the options and monetary incentives to use alternative forms of transportation, but to clearly and deliberately promote and educate employees of the various options. This will greatly improve the impact of the implemented trip reduction strategies.

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context
- Appropriate for residential, retail, office, industrial and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled
$EF_{running}$ = emission factor for running emissions

Inputs:
The following information needs to be provided by the Project Applicant:

- Percentage of project employees eligible (i.e. percentage of employers choosing to participate)

Mitigation Method:

% Commute VMT Reduction = A * B * C

Where

A = % reduction in commute vehicle trips (from [1])
B = % employees eligible
C = Adjustment from commute VT to commute VMT

Detail:
- A: 4% (per [1])
- C: 1.0 (see Appendix C for detail)

Assumptions:
Data based upon the following references:

[1] Pratt, Dick. Personal communication regarding the *Draft of TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies.* Transit Cooperative Research Program.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[61]
CO_2e	0.8 – 4.0% of running
PM	0.8 – 4.0% of running
CO	0.8 – 4.0% of running
NOx	0.8 – 4.0% of running
SO_2	0.8 – 4.0% of running
ROG	0.5 – 2.4% of total

[61] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Discussion:

The effectiveness of commute trip reduction marketing in reducing VMT depends on which commute reduction strategies are being promoted. The effectiveness levels provided below should only be applied if other programs are offered concurrently, and represent the total effectiveness of the full suite of measures.

This strategy is often part of a CTR Program, another strategy documented separately (see strategy T# E1). Take care not to double count the impacts.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (20% eligible) = 4% * 20% = 0.8%
- High Range % VMT Reduction (100% eligible) = 4% * 100% = 4.0%

Preferred Literature:

- 4-5% commute vehicle trips reduced with full-scale employer support

TCRP 95 Draft Chapter 19 notes the average empirically-based estimate of reductions in vehicle trips for full-scale, site-specific employer support programs alone is 4-5%. This effectiveness assumes there are alternative commute modes available which have on-going employer support. For a program to receive credit for such outreach and marketing efforts, it should contain guarantees that the program will be maintained permanently, with promotional events delivered regularly and with routine performance monitoring.

Alternative Literature:

- 5-15% reduction in commute vehicle trips
- 3% increase in effectiveness of marketed transportation demand management (TDM) strategies

VTPI [2] notes that providing information on alternative travel modes by employers was one of the most important factors contributing to mode shifting. One study (Shadoff,1993) estimates that marketing increases the effectiveness of other TDM strategies by up to 3%. Given adequate resources, marketing programs may reduce vehicle trips by 5-15%. The 5 – 15% range comes from a variety of case studies across the world. U.S. specific case studies include: 9% reduction in vehicle trips with TravelSmart in Portland (12% reduction in VMT), 4-8% reduction in vehicle trips from four cities with individualized marketing pilot projects from the Federal Transit Administration (FTA). Averaged across the four pilot projects, there was a 6.75% reduction in VMT.

Alternative Literature References:

[2] VTPI, TDM Encyclopedia – TDM Marketing; http://www.vtpi.org/tdm/tdm23.htm; accessed 3/5/2010. Table 7 (citing FTA, 2006)

Other Literature Reviewed:

None

3.4.8 Implement Preferential Parking Permit Program

Range of Effectiveness: Grouped strategy (see TRT-1 through TRT-3)

Measure Description:

The project will provide preferential parking in convenient locations (such as near public transportation or building front doors) in terms of free or reduced parking fees, priority parking, or reserved parking for commuters who carpool, vanpool, ride-share or use alternatively fueled vehicles. The project will provide wide parking spaces to accommodate vanpool vehicles.

The impact of preferential parking permit programs has not been quantified by the literature and is likely to have negligible impacts when implemented alone. This strategy should be grouped with Commute Trip Reduction (CTR) Programs (TRT-1 and TRT-2) as a complementary strategy for encouraging non-single occupant vehicle travel.

Measure Applicability:

- Urban, suburban context
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

No quantitative results are available. The case study in the literature implemented a preferential parking permit program as a companion strategy to a comprehensive TDM program. Employees who carpooled at least three times a week qualified to use the spaces.

Alternative Literature References:

[1] Transportation Demand Management Institute of the Association for Commuter Transportation. *TDM Case Studies and Commuter Testimonials*. Prepared for the US EPA. 1997. http://www.epa.gov/OMS/stateresources/rellinks/docs/tdmcases.pdf

Other Literature Reviewed:

None

3.4.9 Implement Car-Sharing Program

Range of Effectiveness: 0.4 – 0.7% vehicle miles traveled (VMT) reduction and therefore 0.4 – 0.7% reduction in GHG emissions.

Measure Description:

This project will implement a car-sharing project to allow people to have on-demand access to a shared fleet of vehicles on an as-needed basis. User costs are typically determined through mileage or hourly rates, with deposits and/or annual membership fees. The car-sharing program could be created through a local partnership or through one of many existing car-share companies. Car-sharing programs may be grouped into three general categories: residential- or citywide-based, employer-based, and transit station-based. Transit station-based programs focus on providing the "last-mile" solution and link transit with commuters' final destinations. Residential-based programs work to substitute entire household based trips. Employer-based programs provide a means for business/day trips for alternative mode commuters and provide a guaranteed ride home option.

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Urban or suburban context

Mitigation Method:

% VMT Reduction = A * B / C

Where
A = % reduction in car-share member annual VMT (from the literature)
B = number of car share members per shared car (from the literature)
C = deployment level based on urban or suburban context

Detail:

- A: 37% *(per [1])*
- B: 20 *(per [2])*
- C:

Project setting	1 shared car per X population
Urban	1,000
Suburban	2,000
Source: *Moving Cooler*	

Assumptions:

Data based upon the following references:

[1] Millard-Ball, Adam. "Car-Sharing: Where and How it Succeeds," (2005) Transit Cooperative Research Program (108). P. 4-22
[2] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (p. B-52, Table D.3) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendices_Complete_102209.pdf

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[62]
CO_2e	0.4 – 0.7% of running
PM	0.4 – 0.7% of running
CO	0.4 – 0.7% of running
NOx	0.4 – 0.7% of running
SO_2	0.4 – 0.7% of running
ROG	0.24 – 0.42% of total

▪ [62] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Discussion:

Variable C in the mitigation method section represents suggested levels of deployment based on the literature. Levels of deployment may vary based on the characteristics of the project site and the needs of the project residents and employees. This variable should be adjusted accordingly.

The methodology for calculation of VMT reduction utilizes *Moving Cooler's* rule of thumb[63] for the estimated number of car share members per vehicle. An estimate of 50% reduction in car-share member annual VMT (from *Moving Cooler*) was high compared to other literature sources, and *TCRP 108's* 37% reduction was used in the calculations instead.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (suburban) = 37% * 20 / 2000 = 0.4%
- High Range % VMT Reduction (urban) = 37% * 20 / 1000 = 0.7%

Preferred Literature:

- 37% reduction in car-share member VMT

The *TCRP 108* [1] report conducted a survey of car-share members in the United States and Canada in 2004. The results of the survey showed that respondents, on average, drove only 63% of the average mileage they previously drove when not car-share members.

Alternative Literature:

Alternate – Residential or Citywide Based:

- 0.05-0.27% reduction in GHG
- 0.33% reduction in VMT in urban areas

Moving Cooler [2] assumed an aggressive deployment of one car per 2,000 inhabitants of medium-density census tracks and of one car per 1,000 inhabitants of high-density census tracks. This strategy assumes providing a subsidy to a public, private, or nonprofit car-sharing organization and providing free or subsidized lease for usage of public street parking. *Moving Cooler* assumed 20 members per shared car and 50% reduction in VMT per equivalent car. The percent reduction calculated assumes a percentage of urban areas are low, medium, and high density, thus resulting in a lower

▪ [63] See discussion in Alternative Literature section for "rule of thumb" detail.

than expected reduction in VMT assuming an aggressive deployment in medium and high density areas.

Alternate – Transit Station and Employer Based:

- 23-44% reduction in drive-alone mode share
- Average daily VMT reduction of 18 – 23 miles

TCRP 95 Draft Chapter 19 [3] looked at two demonstrations, CarLink I and CarLink II, in the San Francisco Bay Area. CarLink I ran from January to November 1999. It involved 54 individuals and 12 rental cars stationed at the Dublin-Pleasanton BART station. CarLink II ran from July 2001 to June 2002 and involved 107 individuals and 19 rental cars. CarLink II was based in Palo Alto in conjunction with Caltrain commuter rail service and several employers in the Stanford Research Park. Both CarLink demonstrations were primarily targeted for commuters. CarLink I had a 23% increase in rail mode share, a reduction in drive-alone mode share of 44%, and a decrease in Average Daily VMT of 18 miles. CarLink II had a VMT for round-trip commuters decrease of 23 miles per day and a mode share for drive alone decrease of 22.9%.

Alternate:

- 50% reduction in driving for car-share members

A UC Berkeley study of San Francisco's City CarShare [4] found that members drive nearly 50% less after joining. The study also found that when people joined the car-sharing organization, nearly 30% reduced their household vehicle ownership and two-thirds avoided purchasing another car. The UC Berkeley study found that almost 75% of vehicle trips made by car-sharing members were for social trips such as running errands and visiting friends. Only 25% of trips were for commuting to work or for recreation. Most trips were also made outside of peak periods. Therefore, car-sharing may generate limited impact on peak period traffic.

Alternative Literature References:

[3] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (p. B-52, Table D.3) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendices_Complete_102209.pdf

[4] Pratt, Dick. *Personal Communication Regarding the Draft of TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies.* Transit Cooperative Research Program.

Cervero, Robert and Yu-Hsin Tsai. *San Francisco City CarShare: Travel-Demand Trends and Second-Year Impacts,* 2005. (Figure 7, p. 35, Table 7, Table 12) http://escholarship.org/uc/item/4f39b7b4

Other Literature Reviewed:

None

3.4.10 Implement a School Pool Program

Range of Effectiveness: 7.2 – 15.8% school vehicle miles traveled (VMT) Reduction and therefore 7.2 – 15.8% reduction in school trip GHG emissions.

Measure Description:

This project will create a ridesharing program for school children. Most school districts provide bussing services to public schools only. SchoolPool helps match parents to transport students to private schools, or to schools where students cannot walk or bike but do not meet the requirements for bussing.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for residential and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Degree of implementation of SchoolPool Program(moderate to aggressive)

Mitigation Method:

$$\% \text{ VMT Reduction} = \text{Families} * B$$

Where

Families = % families that participate (from [1] and [2])

B = adjustments to convert from participation to daily VMT to annual school VMT

Detail:

- Families: 16% (moderate implementation), 35% (aggressive implementation), (from [1] and [2])
- B: 45% (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] Transportation Demand Management Institute of the Association for Commuter Transportation. *TDM Case Studies and Commuter Testimonials*. Prepared for the US EPA. 1997. (p. 10, 36-38) http://www.epa.gov/OMS/stateresources/rellinks/docs/tdmcases.pdf

[2] Denver Regional Council of Governments (DRCOG). *Survey of Schoolpool Participants, April 2008.* http://www.drcog.org/index.cfm?page=SchoolPool. Obtained from Schoolpool Coordinator, Mia Bemelen.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[64]
CO_2e	7.2 – 15.8% of running
PM	7.2 – 15.8% of running
CO	7.2 – 15.8% of running
NOx	7.2 – 15.8% of running
SO_2	7.2 – 15.8% of running
ROG	4.3 – 9.5% of total

Discussion:

This strategy reflects the findings from only one case study.

Example:

Sample calculations are provided below:

- Low Range % School VMT Reduction (moderate implementation) = 16% * 45% = 7.2%
- High Range % School VMT Reduction (aggressive implementation) = 35% * 45% = 15.8%

▪ [64] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Preferred Literature:

- 7,711 – 18,659 daily VMT reduction

As presented in the TDM Case Studies [1] compilation, the SchoolPool program in Denver saved 18,659 VMT per day in 1995, compared with 7,711 daily in 1994 – a 142% increase. The Denver Regional Council of Governments (DRCOG) [2] enrolled approximately 7,000 families and 32 private schools in the program. The DRCOG staff surveyed a school or interested families to collect home location and schedules of the students. The survey also identified prospective drivers. DRCOG then used carpool-matching software and GIS to match families. These match lists were sent to the parents for them to form their own school pools. 16% of families in the database formed carpools. The average carpool carried 3.1 students.

The SchoolPool program is still in effect and surveys are conducted every few years to monitor the effectiveness of the program. The latest survey report received was in 2008. The report showed that the participant database had increased to over 10,000 families, an 18% increase from 2005. 29% of participants used the list to form a school carpool. This percentage was lower than 35% in 2005 but higher than prior to 2005, at 24%. The average number of families in each carpool ranged from 2.1 prior to 2005 to 2.8 in 2008. The average number of carpool days per week was roughly 4.7. The number of school weeks per year was 39. Per discussions with the Schoolpool Coordinator, a main factor of success was establishing a large database. This was achieved by having parents opt-out of the database versus opting-in.

Alternative Literature:

None

Alternative Literature References:

None

Other Literature Reviewed:

None

3.4.11 Provide Employer-Sponsored Vanpool/Shuttle

Range of Effectiveness: 0.3 – 13.4% commute vehicle miles traveled (VMT) reduction and therefore 0.3 – 13.4% reduction in commute trip GHG emissions.

Measure Description:

This project will implement an employer-sponsored vanpool or shuttle. A vanpool will usually service employees' commute to work while a shuttle will service nearby transit stations and surrounding commercial centers. Employer-sponsored vanpool programs entail an employer purchasing or leasing vans for employee use, and often subsidizing the cost of at least program administration, if not more. The driver usually receives personal use of the van, often for a mileage fee. Scheduling is within the employer's purview, and rider charges are normally set on the basis of vehicle and operating cost.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled
$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of employees eligible

Mitigation Method:

$$\% \text{ VMT Reduction} = A * B * C$$

Where
A = % shift in vanpool mode share of commute trips (from [1])
B = % employees eligible
C = adjustments from vanpool mode share to commute VMT

Detail:

- A: 2-20% annual reduction in vehicle mode share (*from [1]*)
  - Low range: low degree of implementation, smaller employers
  - High range: high degree of implementation, larger employers
- C: 0.67 (See Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] TCRP Report 95. *Chapter 5: Vanpools and Buspools - Traveler Response to Transportation System Changes.* http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c5.pdf. (p.5-8)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[65]
CO_2e	0.3 – 13.4% of running
PM	0.3 – 13.4% of running
CO	0.3 – 13.4% of running
NOx	0.3 – 13.4% of running
SO_2	0.3 – 13.4% of running
ROG	0.18 – 8.0% of total

Discussion:

Vanpools are generally more successful with the largest of employers, as large employee counts create the best opportunities for employees to find a suitable number of travel companions to form a vanpool. In the San Francisco Bay Area several large companies (such as Google, Apple, and Genentech) provide regional bus transportation for their employees. No specific studies of these large buspools were identified in the literature. However, the GenenBus serves as a key element of the overall commute trip reduction (CTR) program for Genentech, as discussed in the CTR Program – Required strategy.

This strategy is often part of a CTR Program, another strategy documented separately (see strategy T# E1). Take care not to double count the impacts.

Example:

Sample calculations are provided below:

[65] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

- Low Range % VMT Reduction (low implementation/small employer, 20% eligible) = 2% * 20% * 0.67 = 0.3%
- High Range % VMT Reduction (high implementation/large employer, 100% eligible) = 20% * 100% * 0.67 = 13.4%

Preferred Literature:

- 2-20% vanpool mode share

TCRP Report 95 [1] notes that vanpools can capture 2 to 20% mode share. This range can be attributed to differences in programs, access to high-occupancy vehicle (HOV) lanes, and geographic range. The *TCRP Report* highlights a case study of the 3M Corporation, which with the implementation of a vanpooling program saw drive alone mode share decrease by 10 percentage points and vanpooling mode share increase to 7.8 percent. The *TCRP Report* notes most vanpools programs do best where one-way trip lengths exceed 20 miles, where work schedules are fixed and regular, where employer size is sufficient to allow matching of 5 to 12 people from the same residential area, where public transit is inadequate, and were some congestion or parking problems exist.

Alternative Literature:

In *TDM Case Studies* [2], a case study of Kaiser Permanente Hospital has shown their employer-sponsored shuttle service eliminated 380,100 miles per month, or nearly 4 million miles of travel per year, and four tons of smog precursors annually.

Alternative Literature References:

[2] Transportation Demand Management Institute of the Association for Commuter Transportation. *TDM Case Studies and Commuter Testimonials*. Prepared for the US EPA. 1997. http://www.epa.gov/OMS/stateresources/rellinks/docs/tdmcases.pdf

Other Literature Reviewed:

None

3.4.12 Implement Bike-Sharing Programs

Range of Effectiveness: Grouped strategy (see SDT-5 and LUT-9)

Measure Description:

This project will establish a bike sharing program. Stations should be at regular intervals throughout the project site. The number of bike-share kiosks throughout the project area should vary depending on the density of the project and surrounding area. Paris' bike-share program places a station every few blocks throughout the city (approximately 28 bike stations/square mile). Bike-station density should increase around commercial and transit hubs.

Bike sharing programs have minimal impacts when implemented alone. This strategy's effectiveness is heavily dependent on the location and context. Bike-sharing programs have worked well in densely populated areas (examples in Barcelona, London, Lyon, and Paris) with existing infrastructure for bicycling. Bike sharing programs should be combined with **Bike Lane Street Design (SDT-5)** and **Improve Design of Development (LUT-9)**.

Taking evidence from the literature, a 135-300% increase in bicycling (of which roughly 7% are shifting from vehicle travel) results in a negligible impact (around 0.03% vehicle miles traveled (VMT) reduction (see Appendix C for calculations)).

Measure Applicability:

- Urban and suburban-center context only
- Negligible in a rural context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Alternative Literature:

Alternate:

The International Review [1] found bike mode share increases:

- from 0.75% in 2005 to 1.76% in 2007 in Barcelona (Romero, 2008) (135% increase)
- From 1% in 2001 to 2.5% in 2007 in Paris (Nadal, 2007; City of Paris, 2007) (150% increase)
- From 0.5% in 1995 to 2% in 2006 in Lyon (Bonnette, 2007; Velo'V, 2009) (300% increase)

London [2] is the only study that reports the breakdown of the prior mode In London: 6% of users reported shifting from driving, 34% from transit, 23% said they would not have travelled (Noland and Ishaque, 2006). Additionally, 68% of the bike trips were for leisure or recreation. Companion strategies included concurrent improvements in bicycle facilities.

The London program was implemented west of Central London in a densely populated area, mainly residential, with several employment centers. A relatively well developed bike network existed, including over 1,000 bike racks. The program implemented 25 locker stations with 70 bikes total.

Alternate:

- 1/3 vehicle trip reduced per day per bicycle (1,000 vehicle trips reduced per day in Lyon)

The Bike Share Opportunities [3] report looks at two case studies of bike-sharing implementation in France. In Lyon, the 3,000 bike-share system shifts 1,000 car trips to bicycle each day. Surveys indicate that 7% of the bike share trips would have otherwise been made by car. Lyon saw a 44% increase in bicycle riding within the first year of their program while Paris saw a 70% increase in bicycle riding and a 5% reduction in car use and congestion within the first year and a half of their program. The Bike Share Opportunities report found that population density is an important part of a successful program. Paris' bike share subscription rates range between 6% and 9% of the total population. This equates to an average of 75,000 rentals per day. The effectiveness of bike share programs at sub-city scales are not addressed in the literature.

Alternative Literature References:

[1] Pucher J., Dill, J., and Handy, S. Infrastructure, Programs and Policies to Increase Bicycling: An International Review. February 2010. (Table 4)

[2] Noland, R.B., Ishaque, M.M., 2006. "Smart Bicycles in an urban area: Evaluation of a pilot scheme in London." *Journal of Public Transportation*. 9(5), 71-95. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.117.8173&rep=rep1&type=pdf#page=76

[3] NYC Department of City Planning, *Bike-Share Opportunities in New York City,* 2009. (p. 11, 14, 24, 68) http://www.nyc.gov/html/dcp/html/transportation/td_bike_share.shtml

Other Literature Reviewed:

None

3.4.13 Implement School Bus Program

Measure Effectiveness Range: 38 – 63% School VMT Reduction and therefore 38 – 63% reduction in school trip GHG emissions[66]

Measure Description:

The project will work with the school district to restore or expand school bus services in the project area and local community.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for residential and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of families expected to use/using school bus program

Mitigation Method:

$$\%\ VMT\ Reduction = A * B$$

Where

A = % families expected to use/using school bus program

B = adjustments to convert from participation to school day VMT to annual school VMT

[66] Transit vehicles may also result in increases in emissions that are associated with electricity production or fuel use. The Project Applicant should consider these potential additional emissions when estimating mitigation for these measures.

Detail:

- A: a typical range of 50 – 84% (see discussion section)
- B: 75% (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] JD Franz Research, Inc.; *Lamorinda School Bus Program, 2003 Parent Survey, Final Report;* January 2004; obtained from Juliet Hansen, Program Manager. (p. 5)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[67]
CO_2e	38 – 63% of running
PM	38 – 63% of running
CO	38 – 63% of running
NOx	38 – 63% of running
SO_2	38 – 63% of running
ROG	23 – 38% of total

Discussion:

The literature presents a high range of effectiveness showing 84% participation by families. 50% is an estimated low range assuming the project has a minimum utilization goal. Note that the literature presents results from a single case study.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (50% participation) = 50% * 75% = 38%
- High Range % VMT Reduction (85% participation) = 84% * 75% = 63%

Preferred Literature:

- 84% penetration rate
- 2,451 – 2,677 daily vehicle trips reduced
- 441,180 – 481,860 annual vehicle trips reduced

[67] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

The Lamorinda School Bus Program was implemented to reduce traffic congestion in the communities of Lafayette, Orinda, and Moraga, California. In 2003, a parent survey was conducted to determine the extent to which the program diverted or eliminated vehicle trips. This survey covered a representative sample of all parents (not just those signed up for the school bus program). The range of morning trips prevented is 1,266 to 1,382; the range of afternoon trips prevented is 1,185 to 1,295. Annualized, the estimated total trip prevention is between 441,180 to 481,860. 83% of parents surveyed reported that their child usually rides the bus to school in the morning. 84% usually rode the bus back home in the afternoons. The data came from surveys and the results are unique to the location and extent of the program. The report did not indicate the number of school buses in operation during the time of the survey.

Alternative Literature:

None

Alternative Literature References:

None

Other Literature Reviewed:

None

3.4.14 Price Workplace Parking

Range of Effectiveness: 0.1 – 19.7% commute vehicle miles traveled (VMT) reduction and therefore 0.1 -19.7% reduction in commute trip GHG emissions.

Measure Description:

The project will implement workplace parking pricing at its employment centers. This may include: explicitly charging for parking for its employees, implementing above market rate pricing, validating parking only for invited guests, not providing employee parking and transportation allowances, and educating employees about available alternatives.

Though similar to the Employee Parking "Cash-Out" strategy, this strategy focuses on implementing market rate and above market rate pricing to provide a price signal for employees to consider alternative modes for their work commute.

Measure Applicability:

- Urban and suburban context
- Negligible impact in a rural context
- Appropriate for retail, office, industrial, and mixed-use projects
- Reductions applied only if complementary strategies are in place:
  - Residential parking permits and market rate public on-street parking - to prevent spill-over parking
  - Unbundled parking - is not required but provides a market signal to employers to transfer over the, now explicit, cost of parking to the employees. In addition, unbundling parking provides a price with which employers can utilize as a means of establishing workplace parking prices.

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Location of project site: low density suburb, suburban center, or urban location
- Daily parking charge ($1 - $6)
- Percentage of employees subject to priced parking

Mitigation Method:

% VMT Reduction = A * B

Where

A = Percentage reduction in commute VMT (from [1] and [2])

B = Percent of employees subject to priced parking

Detail:

- A:

Project Location	Daily Parking Charge			
	$1	$2	$3	$6
Low density suburb	0.5%	1.2%	1.9%	2.8%
Suburban center	1.8%	3.7%	5.4%	6.8%
Urban Location	6.9%	12.5%	16.8%	19.7%
Moving Cooler, VTPI, Fehr & Peers. Note: 2009 dollars.				

Assumptions:

Data based upon the following references:

[1] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (Table 5.13, Table D.3) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendices_Complete_102209.pdf

[2] VTPI, Todd Litman, *Transportation Elasticities,*(Table 15) *http://www.vtpi.org/elasticities.pdf.*

Comsis Corporation (1993), *Implementing Effective Travel Demand Management Measures: Inventory of Measures and Synthesis of Experience*, USDOT and Institute of Transportation Engineers (www.ite.org); www.bts.gov/ntl/DOCS/474.html.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[68]
CO_2e	0.1 – 19.7% of running
PM	0.1 – 19.7% of running
CO	0.1 – 19.7% of running
NOx	0.1 – 19.7% of running
SO_2	0.1 – 19.7% of running
ROG	0.06 – 11.8% of total

Discussion:

Priced parking can result in parking spillover concerns. The highest VMT reductions should be given only with complementary strategies such as parking time limits or neighborhood parking permits are in place in surrounding areas.

Example:

Sample calculations are provided below:

- Low Range % Commute VMT Reduction (low density suburb, $1/day, 20% priced) = 0.5% * 20% = 0.1%
- High Range % Commute VMT Reduction (urban, $6/day, 100% priced) = 19.7% * 100% = 19.7%

Preferred Literature:

The table above (variable A) was calculated using the percent commute VMT reduction from *Moving Cooler* (0.5% - 6.9% reduction for $1/day parking charge). The percentage reductions for $2 - $6 / day parking charges were extrapolated by multiplying the *Moving Cooler* percentages with the ratios from the VTPI table below (percentage increases). For example, to obtain a percent VMT reduction for a $6/day parking charge for a low density suburb, 0.5% * ((36.1%-6.5%) /6.5%) = 2.3%. The methodology was utilized to capture the non-linear effect of parking charges on trip reduction (VTPI) while maintaining a conservative estimate of percent reductions (*Moving Cooler*).

Preferred:

- 0.5-6.9% reduction in commuting VMT
- 0.44-2.07% reduction in greenhouse gas (GHG) emissions

[68] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Moving Cooler Technical Appendices indicate that increasing employee parking costs $1 per day ($0.50 per vehicle for carpool and free for vanpools) can reduce GHG between 0.44% and 2.07% and reduce commuting VMT between 0.5% and 6.9%. The reduction in GHG varies based on how extensive the implementation of the program is. The reduction in commuting VMT differs for type of urban area as shown in the table below. Please note that these numbers are independent of results for employee parking cash-out strategy (discussed in its own fact sheet).

		Percent Change in Commuting VMT					
Strategy	Description	Large Metropolitan (higher transit use)	Large Metropolitan (lower transit use)	Medium Metro (higher)	Medium Metro (lower)	Small Metro (higher)	Small Metro (lower)
Parking Charges	Parking charge of $1/day	6.9%	0.9%	1.8%	0.5%	1.3%	0.5%
Source: *Moving Cooler*							

Preferred:

Commute Vehicle trip reduction	**Daily Parking Charges**			
Worksite Setting	**$0.75**	**$1.49**	**$2.98**	**$5.96**
Suburb	6.5%	15.1%	25.3%*	36.1%*
Suburban Center	12.3%	25.1%*	37.0%*	46.8%*
Central Business District	17.5%	31.8%*	42.6%*	50.0%*
Source: VTPI [2]				

* Discounts greater than 20% should be capped, as they exceed levels recommended by *TCRP 95* and other literature.

The reduction in commute trips varies by parking fee and worksite setting [2]. For daily parking fees between $1.49 and $5.96, worksites set in low-density suburbs could decrease vehicle trips by 6.5-36.1%, worksites set in activity centers could decrease vehicle trips by 12.3-46.8%, and worksites set in regional central business districts could decrease vehicles by 17.5-50%. (Note that adjusted parking fees (from 1993 dollars to 2009 dollars) were used. Adjustments were taken from the *Santa Monica General Plan EIR Report, Appendix*, Nelson\Nygaard).

Alternative Literature:

Alternate:

- 1 percentage point reduction in auto mode share
- 12.3% reduction in commute vehicle trips

TCRP 95 Draft Chapter 19 [4] found that an increase of $8 per month in employee parking charges was necessary to decrease employee SOV mode split rates by one percentage point. *TCRP 95* compared 82 sites with TDM programs and found that programs with parking fees have an average commute vehicle trip reduction of 24.6%, compared with 12.3% for sites with free parking.

Alternate:

- 1% reduction in VMT ($1 per day charge)
- 2.6% reduction in VMT ($3 per day charge)

The Deakin, et al. report [5] for the California Air Resources Board (CARB) analyzed transportation pricing measures for the Los Angeles, Bay Area, San Diego, and Sacramento metropolitan areas.

Alternative Literature References:

[4] Pratt, Dick. Personal Communication Regarding the Draft of TCRP 95 Traveler Response to Transportation System Changes – Chapter 19 Employer and Institutional TDM Strategies. (Table 19-9)

[5] Deakin, E., Harvey, G., Pozdena, R., and Yarema, G., 1996. *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts.* Final Report. Prepared for California Air Resources Board (CARB), Sacramento, CA (Table 7.2)

Other Literature Reviewed:

None

3.4.15 Implement Employee Parking "Cash-Out"

Range of Effectiveness: 0.6 – 7.7% commute vehicle miles traveled (VMT) reduction and therefore 0.6 – 7.7% reduction in commute trip GHG emissions

Measure Description:

The project will require employers to offer employee parking "cash-out." The term "cash-out" is used to describe the employer providing employees with a choice of forgoing their current subsidized/free parking for a cash payment equivalent to the cost of the parking space to the employer.

Measure Applicability:

- Urban and suburban context
- Not applicable in a rural context
- Appropriate for retail, office, industrial, and mixed-use projects
- Reductions applied only if complementary strategies are in place:
  - Residential parking permits and market rate public on-street parking -to prevent spill-over parking
  - Unbundled parking - is not required but provides a market signal to employers to forgo paying for parking spaces and "cash-out" the employee instead. In addition, unbundling parking provides a price with which employers can utilize as a means of establishing "cash-out" prices.

Baseline Method:

See introduction section.

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage of employees eligible
- Location of project site: low density suburb, suburban center, or urban location

Mitigation Method:

$$\% \text{ VMT Reduction} = A * B$$

Where

A = % reduction in commute VMT (from the literature)

B = % of employees eligible

CEQA# **MM T-9**
MP# **TR-5.3**

TRT-15 Commute Trip Reduction

Detail:

- A: Change in Commute VMT: 3.0% (low density suburb), 4.5% (suburban center), 7.7% (urban) change in commute VMT (source: Moving Cooler)

Assumptions:

Data based upon the following references:

- Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (Table 5.13, Table D.3) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[69]
CO_2e	0.6 – 7.7% of running
PM	0.6 – 7.7% of running
CO	0.6 – 7.7% of running
NOx	0.6 – 7.7% of running
SO_2	0.6 – 7.7% of running
ROG	0.36 – 4.62% of running

Discussion:

Please note that these estimates are independent of results for workplace parking pricing strategy (see strategy number T# E5 for more information).

If work site parking is not unbundled, employers cannot utilize this unbundled price as a means of establishing “cash-out” prices. The table below shows typical costs for parking facilities in large urban and suburban areas in the US. This can be utilized as a reference point for establishing reasonable “cash-out” prices. Note that the table does not include external costs to parking such as added congestion, lost opportunity cost of land devoted to parking, and greenhouse gas (GHG) emissions.

	Structured (urban)	Surface (suburban)
Land (Annualized)	$1,089	$215
Construction (Annualized)	$2,171	$326

[69] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

O & M Costs	$575	$345
Annual Total	$3,835	$885
Monthly Costs	$320	$74
Source: VTPI, *Transportation Costs and Benefit Analysis II – Parking Costs*, April 2010 (p.5.4-10)		

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (low density suburb and 20% eligible) = 3% * 0.2 = 0.6%
- High Range % VMT Reduction (urban and 100% eligible) = 7.7% * 1 = 7.7%

Preferred Literature:

- 0.44% - 2.07% reduction in GHG emissions
- 3.0% - 7.7% reduction in commute VMT

Moving Cooler Technical Appendices indicate that reimbursing "cash-out" participants $1/day can reduce GHG between 0.44% and 2.07% and reduce commuting VMT between 3.0% and 7.7%. The reduction in GHG varies based on how extensive the implementation of the program is. The reduction in commuting VMT differs for type of urban area is shown in the table below.

		Percent Change in Commuting VMT					
Strategy	Description	Large Metropolitan (higher transit use)	Large Metropolitan (lower transit use)	Medium Metro (higher)	Medium Metro (lower)	Small Metro (higher)	Small Metro (lower)
Parking Cash-Out	Subsidy of $1/day	7.7%	3.7%	4.5%	3.0%	4.0%	3.0%

Alternative Literature:

Alternate:

- 2-6% reduction in vehicle trips

VTPI used synthesis data to determine parking cash out could reduce commute vehicle trips by 10-30%. VTPI estimates that the portion of vehicle travel affected by parking cash-out would be about 20% and therefore there would be only about a 2-6% total reduction in vehicle trips attributed to parking cash-out.

Alternate:

- 12% reduction in VMT per year per employee
- 64% increase in carpooling
- 50% increase in transit mode share
- 39% increase in pedestrian/bike share

Shoup looked at eight California firms that complied with California's 1992 parking cash-out law, applicable to employers of 50 or more persons in regions that do not meet the state's clean air standards. To comply, a firm must offer commuters the option to choose a cash payment equal to any parking subsidy offered. Six of companies went beyond compliance and subsidized one or more alternatives to parking (more than the parking subsidy price). The eight companies ranged in size between 120 and 300 employees, and were located in downtown Los Angeles, Century City, Santa Monica, and West Hollywood. Shoup states that an average of 12% fewer VMT per year per employee is equivalent to removing one of every eight cars driven to work off the road.

Alternative Literature Notes:

Litman, T., 2009. "Win-Win Emission Reduction Strategies." Victoria Transport Policy Institute. Website: http://www.vtpi.org/wwclimate.pdf. Accessed March 2010. (p. 5)

Donald Shoup, "Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies." *Transport Policy*, Vol. 4, No. 4, October 1997, pp. 201-216. (Table 1, p. 204)

Other Literature Reviewed:

None

3.5 Transit System Improvements

3.5.1 Provide a Bus Rapid Transit System

Range of Effectiveness: 0.02 – 3.2% vehicle miles traveled (VMT) reduction and therefore 0.02 – 3% reduction in GHG emissions.

Measure Description:

The project will provide a Bus Rapid Transit (BRT) system with design features for high quality and cost-effective transit service. These include:

- Grade-separated right-of-way, including bus only lanes (for buses, emergency vehicles, and sometimes taxis), and other Transit Priority measures. Some systems use guideways which automatically steer the bus on portions of the route.
- Frequent, high-capacity service
- High-quality vehicles that are easy to board, quiet, clean, and comfortable to ride.
- Pre-paid fare collection to minimize boarding delays.
- Integrated fare systems, allowing free or discounted transfers between routes and modes.
- Convenient user information and marketing programs.
- High quality bus stations with Transit Oriented Development in nearby areas.
- Modal integration, with BRT service coordinated with walking and cycling facilities, taxi services, intercity bus, rail transit, and other transportation services.

BRT systems vary significantly in the level of travel efficiency offered above and beyond "identity" features and BRT branding. The following effectiveness ranges represent general guidelines. Each proposed BRT should be evaluated specifically based on its characteristics in terms of time savings, cost, efficiency, and way-finding advantages. These types of features encourage people to use public transit and therefore reduce VMT.

Measure Applicability:

- Urban and suburban context
- Negligible in a rural context. Other measures are more appropriate to rural areas, such as express bus service to urban activity centers with park-and-ride lots at system-efficient rural access points.
- Appropriate for specific or general plans

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Existing transit mode share
- Percentage of lines serving Project converting to BRT

The following are optional inputs. Average (default) values are included in the calculations but can be updated to project specificity if desired. Please see Appendix C for calculation detail:

- Average vehicle occupancy

Mitigation Method:

% VMT Reduction = Riders * Mode * Lines * D

Where

Riders = % increase in transit ridership on BRT line (28% from [1])
Mode = Existing transit mode share (see table below)
Lines = Percentage of lines serving project converting to BRT
D = Adjustments from transit ridership increase to VMT (0.67, see Appendix C)

Project setting	Transit mode share
Suburban	1.3%
Urban	4%
Urban Center	17%
Source: NHTS, 2001 http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001_StwTravelSurveyWkdayRpt.pdf (Urban – MTC, SACOG. Suburban – SCAG, SANDAG, Fresno County.) Urban Center from San Francisco County Transportation Authority Countywide Transportation Plan, 2000.	

- D: 0.67 (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] FTA, August 2005. "Las Vegas Metropolitan Area Express BRT Demonstration Project", NTD, http://www.ntdprogram.gov/ntdprogram/cs?action=showRegionAgencies&region=9

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[70]
CO_2e	0.02 – 3.2% of running
PM	0.02 – 3.2% of running
CO	0.02 – 3.2% of running
NOx	0.02 – 3.2% of running
SO_2	0.02 – 3.2% of running
ROG	0.012 – 1.9% of total

Discussion:

Increases in transit ridership due to shifts from other lines do not need to be addressed since it is already incorporated in the literature.

In general, transit operational strategies alone are not enough for a large modal shift [2], as evidenced by the low range in VMT reductions. Through case study analysis, the TCRP report [2] observed that strategies that focused solely on improving level of service or quality of transit were unsuccessful at achieving a significant shift. Strategies that reduce the attractiveness of vehicle travel should be implemented in combination to attract a larger shift in transit ridership. The three following factors directly impact the attractiveness of vehicle travel: urban expressway capacity, urban core density, and downtown parking availability.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (suburban,10% of lines) = 28% * 1.3% * 10% * 0.67 = 0.02%

[70] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

- High Range % VMT Reduction (urban, 100% of lines) = 28% * 17% * 100% * 0.67 = 3.2%

Preferred Literature:

- 28% increase in transit ridership in the existing corridor

The FTA study [1] looks at the implementation of the Las Vegas BRT system. The BRT supplemented an existing route along a 7.5 mile corridor. The existing route was scaled back. Total ridership on the corridor (both routes combined) increased 61,704 monthly riders, 28% increase on the existing corridor and 1.4% increase in system ridership. The route represented an increase in 2.1% of system service miles provided.

Alternative Literature:

Alternate:

- 27-84% increase in total transit ridership

Various bus rapid transit systems obtained the following total transit ridership growth: Vancouver 96B (30%), Las Vegas Max (35-40%), Boston Silver Line (84%), Los Angeles (27-42%), and Oakland (66%). VTPI [3] obtained the BRT data from BC Transit's unpublished research. The effectiveness of a BRT strategy depends largely on the land uses the BRT serves and their design and density.

Alternate:

- 50% increase in weekly transit ridership
- 60 – 80% shorter travel time compared to vehicle trip

The Martin Luther King, Jr. East Busway in Pennsylvania opened in 1983 as a separate roadway exclusively for public buses. The busway was 6.8 miles long with six stations. Ridership has grown from 20,000 to 30,000 weekday riders over 10 years. The busway saves commuters significant time compared with driving: 12 minutes versus 30-45 minutes in the AM or an hour in the PM [4].

Alternative Literature References:

[2] Transit Cooperative Research Program. TCRP 27 – Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It (p.47-48). 1997. [cited in discussion section above]

[3] TDM Encyclopedia; Victoria Transport Policy Institute (2010). Bus Rapid Transit; (http://www.vtpi.org/tdm/tdm120.htm); updated 1/25/2010; accessed 3/3/2010.

[4] Transportation Demand Management Institute of the Association for Commuter Transportation. *TDM Case Studies and Commuter Testimonials*. Prepared for the US EPA. 1997. (p.55-56) http://www.epa.gov/OMS/stateresources/rellinks/docs/tdmcases.pdf

3.5.2 Implement Transit Access Improvements

Range of Effectiveness: Grouped strategy. [See TST-3 and TST-4]

Measure Description:

This project will improve access to transit facilities through sidewalk/ crosswalk safety enhancements and bus shelter improvements. The benefits of Transit Access Improvements alone have not been quantified and should be grouped with Transit Network Expansion (TST-3) and Transit Service Frequency and Speed (TST-4).

Measure Applicability:

- Urban, suburban context
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

No literature was identified that specifically looks at the quantitative impact of improving transit facilities as a standalone strategy.

Alternative Literature References:

None

Other Literature Reviewed:

None

3.5.3 Expand Transit Network

Range of Effectiveness: 0.1 – 8.2% vehicle miles travelled (VMT) reduction and therefore 0.1 – 8.2% reduction in GHG emissions[71]

Measure Description:

The project will expand the local transit network by adding or modifying existing transit service to enhance the service near the project site. This will encourage the use of transit and therefore reduce VMT.

Measure Applicability:

- Urban and suburban context
- May be applicable in a rural context but no literature documentation available (effectiveness will be case specific and should be based on specific assessment of levels of services and origins/destinations served)
- Appropriate for specific or general plans

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage increase transit network coverage
- Existing transit mode share
- Project location: urban center, urban, or suburban

[71] Transit vehicles may also result in increases in emissions that are associated with electricity production or fuel use. The Project Applicant should consider these potential additional emissions when estimating mitigation for these measures.

The following are optional inputs. Average (default) values are included in the calculations but can be updated to project specificity if desired. Please see Appendix C for calculation detail:

- Average vehicle occupancy

Mitigation Method:

% VMT Reduction = Coverage * B * Mode * D

Where

Coverage = % increase in transit network coverage
B = elasticity of transit ridership with respect to service coverage (see Table below)
Mode = existing transit mode share
D = adjustments from transit ridership increase to VMT (0.67, from Appendix C)

B:

Project setting	Elasticity
Suburban	1.01
Urban	0.72
Urban Center	0.65
Source: TCRP 95, Chapter 10	

Mode: Provide existing transit mode share for project or utilize the following averages

Project setting	Transit mode share
Suburban	1.3%
Urban	4%
Urban Center	17%
Source: NHTS, 2001http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001_StwTravelSurveyWkdayRpt.pdf (Urban – MTC, SACOG. Suburban – SCAG, SANDAG, Fresno County.) Urban Center from San Francisco County Transportation Authority Countywide Transportation Plan, 2000.	

Assumptions:

Data based upon the following references:

[1] Transit Cooperative Research Program. TCRP Report 95 Traveler Response to System Changes – Chapter 10: Bus Routing and Coverage. 2004. (p. 10-8 to 10-10)

Emission Reduction Ranges and Variables:

Pollut0ant	Category Emissions Reductions[72]
CO_2e	0.1 – 8.2% of running
PM	0.1 – 8.2% of running
CO	0.1 – 8.2% of running
NOx	0.1 – 8.2% of running
SO_2	0.1 – 8.2% of running
ROG	0.06 – 4.9% of total

Discussion:

In general, transit operational strategies alone are not enough for a large modal shift [2], as evidenced by the low range in VMT reductions. Through case study analysis, the TCRP report [2] observed that strategies that focused solely on improving level of service or quality of transit were unsuccessful at achieving a significant shift. Strategies that reduce the attractiveness of vehicle travel should be implemented in combination to attract a larger shift in transit ridership. The three following factors directly impact the attractiveness of vehicle travel: urban expressway capacity, urban core density, and downtown parking availability.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (10% expansion, suburban) = 10% * 1.01 * 1.3% * .67 = 0.1%
- High Range % VMT Reduction (100% expansion, urban) = 100% * 0.72 * 17% * .67 = 8.2%

The low and high ranges are estimates and may vary based on the characteristics of the project.

[72] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

Preferred Literature:

- 0.65 = elasticity of transit ridership with respect to service coverage/expansion (in radial routes to central business districts)
- 0.72 = elasticity of transit ridership with respect to service coverage/expansion (in central city routes)
- 1.01 = elasticity of transit ridership with respect to service coverage/expansion (in suburban routes)

TCRP 95 Chapter 10 [1] documents the results of system-wide service expansions in San Diego. The least sensitivity to service expansion came from central business districts while the largest impacts came from suburban routes. Suburban locations, with traditionally low transit service, tend to have greater ridership increases compared to urban locations which already have established transit systems. In general, there is greater opportunity in suburban locations.

Alternative Literature:

- -0.06 = elasticity of VMT with respect to transit revenue miles

Growing Cooler [3] modeled the impact of various urban variables (including transit revenue miles and transit passenger miles) on VMT, using data from 84 urban areas around the U.S.

Alternative Literature References:

[2] Transit Cooperative Research Program. TCRP 27 – Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It (p.47-48). 1997. [cited in discussion section above]

[3] Ewing, et al, 2008. Growing Cooler – The Evidence on Urban Development and Climate Change. Urban Land Institute.

3.5.4 Increase Transit Service Frequency/Speed

Range of Effectiveness: 0.02 – 2.5% vehicle miles traveled (VMT) reduction and therefore 0.02 – 2.5% reduction in GHG emissions[73]

Measure Description:

This project will reduce transit-passenger travel time through more reduced headways and increased speed and reliability. This makes transit service more attractive and may result in a mode shift from auto to transit which reduces VMT.

Measure Applicability:

- Urban and suburban context
- May be applicable in a rural context but no literature documentation available (effectiveness will be case specific and should be based on specific assessment of levels of services and origins/destinations served)
- Appropriate for specific or general plans

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Percentage reduction in headways (increase in frequency)
- Level of implementation
- Project setting: urban center, urban, suburban
- Existing transit mode share

[73] Transit vehicles may also result in increases in emissions that are associated with electricity production or fuel use. The Project Applicant should consider these potential additional emissions when estimating mitigation for these measures.

The following are optional inputs. Average (default) values are included in the calculations but can be updated to project-specific values if desired. Please see Appendix C for calculation detail:

- Average vehicle occupancy

Mitigation Method:

% VMT Reduction = Headway * B * C * Mode * E

Where

Headway = % reduction in headways
B = elasticity of transit ridership with respect to increased frequency of service (from [1])
C = adjustment for level of implementation
Mode = existing transit mode share
E = adjustments from transit ridership increase to VMT

Detail:

- Headway: reasonable ranges from 15 – 80%
- B:

Setting	Elasticity
Urban	0.32
Suburban	0.36
Source: TCRP Report 95 Chapter 9	

- C:

Level of implementation = number of lines improved / total number of lines serving project	Adjustment
<50%	50%
>=50%	85%
Fehr & Peers, 2010.	

- Mode: Provide existing transit mode share for project or utilize the following averages

Project setting	Transit mode share
Suburban	1.3%
Urban	4%
Urban Center	17%
Source: NHTS, 2001http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001_StwTravelSurveyWkdayRpt.pdf (Urban – MTC, SACOG. Suburban – SCAG, SANDAG, Fresno County.)	

Urban Center from San Francisco County Transportation Authority Countywide Transportation Plan, 2000.

- E: 0.67 (see Appendix C for detail)

Assumptions:

Data based upon the following references:

[1] Transit Cooperative Research Program. TCRP Report 95 Traveler Response to System Changes – Chapter 9: Transit Scheduling and Frequency (p. 9-14)

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[74]
CO_2e	0.02 – 2.5% % of running
PM	0.02 – 2.5% % of running
CO	0.02 – 2.5% % of running
NOx	0.02 – 2.5% % of running
SO_2	0.02 – 2.5% % of running
ROG	0.01 – 1.5% % of total

Discussion:

Reasonable ranges for reductions were calculated assuming existing 30-minute headways reduced to 25 minutes and 5 minutes to establish the estimated low and high reductions, respectively.

The level of implementation adjustment is used to take into account increases in transit ridership due to shifts from other lines. If increases in frequency are only applied to a percentage of the lines serving the project, then we conservatively estimate that 50% of the transit ridership increase is a shift from the existing lines. If frequency increases are applied to a majority of the lines serving the project, we conservatively assume at least some of the transit ridership (15%) comes from existing riders.

In general, transit operational strategies alone are not enough for a large modal shift [2], as evidenced by the low range in VMT reductions. Through case study analysis, the TCRP report [2] observed that strategies that focused solely on improving level of service or quality of transit were unsuccessful at achieving a significant shift. Strategies that reduce the attractiveness of vehicle travel should be implemented in combination to attract a larger shift in transit ridership. The three following factors directly impact the

[74] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

attractiveness of vehicle travel: urban expressway capacity, urban core density, and downtown parking availability.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (15% reduction in headways, suburban, <50% implementation) = 15% * 0.36 * 50% * 1.3% *0.67 = 0.02%
- High Range % VMT Reduction (80% reduction in headways, urban, >50% implementation) = 80% * 0.32 * 85% * 17% * 0.67 = 2.5%

Preferred Literature:

- 0.32 = elasticity of transit ridership with respect to transit service (urban)
- 0.36 – 0.38 = elasticity of transit ridership with respect to transit service (suburban)

TCRP 95 Chapter 9 [1] documents the results of frequency changes in Dallas. Increases in frequency are more sensitive in a suburban environment. Suburban locations, with traditionally low transit service, tend to have greater ridership increases compared to urban locations which already have established transit systems. In general, there is greater opportunity in suburban locations

Alternative Literature:

- 0.5 = elasticity of transit ridership with respect to increased frequency of service
- 1.5 to 2.3% increase in annual transit trips due to increased frequency of service
- 0.4-0.5 = elasticity of ridership with respect to increased operational speed
- 4% - 15% increase in annual transit trips due to increased operational speed
- 0.03-0.09% annual GHG reduction (for bus service expansion, increased frequency, and increased operational speed)

For increased frequency of service strategy, *Moving Cooler* [3] looked at three levels of service increases, 3%, 3.5% and 4.67% increases in service, resulting in a 1.5 – 2.3% increase in annual transit trips. For increased speed and reliability, Moving Cooler looked at three levels of speed/reliability increases. Improving travel speed by 10% assumed implementing signal prioritization, limited stop service, etc. over 5 years. Improving travel speed by 15% assumed all above strategies plus signal synchronization and intersection reconfiguration over 5 years. Improving travel speed by 30% assumed all above strategies and an improved reliability by 40%, integrated fare system, and implementation of BRT where appropriate. *Moving Cooler* calculates estimated 0.04-0.14% annual GHG reductions in combination with bus service expansion strategy.

Alternative Literature References:

[2] Transit Cooperative Research Program. TCRP 27 – Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It (p.47-48). 1997. [cited in discussion section]

[3] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (p B-32, B-33, Table D.3) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendices_Complete_102209.pdf

3.5.5 Provide Bike Parking Near Transit

Range of Effectiveness: Grouped strategy. [See TST-3 and TST-4]

Measure Description:

Provide short-term and long-term bicycle parking near rail stations, transit stops, and freeway access points. The benefits of Station Bike Parking have no quantified impacts as a standalone strategy and should be grouped with Transit Network Expansion (TST-3) and Increase Transit Service Frequency and Speed (TST-4) to encourage multi-modal use in the area and provide ease of access to nearby transit for bicyclists.

Measure Applicability:

- Urban, suburban context
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

No literature was identified that specifically looks at the quantitative impact of including transit station bike parking.

Alternative Literature References:

None

Other Literature Reviewed:

None

3.5.6 Provide Local Shuttles

Range of Effectiveness: Grouped strategy. [See TST-4 and TST-5]

Measure Description:

The project will provide local shuttle service through coordination with the local transit operator or private contractor. The local shuttles will provide service to transit hubs, commercial centers, and residential areas. The benefits of Local Shuttles alone have not been quantified and should be grouped with Transit Network Expansion (TST-4) and Transit Service Frequency and Speed (TST-5) to solve the “first mile/last mile” problem. In addition, many of the CommuteTrip Reduction Programs (Section 2.4, TRP 1-13) also included local shuttles.

Measure Applicability:

- Urban, suburban context
- Appropriate for large residential, retail, office, mixed use, and industrial projects

Alternative Literature:

No literature was identified to support the effectiveness of this strategy alone.

Alternative Literature References:

None

Other Literature Reviewed:

None

3.6 Road Pricing/Management

3.6.1 Implement Area or Cordon Pricing

Range of Effectiveness: 7.9 – 22.0% vehicle miles traveled (VMT) reduction and therefore 7.9 – 22.0% reduction in GHG emissions.

Measure Description:
This project will implement a cordon pricing scheme. The pricing scheme will set a cordon (boundary) around a specified area to charge a toll to enter the area by vehicle. The cordon location is usually the boundary of a central business district (CBD) or urban center, but could also apply to substantial development projects with limited points of access, such as the proposed Treasure Island development in San Francisco. The cordon toll may be static/constant, applied only during peak periods, or be variable, with higher prices during congested peak periods. The toll price can be based on a fixed schedule or be dynamic, responding to real-time congestion levels. It is critical to have an existing, high quality transit infrastructure for the implementation of this strategy to reach a significant level of effectiveness. The pricing signals will only cause mode shifts if alternative modes of travel are available and reliable.

Measure Applicability:
- Central business district or urban center only

Baseline Method:
See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:
The following information needs to be provided by the Project Applicant:

- Percentage increase in pricing for passenger vehicles to cross cordon
- Peak period variable price or static all-day pricing (London scheme)

The following are optional inputs. Average (default) values are included in the calculations but can be updated to project-specific values if desired. Please see Appendix C for calculation detail:

- % (due to pricing) route shift, time-of-day shift, HOV shift, trip reduction, shift to transit/walk/bike

Mitigation Method:

% VMT Reduction = Cordon$ * B * C

Where

Cordon$ = % increase in pricing for passenger vehicles to cross cordon

B = Elasticity of VMT with respect to price (from [1])

C = Adjustment for % of VMT impacted by congestion pricing and mode shifts

Detail:

- Cordon$: reasonable range of 100 – 500% (See Appendix C for detail))
- B: 0.45 [1]
- C:

Cordon pricing scheme	Adjustment
Peak-period variable pricing	8.8%
Static all-day pricing	21%
Source: See Appendix C for detail	

Assumptions:

Data based upon the following references:

[1] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. (p. B-13, B-14) http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

- Referencing: VTPI, *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior.* July 2008. www.vtpi.org

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[75]
CO_2e	7.9 - 22.0% of running
PM	7.9 - 22.0% of running
CO	7.9 - 22.0% of running
NOx	7.9 - 22.0% of running
SO_2	7.9 - 22.0% of running
ROG	4.7 – 13.2% of total

Discussion:

The amount of pricing will vary on a case-by-case basis. The 100 – 500% increase is an estimated range of increases and should be adjusted to reflect the specificities of the pricing scheme implemented. Take care in calculating the percentage increase in price if baseline is $0.00. An upper limit of 500% may be a good check point. If baseline is zero, the Project Applicant may want to conduct calculations with a low baseline such as $1.00.

These calculations assume that the project is within the area cordon, essentially assuming that 100% of project trips will be affected. See Appendix C to make appropriate adjustments.

Example:

Sample calculations are provided below:

- Low Range % VMT Reduction (100% increase in price, peak period pricing) = 100% * 0.45 * 8.8% = 4.0%
- High Range % VMT Reduction (500% increase in price, all-day pricing) = 500% * 0.45 * 21% = 47.3% = 22% (established maximum based on literature)

Preferred Literature:

- -0.45 VMT elasticity with regard to pricing
- 0.04-0.08% greenhouse gas (GHG) reduction

Moving Cooler [1] assumes an average of 3% of regional VMT would cross the CBD cordon. A VMT reduction of 20% was estimated to require an average of 65 cents/mile applied to all congested VMT in the CBD, major employment, and retail centers. The

[75] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

range in GHG reductions is attributed to the range of implementation and start date. *Moving Cooler* reports an elasticity range from -0.15 to -0.47 from VTPI. *Moving Cool*er utilizes a stronger elasticity (0.45) to represent greater impact cordon pricing will have on users compared to other pricing strategies.

Alternative Literature:

- 6.5-14.0% reduction in carbon emissions
- 16-22% reduction in vehicles
- 6-9% increase in transit use

The Center for Clean Air Policy (CCAP) [2] cites two case studies in Europe, one in London and one in Stockholm, which show vehicle reductions of 16% and 22%, respectively. London's fee reduced CO_2 by 6.5%. Stockholm's program reduced injuries by 10%, increased transit use by 6-9%, and reduced carbon emissions by 14% in the central city within months of implementation.

Alternative Literature References:

[2] Center for Clean Air Policy (CCAP), *Short-term Efficiency Measures.* (p. 1) http://www.ccap.org/docs/resources/715/Short-Term%20Travel%20Efficiency%20Measures%20cut%20GHGs%209%2009%20final.pdf

CCAP cites Transport for London. *Central London Congestion Charging: Impacts Monitoring*, *Sixth Annual Report*. July 2008 http://www.tfl.gov.uk/assets/downloads/sixth-annual-impacts-monitoring-report-2008-07.pdf (p. 6) and Leslie Abboud and Jenny Clevstrom, "Stockholm's Syndrome," August 29, 2006, *Wall Street Journal.*http://transportation.northwestern.edu/mahmassani/Media/WSJ_8.06.pdf (p. 2)

Other Literature Reviewed:

None

3.6.2 Improve Traffic Flow

Range of Effectiveness: 0 - 45% reduction in GHG emissions

Measure Description:

The project will implement improvements to smooth traffic flow, reduce idling, eliminate bottlenecks, and management speed. Strategies may include signalization improvements to reduce delay, incident management to increase response time to breakdowns and collisions, Intelligent Transportation Systems (ITS) to provide real-time information regarding road conditions and directions, and speed management to reduce high free-flow speeds.

This measure does not take credit for any reduction in GHG emissions associated with changes to non-project traffic VMT. If Project Applicant wants to take credit for this benefit, the non-project traffic VMT would also need to be covered in the baseline conditions.

Measure Applicability:

- Urban, suburban, and rural context

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

Inputs:

The following information needs to be provided by the Project Applicant:

- Average base-year travel speed (miles per hour (mph)) on implemented roads (congested[76] condition)

[76] A roadway is considered "congested" if operating at Level of Service (LOS) E or F

- Future travel speed (mph) on implemented roads for both a) congested and b) free-flow[77] condition
- Total vehicle miles traveled (VMT) on implemented roadways
- Total project-generated VMT

Mitigation Method:

$$\% \ CO_2 \text{ Emissions Reduction} = 1 - \frac{\text{Project GHG Emission}_{\text{post strategy}}}{\text{Project GHG emission}_{\text{baseline}}}$$

Where

Project GHG $emission_{post\ strategy}$ = $EF_{running}$ after strategy implementation * project VMT
Project GHG $emission_{baseline}$ = $EF_{running}$ before strategy implementation * project VMT
$EF_{running}$ = emission factor for running emissions [from table presented under "Detail" below]

Detail:

mph	Grams of CO_2 / mile	
	congested	Free-flow
5	1,110	823
10	715	512
15	524	368
20	424	297
25	371	262
30	343	247
35	330	244
40	324	249
45	323	259
50	325	273
55	328	289
60	332	306
65	339	325
70	353	347
75	377	375
80	420	416
85	497	478
Source: Barth, 2008, Fehr & Peers [1]		

[77] A roadway is considered "free flow" if operating at LOS D or better

By only including the project VMT portion, the reduction is typically on scale with the percentage of cost for traffic improvements and full reduction calculated for project VMT should be used. However, if the project cost is a greater share than their contribution to the VMT on the road, than the project and non-project VMT should be calculated and the percent reduction should be multiplied by the percent cost allocation. The GHG emission reductions associated with non-project VMT (if applicable) would be calculated as follows:

$$\text{Metric Tonnes GHG reduced due to improving non-Project traffic flow} = \text{\% Cost Allocation} * \text{Non-Project VMT} * (EF_{congested} - EF_{freeflow}) / (1{,}000{,}000 \text{ gram/MT})$$

Where:

Non-Project VMT that the Project's cost share impacts = portion of non-project VMT

$EF_{congested}$ = emissions for congested road in g/VMT

$EF_{freeflow}$ = emissions for freeflow road in g/VMT

Assumptions:

Data based upon the following references:

[1] Barth and Boriboonsomsin, "Real World CO_2 Impacts of Traffic Congestion", *Transportation Research Record, Journal of the Transportation Research Board,* No. 2058, Transportation Research Board, National Academy of Science, 2008.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions[78]
CO_2e	0 - 45% of running
PM	0 - 45% of running
CO	0 - 45% of running

[78] The percentage reduction reflects emission reductions from running emissions. The actual value will be less than this when starting and evaporative emissions are factored into the analysis. ROG emissions have been adjusted to reflect a ratio of 40% evaporative and 60% exhaust emissions based on a statewide EMFAC run of all vehicles.

NOx	0 - 45% of running
SO_2	0 - 45% of running
ROG	0 - 27% of total

Discussion:

Care must be taken when estimating effectiveness since significantly improving traffic flow essentially lowers the cost and delay involved in travel, which under certain circumstances may induce additional VMT. [See Appendix C for a discussion on induced travel.]

The range of effectiveness presented above is a very rough estimate as emissions reductions will be highly dependent on the level of implementation and degree of congestion on the existing roadways. In addition, the low range of effectiveness was stated at 0% to highlight the potential of induced travel negating benefits achieved from this strategy.

Example:

Sample calculations are provided below:

- Signal timing coordination implementation:
  - Existing congested speeds of 25 mph
  - Conditions post-implementation: would improve to 25 mph free flow speed
  - Proposed project daily traffic generation is 200,000 VMT
  - Project CO_2 Emissions$_{baseline}$ = (371 g CO_2/mile) * (200,000 VMT daily) * (1 MT / 1 x 10^6 g) = 74 MT of CO_2 daily
  - Project CO_2 Emissions$_{post\ strategy}$ = (262 g CO_2/mile) * (200,000 VMT daily) * (1 MT / 1 x 10^6 g) = 52.4 MT of CO_2 daily
  - Percent CO_2emissions reduction = 1- (52.4 MT/ 74 MT) = 29%
- Speed management technique:
  - Existing free-flow speeds of 75 mph
  - Conditions post-implementation: reduce to 55 mph free flow speed
  - Proposed project daily traffic generation is 200,000 VMT
  - Project CO_2 Emissions$_{baseline}$ = (375 g CO_2/mile) * (200,000 VMT daily) * (1 MT / 1 x 10^6 g) = 75 MT of CO_2 daily
  - Project CO_2 Emissions$_{post\ strategy}$ = (289 g CO_2/mile) * (200,000 VMT daily) * (1 MT / 1 x 10^6 g) = 58 MT of CO_2 daily
  - Percent CO_2emissions reduction= 1 – (58 tons/ 75 tons) = 23%

Preferred Literature:

- 7 – 12% reduction in CO_2 emissions

This study [1] examined traffic conditions in Southern California using energy and emissions modeling and calculated the impacts of 1) congestion mitigation strategies to smooth traffic flow, 2) speed management techniques to reduce high free-flow speeds, and 3) suppression techniques to eliminate acceleration/deceleration associated with stop-and-go traffic. Using typical conditions on Southern California freeways, the strategies could reduce emissions by 7 to 12 percent.

The table (in the mitigation method section) was calculated using the CO_2 emissions equation from the report:

$$\ln(y) = b_0 + b_1 * x + b_2 * x^2 + b_3 * x^3 + b_4 * x^4$$

where

y = CO_2 emission in grams / mile
x = average trip speed in miles per hour (mph)

The coefficients for b_i were based off of Table 1 of the report, which then provides an equation for both congested conditions (real-world) and free-flow (steady-state) conditions.

Alternative Literature:

- 4 - 13% reduction in fuel consumption

The FHWA study [2] looks at various case studies of traffic flow improvements. In Los Angeles, a new traffic control signal system was estimated to reduce signal delays by 44%, vehicle stops by 41%, and fuel consumption by 13%. In Virginia, a study of retiming signal systems estimated reductions of stops by 25%, travel time by 10%, and fuel consumption by 4%. In California, optimization of 3,172 traffic signals through 1988 (through California's Fuel Efficient Traffic Signal Management program) documented an average reduction in vehicle stops of 16% and in fuel use of 8.6%. The 4-13% reduction in fuel consumption applies only to that vehicular travel directly benefited by the traffic flow improvements, specifically the VMT within the corridor in which the ITS is implemented and only during the times of day that would otherwise be congested without ITS. For example, signal coordination along an arterial normally congested in peak commute hours would produce a 4-13% reduction in fuel consumption only for the VMT occurring along that arterial during weekday commute hours.

Alternate:

- Up to 0.02% *increase* in greenhouse gas (GHG) emissions

Moving Cooler [3] estimates that bottleneck relief will result in an increase in GHG emissions during the 40-year period, 2010 to 2050. In the short term, however, improved roadway conditions may improve congestion and delay, and thus reduce fuel consumption. VMT and GHG emissions are projected to increase after 2030 as induced demand begins to consume the roadway capacity. The study estimates a maximum increase of 0.02% in GHG emissions.

Alternative Literature References:

[2] FHWA, *Strategies to Reduce Greenhouse Gas Emissions from Transportation Sources*. http://www.fhwa.dot.gov/environment/glob_c5.pdf.

[3] Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions.* Technical Appendices. Prepared for the Urban Land Institute. http://www.movingcooler.info/Library/Documents/Moving%20Cooler_Appendix%20B_Effectiveness_102209.pdf

Other Literature Reviewed:

None

3.6.3 Required Project Contributions to Transportation Infrastructure Improvement Projects

Range of Effectiveness: Grouped strategy. [See RPT-2 and TST-1 through 7]

Measure Description:

The project should contribute to traffic-flow improvements or other multi-modal infrastructure projects that reduce emissions and are not considered as substantially growth inducing. The local transportation agency should be consulted for specific needs.

Larger projects may be required to contribute a proportionate share to the development and/or continuation of a regional transit system. Contributions may consist of dedicated right-of-way, capital improvements, easements, etc. The local transportation agency should be consulted for specific needs.

Refer to Traffic Flow Improvements (RPT-2) or the Transit System Improvements (TST-1 through 7) strategies for a range of effectiveness in these categories. The benefits of Required Contributions may only be quantified when grouped with related improvements.

Measure Applicability:

- Urban, suburban, and rural context
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

Although no literature discusses project contributions as a standalone measure, this strategy is a supporting strategy for most operations and infrastructure projects listed in this report.

Other Literature Reviewed:

None

3.6.4 Install Park-and-Ride Lots

Range of Effectiveness: Grouped strategy. [See RPT-1, TRT-11, TRT-3, and TST-1 through 6]

Measure Description:

This project will install park-and-ride lots near transit stops and High Occupancy Vehicle (HOV) lanes. Park-and-ride lots also facilitate car- and vanpooling. Refer to Implement Area or Cordon Pricing (RPT-1), Employer-Sponsored Vanpool/Shuttle (TRT-11), Ride Share Program (TRT-3), or the Transit System Improvement strategies (TST-1 through 6) for ranges of effectiveness within these categories. The benefits of Park-and-Ride Lots are minimal as a stand-alone strategy and should be grouped with any or all of the above listed strategies to encourage carpooling, vanpooling, ride-sharing, and transit usage.

Measure Applicability:

- Suburban and rural context
- Appropriate for residential, retail, office, mixed use, and industrial projects

Alternative Literature:

Alternate:

- 0.1 – 0.5% vehicle miles traveled (VMT) reduction

A 2005 FHWA [1] study found that regional VMT in metropolitan areas may be reduced between 0.1 to 0.5% (citing Apogee Research, Inc., 1994). The reduction potential of this strategy may be limited because it reduces the trip length but not vehicle trips.

Alternate:

- 0.50% VMT reduction per day

Washington State Department of Transportation (WSDOT) [2] notes the above number applies to countywide interstates and arterials.

Alternative Literature References:

[1] FHWA. Transportation and Global Climate Change: A Review and Analysis of the Literature – Chapter 5: Strategies to Reduce Greenhouse Gas Emissions from Transportation Sources. http://www.fhwa.dot.gov/environment/glob_c5.pdf

[2] Washington State Department of Transportation. *Cost Effectiveness of Park-and-Ride Lots in the Puget Sound Area.* http://www.wsdot.wa.gov/research/reports/fullreports/094.1.pdf

Other Literature Reviewed:

None

3.7 Vehicles

3.7.1 Electrify Loading Docks and/or Require Idling-Reduction Systems

Range of Effectiveness: 26-71% reduction in TRU idling GHG emissions

Measure Description:

Heavy-duty trucks transporting produce or other refrigerated goods will idle at truck loading docks and during layovers or rest periods so that the truck engine can continue to power the cab cooling elements. Idling requires fuel use and results in GHG emissions.

The Project Applicant should implement an enforcement and education program that will ensure compliance with this measure. This includes posting signs regarding idling restrictions as well as recording engine meter times upon entering and exiting the facility.

Measure Applicability:

- Truck refrigeration units (TRU)

Inputs:

The following information needs to be provided by the Project Applicant:

- Electricity provider for the Project
- Horsepower of TRU
- Hours of operation

Baseline Method:

$$\text{GHG emission} = \frac{CO_2\ \text{Exhaust}}{\text{Activity} \times \text{AvgHP} \times LF} \times Hp \times Hr \times C \times LF$$

Where:

GHG emission = MT CO_2e

CO_2 Exhaust = Statewide daily CO_2 emission from TRU for the relevant horsepower tier (tons/day). Obtained from OFFROAD2007.

Activity = Statewide daily average TRU operating hours for the relevant horsepower tier (hours/day). Obtained from OFFROAD2007.

AvgHP = Average TRU horsepower for the relevant horsepower tier (HP). Obtained from OFFROAD2007.

Hp = Horsepower of TRU.

Hr = Hours of operation.

C = Unit conversion factor

LF = Load factor of TRU for the relevant horsepower tier (dimensionless). Obtained from OFFROAD 2007.

Note that this method assumes the load factor of the TRU is same as the default in OFFROAD2007.

Mitigation Method:

Electrify loading docks

TRUs will be plugged into electric loading dock instead of left idling. The indirect GHG emission from electricity generation is:

$$\text{GHG emission} = Utility \times Hp \times LF \times Hr \times C$$

Where:

GHG emissions = MT CO_2e
Utility = Carbon intensity of Local Utility (CO_2e/kWh)
Hp = Horsepower of TRU.
LF = Load factor of TRU for the relevant horsepower tier (dimensionless). Obtained from OFFROAD2007.
Hr = Hours of operation.
C = Unit conversion factor

$$\text{GHG Reduction \%}^{79} = 1 - \frac{Utility \times C}{EF \times 10^{-6}}$$

Idling Reduction

Emissions from reduced TRU idling periods are calculated using the same methodology for the baseline scenario, but with the shorter hours of operation.

$$\text{GHG Reduction \%} = 1 - \frac{time_{mitigated}}{time_{baseline}}$$

Electrify loading docks

Power Utility	TRU Horsepower (HP)	Idling Emission Reductions[80]
LADW&P	< 15	26.3%
	< 25	26.3%
	< 50	35.8%

[79] This assumes energy from engine losses are the same.
[80] This reduction percentage applies to all GHG and criteria pollutant idling emissions.

PG&E	< 15	72.9%
	< 25	72.9%
	< 50	76.3%
SCE	< 15	61.8%
	< 25	61.8%
	< 50	66.7%
SDGE	< 15	53.5%
	< 25	53.5%
	< 50	59.5%
SMUD	< 15	67.0%
	< 25	67.0%
	< 50	71.2%

Idling Reduction

Emission reduction from shorter idling period is same as the percentage reduction in idling time.

Discussion:

The output from OFFROAD2007 shows the same emissions within each horsepower tier regardless of the year modeled. Therefore, the emission reduction is dependent on the location of the Project and horsepower of the TRU only.

Assumptions:

Data based upon the following references:

- California Air Resources Board. Off-road Emissions Inventory. OFFROAD2007. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm
- California Climate Action Registry Reporting Online Tool. 2006 PUP Reports. Available online at: https://www.climateregistry.org/CARROT/public/reports.aspx

Preferred Literature:

The electrification of truck loading docks can allow properly equipped trucks to take advantage of external power and completely eliminate the need for idling. Trucks would need to be equipped with internal wiring, inverter, system, and a heating, ventilation, and air conditioning (HVAC) system. Under this mitigation measure, the direct emissions from fuel combustion are completely displaced by indirect emissions from the CO_2 generated during electricity production. The amount of electricity required depends on the type of truck and refrigeration elements; this data could be determined from manufacturer specifications. The total kilowatt-hours required should be multiplied by the carbon-intensity factor of the local utility provider in order to calculate the amount of indirect CO_2 emissions. To take credit for this mitigation measure, the Project Applicant would need to provide detailed evidence supporting a calculation of the emissions reductions.

Alternative Literature:

None

Other Literature Reviewed:

1. USEPA. 2002. Green Transport Partnership, A Glance at Clean Freight Strategies: Idle Reduction. Available online at: http://nepis.epa.gov/Adobe/PDF/P1000S9K.PDF
2. ATRI. 2009. Research Results: Demonstration of Integrated Mobile Idle Reduction Solutions. Available online at: http://www.atri-online.org/research/results/ATRI1pagesummaryMIRTDemo.pdf

None

3.7.2 Utilize Alternative Fueled Vehicles

Range of Effectiveness: Reduction in GHG emissions varies depending on vehicle type, year, and associated fuel economy.

Measure Description:

When construction equipment is powered by alternative fuels such as biodiesel (B20), liquefied natural gas (LNG), or compressed natural gas (CNG) rather than conventional petroleum diesel or gasoline, GHG emissions from fuel combustion may be reduced.

Measure Applicability:

- Vehicles

Inputs:

The following information needs to be provided by the Project Applicant:

- Vehicle category
- Traveling speed (mph)
- Number of trips and trip length, or Vehicle Miles Traveled (VMT)
- Fuel economy (mpg) or Fuel consumption

Baseline Method:

$$\text{Baseline } CO_2 \text{ Emission} = EF \times \frac{1}{FE} \times VMT \times C$$

Where:

Baseline CO_2 Emission	=	MT of CO_2
EF	=	CO_2 emission factor, from CCAR General Reporting Protocol (g/gallon)
VMT	=	Vehicle miles traveled (VMT) = T x L
FE	=	Fuel economy (mpg)
C	=	Unit conversion factor

$$\text{Baseline } N_2O/CH_4 \text{ Emission} = EF \times VMT \times C$$

Where:

Baseline N_2O/CH_4 Emission	=	MT of N_2O or CH_4
EF	=	N_2O or CH_4 emission factor, from CCAR General Reporting Protocol (g/mile)
VMT	=	Vehicle miles traveled (VMT) = T x L
T	=	Number of one-way trips
L	=	One-way trip length
FC	=	Fuel consumption (gallon) = VMT/FE

FE = Fuel economy (mpg)
C = Unit conversion factor

The total baseline GHG emission is the sum of the emissions of CO_2, N_2O and CH_4, adjusted by their global warming potentials (GWP):

Baseline GHG Emission
= Baseline CO_2 Emission + Baseline N_2O Emission × 310 +Baseline CH_4 Emission × 21

Where:

Baseline GHG Emission = MT of CO_2e
310 = GWP of N_2O
21 = GWP of CH_4

Mitigation Method:

Mitigated emissions from using alternative fuel is calculated using the same methodology before, but using emission factors for the alternative fuel, and fuel consumption calculated as follows:

$$GHG emissions = \frac{1}{FE} \times ER \times VMT \times EF_{CO2} + VMT \times EF_{N20} + VMT \times EF_{CH4}$$

Where:

ER = Energy ratio from US Department of Energy (see table below)
EF = Emission Factor for pollutant
VMT = Vehicle miles traveled (VMT)
FE = Fuel economy (mpg)

Fuel	Energy Ratio: Amount of fuel needed to provide same energy as			
	1 gallon of Gasoline		1 gallon of Diesel	
Gasoline	1	gal	1.13	gal
#2 Diesel	0.88	gal	1	gal
B20	0.92	gal	1.01	gal
CNG	126.67	ft^3	143.14	ft^3
LNG	1.56	gal	1.77	gal
LPC	1.37	gal	1.55	gal

Emission reductions can be calculated as:

$$\text{Reduction} = 1 - \frac{\text{Mitigated Emission}}{\text{Running Emission}}$$

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Range Not Quantified[81]
PM	Range Not Quantified
CO	Range Not Quantified
NOx	Range Not Quantified
SO_2	Range Not Quantified
ROG	Range Not Quantified

Discussion:

Using the methodology described above, only the running emission is considered. A hypothetical scenario for a gasoline fueled light duty automobile in 2015 is illustrated below. The CO_2 emission factor from motor gasoline in CCAR 2009 is 8.81 kg/gallon. Assuming the automobile makes two trips of 60 mile each per day, and using the current passenger car fuel economy of 27.5 mpg under the CAFE standards, then the annual baseline CO_2 emission from the automobile is:

$$8.81 \times \frac{2 \times 60 \times 365}{27.5} \times 10^{-3} = 14.0 \text{ MT/year}$$

Where 10^{-3} is the conversion factor from kilograms to MT.

Using the most recent N_2O emission factor of 0.0079 g/mile in CCAR 2009 for gasoline passenger cars, the annual baseline N_2O emission from the automobile is:

$$0.0079 \times 2 \times 365 \times 60 \times 10^{-6} = 0.000346 \text{ MT/year}$$

[81] The emissions reductions varies and depends on vehicle type, year, and the associated fuel economy. The methodology above describes how to calculate the expected GHG emissions reduction assuming the required input parameters are known.

Similarly, using the same formula with the most recent CH_4 emission factor of 0.0147 g/mile in CCAR 2009 for gasoline passenger cars, the annual baseline CH_4 emission from the automobile is calculated to be 0.000644 MT/year.

Thus, the total baseline GHG emission for the automobile is:

$$14.0 + 0.000346 \times 310 + 0.000644 \times 21 = 14.1 \text{ MT/year}$$

If compressed natural gas (CNG) is used as alternative fuel, the CNG consumption for the same VMT is:

$$\frac{2 \times 60 \times 365}{27.5} \times 126.67 = 201{,}751 \text{ ft}^3$$

Using the same formula as for the baseline scenario but with emission factors of CNG and the CNG consumption, the mitigated GHG emission can be calculated as shown in the table below

Pollutant	Emission (MT/yr)
CO_2	11.0
N_2O	0.0022
CH_4	0.0323
CO_2e	12.4

Therefore, the emission reduction is:

$$1 - \frac{12.4}{14.0} = 11.4\%$$

Notice that in the baseline scenario, N_2O and CH_4 only make up <1% of the total GHG emissions, but actually increase for the mitigated scenario and contribute to >10% of total GHG emissions.

Assumptions:
Data based upon the following references:

- California Climate Action Registry (CCAR). 2009. General Reporting Protocol. Version 3.1. Available online at: http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html

- US Department of Energy. 2010. Alternative and Advanced Fuels – Fuel Properties. Available online at: http://www.afdc.energy.gov/afdc/fuels/properties.html

Preferred Literature:

The amount of emissions avoided from using alternative fuel vehicles can be calculated using emission factors from the California Climate Action Registry (CCAR) General Reporting Protocol [1]. Multiplying this factor by the fuel consumption or vehicle miles traveled (VMT) gives the direct emissions of CO_2 and N_2O /CH_4, respectively. Fuel consumption and VMT can be calculated interchangeably with the fuel economy (mpg). The total GHG emission is the sum of the emissions from the three chemicals multiplied by their respective global warming potential (GWP).

Assuming the same VMT, the amount of alternative fuel required to run the same vehicle fleet can be calculated by multiplying gasoline/diesel fuel consumption by the equivalent-energy ratio obtained from the US Department of Energy [2]. Using the alternative fuel consumption and the emission factors for the alternative fuel from CCAR, the mitigated GHG emissions can be calculated. The GHG emissions reduction associated with this mitigation measure is therefore the difference in emissions from these two scenarios.

Alternative Literature:

None

Notes:

[1] California Climate Action Registry (CCAR). 2009. General Reporting Protocol. Version 3.1. Available online at: http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html
[2] US Department of Energy. 2010. Alternative and Advanced Fuels – Fuel Properties. Available online at: http://www.afdc.energy.gov/afdc/fuels/properties.html

Other Literature Reviewed:

None

3.7.3 Utilize Electric or Hybrid Vehicles

Range of Effectiveness: 0.4 - 20.3% reduction in GHG emissions

Measure Description:

When vehicles are powered by grid electricity rather than fossil fuel, direct GHG emissions from fuel combustion are replaced with indirect GHG emissions associated with the electricity used to power the vehicles. When vehicles are powered by hybrid-electric drives, GHG emissions from fuel combustion are reduced.

Measure Applicability:

- Vehicles

Inputs:

The following information needs to be provided by the Project Applicant:

- Vehicle category
- Traveling speed (mph)
- Number of trips and trip length, or Vehicle Miles Traveled (VMT)
- Fuel economy (mpg)

Baseline Method:

$$\text{Baseline Emission} = EF \times (1 - R) \times VMT \times C$$

Where:

Baseline Emission	=	MT of Pollutant
EF	=	Running emission factor for pollutant at traveling speed, from EMFAC.
VMT	=	Vehicle miles traveled (VMT)
R	=	Additional reduction in EF due to regulation (see Table 1)
C	=	Unit conversion factor

Mitigation Method:

<u>Fully Electric Vehicle</u>

Vehicle will run solely on electricity. The indirect GHG emission from electricity generation is:

$$\text{Mitigated Emission} = \text{Utility} \times \frac{1}{FE} \times VMT \times ER \times C$$

Where:

Mitigated Emission = MT of CO_2e
Utility = Carbon intensity of Local Utility (CO_2e/kWh)
VMT = Vehicle miles traveled (VMT)
ER = Energy Ratio = 33.4 kWh/gallon-gasoline or 37.7 kWh/gallon-diesel
FE = Fuel Economy (mpg)
C = Unit conversion factor

Power Utility	Carbon-Intensity (lbs CO_2e/MWh)
LADW&P	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

Criteria pollutant emissions will be 100% reduced for equipment running solely on electricity.

Hybrid-Electric Vehicle

The Project Applicant has to determine the fuel consumption reduced from using the hybrid-electric vehicle. The emission reductions for all pollutants are the same as the fuel reduction.

Emission reductions can be calculated as:

$$\text{GHG Reduction\%} = 1 - \frac{\text{Mitigated Emission}}{\text{Running Emission}}$$

Emission Reduction Ranges and Variables:

See Table VT-3.1 below.

Discussion:

Using the methodology described above, only the running emission is considered. A hypothetical scenario for a gasoline fueled light duty automobile with catalytic converter in 2015 is illustrated below. The running CO_2 emission factor at 30 mph from an EMFAC run of the Sacramento county with temperature of 60F and relative humidity of 45% is 336.1 g/mile. From Table VT-3.1, there will be an additional reduction of 9.1% for the emission factor in 2015 due to Pavley standard. Assuming the automobile makes two trips of 60 mile each per day, then annual baseline emission from the automobile is:

$$336.1 \times (100\% - 9.1\%) \times 2 \times 365 \times 60 \times 10^{-6} = 13.4 \text{ MT/year}$$

Where 10^{-6} is the conversion factor from grams to MT. Assuming the current passenger car fuel economy of 27.5 mpg under the CAFE standards, and using the carbon-intensity factor for PG&E, the electric provider for the Sacramento region, the mitigated emission from replacing the automobile described above with electric vehicle would be:

$$\left(456 \times \frac{2 \times 365 \times 60}{27.5} \times 33.4 \times \frac{1}{2{,}204 \times 10^{3}}\right) = 11.0 \text{ MT/year}$$

Therefore, the emission reduction is:

$$1 - \frac{11.0}{13.4} = 17.9\%$$

Assumptions:

Data based upon the following references:

- California Air Resources Board. EMFAC2007. Available online at: http://www.arb.ca.gov/msei/onroad/latest_version.htm
- California Climate Action Registry (CCAR). 2009. General Reporting Protocol. Version 3.1. Available online at: http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html
- California Climate Action Registry Reporting Online Tool. 2006 PUP Reports. Available online at: https://www.climateregistry.org/CARROT/public/reports.aspx
- US Department of Energy. 2010. Alternative and Advanced Fuels – Fuel Properties. Available online at: http://www.afdc.energy.gov/afdc/fuels/properties.html

Preferred Literature:

The amount of emissions avoided from using electric and hybrid vehicles can be calculated using CARB's EMFAC model, which provides state-wide and regional running emission factors for a variety of on-road vehicles in units of grams per mile [1]. Multiplying this factor by the vehicle miles traveled (VMT) gives the direct emissions. For criteria pollutant, emissions can be assumed to be 100% reduced from running on electricity. For GHG, assuming the same VMT, the electricity required to run the same vehicle fleet can be calculated by dividing by the fuel economy (mph) and multiplying the gasoline-electric energy ratio obtained from the US Department of Energy [2]. Multiplying this value by the carbon-intensity factor of the local utility gives the amount of indirect GHG emissions associated with electric vehicles. The GHG emissions reduction associated with this mitigation measure is therefore the difference in emissions from these two scenarios.

Alternative Literature:

None

Notes:

[1] California Air Resources Board. EMFAC2007. Available online at: http://www.arb.ca.gov/msei/onroad/latest_version.htm
[2] US Department of Energy. 2010. Alternative and Advanced Fuels – Fuel Properties. Available online at: http://www.afdc.energy.gov/afdc/fuels/properties.html

Other Literature Reviewed:

None

Table VT-3.1
Reduction in EMFAC Running Emission Factor from New Regulations

Year	Vehicle Class	Reduction	Pollutant	Regulation
2010	LDA/LDT/MDV	0.4%	CO_2	Pavley Standard
2011	LDA/LDT/MDV	1.6%	CO_2	Pavley Standard
2012	LDA/LDT/MDV	3.5%	CO_2	Pavley Standard
2013	LDA/LDT/MDV	5.3%	CO_2	Pavley Standard
2014	LDA/LDT/MDV	7.1%	CO_2	Pavley Standard
2015	LDA/LDT/MDV	9.1%	CO_2	Pavley Standard
2016	LDA/LDT/MDV	11.0%	CO_2	Pavley Standard
2017	LDA/LDT/MDV	13.1%	CO_2	Pavley Standard
2018	LDA/LDT/MDV	15.5%	CO_2	Pavley Standard
2019	LDA/LDT/MDV	17.9%	CO_2	Pavley Standard
2020	LDA/LDT/MDV	20.3%	CO_2	Pavley Standard
2011	Other Buses	21.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	School Bus	19.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT Agriculture	17.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT CA International Registration Plan	4.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT Instate	6.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT Out-of-state	4.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Agriculture	23.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT CA International Registration Plan	1.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Non-neighboring Out-of-state	0.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Neighboring Out-of-state	2.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Singleunit	10.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Tractor	9.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	Other Buses	25.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	Power Take Off	28.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	School Bus	45.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	MHDDT Agriculture	20.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	MHDDT CA International Registration Plan	12.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	MHDDT Instate	11.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles

Year	Vehicle Class	Reduction	Pollutant	Regulation
				Regulation
2012	MHDDT Out-of-state	12.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Agriculture	29.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT CA International Registration Plan	8.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Non-neighboring Out-of-state	15.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Neighboring Out-of-state	15.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Drayage at Other Facilities	9.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Drayage in Bay Area	9.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Drayage near South Coast	7.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Singleunit	14.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Tractor	13.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	Other Buses	45.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	Power Take Off	57.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	School Bus	68.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT Agriculture	31.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT CA International Registration Plan	55.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT Instate	64.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT Out-of-state	55.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Agriculture	48.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT CA International Registration Plan	60.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Non-neighboring Out-of-state	50.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Neighboring Out-of-state	63.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Drayage at Other Facilities	67.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Drayage in Bay Area	65.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Drayage near South Coast	51.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2013	HHDDT Singleunit	66.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Tractor	69.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	Other Buses	53.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	Power Take Off	63.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	School Bus	71.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Agriculture	33.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT CA International Registration Plan	65.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Instate	77.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Out-of-state	65.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Agriculture	52.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT CA International Registration Plan	63.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Non-neighboring Out-of-state	46.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Neighboring Out-of-state	64.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Singleunit	79.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Tractor	79.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Utility	4.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	Other Buses	49.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	Power Take Off	61.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	School Bus	71.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Agriculture	34.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT CA International Registration Plan	60.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Instate	74.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Out-of-state	60.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2015	HHDDT Agriculture	53.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT CA International Registration Plan	55.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Non-neighboring Out-of-state	37.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Neighboring Out-of-state	55.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Singleunit	77.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Tractor	76.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Utility	4.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	Other Buses	43.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	Power Take Off	75.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	School Bus	70.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Agriculture	32.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT CA International Registration Plan	56.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Instate	73.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Out-of-state	56.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Agriculture	51.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT CA International Registration Plan	45.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Non-neighboring Out-of-state	27.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Neighboring Out-of-state	46.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Singleunit	75.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Tractor	73.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Utility	4.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	Other Buses	36.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	Power Take Off	71.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	School Bus	67.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2017	MHDDT Agriculture	55.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT CA International Registration Plan	52.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT Instate	70.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT Out-of-state	52.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Agriculture	58.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT CA International Registration Plan	37.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Non-neighboring Out-of-state	18.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Neighboring Out-of-state	37.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Singleunit	73.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Tractor	70.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Utility	3.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	Other Buses	31.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	Power Take Off	67.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	School Bus	74.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Agriculture	53.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT CA International Registration Plan	47.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Instate	68.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Out-of-state	47.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Agriculture	55.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT CA International Registration Plan	30.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Non-neighboring Out-of-state	11.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Neighboring Out-of-state	30.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Singleunit	72.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2018	HHDDT Tractor	67.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Utility	3.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	Other Buses	27.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	Power Take Off	76.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	School Bus	73.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Agriculture	53.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT CA International Registration Plan	42.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Instate	65.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Out-of-state	42.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Agriculture	54.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT CA International Registration Plan	24.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Non-neighboring Out-of-state	5.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Neighboring Out-of-state	24.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Singleunit	69.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Tractor	64.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Utility	3.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	Other Buses	23.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	Power Take Off	74.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	School Bus	71.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Agriculture	52.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT CA International Registration Plan	37.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Instate	60.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Out-of-state	37.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Utility	0.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2020	HHDDT Agriculture	52.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT CA International Registration Plan	19.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Non-neighboring Out-of-state	3.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Neighboring Out-of-state	20.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Singleunit	66.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Tractor	61.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Utility	2.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	Other Buses	21.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	Power Take Off	79.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	School Bus	68.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Agriculture	51.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT CA International Registration Plan	33.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Instate	57.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Out-of-state	33.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Utility	5.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Agriculture	50.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT CA International Registration Plan	16.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Non-neighboring Out-of-state	3.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Neighboring Out-of-state	16.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Drayage at Other Facilities	10.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Drayage in Bay Area	9.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Drayage near South Coast	9.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Singleunit	64.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Tractor	59.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Utility	5.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2022	Other Buses	20.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	Power Take Off	79.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	School Bus	66.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Agriculture	50.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT CA International Registration Plan	28.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Instate	53.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Out-of-state	28.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Utility	6.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Agriculture	49.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT CA International Registration Plan	13.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Non-neighboring Out-of-state	1.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Neighboring Out-of-state	14.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Drayage at Other Facilities	10.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Drayage in Bay Area	8.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Drayage near South Coast	8.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Singleunit	61.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Tractor	55.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Utility	5.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	Other Buses	18.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	Power Take Off	74.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	School Bus	64.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT Agriculture	79.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT CA International Registration Plan	23.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT Instate	48.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT Out-of-state	23.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2023	MHDDT Utility	7.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Agriculture	68.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT CA International Registration Plan	11.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Non-neighboring Out-of-state	1.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Neighboring Out-of-state	11.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Drayage at Other Facilities	9.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Drayage in Bay Area	8.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Drayage near South Coast	8.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Singleunit	56.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Tractor	51.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Utility	4.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	Other Buses	15.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	Power Take Off	68.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	School Bus	61.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Agriculture	77.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT CA International Registration Plan	20.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Instate	43.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Out-of-state	20.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Utility	5.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Agriculture	65.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT CA International Registration Plan	9.1%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Non-neighboring Out-of-state	0.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Neighboring Out-of-state	9.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Drayage at Other Facilities	9.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Drayage in Bay Area	7.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2024	HHDDT Drayage near South Coast	7.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Singleunit	50.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Tractor	46.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Utility	3.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	Other Buses	13.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	Power Take Off	62.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	School Bus	58.2%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Agriculture	75.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT CA International Registration Plan	15.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Instate	37.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Out-of-state	15.3%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Utility	3.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Agriculture	62.7%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT CA International Registration Plan	6.8%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Non-neighboring Out-of-state	0.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Neighboring Out-of-state	7.0%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Drayage at Other Facilities	8.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Drayage in Bay Area	7.5%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Drayage near South Coast	7.6%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Singleunit	44.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Tractor	42.9%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Utility	2.4%	PM2.5	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT CA International Registration Plan	1.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT Instate	2.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	MHDDT Out-of-state	1.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2011	HHDDT CA International Registration Plan	0.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Non-neighboring Out-of-state	0.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Neighboring Out-of-state	1.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Singleunit	4.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2011	HHDDT Tractor	3.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	Power Take Off	13.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	School Bus	2.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	MHDDT CA International Registration Plan	1.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	MHDDT Instate	2.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	MHDDT Out-of-state	1.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT CA International Registration Plan	0.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Non-neighboring Out-of-state	0.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Neighboring Out-of-state	0.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Singleunit	3.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2012	HHDDT Tractor	3.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	Other Buses	18.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	Power Take Off	34.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	School Bus	4.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT Agriculture	5.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT CA International Registration Plan	12.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT Instate	25.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	MHDDT Out-of-state	12.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Agriculture	10.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT CA International Registration Plan	8.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Non-neighboring Out-of-state	1.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2013	HHDDT Neighboring Out-of-state	8.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Singleunit	33.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2013	HHDDT Tractor	28.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	Other Buses	40.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	Power Take Off	37.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	School Bus	6.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Agriculture	9.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT CA International Registration Plan	22.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Instate	34.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Out-of-state	22.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	MHDDT Utility	0.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Agriculture	17.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT CA International Registration Plan	13.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Non-neighboring Out-of-state	4.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Neighboring Out-of-state	14.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Singleunit	45.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Tractor	36.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2014	HHDDT Utility	1.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	Other Buses	52.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	Power Take Off	33.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	School Bus	6.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Agriculture	18.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT CA International Registration Plan	20.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Instate	31.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	MHDDT Out-of-state	20.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2015	MHDDT Utility	0.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Agriculture	27.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT CA International Registration Plan	11.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Non-neighboring Out-of-state	2.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Neighboring Out-of-state	12.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Singleunit	42.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Tractor	34.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2015	HHDDT Utility	1.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	Other Buses	54.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	Power Take Off	43.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	School Bus	4.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Agriculture	19.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT CA International Registration Plan	22.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Instate	32.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Out-of-state	22.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	MHDDT Utility	0.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Agriculture	29.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT CA International Registration Plan	11.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Non-neighboring Out-of-state	3.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Neighboring Out-of-state	13.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Singleunit	43.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Tractor	35.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2016	HHDDT Utility	1.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	Other Buses	59.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	Power Take Off	38.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2017	MHDDT Agriculture	43.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT CA International Registration Plan	27.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT Instate	35.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT Out-of-state	27.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	MHDDT Utility	1.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Agriculture	45.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT CA International Registration Plan	14.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Non-neighboring Out-of-state	7.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Neighboring Out-of-state	17.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Singleunit	46.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Tractor	38.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2017	HHDDT Utility	1.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	Other Buses	56.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	Power Take Off	32.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	School Bus	7.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Agriculture	41.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT CA International Registration Plan	26.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Instate	41.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Out-of-state	26.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	MHDDT Utility	1.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Agriculture	42.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT CA International Registration Plan	15.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Non-neighboring Out-of-state	4.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Neighboring Out-of-state	16.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Singleunit	51.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2018	HHDDT Tractor	43.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2018	HHDDT Utility	1.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	Other Buses	52.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	Power Take Off	38.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	School Bus	6.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Agriculture	40.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT CA International Registration Plan	22.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Instate	38.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Out-of-state	22.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	MHDDT Utility	1.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Agriculture	40.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT CA International Registration Plan	12.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Non-neighboring Out-of-state	2.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Neighboring Out-of-state	13.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Singleunit	48.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Tractor	41.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2019	HHDDT Utility	1.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	Other Buses	49.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	Power Take Off	41.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	School Bus	5.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Agriculture	38.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT CA International Registration Plan	19.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Instate	34.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Out-of-state	19.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	MHDDT Utility	1.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2020	HHDDT Agriculture	38.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT CA International Registration Plan	9.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Non-neighboring Out-of-state	1.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Neighboring Out-of-state	10.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Singleunit	45.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Tractor	39.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2020	HHDDT Utility	1.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	Other Buses	48.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	Power Take Off	51.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	School Bus	4.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Agriculture	38.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT CA International Registration Plan	21.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Instate	41.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Out-of-state	21.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	MHDDT Utility	33.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Agriculture	37.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT CA International Registration Plan	9.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Non-neighboring Out-of-state	1.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Neighboring Out-of-state	9.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Drayage at Other Facilities	40.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Drayage in Bay Area	41.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Drayage near South Coast	39.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Singleunit	54.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Tractor	45.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2021	HHDDT Utility	21.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2022	Other Buses	48.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	Power Take Off	60.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	School Bus	3.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Agriculture	40.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT CA International Registration Plan	20.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Instate	41.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Out-of-state	20.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	MHDDT Utility	28.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Agriculture	40.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT CA International Registration Plan	8.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Non-neighboring Out-of-state	1.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Neighboring Out-of-state	9.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Drayage at Other Facilities	39.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Drayage in Bay Area	40.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Drayage near South Coast	39.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Singleunit	54.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Tractor	45.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2022	HHDDT Utility	18.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	Other Buses	47.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	Power Take Off	54.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	School Bus	2.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT Agriculture	65.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT CA International Registration Plan	18.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT Instate	39.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	MHDDT Out-of-state	18.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2023	MHDDT Utility	25.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Agriculture	59.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT CA International Registration Plan	7.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Non-neighboring Out-of-state	1.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Neighboring Out-of-state	8.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Drayage at Other Facilities	38.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Drayage in Bay Area	39.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Drayage near South Coast	38.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Singleunit	52.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Tractor	44.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2023	HHDDT Utility	16.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	Other Buses	43.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	Power Take Off	47.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	School Bus	1.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Agriculture	63.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT CA International Registration Plan	15.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Instate	33.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Out-of-state	15.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	MHDDT Utility	19.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Agriculture	56.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT CA International Registration Plan	6.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Non-neighboring Out-of-state	0.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Neighboring Out-of-state	6.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Drayage at Other Facilities	38.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Drayage in Bay Area	39.4%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

Year	Vehicle Class	Reduction	Pollutant	Regulation
2024	HHDDT Drayage near South Coast	37.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Singleunit	47.2%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Tractor	39.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2024	HHDDT Utility	13.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	Other Buses	39.0%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	Power Take Off	39.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	School Bus	1.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Agriculture	61.1%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT CA International Registration Plan	11.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Instate	28.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Out-of-state	11.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	MHDDT Utility	13.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Agriculture	53.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT CA International Registration Plan	4.6%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Non-neighboring Out-of-state	0.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Neighboring Out-of-state	4.8%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Drayage at Other Facilities	37.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Drayage in Bay Area	38.9%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Drayage near South Coast	37.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Singleunit	41.5%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Tractor	35.7%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation
2025	HHDDT Utility	10.3%	NOx	On-Road Heavy-Duty Diesel Vehicles Regulation

4.0 Water

4.1 Water Supply

4.1.1 Use Reclaimed Water

Range of Effectiveness: Up to 40% in Northern California and up to 81% in Southern California

Measure Description:

California water supplies come from ground water, surface water, and from reservoirs, typically fed from snow melt. Some sources of water are transported over long distances, and sometimes over terrain to reach the point of consumption. Transporting water can require a significant amount of electricity. In addition, treating water to potable standards can also require substantial amounts of energy. Reclaimed water is water reused after wastewater treatment for non-potable uses instead of returning the water to the environment. This is different than gray water, which has not been through wastewater treatment. Reclaimed non-potable water requires significantly less energy to collect, treat, and redistribute water to the point of local areas of non-potable water consumption. Since less energy is required to provide reclaimed water, fewer GHGs will be associated with reclaimed water use compared to the average California water supply use.

This measure describes how to calculate GHG savings from using reclaimed water instead of new potable water supplies for outdoor water uses or other non-potable water uses. The baseline scenario document outlines average Northern and Southern California electricity-use water factors, and assumes that all water is treated to potable standards.

Measure Applicability:

- Non-potable water use

Inputs:

The following information needs to be provided by the Project Applicant:

- Reclaimed water use (million gallons)
- Total non-potable water use (million gallons)

Baseline Method:

$$\text{GHG emissions} = \text{Water}_{\text{non-potable total}} \times \text{Electricity}_{\text{baseline}} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$Water_{non\text{-}potable\ total}$ = Total volume of non-potable water used (million gallons)
Provided by Applicant

$Electricity_{baseline}$ = Electricity required to supply, treat, and distribute water (kWh/million gallons)
Northern California Average: 3,500 kWh/million gallons
Southern California Average: 11,111 kWh/million gallons

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

A million gallons of reclaimed water would use an average of 2,100 kWh electricity per million gallons of water (range of 1,200 to 3,000 kWh). Therefore the percent reduction in GHG emissions associated with implementing reclaimed water usage is:

$$\text{GHG emission reduction} = \frac{Water_{reclaimed}}{Water_{non\text{-}potable\ total}} \times \frac{Electricity_{baseline} - Electricity_{reclaimed}}{Electricity_{baseline}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for non-potable water use.

$Water_{reclaimed}$ = Total volume of reclaimed water used (million gallons)
Provided by Applicant

$Water_{non\text{-}potable\ total}$ = Total volume of non-potable water used (million gallons)
Provided by Applicant

$Electricity_{reclaimed}$ = Electricity required to treat and distribute reclaimed water (2,100 kWh/million gallons)

$Electricity_{baseline}$ = Electricity required to supply and distribute water
Northern California Average: 3,500 kWh/million gallons
Southern California Average: 11,111 kWh/million gallons

Therefore, for projects in Northern California, the reduction in GHG emissions is:

$$\text{GHG emission reduction} = \frac{Water_{reclaimed}}{Water_{non\text{-}potable\ total}} \times \frac{(3{,}500 - 2{,}100)}{3{,}500} = \frac{Water_{reclaimed}}{Water_{non\text{-}potable\ total}} \times 0.40$$

And for projects in Southern California, the reduction in GHG emissions is:

$$\text{GHG emission reduction} = \frac{Water_{reclaimed}}{Water_{non\text{-}potable\ total}} \times \frac{(11{,}111 - 2{,}100)}{11{,}111} = \frac{Water_{reclaimed}}{Water_{non\text{-}potable\ total}} \times 0.81$$

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	N. California: Up to 40% if assuming 100% reclaimed water S. California: Up to 81% if assuming 100% reclaimed water Percent reduction would scale down linearly as the percent reclaimed water decreases.
All other pollutants	Not quantified[82]

Discussion:

If the Project Applicant uses 100 million gallons of non-potable water for a project in Northern California, they would calculate baseline emissions as described in the baseline methodologies document. If the applicant then selects to mitigate water by committing to using 40 million gallons of reclaimed water in place of the usual water source, the applicant would reduce the amount of GHG emissions associated with outdoor water use by 16%

$$\text{GHG Emission Reduced} = \frac{40}{100} \times 0.40 = 0.16 \text{ or } 16\%$$

Assumptions:

Data based upon the following reference:

[1] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

Preferred Literature:

GHG emissions from the mitigated scenario should be calculated based on the 2006 CEC report, which presents regional baseline electricity-use water factors and a factor of 1,200-3,000 kWh per million gallons for reclaimed water. GHG emissions are calculated by multiplying the amount of water (million gallons) by the electricity-use water factor (kWh per million gallons) by the carbon-intensity of the local utility (CO_2e per kWh). The GHG emissions reductions associated with this mitigation measure are

[82] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

associated with the difference between the baseline potable water electricity-use water factor and the mitigated scenario.

Alternative Literature:

None

Other Literature Reviewed:

None

4.1.2 Use Gray Water

Range of Effectiveness: Up to 100% of outdoor water GHG emissions if outdoor water use is replaced completely with graywater

Measure Description:

California water supplies come from ground water, surface water, and from reservoirs, typically fed from snow melt. Some sources of water are transported over long distances, and sometimes over terrain to reach the point of consumption. Transporting water can require a significant amount of electricity. In addition, treating water to potable standards can also require substantial amounts of energy. Untreated wastewater generated from bathtubs, showers, bathroom wash basins, and clothes washing machines is known as graywater and is collected and distributed onsite for irrigation of landscape and mulch. Since graywater does not require treatment or energy to redistribute it onsite, there are negligible GHG emissions associated with the use of graywater.

This measure describes how to calculate GHG savings from using graywater instead of new potable water supplies for landscape irrigation and other outdoor uses. The baseline scenario document outlines average Northern and Southern California electricity-use water factors, and assumes that all water is non-potable.

Measure Applicability:

- Outdoor water use

Inputs:

The following information needs to be provided by the Project Applicant:

- Graywater use[83] (million gallons), or:
    - Type of graywater system, which must be compliant with the California Plumbing Code, and
    - Number of residents in homes with compliant graywater systems
- Total outdoor water use (million gallons)

Baseline Method:

$$\text{GHG emissions} = \text{Water}_{\text{outdoor total}} \times \text{Electricity}_{\text{baseline}} \times \text{Utility}$$

[83] Note that this is the amount of graywater used, which may be less than the amount of graywater generated. A project may generate and collect more graywater than is needed for landscape irrigation. The Project Applicant should only take credit for the amount of potable water which is displaced by graywater. The amount of landscape irrigation water demand (graywater demand) is calculated according to the methodology described in WUW-3 and the baseline methodologies document.

Where:

GHG emissions = MT CO_2e

$Water_{outdoor\ total}$ = Total volume of outdoor water used (million gallons)
Provided by Applicant

$Electricity_{baseline}$ = Electricity required to supply, treat, and distribute water (kWh/million gallons)
Northern California Average: 3,500 kWh/million gallons
Southern California Average: 11,111 kWh/million gallons

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

If the Project Applicant cannot provide the total amount of graywater used, the graywater use can be calculated based on the following equation:

$Water_{graywater}$ =

$$\left[\left(25 \times Residents_{graywater\text{-}sbw}\right) + \left(15 \times Residents_{graywater\text{-}laundry}\right)\right] \frac{gallons}{day} \times \frac{365\ days}{year} \times \frac{1\ million\ gallons}{10^6\ gallons}$$

Where:

$Water_{graywater}$ = Total volume of graywater used (million gallons).

$Residents_{graywater\text{-}sbw}$ = Total number of residents in homes with graywater systems based on graywater generated from showers, bathtubs, and wash basins

25 = gallons per day per residential occupant from showers, bathtubs, and washbasins [1]

$Residents_{graywater\text{-}laundry}$ = Total number of residents in homes with graywater systems based on graywater generated from laundry machines

15 = gallons per day per residential occupant from laundry machines [1]

The percent reduction in GHG emissions associated with implementing graywater usage is therefore:

$$GHG\ emission\ reduction = \frac{Water_{graywater}}{Water_{oudoor\ total}} \times \frac{Electricity_{baseline} - Electricity_{graywater}}{Electricity_{baseline}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for outdoor water use.

$Water_{graywater}$ = Total volume of graywater used (million gallons)
Provided by Applicant or calculated using equation above

$Water_{outdoor\ total}$ = Total volume of outdoor water used (million gallons)
Provided by Applicant

$Electricity_{graywater}$	=	Electricity required to distribute graywater (0 kWh/million gallons)[84]
$Electricity_{baseline}$	=	Electricity required to supply, treat, and distribute water Northern California Average: 3,500 kWh/million gallons [2] Southern California Average: 11,111 kWh/million gallons [2]

Therefore, for projects in Northern California, the reduction in GHG emissions is:

$$\text{GHG emission reduction} = \frac{Water_{graywater}}{Water_{outdoor\ total}} \times \frac{(3{,}500 - 0)}{3{,}500} = \frac{Water_{graywater}}{Water_{outdoor\ total}}$$

And for projects in Southern California, the reduction in GHG emissions is:

$$\text{GHG emission reduction} = \frac{Water_{graywater}}{Water_{outdoor\ total}} \times \frac{(11{,}111 - 0)}{11{,}111} = \frac{Water_{graywater}}{Water_{outdoor\ total}}$$

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	N. California: Up to 100% if assuming 100% graywater S. California: Up to 100% if assuming 100% graywater Percent reduction would scale down linearly as the percent reclaimed water decreases.
All other pollutants	Not Quantified[85]

Discussion:

If the Project Applicant uses 100 million gallons of water for outdoor uses in a project in Northern California, they would calculate baseline emissions as described above and in the baseline methodologies document. If the Project Applicant then selects to mitigate water by committing to establishing graywater systems based on graywater recovery from laundry machines in 500 homes with an average of 3 people in each home, the amount of graywater used is then:

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[84] In some cases the distribution of graywater will require some amount of electricity; for example, graywater generated at residences and pumped to a nearby park. In those cases, $Electricity_{graywater}$ will be non-zero.

[85] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

$Water_{graywater}$ =

$$\left[(25\times 0)+(15\times 500\times 3)\right]\frac{\text{gallons}}{\text{day}}\times\frac{365\,\text{days}}{\text{year}}\times\frac{1\,\text{milliongallons}}{10^6\ \text{gallons}} = 8.2 \text{ million gallons}$$

Then the Project Applicant would reduce the amount of GHG emissions associated with outdoor water use by 8.2%

$$\text{GHG Emission Reduced} = \frac{8.2}{100} = 0.082 \text{ or } 8.2\%$$

Assumptions:

Data based upon the following references:

[1] 2007 CPC, Title 24, Part 5, Chapter 16A, Part I – Nonpotable Water Reuse Systems. Available online at: http://www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf

[2] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

Preferred Literature:

Assuming a compliant graywater system is installed, Part 1606A.0 of the California Plumbing Code (CPC) estimates 25 gallons per day per residential occupant of graywater generation from showers, bathtubs, and wash basins, and 15 gallons per day per residential occupant of graywater discharge from laundry machines. Electricity and CO_2 savings from using graywater are determined by comparing to the emissions that would have been associated with the water use if the graywater demand had instead been supplied by potable water. The baseline emissions should be calculated based on the 2006 CEC methodology. A development may generate and collect more graywater than is needed for landscape irrigation. A Project Applicant should only take credit for emissions reductions associated with the amount of potable water which is displaced by graywater. The amount of landscape irrigation water demand (graywater demand) is calculated according to the methodology described in the baseline methodologies document and WUW-3.

Alternative Literature:

None

Other Literature Reviewed:

[3] Arizona Department of Environmental Quality. 2009. Using Gray Water at Home Brochure. Available online at: http://www.azdeq.gov/environ/water/permits/download/graybro.pdf

[4] Arizona Department of Water Resources. Technologies – Irrigation, Rainwater Harvesting, Gray Water Reuse and Artificial Turf. Available online at: http://www.azwater.gov/AzDWR/StatewidePlanning/Conservation2/Technologies/Tech%20pages%20templates/LandscapeIrrigation.htm. Accessed February 2010.

[5] AAC, Title 18, Chapter 9, Article 7. Direct Reuse of Reclaimed Water. Available online at: http://www.azsos.gov/public_services/title_18/18-09.pdf

[6] Oasis Design. Graywater Information Central. Available online at: http://www.graywater.net/. Accessed February 2010.

4.1.3 Use Locally Sourced Water Supply

Range of Effectiveness: 0 – 60% for Northern and Central California, 11 – 75% for Southern California

Measure Description:

California water supplies come from ground water, surface water, and from reservoirs, typically fed from snow melt. Some sources of water are transported over long distances, and sometimes over terrain to reach the point of consumption. Transporting water can require a significant amount of electricity. Using locally-sourced water or water from less energy-intensive sources reduces the electricity and indirect CO_2 emissions associated with water supply and transport.

This measure describes how to calculate GHG savings from using local or less energy-intensive water sources instead of water from the typical mix of Northern and Southern California sources. According to the 2006 CEC report [1], water in Northern California (which also includes the Central Coast and San Joaquin Valley for this study) is primarily supplied by deliveries from the State Water Project and groundwater, and to a lesser extent is supplied by the gravity-dominated systems of Hetch Hetchy and the Mokelumne Aqueduct. In contrast, water imported from the State Water Project is Southern California's dominant water source. The baseline scenario uses average Northern and Southern California electricity intensity factors as reported in 2006 CEC and detailed in the Baseline Method below.

Measure Applicability:

- Indoor (potable) and outdoor (non-potable) water use

Inputs:

- Total potable and non-potable water use (million gallons)

Baseline Method:

$$\text{GHG emissions} = \text{Water}_{baseline} \times \text{Electricity}_{baseline} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$\text{Water}_{baseline}$ = Total volume of water used (million gallons)
Provided by Applicant

$\text{Electricity}_{baseline}$ = Electricity required to supply, treat, and distribute water (and for indoor uses, the electricity required to treat the resulting wastewater) (kWh/million gallons)
Indoor Uses:
Northern California Average: 5,411 kWh/million gallons [1]
Southern California Average: 13,022 kWh/million gallons [1]

Outdoor Uses:
Northern California Average: 3,500 kWh/million gallons [1]
Southern California Average: 11,111 kWh/million gallons [1]
Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

Table WSW-3.1 shows that water from local or nearby groundwater basins, nearby surface water, and gravity-dominated systems have smaller energy-intensity factors than the average Northern and Southern California energy-intensity factors. The Project Applicant should use Table WSW-3.1 to identify the outdoor and indoor electricity intensity factors associated with the Project's water source(s). The GHG emission reduction is then calculated as follows:

$$\text{GHG emission reduction} = \frac{Water_{mitigated}}{Water_{baseline}} \times \frac{Electricity_{baseline} - Electricity_{mitigated}}{Electricity_{baseline}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for water use
$Water_{mitigated}$ = Volume of water to be supplied from the mitigated (local or less energy-intensive) source
Provided by Applicant
$Water_{baseline}$ = Total volume of water used (million gallons)
Provided by Applicant
$Electricity_{mitigated}$ = Electricity required to distribute water for Project from mitigated (local or less-energy intensive) source
$Electricity_{baseline}$ = Baseline electricity required to supply, treat, and distribute water (and for indoor uses, the electricity required to treat the resulting wastewater) (kWh/million gallons)
Indoor Uses:
Northern California Average: 5,411 kWh/million gallons [1]
Southern California Average: 13,022 kWh/million gallons [1]
Outdoor Uses:
Northern California Average: 3,500 kWh/million gallons [1]
Southern California Average: 11,111 kWh/million gallons [1]

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Assuming 100% of water is sourced locally: Indoor Uses: • 0-40% reduction for Northern and Central California • 11-64% reduction for Southern California Outdoor Uses: • 0-60% reduction for Northern and Central California • 12-75% reduction for Southern California
All other pollutants	Not Quantified[86]

Discussion:

Assume a Project is located in Southern California within the Chino Basin and has a total indoor water demand of 100 million gallons. Assume 70 million gallons will be sourced from a water district which obtains its water from the typical Southern California water sources. Therefore, for these 70 million gallons the baseline outdoor water electricity-intensity factor for Southern California is used. Assume that the Project Applicant chooses to mitigate the Project by sourcing the remaining 30 million gallons from the Chino Basin. The expected GHG emission reduction is then:

$$\text{GHG Emission Reduced} = \frac{30}{100} \times \frac{11{,}111 - 4{,}298}{11{,}111} = 0.18 \text{ or } 18\%$$

Assumptions:

Data based upon the following reference:

[1] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

[86] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

[2]CEC. 2005. California's Water-Energy Relationship. Final Staff Report. CEC 700-2005-011-SF. Available online at: http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF
[3]NRDC. 2004. Energy Down the Drain: The Hidden Costs of California's Water Supply. Prepared by NRDC and the Pacific Institute. Available online at: http://www.nrdc.org/water/conservation/edrain/edrain.pdf

Preferred Literature:

Electricity and CO_2 savings from using locally-sourced water or water from sources which require below-average electricity intensities for supply and conveyance (such as gravity-dominated systems or local groundwater basins that are not very deep) are determined by comparing to the emissions that would have occurred if the water had instead been conveyed from typical water sources for the region. According to the 2005 and 2006 CEC reports [1,2], the typical mix of water sources in Northern and Central California is the State Water Project, groundwater, and gravity-dominated systems such as Hetch Hetchy and the Mokelumne Aqueduct. The majority of water in Southern California is supplied by imports from the State Water Project and the Colorado River Aqueduct. Examples of mitigated electricity-intensity factors are shown in Table WSW-3.1 and are based on data provided in 2006 CEC [1], 2005 CEC [2], and 2004 NRDC [3]. GHG emissions are calculated by multiplying the amount of water (million gallons) by the electricity-use water factor (kWh per million gallons) by the carbon-intensity of the local utility (CO_2e per kWh). The GHG emissions reductions associated with this mitigation measure are associated with the difference between the baseline water electricity-intensity factor and the mitigated electricity-intensity factor.

Alternative Literature:

None

Other Literature Reviewed:

None

Table WSW-3.1

Energy Intensity of Water Use (kWh/MG) by Region

REGION	WATER USE SEGMENT						
	Supply & Conveyance[1]		Treatment[1]	Distribution[1]	*OUTDOOR TOTAL (NON-POTABLE)*[2]	Wastewater Treatment[1]	*INDOOR TOTAL (POTABLE)*[3]
Northern California	SWP to Bay Area *surface water*	3,150	111	1,272	***4,533***	1,911	***6,444***
	Hetch Hetchy to Bay Area *gravity dominated*	0	111	1,272	***1,383***	1,911	***3,294***
	Mokelumne Aqueduct to Bay Area *gravity dominated*	160	111	1,272	***1,543***	1,911	***3,454***
Central California	SWP to Central Coast *surface water*	3,150	111	1,272	***4,533***	1,911	***6,444***
	SWP to San Joaquin Valley *surface water*	1,510	111	1,272	***2,893***	1,911	***4,804***
	San Joaquin River Basin & Central Coast[4] *groundwater*	896	111	1,272	***2,279***	1,911	***4,190***
	Tulare Lake Basin[4] *groundwater*	537	111	1,272	***1,920***	1,911	***3,831***
	Fresno and Kings Counties (Westlands WD)[4] *groundwater*	2,271	111	1,272	***3,654***	1,911	***5,565***
Southern California	SWP to L.A. Basin *surface water*	8,325	111	1,272	***9,708***	1,911	***11,619***
	Colorado River Aqueduct to L.A. Basin *surface water*	6,140	111	1,272	***7,523***	1,911	***9,434***
	Chino Basin[5] *groundwater*	2,915	111	1,272	***4,298***	1,911	***6,209***
	Los Angeles[4] *groundwater*	1,780	111	1,272	***3,163***	1,911	***5,074***
	San Diego County (Sweetwater WD)[4] *groundwater*	1,433	111	1,272	***2,816***	1,911	***4,727***
	San Diego County (Yuima WD)[4]	2,029	111	1,272	***3,412***	1,911	***5,323***

REGION	WATER USE SEGMENT						
	Supply & Conveyance[1]		Treatment[1]	Distribution[1]	*OUTDOOR TOTAL (NON-POTABLE)*[2]	Wastewater Treatment[1]	*INDOOR TOTAL (POTABLE)*[3]
	groundwater						
State-wide	Local / Intrabasin	120	111	1,272	***1,503***	1,911	***3,414***
	Groundwater	4.45 kWh / MG / foot of well depth	111	1,272	***TBC***	1,911	***TBC***
	Ocean Desalination	13,800	111	1,272	***15,183***	1,911	***17,094***
	Brackish Water Desalination	3,230	111	1,272	***4,613***	1,911	***6,524***

Abbreviations:
CEC - California Energy Commission
kWh - kilowatt hour
MG - million gallons
NRDC - Natural Resources Defense Council
SWP - State Water Project
TBC - to be calculated based on well depth
WD - Water District

Notes:
1. Treatment, Distribution, and Wastewater Treatment electricity-intensity factors from 2006 CEC. Supply & Conveyance electricity-intensity factors from 2006 CEC unless otherwise noted.
2. Outdoor (Non-Potable) electricity-intensity factor is the sum of the Supply & Conveyance, Treatment, and Distribution electricity-intensity factors.
3. Indoor (Potable) electricity-intensity factor is the sum of the Supply & Conveyance, Treatment, Distribution, and Wastewater Treatment electricity-intensity factors.
4. Supply & Conveyance electricity-intensity factor from 2004 NRDC.
5. Supply & Conveyance electricity-intensity factor from 2005 CEC.

Sources:
CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December. Available at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

CEC. 2005. California's Water-Energy Relationship. Final Staff Report. CEC 700-2005-011-SF. Available online at: http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF

NRDC. 2004. Energy Down the Drain: The Hidden Costs of California's Water Supply. Prepared by NRDC and the Pacific Institute. Available online at: http://www.nrdc.org/water/conservation/edrain/edrain.pdf

4.2 Water Use

4.2.1 Install Low-Flow Water Fixtures

Range of Effectiveness: 20% of GHG emissions associated with indoor Residential water use; 17-31% of GHG emissions associated with Non-Residential indoor water use.

Measure Description:

Water use contributes to GHG emissions indirectly, via the production of the electricity that is used to pump, treat, and distribute the water. Installing low-flow or high-efficiency water fixtures in buildings reduces water demand, energy demand, and associated indirect GHG emissions.

This measure describes how to calculate GHG savings from installing low-flow water toilets, urinals, showerheads, or faucets, or high-efficiency clothes washers and dishwashers in residential and commercial buildings. To take credit for this mitigation measure, the Project Applicant must know the total expected indoor water demand before and after installation of low-flow or high-efficiency water fixtures. If expected water demand after implementation of the mitigation measure is not known, it can be calculated based on the information provided below. Water flow rates presented here in Tables WUW-1.1 and WUW-1.3 are based on technical specifications in the California Code of Regulations Title 20 (Appliance Efficiency Regulations) [2], Title 24 (California Green Building Standards Code) [1] and ENERGY STAR [5-8]. Indoor water end-uses for residential and commercial buildings presented here in Tables WUW-1.1 and WUW-1.2 are based on data provided in a 2003 report by the Pacific Institute for Studies in Development, Environment, and Security [3]. This report incorporates data from the most comprehensive end-use survey available to date, the 1999 Residential End Uses of Water survey published by the American Water Works Association [4], as well as California-specific population, water, and appliance data. California-specific data includes local utility water use and market penetration rates of low-flow and high-efficiency water fixtures.

The baseline scenario document describes the method to calculate baseline GHG emissions. It provides average Northern and Southern California electricity-use water factors and assumes that all water is treated to potable standards.

The percent reduction in GHG emissions is calculated based on the baseline scenario water use and the percent reduction in indoor water use achieved from a Project Applicant's commitment to installing low-flow and high-efficiency water fixtures. Table WUW-1.4 lists the estimated percent reductions in GHG emissions by water fixture and land use. The sum of all percent reductions applicable to the Project gives the overall percent reduction in GHG emissions expected from this mitigation measure. The details of these calculations are described below.

Measure Applicability:

- Indoor water use
- To meet CEQA enforcement requirements, the Project Applicant should only take credit for this mitigation measure if the clothes washers and dishwashers are supplied by the Project Applicant/builder.

Inputs:

The following information needs to be provided by the Project Applicant:

- Total expected indoor water demand, without installation of low-flow or high-efficiency fixtures (million gallons), AND
- Total expected indoor water demand, after installation of low-flow or high-efficiency fixtures (million gallons), OR
- Commitment to low-flow or high-efficiency water fixtures (toilets, showerheads, sink faucets, dishwashers, clothes washers, or all of the above)

Baseline Method:

$$\text{GHG emissions} = \text{Water}_{\text{baseline}} \text{ x Electricity x Utility}$$

Where:

GHG emissions = MT CO_2e

$\text{Water}_{\text{baseline}}$ = Total expected indoor water demand, without installation of low-flow and high-efficiency fixtures (million gallons)
Provided by Applicant

Electricity = Electricity required to supply, treat, and distribute water and the resulting wastewater (kWh/million gallons)
Northern California Average: 5,411 kWh/million gallons
Southern California Average: 13,022 kWh/million gallons

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

Since this mitigation method does not change the electricity intensity factor (kWh/million gallons) associated with the supply, treatment, and distribution of the water, the percent reduction in GHG emissions is dependent only on the change in water consumption.

The Project Applicant can choose to compute the percent reduction in GHG emissions in one of three ways:

Method A

The Project Applicant can use Table WUW-1.4 to calculate the overall percent reduction in GHG emissions from committing to installing certain low-flow or high-efficiency water fixtures. The Project Applicant may commit to installing fixtures based on three standards: the California Green Building Standards Code (CGBSC) mandatory requirements, the CGBSC voluntary standards, or the ENERGY STAR standards. Table WUW-1.4 presents the percent reductions in GHG emissions for each of these three standards based on water fixture type (toilet, showerhead, clothes washer, etc) and land use type (residential, office, restaurant, etc). Note that in Table WUW-1.4, it is assumed that a Project Applicant commits to installing low-flow or high-efficiency fixtures for 100% of an end-use category (i.e. either 0% or 100% of toilets will be low-flow, either 0% or 100% of clothes washers will be high-efficiency, etc). The total percent reduction in GHG emissions expected from this mitigation measure is then simply the sum of all of the individual percent reductions:

$$\text{GHG emission reduction} = \sum \text{PercentReduction}_{\text{Fixture}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for indoor water use.
$\text{PercentReduction}_{\text{Fixture}}$ = Percent reduction in GHG emissions from each individual water fixture (i.e. toilet, bathroom faucet, dishwasher, etc.)
Provided in Table WUW-1.4

Method B

If the Project Applicant can provide detailed and substantial evidence to support a calculation of $\text{Water}_{\text{mitigated}}$, then that value can be used to calculate the percent GHG emission reduction using the following equation:

$$\text{GHG emission reduction} = \frac{\text{Water}_{\text{baseline}} - \text{Water}_{\text{mitigated}}}{\text{Water}_{\text{baseline}}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for indoor water use.
$\text{Water}_{\text{baseline}}$ = Total expected indoor water demand, without installation of low-flow and high-efficiency fixtures (million gallons)
Provided by Applicant
$\text{Water}_{\text{mitigated}}$ = Total calculated indoor water demand, after installation of low-flow and high-efficiency fixtures (million gallons)
Provided by Applicant or calculated using equations below

As shown in this equation, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Method C

The Project Applicant may choose to install fixtures which exceed the requirements of the California Green Building Standards Code but have different flow rates than those specified in the Tables WUW-1.1 and WUW-1.3. To take credit for this mitigation measure, the Project Applicant would need to calculate the percent reduction in GHG emissions using the equations below. In these equations, it is assumed that a Project Applicant commits to installing low-flow or high-efficiency fixtures for 100% of an end-use category (i.e. either 0% or 100% of toilets will be low-flow, either 0% or 100% of clothes washers will be high-efficiency, etc). More complicated equations are necessary to account for less than 100% commitment in one or more end-use categories.

$$Water_{mitigated} = \sum EndUseWater_{mitigated}$$

End-Uses are toilets, urinals, showerheads, bathroom faucets, kitchen faucets, dishwashers, clothes washers, and leaks and other.

Where,

$$EndUseWater_{mitigated} = EndUse_{PercentIndoor} \times Water_{baseline} \times \frac{EndUseFlowRate_{mitigated}}{EndUseFlowRate_{unmitigated}}$$

$EndUse_{PercentIndoor}$ = % of Indoor Water Use for that end-use
Provided in Table WUW-1.1 for Residential Buildings
Provided in Table WUW-1.1 for Non-Residential Buildings

$Water_{baseline}$ = Total expected indoor water demand, without installation of low-flow and high-efficiency fixtures (million gallons)
Provided by Applicant

$EndUseFlowRate_{baseline}$ = Baseline current California standard water flow rate for that end-use
Provided in Table WUW-1.1 for Residential Buildings
Provided in Table WUW-1.3 for Non-Residential Buildings

$EndUseFlowRate_{mitigated}$ = Mitigated water flow rate for that end use
Provided by Applicant, supported by manufacturer specification or technical sheets

For the Leak, Other end use and all end-uses where the Project Applicant makes no commitment to installing low-flow or high-efficiency water fixtures, $EndUseFlowRate_{mitigated} = EndUseFlowRate_{unmitigated}$, so then $EndUseWater_{mitigated} = EndUse_{PercentIndoor} \times Water_{baseline}$.

Then the percent reduction in GHG emissions is calculated as follows:

$$\text{GHG emission reduction} = \frac{Water_{baseline} - Water_{mitigated}}{Water_{baseline}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for indoor water use.

$Water_{baseline}$ = Total expected indoor water demand, without installation of low-flow and high-efficiency fixtures (million gallons)
Provided by Applicant

$Water_{mitigated}$ = Total calculated indoor water demand, after installation of low-flow and high-efficiency fixtures (million gallons)
Calculated by Applicant using equation above

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Estimated 20% reduction for residential buildings, assuming the Project Applicant commits to installing 100% of fixtures with the lowest flow rates presented in Table WUW-1.1. Estimated 17-31% reduction for non-residential buildings, assuming the Project Applicant commits to installing 100% of fixtures with the lowest flow rates presented in Table WUW-1.3.
All other pollutants	Not Quantified[87]

Discussion:

In this example, assume that a Project Applicant commits to installing the following:

For residences:

- 2010 CGBSC Mandatory Requirements for toilet, showerhead, bathroom faucet, and kitchen faucet
- ENERGY STAR residential standard dishwasher

For hotel:

- 2010 CGBSC Voluntary Standards for toilet, urinal, showerhead, bathroom faucet, and kitchen faucet
- ENERGY STAR top-loading clothes washer
- ENERGY STAR commercial dishwasher (high temp, under counter)

Using Method A, the following equation is employed:

$$\text{GHG emission reduction} = \sum PercentReduction_{Fixture}$$

[87] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

From Table WUW-1.4, the percent reduction in GHG emissions associated with indoor water use is then:

For residences:

$$6.6\% + 4.4\% + 5.7\% + 3.3\% + 0.2\% = 20.2\%$$

For hotel:

$$13.8\% + 5.4\% + 1.2\% + 0.8\% + 1.9\% + 6.4\% + 1.5\% = 31.0\%$$

Assumptions:

Data based upon the following references:

[1] CCR Title 24, Part 11. 2010. Draft California Green Building Standards Code. Available online at: http://www.documents.dgs.ca.gov/bsc/documents/2010/Draft-2010-CALGreenCode.pdf
[2] CCR Title 20, Division 2, Chapter 4, Article 4, Section 1605. Appliance Efficiency Regulations.
[3] Gleick, P.H.; Haasz, D.; Henges-Jeck, C.; Srinivasan, V.; Cushing, K.K.; Mann, A. 2003. Waste Not, Want Not: The Potential for Urban Water Conservation in California. Published by the Pacific Institute for Studies in Development, Environment, and Security. Full report available online at: http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf. Appendices available online at: http://www.pacinst.org/reports/urban_usage/appendices.htm
[4] Mayer, P.W.; DeOreo, W.B.; Opitz, E.M.; Kiefer, J.C.; Davis, W.Y.; Dziegielewski, B.; Nelson, J.O. 1999. Residential End Uses of Water. Published by the American Water Works Association Research Foundation.
[5] USEPA. ENERGY STAR: Clothes Washers Key Product Criteria. Available online at: http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers
[6] USEPA. ENERGY STAR: Commercial Clothes Washers for Consumers. Available online at: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CCW
[7] USEPA. ENERGY STAR: Dishwashers Key Product Criteria. Available online at: http://www.energystar.gov/index.cfm?c=dishwash.pr_crit_dishwashers
[8] USEPA. ENERGY STAR Commercial Dishwashers Savings Calculator. Available online at: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COH

Preferred Literature:

For the baseline scenario, the California Green Building Standards Code [1] specifies baseline water flow rates for toilets, showerheads, urinals, bathroom faucets, and kitchen faucets. The California Appliance Efficiency Regulation (Title 20) [2] specifies baseline water flow rates for residential and commercial dishwashers and clothes washers. For the mitigated scenario, the 2010 CGBSC also specifies water flow rates for toilets, showerheads, urinals, bathroom faucets, and kitchen faucets which become mandatory in 2011, additional voluntary flow rates for these same fixtures, and voluntary flow rates for commercial dishwashers and clothes washers. In addition, ENERGY STAR-certified residential and commercial dishwashers and clothes washers have mitigated water flow rates [5-8].

Alternative Literature:

None

Other Literature Reviewed:

[9] USEPA. Water Sense: Product Factsheets and Final Specifications. Available online at: http://www.epa.gov/watersense/products/index.html. Accessed February 2010.

USEPA WaterSense labeled products include toilets, bathroom sink faucets, and flushing urinals, and are certified to meet USEPA's standards for improved water efficiency. While WaterSense models do perform with greater water efficiency than federal standard models, they are not more efficient than the models required in California starting in 2011 due to the 2010 CGBSC. Furthermore, WaterSense models are compared to federal standard models and calculations would need to be adjusted to account for differences in California standards. USEPA reports that toilets, bathroom faucets, and showers account for 30%, 15%, and 17% of indoor household water use, respectively. USEPA reports that WaterSense toilets use 20% less water than the federal standard model, while WaterSense bathroom faucets use 30% less water. Federal standard showerheads use 2.5 gallons of water per minute while the WaterSense models use 2.0 gallons of water per minute, which is equivalent to the 2010 CGBSC Mandatory Requirement. Further, federal standard flushing urinal models use 1.0 gallons per flush, while WaterSense models uses 0.5 gallons per flush, which is equivalent to the 2010 CGBSC Mandatory Requirement.

Table WUW-1.1
Reduction in Water use from Low-flow or High-efficiency Residential Water Fixtures

Fixture	% of Indoor Water Use[1]	Water Flow Rate				
		Baseline Current California Standard[2]	Mitigated 2010 California Green Building Standards Code (Mandatory in 2011)[3]	Mitigated 2010 California Green Building Standards Code (Voluntary)[4]	Mitigated ENERGY STAR[5]	Unit
Toilet	33%	1.6	1.28	--	--	gallons/flush
Showerhead	22%	2.5	2.0	--	--	gallons/minute @ 60 psi
Bathroom Faucet	18%	2.2	1.5	--	--	gallons/minute @ 60 psi
Kitchen Faucet		2.2	1.8	--	--	gallons/minute @ 60 psi
Standard Dishwasher	1%	6.5	--	5.8	5.0	gallons/cycle
Compact Dishwasher		4.5	--	--	3.5	gallons/cycle
Top-loading Clothes Washer	14%	6.0	--	--	6.0	gallons/cycle/ cubic foot
Front-loading Clothes Washer		6.0	--	--	6.0	gallons/cycle/ cubic foot
Leaks, Other	12%	--	--	--	--	--

Notes:

1. Indoor household end use of water 2000 estimates from Figure 2-4c of the Pacific Institute report.
2. Baseline water flow rates for toilets, showerheads, bathroom faucets, and kitchen faucets are from the 2010 California Green Building Standards Code. Baseline water flow rates for dishwashers and clothes washers are from CCR Title 20, Division 2, Chapter 4, Article 4, Section 1605.2 (Appliance Efficiency Regulations for appliances sold in California).
3. Mitigated water flow rates for toilets, showerheads, bathroom faucets, and kitchen faucets are voluntary in 2010 and mandatory starting January 1, 2011.
4. Mitigated water flow rates for dishwashers and clothes washers are voluntary.
5. In some cases, the 2011 ENERGY STAR dishwasher and clothes washer models have lower flow rates than the 2010 California Green Building Standards Code. Using these ENERGY STAR models results in an additional mitigation beyond what is recommended by the 2010 California Green Building Standards Code.

Table WUW-1.2
Percent Indoor Water Use by End-Use in Non-Residential Buildings

End-Use	OFFICE		HOTEL		RESTAURANT		GROCERY STORE		NON-GROCERY RETAIL STORES		K-12 SCHOOL		OTHER SCHOOL	
	Total[1]	Indoor[2]	Total[1]	Indoor[2]	Total[1]	Indoor[2]	Total[1]	Indoor[2]	Total[1]	Indoor[2]	Total[1]	Indoor[2]	Total[1]	Indoor[2]
Restroom	26%	--	51%	--	34%	--	17%	--	26%	--	20%	--	20%	--
Toilets (72% of Restroom)	--	48%	--	46%	--	27%	--	26%	--	46%	--	51%	--	37%
Urinals (17% of Restroom)	--	11%	--	11%	--	6%	--	6%	--	11%	--	12%	--	9%
Faucets (4% of Restroom)	--	3%	--	3%	--	1%	--	1%	--	3%	--	3%	--	2%
Showers (7% of Restroom)	--	5%	--	4%	--	3%	--	2%	--	4%	--	5%	--	4%
Kitchen	3%	--	10%	--	46%	--	9%	--	4%	--	2%	--	1%	--
Faucets (57% of Kitchen)	--	4%	--	7%	--	29%	--	11%	--	6%	--	4%	--	1%
Dishwashers (24% of Kitchen)	--	2%	--	3%	--	12%	--	5%	--	2%	--	2%	--	1%
Ice Making (19% of Kitchen)	--	1%	--	2%	--	10%	--	4%	--	2%	--	1%	--	0%
Laundry	0%	0%	14%	18%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%
Other	10%	26%	5%	6%	12%	13%	22%	46%	11%	27%	6%	21%	17%	44%
Landscaping	38%	--	10%	--	6%	--	3%	--	38%	--	72%	--	61%	--
Cooling	23%	--	10%	--	2%	--	49%	--	21%	--	unknown	--	unknown	--
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Notes:

1. Water end-use data from Figures E-1, E-2, E-5, E-6, E-7, E-8, and E-9 of Appendix E of the Pacific Institute report.
2. Indoor end-use data calculated based on the total water use data for the relevant building category and Figure 4-3 and Figure 4-4 of the Pacific Institute report. Figure 4-3 shows the breakdown of restroom water use by end-use in the commercial & industry sector. Figure 4-4 shows the breakdown of kitchen water use by end-use in the commercial & industry sector; it was assumed that all end-uses except dishwashing and ice making are associated with faucet water use.

Table WUW-1.3
Reduction in Water use from Low-flow or High-efficiency Non-Residential Water Fixtures

Fixture	Water Flow Rate				
	Baseline Current California Standard[1]	Mitigated 2010 California Green Building Standards Code (Mandatory in 2011)[2]	Mitigated 2010 California Green Building Standards Code (Voluntary)[3]	Mitigated ENERGY STAR[4]	Unit
Toilet	1.6	1.28	1.12	--	gallons/flush
Urinal	1.0	0.5	0.5	--	gallons/flush
Showerhead	2.5	2.0	1.8	--	gallons/minute @ 60 psi
Bathroom Faucet	0.5	0.4	0.35	--	gallons/minute @ 60 psi
Kitchen Faucet	2.2	1.8	1.6	--	gallons/minute @ 60 psi
Dishwasher: High Temp, Under Counter	1.98	--	0.90	1.00	gallons/rack
Dishwasher: High Temp, Door	1.44	--	0.95	0.95	gallons/rack
Dishwasher: High Temp, Single Tank Conveyor	1.13	--	0.70	0.70	gallons/rack
Dishwasher: High Temp, Multi Tank Conveyor	1.10	--	0.70	0.54	gallons/rack
Dishwasher: Low Temp, Under Counter	1.95	--	0.98	1.70	gallons/rack
Dishwasher: Low Temp, Door	1.85	--	1.16	1.18	gallons/rack
Dishwasher: Low Temp, Single Tank Conveyor	1.23	--	0.62	0.79	gallons/rack
Dishwasher: Low Temp, Multi Tank Conveyor	0.99	--	0.62	0.54	gallons/rack
Top-loading Clothes Washer	9.5	--	8.6	6.0	gallons/cycle/ cubic foot
Front-loading Clothes Washer	9.5	--	8.6	6.0	gallons/cycle/ cubic foot

Notes:

1. Baseline water flow rates for toilets, showerheads, bathroom faucets, and kitchen faucets are from the 2010 California Green Building Standards Code. Baseline water flow rates for dishwashers are from the ENERGY STAR Commercial Dishwasher Calculator. Baseline water flow rates for clothes washers are from CCR Title 20, Division 2, Chapter 4, Article 4, Section 1605.2 (Appliance Efficiency Regulations for appliances sold in California).

2. These mitigated water flow rates for toilets, showerheads, bathroom faucets, and kitchen faucets are voluntary in 2010 and mandatory starting January 1, 2011.

3. These mitigated water flow rates for toilets, showerheads, bathroom faucets, and kitchen faucets are voluntary and represent the maximum recommended flow rate in order to achieve an overall 30% reduction in water use. Mitigated water flow rates for dishwashers and clothes washers are also voluntary. The range of values shown here represents different types of commercial dishwashers (high-temperature or chemical; conveyor, door, or undercounter models). See Appendix A5 of the 2010 California Green Building Standards Code for details.

4. In some cases, the ENERGY STAR dishwasher and clothes washer models have lower flow rates than the 2010 California Green Building Standards Code. Using these ENERGY STAR models results in an additional mitigation beyond what is recommended by the 2010 California Green Building Standards Code. See the following ENERGY STAR website for details: http://www.energystar.gov/index.cfm?c=comm_dishwashers.pr_crit_comm_dishwashers

Table WUW-1.4

Percent Reductions in GHG emissions from Installing Low-Flow or High-Efficiency Water Fixtures

FIXTURE	LAND USE							
	RESIDENTIAL	OFFICE	HOTEL	RESTAURANT	GROCERY STORE	NON-GROCERY RETAIL STORE	K-12 SCHOOL	OTHER SCHOOL
2010 California Green Building Standards Code (Mandatory Requirements starting in 2011):								
Toilet	6.6%	9.6%	9.2%	5.3%	5.1%	9.1%	10.3%	7.4%
Urinal	N/A	5.7%	5.4%	3.1%	3.0%	5.4%	6.1%	4.4%
Showerhead	4.4%	0.9%	0.9%	0.5%	0.5%	0.9%	1.0%	0.7%
Bathroom Faucet	5.7%	0.5%	0.5%	0.3%	0.3%	0.5%	0.6%	0.4%
Kitchen Faucet	3.3%	0.8%	1.3%	5.2%	1.9%	1.0%	0.7%	0.3%
2010 California Green Building Standards Code (Voluntary Standards):								
Toilet	N/A	14.4%	13.8%	8.0%	7.7%	13.7%	15.4%	11.1%
Urinal	N/A	5.7%	5.4%	3.1%	3.0%	5.4%	6.1%	4.4%
Showerhead	N/A	1.3%	1.2%	0.7%	0.7%	1.2%	1.4%	1.0%
Bathroom Faucet	N/A	0.8%	0.8%	0.4%	0.4%	0.8%	0.9%	0.6%
Kitchen Faucet	N/A	1.2%	1.9%	7.8%	2.9%	1.5%	1.1%	0.4%
Top-Loading Clothes Washer	N/A	N/A	1.8%	N/A	N/A	N/A	N/A	0.3%

FIXTURE	LAND USE							
	RESIDENTIAL	OFFICE	HOTEL	RESTAURANT	GROCERY STORE	NON-GROCERY RETAIL STORE	K-12 SCHOOL	OTHER SCHOOL
Front-Loading Clothes Washer	N/A	N/A	1.8%	N/A	N/A	N/A	N/A	0.3%
Residential Standard Dishwasher	0.1%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential Compact Dishwasher	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Commercial Dishwasher: High Temp, Under Counter	N/A	1.0%	1.6%	6.5%	2.5%	1.3%	0.9%	0.3%
Commercial Dishwasher: High Temp, Door	N/A	0.6%	1.0%	4.1%	1.5%	0.8%	0.6%	0.2%
Commercial Dishwasher: High Temp, Single Tank Conveyor	N/A	0.7%	1.1%	4.6%	1.7%	0.9%	0.7%	0.2%
Commercial Dishwasher: High Temp, Multi Tank Conveyor	N/A	0.7%	1.1%	4.4%	1.6%	0.9%	0.6%	0.2%
Commercial Dishwasher: Low Temp, Under Counter	N/A	0.9%	1.5%	6.0%	2.2%	1.2%	0.9%	0.3%
Commercial Dishwasher: Low Temp, Door	N/A	0.7%	1.1%	4.5%	1.7%	0.9%	0.6%	0.2%
Commercial Dishwasher: Low Temp, Single Tank Conveyor	N/A	0.9%	1.5%	6.0%	2.2%	1.2%	0.9%	0.3%

FIXTURE	LAND USE							
	RESIDENTIAL	OFFICE	HOTEL	RESTAURANT	GROCERY STORE	NON-GROCERY RETAIL STORE	K-12 SCHOOL	OTHER SCHOOL
Commercial Dishwasher: Low Temp, Multi Tank Conveyor	N/A	0.7%	1.1%	4.5%	1.7%	0.9%	0.6%	0.2%
ENERGY STAR Standards:								
Top-Loading Clothes Washer	N/A	N/A	6.4%	N/A	N/A	N/A	N/A	0.9%
Front-Loading Clothes Washer	N/A	N/A	6.4%	N/A	N/A	N/A	N/A	0.9%
Residential Standard Dishwasher	0.2%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential Compact Dishwasher	0.2%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Commercial Dishwasher: High Temp, Under Counter	N/A	0.9%	1.5%	5.9%	2.2%	1.2%	0.8%	0.3%
Commercial Dishwasher: High Temp, Door	N/A	0.6%	1.0%	4.1%	1.5%	0.8%	0.6%	0.2%
Commercial Dishwasher: High Temp, Single Tank Conveyor	N/A	0.7%	1.1%	4.6%	1.7%	0.9%	0.7%	0.2%
Commercial Dishwasher: High Temp, Multi Tank Conveyor	N/A	0.9%	1.5%	6.1%	2.3%	1.2%	0.9%	0.3%
Commercial Dishwasher: Low Temp, Under Counter	N/A	0.2%	0.4%	1.5%	0.6%	0.3%	0.2%	0.1%

FIXTURE	LAND USE							
	RESIDENTIAL	OFFICE	HOTEL	RESTAURANT	GROCERY STORE	NON-GROCERY RETAIL STORE	K-12 SCHOOL	OTHER SCHOOL
Commercial Dishwasher: Low Temp, Door	N/A	0.7%	1.1%	4.3%	1.6%	0.8%	0.6%	0.2%
Commercial Dishwasher: Low Temp, Single Tank Conveyor	N/A	0.7%	1.1%	4.3%	1.6%	0.8%	0.6%	0.2%
Commercial Dishwasher: Low Temp, Multi Tank Conveyor	N/A	0.8%	1.4%	5.5%	2.0%	1.1%	0.8%	0.3%

Notes:

N/A indicates that either (a) an improved standard does not exist, or (b) the percent of indoor water use for that fixture and land use is typically zero. For example, (a) the ENERGY STAR standard for residential clothes washers is the same as the baseline current California standard, and (b) no water is expected to be used for laundry (clothes washers) in the Office land use.

4.2.2 Adopt a Water Conservation Strategy

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. It is equal to the Percent Reduction in water commitment.

Measure Description:

Water use contributes to GHG emissions indirectly, via the production of the electricity that is used to pump, treat, and distribute the water. Reducing water use reduces energy demand and associated indirect GHG emissions.

This mitigation measure describes how to calculate GHG emissions reductions from a Water Conservation Strategy which achieves X% reduction in water use (where X% is the specific percentage reduction in water use committed to by the Project Applicant). The steps taken to achieve this X% reduction in water use can vary in nature and may incorporate technologies which have not yet been established at the time this document was written. In order to take credit for this mitigation measure, the Project Applicant would need to provide detailed and substantial evidence supporting the percent reduction in water use.

The expected percent reduction is applied to the baseline water use, calculated according to the baseline methodology document. The energy-intensity factor associated with water conveyance, treatment, and distribution is provided in the 2006 CEC report [1].

This measure may incorporate other mitigation measures (WUW-1 through 6) of this document. As such, if this measure is used, the other measures cannot be used. These measures can be consulted to assist in determining methods of quantification and typical ranges of effectiveness.

Measure Applicability:

- Indoor and/or Outdoor water use

Inputs:

The following information needs to be provided by the Project Applicant:

- Total expected water demand, without implementation of Water Conservation Strategy (million gallons)
- Percent reduction in water use after implementation of Water Conservation Strategy (%)

Baseline Method:

$$\text{GHG emissions} = \text{Water}_{baseline} \times \text{Electricity} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$Water_{baseline}$ = Total expected water demand, without implementation of Water Conservation Strategy (million gallons)
Provided by Applicant

Electricity = Electricity required to supply, treat, and distribute water (and for indoor uses, the electricity required to treat the wastewater) (kWh/million gallons)
Northern California Avg (outdoor uses): 3,500 kWh/million gallons [1]
Northern California Avg (indoor uses): 5,411 kWh/million gallons [1]
Southern California Avg (outdoor uses): 11,111 kWh/million gallons [1]
Southern California Avg (indoor uses): 13,022 kWh/million gallons [1]

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

If there are percent reductions associated with both indoor and outdoor water use, the GHG emissions from indoor and outdoor water use should be calculated separately and then summed. Thus,

$$\text{Total GHG emissions} = \text{GHG emissions}_{indoor} + \text{GHG emissions}_{outdoor}$$

Mitigation Method:

Since this mitigation method does not change the electricity intensity factor (kWh/million gallons) associated with the supply and distribution of the water, the percent reduction in GHG emissions is dependent only on the change in water consumption:

$$\text{GHG emission reduction} = \text{PercentReduction}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for water use.

PercentReduction = Expected percent reduction in water use after implementation of Water Conservation Strategy (%)
Provided by Applicant

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	To be determined by Applicant

All other pollutants	Not Quantified[88]

Discussion:

The percent reduction in GHG emissions is equivalent to the percent reduction in indoor and outdoor water usage. Therefore, if a Project Applicant implements a Water Conservation Strategy which achieves a 10% reduction in water use, the GHG emissions associated with water use are reduced by 10%.

Assumptions:

Data based upon the following reference:

[1] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

Preferred Literature:

2006 CEC report

Alternative Literature:

None

Other Literature Reviewed:

None

[88] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

4.2.3 Design Water-Efficient Landscapes

Range of Effectiveness: 0 – 70% reduction in GHG emissions from outdoor water use

Measure Description:

Water use contributes to GHG emissions indirectly, via the production of the electricity that is used to pump, treat, and distribute the water. Designing water-efficient landscapes for a project site reduces water consumption and the associated indirect GHG emissions. Examples of measures which a Project Applicant should consider when designing landscapes are reducing lawn sizes, planting vegetation with minimal water needs such as California native species, choosing vegetation appropriate for the climate of the project site, and choosing complimentary plants with similar water needs or which can provide each other with shade and/or water.

This measure describes how to calculate GHG savings from residential and commercial landscape plantings which have decreased watering demands compared to standard California landscape plantings. The methodology for calculating water demand presented here is based on the California Department of Water Resources (CDWR) 2009 Model Water Efficient Landscape Ordinance [1] and the CDWR 2000 report: "A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III" ("WUCOLS") [2].

By January 1, 2010, all local water agencies were required to adopt the CDWR Model Water Efficient Landscape Ordinance or develop their own local ordinance which is at least as effective at conserving water as the Model Ordinance. Some local agencies have published or are in the process of developing local ordinances.[89] A Project Applicant may choose to use the methodology presented in a local ordinance to demonstrate a percent reduction in water use and GHG emissions; however, the calculations will be similar to the methodology presented in the CDWR Model Ordinance and re-described here.

Measure Applicability:

- Outdoor water use

Inputs:

The following information needs to be provided by the Project Applicant:

[89] List of local water agencies and a description of their plans to either adopt the CDWR Model Ordinance or develop their own ordinance: ftp://ftp.water.ca.gov/Model-Water-Efficient-Landscape-Ordinance/Local-Ordinances/

- $Water_{baseline}$, to be calculated by the Project Applicant using the methodology described below
- $Water_{mitigated}$, to be calculated by the Project Applicant using the methodology described below

Baseline Method:

The Project's baseline water use is the Maximum Applied Water Allowance (MAWA) described in the Model Water Efficient Landscape Ordinance:

$$MAWA = ET_0 \times 0.62 \times [(0.7 \times LA) + (0.3 \times SLA)]$$

Where:

MAWA	=	Maximum Applied Water Allowance (gallons per year)
ET_0	=	Annual Reference Evapotranspiration[90] from Appendix A of the Model Water Efficient Landscape Ordinance (inches per year)
0.7	=	ET Adjustment Factor (ETAF)
LA	=	Landscape Area[91] includes Special Landscape Area[92] (square feet)
0.62	=	Conversion factor (to gallons per square foot)
SLA	=	Portion of the landscape area identified as Special Landscape Area (square feet)
0.3	=	the additional ET Adjustment Factor for Special Landscape Area

Then the baseline GHG emissions are calculated as follows:

$$GHG\ emissions = MAWA \times Electricity \times Utility$$

Where:

GHG emissions	=	MT CO_2e
Electricity	=	Electricity required to supply, treat, and distribute water (kWh/million gallons)
		Northern California Average (outdoor uses): 3,500 kWh/million gallons
		Southern California Average (outdoor uses): 11,111 kWh/million gallons

[90] Evapotranspiration is water lost to the atmosphere due to evaporation from soil and transpiration from plant leaves. For a more detailed definition, see this California Irrigation Management Information System (CIMIS) website: http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp;jsessionid=91682943559928B8A9A243D2A2665E19

[91] § 491 Definitions in Model Water Efficient Landscape Ordinance: "Landscape Area (LA) means all the planting areas, turf areas, and water features in a landscape design plan subject to the Maximum Applied Water Allowance calculation. The landscape area does not include footprints of buildings or structures, sidewalks, driveways, parking lots, decks, patios, gravel or stone walks, other pervious or non-pervious hardscapes, and other non-irrigated areas designed for non-development (e.g., open spaces and existing native vegetation)."

[92] § 491 Definitions in Model Water Efficient Landscape Ordinance: "Special Landscape Area (SLA) means an area of the landscape dedicated solely to edible plants, areas irrigated with recycled water, water features using recycled water and areas dedicated to active play such as parks, sports fields, golf courses, and where turf provides a playing surface."

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

Since this mitigation method does not change the electricity intensity factor (kWh/million gallons) associated with the supply, treatment, and distribution of the water, the percent reduction in GHG emissions is dependent only on the change in water consumption.

The Project's mitigated water use is the Estimated Total Water Use (ETWU) described in the Model Water Efficient Landscape Ordinance:

$$ETWU = ET0 \times 0.62 \times \left(\frac{PF \times HA}{IE} + SLA \right)$$

Where:

ETWU	=	Estimated total water use (gallons per year)
ET_0	=	Annual Reference Evapotranspiration from Appendix A of the Model Water Efficient Landscape Ordinance (inches per year)
PF	=	Plant Factor from WUCOLS[93] see Table WUW-3.1 for examples and WUCOLS for a complete list of values
HA	=	Hydrozone Area[94] (square feet)
SLA	=	Special Landscape Area (square feet)
0.62	=	Conversion factor (to gallons per square foot)
IE	=	Irrigation Efficiency[95] (minimum 0.71)

Then the percent reduction in GHG emissions is calculated as follows:

$$\text{GHG emission reduction} = \frac{MAWA - ETWU}{MAWA}$$

[93] § 491 Definitions in Model Water Efficient Landscape Ordinance: "Plant Factor (PF)" is a factor, when multiplied by ET_0, estimates the amount of water needed by plants." The Model Water Efficient Landscape Ordinance indicates that PF is 0-0.3 for low water use plants, 0.4-0.6 for moderate water use plants, and 0.7-1.0 for high water use plants. PF is equivalent to the "species factor" (k_s) in WUCOLS. See Table A above for examples of low, moderate, and high water use plants from WUCOLS. For a complete list of PF (k_s) values, see the species evaluation list in WUCOLS.

[94] § 491 Definitions in Model Water Efficient Landscape Ordinance: "Hydrozone means a portion of the landscaped area having plants with similar water needs. A hydrozone may be irrigated or non-irrigated."

[95] § 491 Definitions in Model Water Efficient Landscape Ordinance: "Irrigation Efficiency (IE) means the measurement of the amount of water beneficially used divided by the amount of water applied. Irrigation efficiency is derived from measurements and estimates of irrigation system characteristics and management practices. The minimum average irrigation efficiency for purposes of the ordinance is 0.71. Greater irrigation efficiency can be expected from well designed and maintained systems."

As shown in this equation, the regional electricity intensity factor and utility carbon intensity factor do not play a role in determining the percentage reduction in GHG emissions. Furthermore, since ET_0 is a multiplier in both MAWA and ETWU, it cancels out and therefore ET_0 does not play a role in determining the percentage reduction in GHG emissions either.

Table WUW-3.1: Example Plant Factor (PF) Values from WUCOLS

Water Needs	PF Range	Plant Type	Species Examples
Low	0 - 0.3	tree	Quercus agrifolia (coast live oak)
			Yucca
			Pinus halepensis (Aleppo pine)
		shrub	Quercus berberidifolia (California scrub oak)
			Lonicera subspicata (chaparral honeysuckle)
			Salvia apiana (white sage)
		vine	Macfadyena unguis-cati (cat's claw)
		groundcover	Arctostaphylos spp. (manzanita)
		perennial	Monardella villosa (coyote mint)
Moderate	0.4 - 0.6	tree	Acer negundo (California box elder)
			Acer paxii (evergreen maple)
		shrub	Buxus microphylla japonica (Japanese boxwood)
		vine	Wisteria
			Aristolochia durior (Dutchman's pipe)
		groundcover	Ceratostigma plumbaginoides (dwarf plumbago)
		perennial	Monarda didyma (bee balm)
	0.6	turf grasses (warm season)	Bermudagrass
			kikuyugrass
			seashore paspalum
			St. Augustinegrass
			zoysiagrass
High	0.7 - 1.0	tree	Betula pendula (European white birch)
			Betula nigra (river/red birch)
		shrub	Cyathea cooperii (Australian tree fern)
			Cornus stolonifera (red osier dogwood)
		groundcover	Soleirolia soleirolii (baby's tears)
		perennial	Mimulus spp., herbaceous (monkey flower)
			Woodwardia radicans (European chain fern)
			Acorus gramineus (sweet flag)
	0.8	turf grasses (cool season)	annual bluegrass
			annual ryegrass
			colonial bentgrass
			creeping bentgrass
			hard fescue
			highland bentgrass
			Kentucky bluegrass
			meadow fescue
			perennial ryegrass
			red fescue
			rough-stalked bluegrass
			tall fescue

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Assuming an irrigation efficiency of 71% as specified in the Model Water Efficient Landscape Ordinance and no Special Landscape Area: • 0% reduction if 100% of vegetation is Moderate PF • 13% reduction if 40% of vegetation is Low PF, 40% is Moderate PF, and 20% is High PF • 35% reduction if 50% of vegetation is Low PF and 50% is Moderate PF • 70% reduction if 100% of vegetation is Low PF
All other pollutants	Not Quantified[96]

Discussion:

Example calculations of MAWA and ETWU are provided in the Model Water Efficient Landscape Ordinance. In this example, assume that the Project Applicant has used the equations to calculate MAWA = 100 million gallons and ETWU = 80 million gallons. Then the GHG emissions reduction is 20%:

$$\text{GHG Emission Reduced} = \frac{100-80}{100} = 0.2 \text{ or } 20\%$$

Assumptions:

Data based upon the following references:

[1] California Department of Water Resources. 2009. Model Water Efficient Landscape Ordinance. Available online at: http://www.water.ca.gov/wateruseefficiency/docs/MWELO09-10-09.pdf

[2] ("WUCOLS"): California Department of Water Resources. 2000. A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III. Available online at: http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf

[3] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

Preferred Literature:

The California Department of Water Resources Model Water Efficient Landscape Ordinance requires that the Estimated Total Water Use (ETWU) of certain landscape

[96] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

projects shall not exceed the Maximum Applied Water Allowance (MAWA) for that landscape area. The MAWA is calculated based on average irrigation efficiencies and plant factors, two major influences on the water demand of a landscape. The ETWU is calculated based on project-specific plant factors and irrigation efficiency.

Alternative Literature:

[4] ("WUCOLS"): California Department of Water Resources. 2000. A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III. Available online at: http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf

[5] The Las Pilitas Nursery website has a user-friendly and searchable database of native California plants: http://www.laspilitas.com/shop/plant-products. As shown in WUCOLS, many California native plants have minimal or very low water needs.

The equation on page 9 of WUCOLS [4] shows that water demand for irrigation landscape plantings (ETL, landscape evapotranspiration) is calculated by multiplying two parameters: the landscape coefficient (KL) and the reference evapotranspiration (ETo). KL values are based on a species factor, density factor, and microclimate factor. The guidance provides detailed instructions on how to assign project-specific values for these three factors. KL can then be divided by the irrigation efficiency to obtain the Total Water Applied, as shown on page 31 of the guidance [4]. Total Water Applied is analogous to ETWU in the methodology shown above. Thus, the detailed WUCOLS methodology could be used to perform a more rigorous calculation of ETWU which incorporates microclimate effects (e.g. windy areas, areas shaded by buildings, etc) and vegetation density effects.

Other Literature Reviewed:

None

4.2.4 Use Water-Efficient Landscape Irrigation Systems

Range of Effectiveness: 6.1% reduction in GHG emissions from outdoor water

Measure Description:

Water use contributes to GHG emissions indirectly, via the production of the electricity that is used to pump, treat, and distribute the water. Using water-efficient landscape irrigation techniques such as "smart" irrigation technology reduces outdoor water demand, energy demand, and the associated GHG emissions.[97]

"Smart" irrigation control systems use weather, climate, and/or soil moisture data to automatically adjust watering schedules in response to environmental and climate changes, such as changes in temperature or precipitation levels. Thus, the appropriate amount of moisture for a certain vegetation type is maintained, and excessive watering is avoided. Many companies which design and install smart irrigation systems, such as Calsense, ET Water, and EPA-certified WaterSense Irrigation Partners, may be able to provide a site-specific estimate of the percent reduction in outdoor water use that can be expected from installing a smart irrigation system. Expected reductions are in the range of 1 – 30%, with the high end of the range associated with historically high water users. To take credit for the high end of the GHG emissions reductions based on these company quotes, the Project Applicant would need to provide detailed and substantial evidence supporting the proposed percent reduction in water use. Alternatively, the Project Applicant could apply the average percent reduction reported in a 2009 study conducted by Aquacraft, Inc. in cooperation with the California Department of Water Resources, the California Urban Water Conservation Council, and a consortium of California water utilities. This comprehensive study showed that smart irrigation systems of various brands achieve an average of 6.1% reduction in outdoor water use in California. This percent reduction is based on a two year study (one year pre and post installation of smart controllers) of over two thousand sites in seventeen different water utilities throughout northern and southern California. While the study also presents utility-specific percent reductions, variations in implementation and sample size between utilities renders these percent reductions insufficient for characterization in a mitigation measure at this time. The study also notes that for a sample of smart controllers where data was collected for three years after installation, the percent reduction in water use increased with time, with the greatest percent reduction achieved in year three.

[97] The installation of smart irrigation controllers will be required starting in 2011 as indicated in the 2010 Draft California Green Building Standards Code. As technology advances and newer generation smart irrigation controllers become available, the Project Applicant may choose to use this mitigation measure to quantify water use and associated GHG reductions beyond what would be achieved with the standards required by the California Green Building Standards Code.

The expected percent reduction is applied to the baseline water use, calculated according to the baseline methodology document. The energy-intensity factor associated with water conveyance and distribution is provided in the 2006 CEC report [2].

Measure Applicability:

- Outdoor water use

Inputs:

The following information needs to be provided by the Project Applicant:

- Total expected outdoor water demand, without installation of smart landscape irrigation controller (million gallons).
- (Optional) Project-specific percent reduction in outdoor water demand, after installation of smart landscape irrigation controller. Percent reduction must be verifiable. Otherwise, use the default value of 6.1%.

Baseline Method:

$$\text{GHG emissions} = \text{Water}_{\text{baseline}} \times \text{Electricity} \times \text{Utility}$$

Where:

GHG emissions = MT CO_2e

$\text{Water}_{\text{baseline}}$ = Total expected outdoor water demand, without installation of smart landscape irrigation controllers (million gallons)
Provided by Applicant

Electricity = Electricity required to supply, treat, and distribute water (kWh/million gallons)
Northern California Average: 3,500 kWh/million gallons
Southern California Average: 11,111 kWh/million gallons

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

Since this mitigation method does not change the electricity intensity factor (kWh/million gallons) associated with the supply and distribution of the water, the percent reduction in GHG emissions is dependent only on the change in water consumption:

$$\text{GHG emission reduction} = \text{PercentReduction} \times \text{Water}_{\text{baseline}}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for outdoor water use.

$\text{Water}_{\text{baseline}}$ = Total expected outdoor water demand, without installation of smart landscape irrigation controllers (million gallons)

Provided by Applicant

PercentReduction = Expected percent reduction in water use after installation of smart landscape irrigation controllers (%)

Provided by Applicant or use default 6.1%

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	6.1% unless project-specific data is provided
All other pollutants	Not Quantified[98]

Discussion:

The percent reduction in GHG emissions is equivalent to the percent reduction in outdoor water usage. Therefore, if a Project Applicant uses the default percent reduction in water usage associated with installing smart landscape irrigation control systems (6.1%), the resulting reduction in GHG emissions is also 6.1%.

Assumptions:

Data based upon the following references:

[1] “Evaluation of California Weather-Based “Smart” Irrigation Controller Programs.” July 2009. Presented to the California Department of Water Resources by The Metropolitan Water District of Southern California and The East Bay Municipal Utility District. Facilitated by the California Urban Water Conservation Council. Prepared by Aquacraft Inc., National Research Center Inc., and Dr. Peter J. Bickel. Available online at: http://www.aquacraft.com/Download_Reports/Evaluation_of_California_Smart_Controller_Programs_-_Final_Report.pdf

[2] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

Preferred Literature:

As described above, the 2009 study [1] conducted by Aquacraft, Inc. in cooperation with the California Department of Water Resources, the California Urban Water Conservation Council, and a consortium of California water utilities showed that smart

[98] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

irrigation systems of various brands achieve an average of 6.1% reduction in outdoor water use in California.

Alternative Literature:

When common watering systems such as in-ground sprinklers are used, much of the water applied to lawns and landscapes is not absorbed by the vegetation. Instead, it is lost through runoff or evaporation. The USEPA reports that a study by the American Water Works Association found that households with in-ground sprinkler systems used 35% more water outdoors than households without these systems, while households with drip irrigation systems used 16% more water [3]. The USEPA reports that hand-held hoses or sprinklers are often more water efficient than automatic irrigation systems.

However, "smart" automatic landscape irrigation systems do exist. Examples include systems which automatically adjust watering schedules in response to environmental and climate changes, such as changes in temperature or precipitation levels. A few references have quantified reductions from this type of irrigation strategy. The Southern Nevada Water Authority reports that smart irrigation systems can reduce outdoor water use by an average of 15 to 30 percent, depending on the system, landscape type, and location [4]. One study conducted in 40 households with historically high water use in Irvine, California showed an average reduction in outdoor water use of 16% [5,6]. Another study conducted in Santa Barbara, California households with historically high water use showed an average water savings of 26% [5,7]. A Project Applicant could also hire an EPA-certified WaterSense Irrigation Partner to design and install a new irrigation system or audit an existing system in an effort to minimize the amount of water consumed [6].

[3] USEPA. 2002. Water-Efficient Landscaping: Preventing Pollution & Using Resources Wisely. Available online at: http://www.epa.gov/npdes/pubs/waterefficiency.pdf
[4] Southern Nevada Water Authority. Smart Irrigation Controllers. Available online at: http://www.snwa.com/html/land_irrig_smartclocks.html. Accessed March 2010.
[5] Irrigation Association. Smart Controller Efficiency Testing. Available online at: http://www.irrigation.org/SWAT/Industry/case-studies.asp. Accessed March 2010.
[6] Irvine Ranch Water District, et al. 2001. Residential Weather-Based Irrigation Scheduling: Evidence from the Irvine "ET Controller" Study. Available online at: http://www.irrigation.org/swat/images/irvine.pdf
[7] Santa Barbara County Water Agency, et al. 2003. Santa Barbara County ET Controller Distribution and Installation Program Final Report. Available online at: http://www.irrigation.org/swat/images/santa_barbara.pdf
[8] USEPA. WaterSense: Landscape Irrigation. Available online at: http://www.epa.gov/WaterSense/services/landscape_irrigation.html

4.2.5 Reduce Turf in Landscapes and Lawns

Range of Effectiveness: Varies and is equal to the percent commitment to turf reduction, assuming no other outdoor water uses

Measure Description:

Water use contributes to GHG emissions indirectly, via the production of the electricity that is used to pump, treat, and distribute the water. Turf grass (i.e. lawn grass) has relatively high water needs compared to most other types of vegetation. For example, trees planted in turf generally do not need additional watering besides what is required for the turf. Water agencies in Southern California have instituted turf removal programs which provide rebates for resident who reduce the turf area in their lawns. Reducing the turf size of landscapes and lawns reduces water consumption and the associated indirect GHG emissions.[99]

This measure describes how to calculate GHG savings from reducing the turf area of an existing lawn by X square feet, or designing a lawn to have X square feet less than the turf area of a standard lawn at the project location.[100]

Additional GHG emissions reductions may occur due to a reduction in fertilizer usage. Since this will vary based on individual occupant behavior, this reduction in GHG emissions from decreased fertilizer usage is not quantified.

Measure Applicability:

- Outdoor water use

Inputs:

The following information needs to be provided by the Project Applicant:

- Turf area of existing lawn or standard lawn at the project location (square feet)
- Turf area reduction commitment (square feet reduced or percent of baseline reduced)

Baseline Method:

---

[99] See the SoCal WaterSmart Residential Turf Program description at http://socalwatersmart.com/index.php?option=com_content&view=article&id=77&Itemid=10. Accessed March 2010.

[100] The Project Applicant would need to provide a value for and evidence supporting this "standard-sized lawn." This value is likely to vary greatly depending on the type of building (single-family, condo, apartment complex, commercial space) as well as location (region in California, urban or suburban).

The methodology for calculating water demand presented here is based on the California Department of Water Resources (CDWR) 2009 Model Water Efficient Landscape Ordinance [1] and the CDWR 2000 report: "A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III" [2].

The Project Applicant should first calculate the amount of water required to support the existing turf or standard-sized turf ($Water_{baseline}$).[101] In the equations below, "crop" also represents "turf grass," or lawn grasses.

$$ET_C = K_c \times ET_0$$

Where:

ET_C = Crop Evapotranspiration, the total amount of water the baseline turf loses during a specific time period due to evapotranspiration[102] (inches water/day)

K_C = Crop Coefficient, factor determined from field research, which compares the amount of water lost by the crop (e.g. turf) to the amount of water lost by a reference crop (unitless)

Species-specific; provided in Table WUW-5.1 below

ET_0 = Reference Evapotransporation, the amount of water lost by a reference crop (inches water/day)

Region-specific; provided in Appendix A of the CDWR Model Water Efficient Landscape Ordinance [1]

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[101] Page 10 of the CDWR report explains that the objective of landscape management is to maintain the "health, appearance, and reasonable growth" of plants, and not necessarily to replenish all of the water lost at maximum evapotranspiration rates. Thus, the CDWR methodology presented here calculates only the amount of water required to sustain the health, appearance, and growth of the plants.

[102] Evapotranspiration is water lost to the atmosphere due to evaporation from soil and transpiration from plant leaves. For a more detailed definition, see this California Irrigation Management Information System (CIMIS) website: http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp;jsessionid=91682943559928B8A9A243D2A2665E19

Table WUW-5.1:
Crop Coefficient for Turf Grasses

Category	Kc	Species
cool season grasses	0.8	annual bluegrass annual ryegrass colonial bentgrass creeping bentgrass hard fescue highland bentgrass Kentucky bluegrass meadow fescue perennial ryegrass red fescue rough-stalked bluegrass tall fescue
warm season grasses	0.6	Bermudagrass kikuyugrass seashore paspalum St. Augustinegrass zoysiagrass

Reference: p. 6 and p. 137 of CDWS report

Then: $$Water_{baseline} = ETC \times Area_{baseline} \times 0.62 \times 365$$

Where:

$Water_{baseline}$ = Volume of water required to support the baseline turf (gallons/year)
$Area_{baseline}$ = Area of existing or standard turf (square feet)
Provided by the Applicant
0.62 = conversion factor (gallons/squarefoot·inches water)
365 = conversion factor (days/year)
ETC = Crop evapotranspiration
Calculated using the equation on page 280

Then the baseline GHG emissions are calculated as follows:

$$GHG\ emissions = Water_{baseline} \times Electricity \times Utility$$

Where:

GHG emissions = MT CO_2e
Electricity = Electricity required to supply, treat, and distribute water (kWh/million gallons)

Northern California Average (outdoor uses): 3,500 kWh/million gallons
Southern California Average (outdoor uses): 11,111 kWh/million gallons

Utility = Carbon intensity of Local Utility (CO_2e/kWh)

Mitigation Method:

The equations above show that the GHG emissions are directly proportional to the water demand, which is in turn directly proportional to the area of the turf. Therefore, only the area of the existing or standard turf and the commitment to turf area reduction (square feet reduced or percent of baseline reduced) are needed to calculate the percent reduction in GHG emissions:

$$\text{GHG emission reduction} = \frac{Area_{reduction}}{Area_{baseline}} = AreaPercentReduction$$

Where:

$Area_{reduction}$ = Area of turf to be reduced (square feet)
Provided by the Applicant

$Area_{baseline}$ = Area of existing or standard turf (square feet)
Provided by the Applicant

AreaPercentReduction = Percent reduction in turf area (%)
Provided by the Applicant

As shown in this equation, the regional electricity intensity factor for water and the utility carbon intensity factor do not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Up to 100%, assuming 100% reduction in turf grass area. This would be the case for rock-lawns, for example.
All other pollutants	Not Quantified[103]

Discussion:

In this example, assume that the Project Applicant has provided detailed evidence to show that the turf area of a standard lawn at the project location is 8,000 square feet. If the Project Applicant then commits to reducing the turf area of lawns by 3,000 square feet, then the GHG emissions reduction is 37.5%.

[103] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

$$\text{GHG Emission Reduced} = \frac{3,000}{8,000} = 0.375 \text{ or } 37.5\%$$

Assumptions:

Data based upon the following references:

[1] California Department of Water Resources. 2009. Model Water Efficient Landscape Ordinance. Available online at: http://www.water.ca.gov/wateruseefficiency/docs/MWELO09-10-09.pdf

[2] California Department of Water Resources. 2000. A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III. Available online at: http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf

[3] CEC. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December. Available online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

Preferred Literature:

See above

Alternative Literature:

None

Other Literature Reviewed:

None

4.2.6 Plant Native or Drought-Resistant Trees and Vegetation

Range of Effectiveness: Best Management Practice; may be quantified if substantial evidence is available.

Measure Description:

California native plants within their natural climate zone and ecotype need minimal watering beyond normal rainfall, so less water is needed for irrigating native plants than non-native species. Drought-resistant vegetation needs even less watering. Water use contributes to GHG emissions indirectly, via the production of the electricity that is used to pump, treat, and distribute the water. Thus, planting native and drought-resistant vegetation reduces water use and the associated GHGs. Designing landscapes with native plants can provide many other benefits, including reducing the need for fertilization and pesticide use, and providing a more natural habitat for native wildlife. Although there is much anecdotal evidence for the benefits of planting native vegetation, few scientific studies have quantified the actual water savings. Therefore, this mitigation measure would most likely be employed as a Best Management Practice. Future studies may quantify the water-saving benefits of planting native or drought-resistant vegetation. In order to take quantitative credit for this mitigation measure, the Project Applicant would need to provide detailed and substantial evidence supporting a percent reduction in water use. The percent reduction would be applied to the baseline water use, calculated according to the baseline methodology described in WUW-3 (Design water efficient landscapes) and the baseline methodology document.

Measure Applicability:

- Outdoor water use

Inputs:

The following information needs to be provided by the Project Applicant:

- Percent reduction in water use, calculated using detailed and substantial evidence
- $Water_{baseline}$, to be calculated by the Project Applicant using the baseline methodology described in WUW-3 (Design water efficient landscapes) and the baseline methodology document

Baseline Method

See WUW-3 (Design water efficient landscapes)

Mitigation Method

Since this mitigation method does not change the electricity intensity factor (kWh/million gallons) associated with the supply, treatment, and distribution of the water, the percent reduction in GHG emissions is dependent only on the change in water consumption:

$$\text{GHG emission reduction} = \text{PercentReduction} \times \text{Water}_{baseline}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions for outdoor water use.

$\text{Water}_{baseline}$ = Baseline water demand, without planting native or drought-resistant vegetation
Provided by Applicant, calculated using baseline methodology of Mitigation Measure WUW-3

PercentReduction = Expected percent reduction in water use resulting from planting native or drought-resistant vegetation
Provided by Applicant

As shown in these equations, the carbon intensity of the local utility does not play a role in determining the percentage reduction in GHG emissions.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	To be determined by Applicant
All other pollutants	Not Quantified[104]

Discussion:

Currently there is not sufficient substantial evidence supporting a generalized reduction in emissions due to planting native or drought tolerant species. However, if the project applicant is able to provide sufficient substantial evidence supporting a reduction in water usage associated with native or drought tolerant species, the percent reduction in GHG emissions is equivalent to the percent reduction in outdoor water usage. Therefore, if a Project Applicant can support a 10% reduction in water use by native and drought tolerant species, the GHG emissions associated with water use are reduced by 10%.

Assumptions:

None

[104] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

Alternative Literature:

The EPA reports that while there is anecdotal evidence for the water-saving benefits of planting native and drought-resistant vegetation, there are very few scientific studies available which quantify the benefits. There are several good resources available which describe the qualitative benefits. The California Native Plant Society provides many resources for designing a native plant garden, including how to identify native plants and where to buy them. The Las Pilitas Nursery provides similar resources and also lists species of drought-resistant plants that are best for specific California regions. The EPA also provides tips for designing landscapes with native plants.

USEPA. “Exploring the Environmental, Social and Economic Benefits Conference,” December 6-7, 2004. USEPA. Greenacres: Landscaping with Native Plants Research Needs. Available online at: http://www.epa.gov/greenacres/conf12_04/conf_A.html. Accessed March 2010.
California Native Plant Society. Homepage. Available online at: http://www.cnps.org/. Accessed March 2010.
Las Pilitas Nursery. Drought Tolerant or Resistant Native Plants. Available online at: http://www.laspilitas.com/garden/Drought_resistant_plants_for_a_California_garden.html. Accessed March 2010.
USEPA. Greenacres: Native Plants Brochure. Available online at: http://www.epa.gov/greenacres/navland.html#Introduction. Accessed March 2010.

Alternative Literature:

None.

Other Literature Reviewed:

None

5.0 Landscaping Equipment

5.1 Landscaping Equipment

5.1.1 Prohibit Gas Powered Landscape Equipment.

Measure Description:

Electric lawn equipment including lawn mowers, leaf blowers and vacuums, shredders, trimmers, and chain saws are available. When electric landscape equipment is used in place of a conventional gas-powered equipment, direct GHG emissions from natural gas combustion are replaced with indirect GHG emissions associated with the electricity used to power the equipment.

Measure Applicability:

[1] Landscaping equipment

Inputs:

The following information needs to be provided by the Project Applicant:

- Electricity provider for the Project
- Horsepower of landscaping equipment
- Hours of operation

Baseline Method:

Look up landscape equipment emission factor based on type of fuel used:

Landscaping Equipment Horsepower	CO_2 Emission Factor from Gasoline (g/hp-hr)
< 25	429.44
25 – 50	783.30
50 – 120	774.50
120 –175	753.25
> 175	732.00

$$\text{GHG emission} = EF \times Hp \times LF \times Hr \times 10^{-6}$$

Where:

GHG emission = MT CO_2e per year

EF = CO_2 emission factor for the relevant horsepower tier show in table above (g/hp-hr). Obtained from OFFROAD2007.

Hp = Horsepower of landscaping equipment
LF = Load factor of equipment for the relevant horsepower tier (dimensionless). Obtained from OFFROAD2007.
Hr = Hours of operation per year
10^{-6} = Unit conversion from grams to MT

Mitigation Method:

Landscaping equipment will run on electricity instead of gasoline. The indirect GHG emission from electricity generation is:

$$\text{GHG emission} = \text{Utility} \times \text{Hp} \times \text{LF} \times \text{Hr} \times \text{C}$$

Where:
GHG emissions = MT CO_2e
Utility = Carbon intensity of Local Utility (CO_2e/kWh). See table below.
Hp = Horsepower of landscaping equipment.
LF = Load factor of equipment for the relevant horsepower tier (dimensionless). Obtained from OFFROAD2007.
Hr = Hours of operation.
C = Unit conversion factor

Power Utility	Carbon-Intensity (lb CO_2e/kWh)
LADWP	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

GHG Reduction %[105] $= 1 - \dfrac{\text{Utility} \times \text{C}}{\text{EF} \times 10^{-6}}$

EF = Emission Factor for the relevant fuel horsepower tier (g/hp-hr) Obtained from OFFROAD2007. See accompanying tables.

Emission Reduction Ranges and Variables:

Power Utility	Equipment Horsepower	Project GHG Emission Reductions
LADWP	< 25	2.5%
	25 – 50	46.5%

[105] This assumes energy from engine losses are the same.

Power Utility	Equipment Horsepower	Project GHG Emission Reductions
	50 – 120	45.9%
	120 –175	44.4%
	> 175	42.8%
PG&E	< 25	64.1%
	25 – 50	80.3%
	50 – 120	80.1%
	120 –175	79.5%
	> 175	78.9%
SCE	< 25	49.5%
	25 – 50	72.3%
	50 – 120	72.0%
	120 –175	71.2%
	> 175	70.4%
SDGE	< 25	38.5%
	25 – 50	66.3%
	50 – 120	65.9%
	120 –175	64.9%
	> 175	63.9%
SMUD	< 25	56.3%
	25 – 50	76.0%
	50 – 120	75.8%
	120 –175	75.1%
	> 175	74.3%

Criteria pollutants will be reduced by reduction in combustion. They will also increase through the increase in energy use. However, the increase may not be in the same air basin.

Discussion:

The output from OFFROAD2007 shows the same emissions within each horsepower tier regardless of the year modeled. Therefore, the emission reduction is dependent on the location of the Project and horsepower of the landscaping equipment only.

Assumptions:

Data based upon the following references:

California Air Resources Board. Off-road Emissions Inventory. OFFROAD2007. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm

California Climate Action Registry Reporting Online Tool. 2006 PUP Reports. Available online at: https://www.climateregistry.org/CARROT/public/reports.aspx

Preferred Literature:

The amount of direct GHG emissions avoided can be calculated using CARB's OFFROAD model, which provides state-wide and regional emission factors for different types of landscaping equipment that can be converted to grams per horsepower-hour [1]. Multiplying this factor by the typical horsepower and load factor of the equipment and number of hours of operation gives the direct GHG emissions. Assuming the same number of operating hours and power output as the gas-powered equipment, the same amount of energy consumption multiplied by the carbon-intensity factor of the local utility gives the amount of indirect GHG emissions associated with using the electric landscape equipment. The GHG emissions reduction associated with this mitigation measure is therefore the difference in emissions from these two scenarios.

Companion Strategy:

In order to take credit for Mitigation Measure 80, a Project Applicant must also commit to providing electrical outlets on the exterior of all buildings (Mitigation Measure 60) so that electrical lawn equipment is compatible with built facilities.

Alternative Literature:

None

Notes:

1. CARB. OFFROAD 2007 Model. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm. Accessed February 2010.

Other Literature Reviewed:

A. USEPA. Lawn Mower Exchange Program Calculator. Available online at: http://www.epa.gov/air/community/mowerexchange_calculator.html. Accessed February 2010.
B. USEPA. Improving Air Quality in Your Community: Outdoor Air – Transportation: Lawn Equipment. Available online at: http://www.epa.gov/air/community/details/yardequip.html. Accessed February 2010.
C. CARB. AB118 Lawn and Garden Equipment Replacement Project. Available online at: http://www.arb.ca.gov/msprog/aqip/lger.htm. Accessed February 2010.
D. SCAQMD. Mow Down Air Pollution Electric Lawn Mower Exchange. Available online at: http://www.aqmd.gov/tao/lawnmower2009.html. Accessed February 2010.
E. VCAPD. Lawn Mower Trade-In Program for Ventura County Residents. Available online at: http://www.vcapcd.org/LawnMower_EN.htm. Accessed February 2010.

F. SMAQMD. Mow Down Air Pollution. Available online at: http://www.airquality.org/mobile/mowdown/index.shtml. Accessed February 2010.

5.1.2 Implement Lawnmower Exchange Program

Range of Effectiveness: Best Management Practice, influences Area GHG emissions from landscape equipment

Measure Description:
When electric and rechargeable battery-powered lawnmowers are used in place of conventional gas-powered lawnmowers, direct GHG emissions from fuel combustion are displaced by indirect GHG emissions associated with the electricity used to power the equipment. The indirect GHG emissions from electricity generation are expected to be significantly less than the direct GHG emissions from gasoline or diesel fuel combustion. Since the magnitude of the GHG emissions reduction depends on the equipment model (including electric power efficiency and battery recharge time), hours of operation, fuel displaced, and number of lawnmowers replaced, the exact GHG emissions reduction is not quantifiable at this time. Therefore, this mitigation measure should be incorporated as a Best Management Practice to allow for educated residents and commercial tenants to reduce their contribution to GHG emissions from landscaping. Many California Air Districts, including eight air districts supported by the CARB Lawn and Garden Equipment Replacement (LGER) Project, already have lawnmower exchange programs in place. This Best Management Practice could involve participating in these established lawnmower exchange programs, supplementing the established programs, or implementing a new program for the Project. The Project Applicant should check with the local air district regarding participating in established programs. The Project Applicant could take quantitative credit for this mitigation measure if detailed and substantial evidence were provided.

Measure Applicability:

- GHG emissions from landscaping

Assumptions:
Data based upon the following references:

- CARB. AB118 Lawn and Garden Equipment Replacement Project. Available online at: http://www.arb.ca.gov/msprog/aqip/lger.htm. Accessed February 2010.
- SCAQMD. Mow Down Air Pollution Electric Lawn Mower Exchange. Available online at: http://www.aqmd.gov/tao/lawnmower2009.html. Accessed February 2010.
- VCAPD. Lawn Mower Trade-In Program for Ventura County Residents. Available online at: http://www.vcapcd.org/LawnMower_EN.htm. Accessed February 2010.
- SMAQMD. Mow Down Air Pollution. Available online at: http://www.airquality.org/mobile/mowdown/index.shtml. Accessed February 2010.

Emission Reduction Ranges and Variables:
This is a Best Management Practice and therefore there is no quantifiable reduction at this time. Check with local agencies for guidance on any allowed reductions associated with implementation of best management practices.

Preferred Literature:
CARB's Lawn and Garden Equipment Replacement (LGER) Project was established to encourage the use of cordless zero-emission lawn and garden equipment and to help bring more electric equipment to the market. The LGER Project provides vouchers for electric cordless residential lawn mowers valued up to $250 for each gas-powered lawnmower turned in. The LGER Project provides grants to eight air districts with existing lawnmower exchange programs, including AVAQMD, MDAQMD, SCAQMD, SDAPCD, SJVAPCD, SMAQMD, VCAPCD, and YSAQMD. Individual air districts may offer vouchers of different values.

Alternative Literature:

None

Other Literature Reviewed:

- USEPA. Lawn Mower Exchange Program Calculator. Available online at: http://www.epa.gov/air/community/mowerexchange_calculator.html. Accessed February 2010.
- USEPA. Improving Air Quality in Your Community: Outdoor Air – Transportation: Lawn Equipment. Available online at: http://www.epa.gov/air/community/details/yardequip.html. Accessed February 2010.

5.1.3 Electric Yard Equipment Compatibility

Range of Effectiveness: Best Management Practice, influences Area GHG emissions from landscape equipment. Not applicable on its own. This measure enhances effectiveness of A-1 and A-2.

Measure Description:

This measure is required to be grouped with measures A-1 "Prohibit Gas Powered Landscape Equipment" and A-2 "Implement a Lawnmower Exchange Program." In order for measures A-1 and A-2 to be feasible, electrical outlets on the exterior of buildings must be accessible so that the electric landscaping equipment can be charged. In this mitigation measure, the Project Applicant commits to providing electrical outlets on the exterior of Project buildings as necessary for sufficient powering of electric lawnmowers and other landscaping equipment.

Measure Applicability:

- This measure is part of a grouped measure
- This measure contributes to reductions in GHG emissions from landscaping

Emission Reduction Ranges and Variables:

This measure is a Best Management Practice grouped with other measures and therefore there is no quantifiable reduction at this time. Check with local agencies for guidance on any allowed reductions associated with implementation of Best Management Practices.

Preferred Literature:

None

6.0 Solid Waste

6.1 Sold Waste

6.1.1 Institute or Extend Recycling and Composting Services

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:
The transport and decomposition of landfill waste and the flaring of landfill gas all produce GHG emissions. Decomposition of waste produces methane, a GHG which has a global warming potential over 20 times that of CO_2. The transport of waste from the site of generation to the landfill produces GHG emissions from the combustion of the fuel used to power the vehicle. Choosing waste management practices which reduce the amount of waste sent to landfills will reduce GHG emissions. Strategies to reduce landfill waste include increasing recycling, reuse, and composting, and encouraging lifestyle choices and office practices which reduce waste generation.

Current protocols for quantifying emissions reductions from diverted landfill waste developed by the USEPA and the California Center for Integrated Waste Management Board (CIWMB) are based on life-cycle approaches, which reflect emissions and reductions in both the upstream and downstream processes around waste management. The Project Applicant should seek local agency guidance on comparing and/or combining operational emissions inventories and life cycle emissions inventories.

Furthermore, while tools are available to quantify the avoided landfill GHG emissions from a specified amount of diverted or recycled waste, taking credit for this mitigation measure also requires the determination of the effects of instituting or extending recycling and composting services. Since both government and privately-sponsored recycling and composting programs vary dramatically in scope, waste materials accepted, and outreach efforts, no literature references exist which provide default values for percent of waste diverted. To take credit for this measure, the Project Applicant would need to provide detailed and substantial evidence supporting the amount of waste reduced or diverted to recycling and composting due to the institution of extended recycling and composting services.

Measure Applicability:

[2] Solid waste disposed to landfill

Inputs:
The following information needs to be provided by the Project Applicant:

- For residential buildings: number of residents
- For shopping malls and office buildings: building square footage
- For public venues: annual number of visitors
- For all other commercial buildings: number of employees
- Waste disposal method
- Amount of waste reduced or diverted to recycling and composting due to the institution of extended recycling and composting services.

Baseline Method:
The Project Applicant must first calculate the total amount of waste generated at the project.

For residential buildings and all commercial buildings except shopping malls and offices:

$$Waste_{baseline\ total} = People \times DisposalRate$$

For shopping malls and office buildings:

$$Waste_{baseline\ total} = SF \times DisposalRate$$

Where:

People = Number of residents, employees, or visitors (for public venues)
Provided by Applicant
SF = Square feet of building
Provided by Applicant
DisposalRate = Annual disposal rate of waste (tons/resident/year, tons/employee/year, or tons/visitor/year)
From Tables SW-1.1 and SW-1.2

The total waste stream is then portioned into material-specific streams (paper, glass, metal, plastic, etc.) using the percentages listed in Table SW-1.3.

USEPA's Waste Reduction Model (WARM) is used to quantify baseline emissions and emissions reductions from diverting landfill waste to composting or recycling. This web-based tool is available online at http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_Form.html. The required inputs are the tons of waste associated with one of three waste management practices: landfill (baseline scenario), recycled (mitigated scenario), combusted (not applicable in California), and composted (mitigated scenario). The amount of each type of waste in tons is entered into the "Tons Landfilled" column in the Baseline Scenario of

WARM to calculate the baseline GHG emissions in metric MT carbon equivalent (MTCE). Other input variables include landfill type (presence of landfill gas control system or not) and distance of waste transport; however, default values can be used.

Mitigation Method:
In WARM, the project applicant specifies the amount of waste associated with each of the three alternative scenarios: waste reduced (e.g. reduced waste generation), waste recycled, and waste composted. WARM then calculates the GHG savings associated with the alternative scenarios as compared with the baseline scenario.

Assumptions:
Data based upon the following reference:

- USEPA. 2009. Waste Reduction Model. Available online at: http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html
- CIWMB. 1999. Statewide Waste Characterization Study: Final Results and Report. Available online at: http://www.calrecycle.ca.gov/publications/LocalAsst/34000009.pdf
- CIWMB. 2006. Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups. Available online at: http://www.ciwmb.ca.gov/WasteChar/WasteStudies.htm#2006Industry

Preferred Literature:
USEPA's WARM was developed to track GHG emission reductions from various waste management options. This tool calculates the GHG emissions associated with a baseline waste management strategy, as well as those associated with an alternative strategy that may include source reduction, recycling, composting, combusting, or landfilling. WARM then calculates the GHG savings associated with the alternative strategy as compared with the baseline strategy. WARM requires input of the estimated tons of waste per material type per disposal strategy. There are 34 different material types (e.g., aluminum cans, mixed paper, yard trimmings, carpet). Other input variables include landfill type (presence of landfill gas control system or not) and distance of waste transport; however, default values can be used. Note that WARM was developed based on a life-cycle approach, which reflects emissions and reductions in both the upstream and downstream processes around waste management. USEPA notes that emission factors developed based on this life cycle approach are not appropriate for use in GHG inventories.

Alternative Literature:
None

Other Literature Reviewed:

- HF&H Consultants. 2008. 5-Year Audit Program Assessment and Final Report. Prepared for StopWaste.Org. Available online at: http://www.stopwaste.org/docs/revised_assessment_report-final_1-08.pdf
- StopWaste.Org. 2008. Multifamily Dwelling Recycling Evaluation Report. Available online at: http://www.stopwaste.org/docs/mfd_evaluation_rpt.pdf

Table SW-1.1
Residential Waste Disposal Rates

Multi-family Homes		
All Counties	All Regions	**Annual Disposal Rate (tons/resident/year)**
		0.46

Single-family Homes		
County	**Region**	**Annual Disposal Rate (tons/resident/year)**
Alameda	Bay Area	0.42
Alpine	Mountain	0.25
Amador	Mountain	0.25
Butte	Central Valley	0.36
Calaveras	Mountain	0.25
Colusa	Central Valley	0.36
Contra Costa	Bay Area	0.42
Del Norte	Coastal	0.44
El Dorado	Mountain	0.25
Fresno	Central Valley	0.36
Glenn	Central Valley	0.36
Humbolt	Coastal	0.44
Imperial	Southern	0.41
Inyo	Mountain	0.25
Kern	Southern	0.41
Kings	Central Valley	0.36
Lake	Central Valley	0.36
Lassen	Mountain	0.25
Los Angeles	Southern	0.41
Madera	Central Valley	0.36
Marin	Bay Area	0.42
Mariposa	Mountain	0.25
Mendocino	Coastal	0.44
Merced	Central Valley	0.36
Modoc	Mountain	0.25
Mono	Mountain	0.25

Single-family Homes		
County	**Region**	**Annual Disposal Rate (tons/resident/year)**
Monterey	Coastal	0.44
Napa	Bay Area	0.42
Nevada	Mountain	0.25
Orange	Southern	0.41
Placer	Central Valley	0.36
Plumas	Mountain	0.25
Riverside	Southern	0.41
Sacramento	Central Valley	0.36
San Benito	Coastal	0.44
San Bernardino	Southern	0.41
San Diego	Southern	0.41
San Francisco	Bay Area	0.42
San Joaquin	Central Valley	0.36
San Luis Obispo	Southern	0.41
San Mateo	Bay Area	0.42
Santa Barbara	Southern	0.41
Santa Clara	Bay Area	0.42
Santa Cruz	Coastal	0.44
Shasta	Mountain	0.25
Sierra	Mountain	0.25
Siskiyou	Mountain	0.25
Solano	Bay Area	0.42
Sonoma	Coastal	0.44
Stanislaus	Central Valley	0.36
Sutter	Central Valley	0.36
Tehama	Central Valley	0.36
Trinity	Mountain	0.25
Tulare	Central Valley	0.36
Tuolumne	Mountain	0.25
Ventura	Southern	0.41
Yolo	Central Valley	0.36
Yuba	Central Valley	0.36

Source:

Single-family Homes		
County	**Region**	**Annual Disposal Rate (tons/resident/year)**

CalRecycle. Solid Waste Characterization Database: Residential Waste Disposal Rates. Available online at: http://www.calrecycle.ca.gov/wastechar/Resdisp.htm

CIWMB. 1999. Statewide Waste Characterization Study: Final Results and Report. Available online at: http://www.calrecycle.ca.gov/publications/LocalAsst/34000009.pdf.

Table SW-1.2
Commercial Waste Disposal Rates

Commercial Industry	Annual Disposal Rate	
Fast-Food Restaurants	2.1	tons/employee/year
Full-Service Restaurants	2.2	tons/employee/year
Food Stores	2.4	tons/employee/year
Durable Wholesale Distributors	1.2	tons/employee/year
Non-Durable Wholesale Distributors	1.4	tons/employee/year
Large Hotels	2.0	tons/employee/year
Building Material & Gardening, Big-Box Stores	3.2	tons/employee/year
Building Material & Gardening, Other Stores	1.7	tons/employee/year
Retail, Big-Box Stores	1.4	tons/employee/year
Retail, Other Stores	0.9	tons/employee/year
Shopping Malls, Anchor Stores	1.1	tons/1,000 sqft/year
Shopping Malls, Other	1.0	tons/1,000 sqft/year
Public Venues and Events	0.1	tons/100 visitors/year
Large Office Buildings	0.9	tons/1,000 sqft/year

Abbreviations:

lb - pound
sqft - square feet

Source:

CIWMB. 2006. Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups. Table 2. Available online at: http://www.ciwmb.ca.gov/WasteChar/WasteStudies.htm#2006Industry

Table SW-1.3
Waste Streams and Percent of Disposed Waste

Building Category	Disposed Waste Streams							
	Paper [Mixed Paper, Broad Definition]	Glass [Glass]	Metal [Mixed Metals]	Plastic [Mixed Plastics]	Electronics [Personal Computers]	Organics [Mixed Organics]	Construction & Demolition [Clay Bricks, Concrete]	Household Hazardous, Special, and Mixed Residue [Mixed MSW]
Residential	27.4%	4.0%	4.6%	8.8%	n/a	45.0%	4.5%	5.5%
Fast-Food Restaurants	33.0%	0.6%	1.6%	11.6%	0.0%	52.5%	0.6%	0.0%
Full-Service Restaurants	17.3%	2.7%	2.8%	7.3%	0.1%	66.5%	1.8%	1.5%
Food Stores	18.5%	0.5%	1.4%	9.5%	0.0%	65.0%	5.0%	0.0%
Durable Wholesale Distributors	26.3%	0.7%	11.4%	9.9%	0.5%	5.4%	43.5%	2.4%
Non-Durable Wholesale Distributors	26.5%	0.5%	3.3%	16.0%	2.6%	32.7%	18.4%	0.1%
Large Hotels	32.3%	4.7%	3.8%	9.7%	0.4%	44.2%	4.8%	0.1%
Building Material & Gardening, Big-Box Stores	12.2%	1.9%	8.3%	7.1%	1.2%	8.0%	60.1%	1.2%
Building Material & Gardening, Other Stores	13.4%	5.3%	3.9%	7.1%	1.9%	18.6%	47.4%	2.3%
Retail, Big-Box Stores	21.7%	1.1%	5.3%	16.0%	0.8%	23.6%	27.1%	4.4%
Retail, Other Stores	31.8%	6.2%	8.7%	14.4%	0.7%	17.5%	15.0%	5.7%
Shopping Malls, Anchor Stores	37.9%	5.0%	3.0%	28.8%	0.1%	15.5%	9.1%	0.5%
Shopping Malls, Other	32.7%	1.8%	2.3%	19.6%	0.2%	35.9%	5.3%	2.0%
Public Venues and Events	42.0%	5.5%	1.8%	14.8%	0.0%	34.0%	0.7%	1.2%
Large Office Buildings	50.3%	1.8%	1.6%	12.5%	0.1%	24.4%	8.3%	1.1%

Abbreviations:
MSW - municipal solid waste

Notes:
The USEPA report identifies waste streams with slightly different names than the CIWMB report. The CIWMB and USEPA waste stream categories were paired; USEPA categories are shown in brackets [ ] above.

Sources:
CIWMB. 1999. Statewide Waste Characterization Study: Final Results and Report. Available online at: http://www.calrecycle.ca.gov/publications/LocalAsst/34000009.pdf

CIWMB. 2006. Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups. Available online at: http://www.ciwmb.ca.gov/WasteChar/WasteStudies.htm#2006Industry

USEPA. 2006. Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. Available online at: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

6.1.2 Recycle Demolished Construction Material

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:
Recycling demolished construction material can contribute to GHG reductions in multiple ways. First, it displaces new construction materials, thereby reducing the need for new raw material acquisition and manufacturing of those new construction materials. Harvesting of raw materials and manufacturing new materials requires energy in the form of fuel combustion and electricity, both of which are associated with GHG emissions. If the process of recycling construction materials is less carbon-intensive than the processes required to harvest and produce new construction materials, recycling these construction materials results in a net reduction in GHG emissions. Second, using local recycled construction material reduces the emissions associated with the transportation of new construction materials, which are typically manufactured farther away from a project site. Third, recycling construction material avoids sending this material to landfills. Wood-based materials decompose in landfills and contribute to methane emissions.

Unlike measures which reduce GHG emissions during the operational lifetime of a project, such as reducing building electricity and water usage, this mitigation effort is realized prior to the actual operational lifetime of a project. Therefore, these GHG emissions reductions are best quantified in terms of a life-cycle analysis. Life cycle analyses examine all stages of the life of a product, including raw material acquisition, manufacture, transportation, installation, use, and disposal or recycling. The Project Applicant should seek local agency guidance on comparing and/or combining operational emissions inventories and life cycle emissions inventories.

Measure Applicability:

- Life cycle emissions from construction materials

Preferred Literature:
The California Integrated Waste Management Board (CIWMB) cites decreases in greenhouse gas emissions as a benefit of construction waste management and recycling in its document “Construction Waste Management” which is used as part of California Sustainable Design Training. The document is available online at: www.calrecycle.ca.gov/greenbuilding/training/statemanual/waste.doc

Alternative Literature:
None

Other Literature Reviewed:
None

7.0 Vegetation

7.1 Vegetation

7.1.1 Urban Tree Planting

Range of Effectiveness: CO_2 reduction varies by the number of trees. VOC emissions may increase.

Measure Description:

Planting trees sequesters CO_2 while the trees are actively growing. The amount of CO_2 sequestered depends on the type of tree. IPCC indicates that in most cases, the active growing period of a tree is 20 years and after this time the amount of carbon in biomass slows and will be completely offset by losses from clipping, pruning, and occasional death [1]. Therefore, the emissions only occur for a 20 year period and are summed over all years to give a net one-time GHG benefit.

If large areas of trees will be planted, the lead agency may want to ensure enforceability by requiring submission of annual inventory consistent with the Urban Forest Protocol [2]. This is a comprehensive protocol that requires maintenance and replacement of trees. If the Project Applicant desires to use this approach, calculation methodologies and assumptions presented in the protocol should be used. The information required to implement this protocol is often not available at the time of the CEQA process.

The type of tree species planted will result in varying degrees of carbon sequestration. In addition, trees emit volatile organic compounds (VOCs), which are criteria pollutant precursors. Therefore the Project Applicant may want to consider these issues when selecting the type of tree to plant. See [3] for details on low-VOC trees.

Measure Applicability:

- New trees

Inputs:

The following information needs to be provided by the Project Applicant:

- Species classes of trees planted, if known
- Number of net new trees in each species class, if known
- Total number of net new trees

Baseline Method:

In the baseline case, there are no net new trees planted.

Mitigation Method:

Look up default annual CO_2 sequestration rates on a per tree basis:

Broad species class	Default annual CO_2 accumulation per tree[1] (MT CO_2/ year)
Aspen	0.0352
Soft maple	0.0433
Mixed hardwood	0.0367
Hardwood maple	0.0521
Juniper	0.0121
Cedar/larch	0.0264
Douglas fir	0.0447
True fir/Hemlock	0.0381
Pine	0.0319
Spruce	0.0337
Miscellaneous[2]	0.0354

1. IPCC's carbon (C) values converted to carbon dioxide (CO_2) using ratio of molecular weights (44/12).
2. Average of all other broad species classes. To be assumed if tree type is not known.

Therefore, the reduction in GHG emissions associated with planting new trees is:

$$\text{GHG emission reduction} = (\text{Growing Period} \times \sum_{i=1}^{n} [\text{ Sequestration } i \times \text{Trees } i\,]\,) \div \text{Total GHG emissions}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions as compared to total GHG emissions.
Growing Period = Growing period for all trees, expressed in years (20).
n = Number of broad species classes. Provided by Applicant.
Sequestration *i* = Default annual CO_2 accumulation per tree for broad species class *i.* Lookup in table above.
Trees *i* = Number of net new trees of broad species class *i.*
Total GHG emissions = Total GHG emissions. Provided by Applicant.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Varies based on number of trees
VOC	May increase
All other pollutants	Not Quantified

Discussion:

If the applicant has baseline total project emissions of 5,000 MT CO_2e per year, and if the applicant elects to mitigate GHG emissions by committing to planting 500 net new "miscellaneous" trees, the applicant would reduce the amount of GHG emissions associated with the project by 7%.

$$\text{GHG Emission Reduced} = \frac{20 \times 0.0354 \times 500}{5,000} = 0.07 \text{ or } 7\%$$

Assumptions:

Data based upon the following reference:

[1] IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Table 8.2. Available online at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_08_Ch8_Settlements.pdf

Preferred Literature:

The IPCC Guidelines [1] provide a method for estimating the amount of carbon sequestered by trees. IPCC default annual CO_2 sequestration rates on a per tree basis are used. Table 8.2 of the IPCC Guidelines provides species class-specific sequestration values. For species that do not appear or if the species is unknown, the average value from Table 8.2 (0.035 MT CO_2 per year per tree) can be assumed to be representative of trees planted. Urban trees are only net carbon sinks when they are actively growing. The IPCC assumes an active growing period of 20 years (see p. 8.9). Thereafter, the accumulation of carbon in biomass slows with age, and will be completely offset by losses from clipping, pruning, and occasional death. Actual active growing periods are subject to, among other things, species, climate regime, and planting density. Additional credit may be taken for planting native trees. See WUW-3 for details on the design of water-efficient landscaping.

Alternative Literature:

The Center for Urban Forest Research Tree Carbon Calculator is based on a small set of data and extrapolates annual tree girth increases for various tree species [1]. Furthermore, it extrapolates the amount of carbon associated with a given girth for each tree species. This method is based on extrapolation of a limited dataset. In addition it requires considerably more input requirements that may not be available for CEQA projects. These inputs include knowledge of specific tree species that will be planted and assumptions regarding anticipated growth rates. Considering the order of magnitude of mitigation from this option, the additional complexity of this method would not generally be warranted for most CEQA projects.

The CAR Urban Forest Sector Protocol [2] provides guidelines for estimating the amount of CO_2 sequestered by common California tree species. This methodology would require Project Applicants to know the tree species to be planted at the time the CEQA analysis is prepared. Furthermore, this methodology would require Project Applicants to estimate the expected diameter of trees, which is dependent on climate and tree sub-species, among other things.

Alternative Literature References:

[2] CAR. 2010. Urban Forest Project Protocol Version 1.1. Available online at: http://www.climateactionreserve.org/how/protocols/adopted/urban-forest/current-urban-forest-project-protocol/

[3] The Center for Urban Forest Research Tree Carbon Calculator. Available online at: http://www.fs.fed.us/ccrc/topics/urban-forests/

Other Literature Reviewed:

None

7.1.2 Create New Vegetated Open Space

Range of Effectiveness: varies based on amount and type of land vegetated

Measure Description:

A development which re-vegetates or creates vegetated land from previously settled land sequesters CO_2 from the atmosphere which would not have been captured had there been no land-type change. There is no reduction in GHG emissions associated with preservation of a land.

Measure Applicability:

- Open space

Inputs:

The following information needs to be provided by the Project Applicant:

- Types of land uses created
- Acres of each land use created

Baseline Method:

In the baseline case, there is no preserved or created open space.

Mitigation Method:

Lookup carbon dioxide sequestered per acre for each land use that will be preserved or created:

Land Use	Sub-Category	Default annual CO_2 accumulation per acre[1] (MT CO_2/ acre)
Forest Land	Scrub	14.3
	Trees	111
Cropland	--	6.9
Grassland	--	4.31
Wetlands	--	0

1. Calculated by multiplying total biomass (MT dry matter/acre) from IPCC data by the carbon fraction in plant material (0.47), then using the ratio of molecular weights (44/12) to convert from MT of carbon (C) to MT of carbon dioxide (CO_2).

Land uses are defined by IPCC as follows:

(i) Forest Land

This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but *in situ* could potentially reach the threshold values used by a country to define the Forest Land category.

(ii) Cropland

This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.

(iii) Grassland

This category includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions.

(iv) Wetlands

This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

$$\text{GHG emission reduction} = \left(\sum_{i=1}^{n} [\text{ Sequestration } i \times \text{Acres } i\ ] \right) \div \text{Total GHG emissions}$$

Where:

GHG emission reduction = Percentage reduction in GHG emissions as compared to total GHG emissions.

n = Number of land uses. Provided by Applicant.

Sequestration *i* = Default annual CO_2 accumulation per acre for land use *i.* Look up in table above.

Acres *i* = Number of acres of land use *i.*

Total GHG emissions = Total one-time GHG emissions. Provided by Applicant.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	Varies
All other pollutants	Not Quantified

Discussion:

If the applicant has baseline one-time emissions of 5,000 MT CO_2e per year, and if the applicant elects to mitigate GHG emissions by committing to creating 50 acres of forest land (scrub) and 20 acres of grassland, the applicant would reduce the amount of one-time GHG emissions by 16%.

$$\text{GHG Emission Reduced} = \frac{14.3 \times 50 + 4.31 \times 20}{5{,}000} = 0.16 \text{ or } 16\%$$

Assumptions:

Data based upon the following references:

[1] IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4. Available online at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Preferred Literature:

The IPCC Guidelines provide a method for calculating changes in CO_2 sequestration due to land-type conversions. While other methods exist, notably the CCAR Forest Protocol [2], the IPCC Guidelines [1] have more general default values available that will be applicable to all areas of California without requiring detailed site-specific information. A general knowledge of the proposed change in land type is sufficient to quantify reductions in greenhouse gas emissions. IPCC designates four general vegetation types: forest land, cropland, grassland, and wetland. The amount of sequestered CO_2 is calculated based on the amount of carbon stock in each type of biomass (MT carbon / hectare vegetation). IPCC defaults for the carbon stock in each vegetation type are summarized in Table 8.4. (Note that this table represents the amount of carbon removed due to land conversion to settlements; it can also be used to calculate the amount of carbon sequestered due to conversion from settlement to vegetated land. Note also that a conversion to wetlands is not relevant for California). In addition to general default values, the IPCC Guidelines have climate and species-specific data available which can be used if details of the proposed development are known. To calculate the final mass of CO_2, the mass of carbon is then multiplied by 3.67, which is the ratio of molecular mass of CO_2 to the molecular mass of carbon. This method assumes that all of the carbon is converted into CO_2, which is appropriate for most CEQA projects.

Alternative Literature:

The CAR Forest Sector Protocol provides guidelines for estimating the amount of CO_2 sequestered by vegetated land [1]. The Protocol is specific to forest land only, and is not appropriate for estimating land-type conversions to or from cropland or grassland. Additionally, the methodology is limited to conversions from vegetated land to settlement or settlement to vegetated land, but is not appropriate for changes from one vegetated land type to another vegetated land type. The Protocol recommends accounting for changes in the organic carbon content of soil, which requires soil sampling and testing. While testing of existing soil is feasible, the protocol does not provide adequate methods for predicting the future soil organic carbon content after a land-type conversion has taken places. Furthermore, soil testing may be a burdensome task for a Project Applicant. Methodologies which provide default values, such as the IPCC Guidelines, are preferable.

Alternative Literature References:

[2] CAR. 2010. Urban Forest Project Protocol Version 1.1. Available online at: http://www.climateactionreserve.org/how/protocols/adopted/urban-forest/current-urban-forest-project-protocol/

Other Literature Reviewed:

None

8.0 Construction

8.1 Construction

8.1.1 Use Alternative Fuels for Construction Equipment

Range of Effectiveness: 0 – 22% reduction in GHG emissions

Measure Description:

When construction equipment is powered by alternative fuels such as compressed natural gas rather than conventional petroleum diesel or gasoline, GHG emissions from fuel combustion may be reduced.

Measure Applicability:

[3] Construction vehicles

Inputs:

The following information needs to be provided by the Project Applicant:

- Fuel type and Horsepower of Construction Equipment
- Hours of operation

Baseline Method:

For all pollutants besides ROG emissions from gasoline-fueled equipment, total emission is equivalent to exhaust emission and is calculated as follows:

$$\text{Exhaust Emission} = \frac{\text{Exhaust}}{\text{Activity} \times \text{AvgHP}} \times \text{Hp} \times \text{Hr} \times \text{C}$$

Where:

Exhaust Emission= MT or tons of pollutant per year

Exhaust = Statewide daily emission from equipment for the relevant horsepower tier of diesel or gasoline fuel (tons/day). Obtained from OFFROAD2007.

Activity = Statewide daily average operating hours for the relevant horsepower tier (hours/day). Obtained from OFFROAD2007.

AvgHP = Average horsepower for the relevant horsepower tier (HP). Obtained from OFFROAD2007.

Hp = Horsepower of equipment.

Hr = Hours of operation.

C = Unit conversion factor

Note that this method assumes the load factor of the equipment is same as the default in OFFROAD2007.

Total GHG emission is calculated as follows:

$$\text{GHG Emission} = CO_2 \text{ Emission} + CH_4 \text{ Emission} \times 21 + N_2O \text{ Emission} \times 310$$

Where:

GHG Emission = MT CO_2e
CO_2 Emission = CO_2 emission calculated as described above with data from OFFROAD2007.
CH_4 Emission = CH_4 emission calculated as described above with data from OFFROAD2007.
N_2O Emission = N_2O emission calculated as described above with data from OFFROAD2007.
21 = Global warming potential of CH_4 following CCAR GPR 2009.
310 = Global warming potential of N_2O following CCAR GPR 2009.

Total ROG emission from gasoline-fueled equipment is calculated as follows:

$$\text{Total ROG Emission} = \text{Exhaust ROG Emission} + \frac{\text{Resting} + \text{Diurnal} + \text{Hot Soak} + \text{Evaporative}}{\text{Activity} \times \text{AvgHP}} \times \text{Hp} \times \text{Hr} \times \text{C}$$

Where:

Total ROG Emission = Tons of ROG emission per year
Exhaust ROG Emission = ROG emission from exhaust calculated as described above (tons/year)
Resting = Statewide daily resting losses from equipment for the relevant horsepower tier (tons/day). Obtained from OFFROAD2007.
Diurnal = Statewide daily diurnal losses from equipment for the relevant horsepower tier (tons/day). Obtained from OFFROAD2007.
Hot Soak = Statewide daily hot soak losses from equipment for the relevant horsepower tier (tons/day). Obtained from OFFROAD2007.
Evaporative = Statewide daily evaporative losses from equipment for the relevant horsepower tier (tons/day). Obtained from OFFROAD2007.
Activity = Statewide daily average operating hours for the relevant horsepower tier (hours/day). Obtained from OFFROAD2007.
AvgHP = Average horsepower for the relevant horsepower tier (HP). Obtained from OFFROAD2007.
Hp = Horsepower of TRU.
Hr = Hours of operation.
C = Unit conversion factor

Mitigation Method:

Mitigated emissions for this measure are calculated using the same method as baseline method, but with emission factors from compressed natural gas in OFFROAD2007.

Emission Reduction Ranges and Variables:

GHG and criteria pollutant emission reductions from switching diesel or gasoline fuel to compressed natural gas fuel for different years are listed in accompanying tables. Only equipment with emission data for compressed natural gas and either diesel or gasoline fuel in OFFROAD2007 are included.

Discussion:

The emission changes vary over a large range for different pollutants and equipment and between diesel and gasoline. In fact, GHG emissions for several types of equipment running on gasoline and all equipment running on diesel would increase from switching to compressed natural gas, as reflected by the negative reductions in the tables. On the other hand, SO_2 emissions are 100% reduced as there is no SO_2 emissions from equipment running on compressed natural gas according to OFFROAD2007. Other trends include no significant change in PM emissions for most gasoline equipment, considerable decrease in CO emissions from gasoline equipment but significant increase in CO emissions from diesel equipment. Therefore, the Project Applicant has to weigh the costs and benefits from switching to compressed natural gas on a case-by-case basis.

Assumptions:

Data based upon the following references:

- California Air Resources Board. Off-road Emissions Inventory. OFFROAD2007. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm
- California Climate Action Registry (CCAR). 2009. General Reporting Protocol. Version 3.1. Available online at: http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html
  California Climate Action Registry Reporting Online Tool. 2006 PUP Reports. Available online at: https://www.climateregistry.org/CARROT/public/reports.aspx

Preferred Literature:

GHG emissions from the combustion of conventional petroleum diesel and gasoline fuel can be calculated using CARB's OFFROAD model emission factors [1]. The model provides state-wide and regional emission factors that can be converted to grams per horsepower-hour. Multiplying this factor by the typical horsepower of the equipment and the estimated number of hours of operation gives the total GHG emissions. In this mitigation measure, compressed natural gas was chosen as the alternative fuel. Emission factors for compressed natural gas can also be obtained from OFFROAD The

GHG emissions reduction associated with this mitigation measure is therefore the difference in emissions from using petroleum diesel or gasoline versus using compressed natural gas. Other types of alternative fuels besides compressed natural gas exist. In order to take credit for this mitigation measure, the Project Applicant would need to provide detailed and substantial documentation showing expected reductions in GHG emissions as a result of running construction equipment on these alternative fuels rather than petroleum diesel or gasoline. One potential issue with quantifying this mitigation measure is the difference in fuel economy between petroleum diesel and alternative fuels.

Alternative Literature:

Many USDOE, NREL, and USEPA reports exist which present data on exhaust emissions from engines operating with alternative fuels. The majority of these reports focuses on oxides of nitrogen (NOx) and particulate matter (PM) emissions and have limited CO_2 emissions and fuel economy data. One NREL report shows CO_2 emissions and fuel economy for three ethanol/diesel blends (7.7%, 10%, and 15%) in three off-road engines (6.8, 8.1, and 12.5 L) and compares the results to engine performance using conventional diesel fuel [5]. However, this report presented engine-specific data from a small study size. Issues with other reports include the study's focus on on-road engines rather than off-road engines which would be used in construction equipment. It would be difficult to generalize the data contained in these reports for a Project Applicant's ease of use.

Notes:

[1] CARB. OFFROAD 2007 Model. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm. Accessed February 2010.

Other Literature Reviewed:

[2] USEPA. 2002. A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions. Available online at: http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf
[3] USDOE. NREL: ReFUEL Laboratory: Data and Resources. Available online at: http://www.nrel.gov/vehiclesandfuels/refuellab/data_resources.html. Accessed March 2010.
[4] USDOE. 2006. NREL: Effects of Biodiesel Blends on Vehicle Emissions. Available online at: http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/40554.pdf
[5] USDOE. 2003. NREL: The Effect of Biodiesel Composition on Engine Emissions from a DDC Series 60 Diesel Engine. Available online at: http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/31461.pdf

Table C-1.1
Emission Reduction Due to Fuel Switch from Gasoline to Compressed Natural Gas

Equipment	Horsepower	2004					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	59%	-27%	36%	91%	98%	100%
	15 - 25	61%	-40%	7%	90%	97%	100%
Air Conditioner	< 175	24%	14%	19%	0%	97%	100%
Baggage Tug	< 120	46%	15%	-4%	0%	93%	100%
Belt Loader	< 120	52%	18%	3%	0%	95%	100%
Bobtail	< 120	55%	17%	19%	0%	95%	100%
Cargo Loader	< 120	41%	16%	2%	0%	93%	100%
Catering Truck	< 250	31%	12%	25%	0%	94%	100%
Forklifts	< 25	53%	-46%	23%	-85%	92%	100%
	25 - 50	94%	22%	-33%	0%	97%	100%
	50 - 120	58%	19%	18%	0%	96%	100%
	120 - 175	24%	17%	24%	0%	94%	100%
Fuel Truck	<175	3%	18%	17%	0%	99%	100%
Generator Sets	<120	52%	18%	14%	0%	96%	100%
	120 - 175	22%	14%	21%	0%	95%	100%
Lav Truck	<175	32%	18%	17%	0%	94%	100%
Lift	<120	53%	17%	14%	0%	96%	100%
Passenger Stand	<175	27%	15%	22%	0%	96%	100%
Service Truck	<250	13%	16%	26%	0%	95%	100%

Equipment	Horsepower	2010					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	58%	-27%	39%	91%	96%	100%
	15 - 25	58%	-37%	32%	90%	95%	100%
Air Conditioner	< 175	29%	14%	19%	0%	98%	100%
Baggage Tug	< 120	13%	13%	-114%	0%	84%	100%
Belt Loader	< 120	27%	15%	-82%	0%	91%	100%
Bobtail	< 120	29%	16%	11%	0%	96%	100%
Cargo Loader	< 120	15%	14%	-70%	0%	89%	100%
Catering Truck	< 250	35%	12%	29%	0%	95%	100%
Forklifts	< 25	53%	-51%	3%	-85%	85%	100%
	25 - 50	95%	22%	18%	0%	98%	100%
	50 - 120	52%	18%	5%	0%	95%	100%
	120 - 175	27%	14%	23%	0%	94%	100%
Fuel Truck	<175	9%	16%	15%	0%	100%	100%
Generator Sets	<120	40%	17%	16%	0%	97%	100%
	120 - 175	26%	14%	23%	0%	95%	100%
Lav Truck	<175	36%	15%	-18%	0%	94%	100%
Lift	<120	44%	17%	16%	0%	96%	100%

Passenger Stand	<175	32%	15%	25%	0%	97%	100%
Service Truck	<250	19%	14%	40%	0%	95%	100%

Equipment	Horsepower	2015					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	58%	-27%	39%	91%	96%	100%
	15 - 25	58%	-37%	32%	90%	94%	100%
Air Conditioner	< 175	31%	13%	23%	0%	99%	100%
Baggage Tug	< 120	8%	14%	-93%	0%	85%	100%
Belt Loader	< 120	22%	16%	-69%	0%	92%	100%
Bobtail	< 120	25%	16%	13%	0%	96%	100%
Cargo Loader	< 120	5%	14%	-91%	0%	88%	100%
Catering Truck	< 250	38%	11%	33%	0%	95%	100%
Forklifts	< 25	53%	-51%	3%	-85%	84%	100%
	25 - 50	95%	22%	34%	0%	98%	100%
	50 - 120	52%	18%	6%	0%	95%	100%
	120 - 175	27%	14%	25%	0%	95%	100%
Fuel Truck	<175	12%	15%	13%	0%	100%	100%
Generator Sets	<120	21%	16%	17%	0%	97%	100%
	120 - 175	29%	13%	24%	0%	96%	100%
Lav Truck	<175	36%	15%	-24%	0%	95%	100%
Lift	<120	37%	16%	16%	0%	96%	100%
Passenger Stand	<175	34%	14%	28%	0%	98%	100%
Service Truck	<250	22%	13%	46%	0%	96%	100%

Equipment	Horsepower	2020					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	58%	-27%	39%	91%	96%	100%
	15 - 25	58%	-37%	32%	90%	94%	100%
Air Conditioner	< 175	32%	13%	24%	0%	99%	100%
Baggage Tug	< 120	7%	15%	-49%	0%	89%	100%
Belt Loader	< 120	21%	16%	-27%	0%	94%	100%
Bobtail	< 120	26%	16%	13%	0%	96%	100%
Cargo Loader	< 120	3%	15%	-62%	0%	91%	100%
Catering Truck	< 250	39%	11%	36%	0%	96%	100%
Forklifts	< 25	53%	-51%	3%	-85%	84%	100%
	25 - 50	95%	22%	36%	0%	98%	100%
	50 - 120	52%	18%	8%	0%	95%	100%
	120 - 175	27%	14%	26%	0%	95%	100%
Fuel Truck	<175	12%	14%	9%	0%	100%	100%
Generator Sets	<120	-5%	16%	17%	0%	98%	100%
	120 - 175	30%	13%	25%	0%	97%	100%
Lav Truck	<175	36%	15%	3%	0%	96%	100%

Lift	<120	30%	16%	15%	0%	97%	100%
Passenger Stand	<175	35%	14%	30%	0%	98%	100%
Service Truck	<250	23%	13%	42%	0%	96%	100%

Equipment	Horsepower	2025					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	58%	-27%	39%	91%	96%	100%
	15 - 25	58%	-37%	32%	90%	94%	100%
Air Conditioner	< 175	32%	13%	27%	0%	99%	100%
Baggage Tug	< 120	8%	15%	-27%	0%	92%	100%
Belt Loader	< 120	21%	17%	-7%	0%	96%	100%
Bobtail	< 120	25%	16%	13%	0%	96%	100%
Cargo Loader	< 120	3%	16%	-40%	0%	93%	100%
Catering Truck	< 250	39%	11%	36%	0%	96%	100%
Forklifts	< 25	53%	-51%	3%	-85%	84%	100%
	25 - 50	95%	21%	36%	0%	98%	100%
	50 - 120	52%	18%	8%	0%	95%	100%
	120 - 175	27%	14%	26%	0%	95%	100%
Fuel Truck	<175	13%	14%	13%	0%	100%	100%
Generator Sets	<120	-15%	16%	18%	0%	98%	100%
	120 - 175	30%	13%	26%	0%	98%	100%
Lav Truck	<175	36%	15%	22%	0%	97%	100%
Lift	<120	27%	16%	15%	0%	97%	100%
Passenger Stand	<175	35%	13%	30%	0%	99%	100%
Service Truck	<250	24%	12%	34%	0%	96%	100%

Table C-1.2
Emission Reduction Due to Fuel Switch from Diesel to Compressed Natural Gas

Equipment	Horsepower	2004					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	-2749%	-27%	55%	36%	73%	100%
	15 - 25	-2912%	-31%	46%	26%	74%	100%
Air Conditioner	<175	-451%	-21%	-30%	84%	87%	100%
Baggage Tug	<120	-507%	-24%	10%	94%	88%	100%
Belt Loader	<120	-469%	-23%	6%	93%	89%	100%
Bobtail	<120	-441%	-22%	23%	93%	91%	100%
Cargo Loader	<120	-625%	-25%	-4%	93%	84%	100%
Catering Truck	<250	-1152%	-22%	-44%	70%	78%	100%
Forklifts	<50	-21%	-23%	-51%	93%	95%	100%
	50 - 120	-594%	-25%	5%	93%	87%	100%
	120 - 175	-581%	-22%	-2%	88%	89%	100%
Generator Sets	<120	-397%	-12%	-2%	92%	91%	100%
	<175	-415%	-12%	-11%	85%	89%	100%
Lav Truck	<175	-457%	-22%	-11%	88%	89%	100%
Lift	<120	-465%	-23%	-5%	92%	89%	100%

Equipment	Horsepower	2010					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	-3037%	-27%	31%	-29%	59%	100%
	15 - 25	-3755%	-32%	40%	-3%	60%	100%
Air Conditioner	<175	-450%	-20%	-36%	73%	85%	100%
Baggage Tug	<120	-556%	-22%	22%	92%	88%	100%
Belt Loader	<120	-513%	-22%	21%	92%	90%	100%
Bobtail	<120	-480%	-19%	64%	91%	96%	100%
Cargo Loader	<120	-678%	-24%	6%	91%	84%	100%
Catering Truck	<250	-1732%	-21%	-38%	53%	73%	100%
Forklifts	<50	-54%	-21%	26%	90%	96%	100%
	50 - 120	-647%	-22%	32%	90%	90%	100%
	120 - 175	-598%	-21%	38%	82%	90%	100%
Generator Sets	<120	-430%	-11%	11%	89%	91%	100%
	<175	-436%	-11%	0%	81%	89%	100%
Lav Truck	<175	-477%	-21%	1%	84%	90%	100%
Lift	<120	-503%	-22%	9%	90%	89%	100%

Equipment	Horsepower	2015					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	-3040%	-27%	28%	-86%	57%	100%
	15 - 25	-4465%	-32%	32%	-48%	46%	100%
Air Conditioner	<175	-450%	-19%	-41%	47%	85%	100%
Baggage Tug	<120	-590%	-21%	30%	91%	89%	100%
Belt Loader	<120	-541%	-21%	31%	90%	91%	100%
Bobtail	<120	-505%	-19%	65%	89%	96%	100%
Cargo Loader	<120	-720%	-22%	4%	88%	83%	100%
Catering Truck	<250	-1899%	-20%	-54%	16%	72%	100%
Forklifts	<50	-85%	-20%	41%	83%	94%	100%
	50 - 120	-682%	-21%	23%	81%	89%	100%
	120 - 175	-596%	-20%	36%	68%	91%	100%
Generator Sets	<120	-456%	-11%	22%	84%	91%	100%
	<175	-444%	-10%	12%	71%	90%	100%
Lav Truck	<175	-483%	-20%	10%	76%	91%	100%
Lift	<120	-531%	-21%	17%	85%	89%	100%

Equipment	Horsepower	2020					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	-3040%	-27%	28%	-91%	57%	100%
	15 - 25	-4722%	-32%	29%	-91%	39%	100%
Air Conditioner	<175	-449%	-19%	-104%	-81%	88%	100%
Baggage Tug	<120	-621%	-20%	31%	87%	90%	100%
Belt Loader	<120	-569%	-20%	31%	85%	91%	100%
Bobtail	<120	-526%	-19%	53%	84%	95%	100%
Cargo Loader	<120	-757%	-21%	-9%	78%	81%	100%
Catering Truck	<250	-1946%	-20%	-120%	-75%	73%	100%
Forklifts	<50	-100%	-20%	32%	60%	91%	100%
	50 - 120	-696%	-21%	-17%	55%	84%	100%
	120 - 175	-596%	-20%	-12%	31%	89%	100%
Generator Sets	<120	-476%	-10%	25%	69%	91%	100%
	<175	-446%	-10%	5%	48%	90%	100%
Lav Truck	<175	-485%	-19%	-3%	56%	91%	100%
Lift	<120	-553%	-20%	13%	72%	89%	100%

Equipment	Horsepower	2025					
		CO	CO_2e	NOx	PM	ROG	SO_2
Aerial Lifts	<15	-3040%	-27%	28%	-91%	57%	100%
	15 - 25	-4803%	-32%	27%	-109%	37%	100%
Air Conditioner	<175	-450%	-19%	-346%	-331%	88%	100%
Baggage Tug	<120	-640%	-19%	17%	79%	89%	100%
Belt Loader	<120	-587%	-20%	16%	72%	90%	100%
Bobtail	<120	-548%	-19%	32%	72%	93%	100%
Cargo Loader	<120	-763%	-20%	-40%	56%	78%	100%
Catering Truck	<250	-1936%	-20%	-330%	-294%	72%	100%
Forklifts	<50	-106%	-20%	19%	-26%	89%	100%
	50 - 120	-703%	-21%	-69%	-48%	79%	100%
	120 - 175	-597%	-20%	-172%	-110%	83%	100%
Generator Sets	<120	-483%	-10%	13%	37%	90%	100%
	<175	-446%	-10%	-37%	-3%	90%	100%
Lav Truck	<175	-486%	-19%	-57%	5%	90%	100%
Lift	<120	-560%	-20%	-8%	37%	87%	100%

8.1.2 Use Electric and Hybrid Construction Equipment

Range of Effectiveness: 2.5 – 80% of GHG emissions from equipment that is electric or hybrid if used 100% of the time

Measure Description:

When construction equipment is powered by grid electricity rather than fossil fuel, direct GHG emissions from fuel combustion are replaced with indirect GHG emissions associated with the electricity used to power the equipment. When construction equipment is powered by hybrid-electric drives, GHG emissions from fuel combustion are reduced.

Measure Applicability:

- Construction vehicles

Inputs:

The following information needs to be provided by the Project Applicant:

- Electricity provider for the Project
- Fuel type and Horsepower of Construction Equipment
- Hours of operation

Baseline Method:

$$\text{Baseline Emission} = EF \times Hp \times LF \times Hr \times C$$

Where:

Emission = MT CO_2e or MT Criteria Pollutant
EF = Emission factor for the relevant fuel horsepower tier (g/hp-hr). Obtained from OFFROAD2007. See accompanying tables
Hp = Horsepower of equipment.
LF = Load factor of equipment for the relevant horsepower tier (dimensionless). Obtained from OFFROAD2007.
Hr = Hours of operation.
C = Unit conversion factor

Mitigation Method:

<u>Fully Electric Vehicle</u>

Construction vehicles will run solely on electricity. The indirect GHG emission from electricity generation is:

$$\text{Mitigated GHG Emission} = Utility \times Hp \times LF \times Hr \times C$$

Where:

GHG emissions = MT CO_2e
Utility = Carbon intensity of Local Utility (CO_2e/kWh)
Hp = Horsepower of equipment.
LF = Load factor of equipment for the relevant horsepower tier (dimensionless). Obtained from OFFROAD2007.
Hr = Hours of operation.
C = Unit conversion factor

Criteria pollutant emissions will be 100% reduced for equipment running solely on electricity.

$$\text{GHG Reduction } \%^{106} = 1 - \frac{\text{Utility} \times C}{EF \times 10^{-6}}$$

Hybrid-Electric Vehicle
GHG Reduction % = Percent Reduction in Fuel Consumption

Emission Reduction Ranges and Variables:

Fully Electric Vehicle

GHG

Utility	Diesel	Compressed Natural Gas 4-strokes	Gasoline 2-strokes	Gasoline 4-strokes				
				<25 HP	25-50 HP	50-120 HP	120-175 HP	175-500 HP
LADW&P	26.3%	37.9%	2.5%	2.5%	46.5%	45.9%	44.4%	42.8%
PG&E	72.9%	77.1%	64.1%	64.1%	80.3%	80.1%	79.5%	78.9%
SCE	61.8%	67.9%	49.5%	49.5%	72.3%	72.0%	71.2%	70.4%
SDGE	53.5%	60.9%	38.5%	38.5%	66.3%	65.9%	64.9%	63.9%
SMUD	67.0%	72.2%	56.3%	56.3%	76.0%	75.8%	75.1%	74.3%

Criteria pollutant

Emissions will be 100% reduced for equipment running on electricity.

Hybrid-Electric Vehicle

GHG

The Project Applicant has to determine the fuel consumption reduced from using the hybrid-electric vehicle. The emission reductions for all pollutants are the same as the fuel reduction.

[106] This assumes energy from engine losses are the same.

Discussion:

The CO_2 emission factor show in the accompanying tables obtained from OFFROAD2007 [1] shows the same emissions within each horsepower tier regardless of the scenario year or equipment model year. The contributions of CH_4 and N_2O to overall GHG emissions is likely small (< 1% of total CO_2e) from diesel construction equipment [2] and were therefore not included. Therefore, the CO_2e emission reduction is dependent on the electricity provider for the Project, horsepower and fuel of the construction equipment only.

On the other hand, the criteria pollutant emission factors from OFFROAD2007 vary for different scenario and equipment model years. The criteria pollutant emission factors presented in the accompanying tables correspond to those of new equipment in the respective scenario years, i.e., model year is the same as scenario year. Since older equipment have higher emission factors due to deterioration and less regulation, the emission reduction calculated from this methodology is likely to be an underestimate.

Assumptions:

Data based upon the following references:

[1] California Air Resources Board. Off-road Emissions Inventory. OFFROAD2007. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm

[2] California Climate Action Registry (CCAR). 2009. General Reporting Protocol. Version 3.1. Available online at: http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html

[3] California Climate Action Registry Reporting Online Tool. 2006 PUP Reports. Available online at: https://www.climateregistry.org/CARROT/public/reports.aspx

Preferred Literature:

Electric construction equipment is available commercially from companies such as Peterson Pacific Corporation and Komptech USA, which specialize in the mechanical processing equipment like grinders and shredders [4,5]. The amount of direct GHG emissions avoided can be calculated using CARB's OFFROAD2007 model, which provides state-wide and regional emission factors for a variety of construction equipment that can be converted to grams per horsepower-hour [6]. Multiplying this factor by the number of hours of operation gives the direct GHG emissions. Assuming the same number of operating hours as the diesel-powered equipment, the electricity required to run a piece of electric construction equipment can be calculated by multiplying the operating hours by the amperage required to run the equipment and the voltage rating (obtained from manufacturer technical specifications) to obtain total kWh required. Multiplying this value by the carbon-intensity factor of the local utility gives the amount of indirect GHG emissions associated with using the electric equipment. The

GHG emissions reduction associated with this mitigation measure is therefore the difference in emissions from these two scenarios.

Construction equipment powered by hybrid-electric drives is also commercially available from companies such as Caterpillar [7]. For example, Caterpillar reports that during an 8-hour shift, its D7E hybrid dozer burns 19.5% fewer gallons of fuel than a conventional dozer while achieving a 10.3% increase in productivity. The D7E model burns 6.2 gallons per hour compared to a conventional dozer which burns 7.7 gallons per hour. The percent reduction in fuel use is directly proportional to the percent reduction in GHG emissions. Assuming complete combustion to CO_2 and a carbon content of 87%, the CO_2 emissions reductions can be calculated. Fuel usage and savings are dependent on the make and model of the construction equipment used. The Project Applicant should calculate project-specific savings and provide manufacturer specifications indicating fuel burned per hour.

Alternative Literature:

None

Notes:

[4] Peterson Pacific Corp. Product Brochure Downloads. Available online at: http://www.petersonpacific.com/content/MediaGallery_56_v. Accessed March 2010.
[5] Komptech USA. Products. Available online at: http://www.komptech.com/usa/products.htm. Accessed March 2010.
[6] CARB. OFFROAD 2007 Model. Available online at: http://www.arb.ca.gov/msei/offroad/offroad.htm. Accessed February 2010.
[7] Caterpillar. D7E Efficiency. Accessed February 2010. Available online at: http://www.cat.com/D7E

Other Literature Reviewed:

None

Table C-2.1
Emissions Factors from Different Fuels

Fuel	HP	CO_2 Emission Factor (g/hp-hr) All Years
Compressed Natural Gas 4-stroke	All	674.66
Diesel	All	568.30
Gasoline 2-stroke	All	429.44
Gasoline 4-stroke	<25	429.44
	25-50	783.30
	50-120	774.50
	120-175	753.25
	175-500	732.00

Fuel	HP	ROG Emission Factor (g/hp-hr)		
		2004	2010	2015+
Compressed Natural Gas 4-strokes	<15	0.14	0.14	0.14
	15-25	0.14	0.14	0.14
	25-50	0.06	0.01	0.01
	50-120	0.07	0.01	0.01
	120-175	0.06	0.01	0.01
	175-250	0.06	0.01	0.01
	250-500	0.06	0.01	0.01
Diesel	<15	0.57	0.41	0.41
	15-25	0.54	0.48	0.48
	25-50	0.54	0.20	0.08
	50-120	0.38	0.16	0.08
	120-175	0.18	0.13	0.08
	175-250	0.12	0.08	0.06
	250-500	0.10	0.08	0.06
	500-750	0.12	0.08	0.06
	750-1000	0.57	0.08	0.06
	>1000	0.57	0.08	0.08
Gasoline 2-stroke	<2	6.70	5.52	5.52
	2-15	4.19	3.59	3.59
	15-25	4.07	3.79	3.79
Gasoline 4-stroke	<5	6.70	5.52	5.52
	5-15	4.19	3.59	3.59
	15-25	4.07	3.79	3.79

Fuel	HP	ROG Emission Factor (g/hp-hr)		
		2004	2010	2015+
	25-50	1.49	0.65	0.65
	50-120	0.91	0.24	0.24
	120-175	0.72	0.15	0.15
	175-250	0.72	0.15	0.15
	250-500	0.72	0.15	0.15

Fuel	HP	CO Emission Factor (g/hp-hr)		
		2004	2010	2015+
Compressed Natural Gas 4-strokes	<15	300	300	300
	15-25	300	300	300
	25-50	7.02	7.02	7.02
	50-120	20	20	20
	120-175	16	16	16
	175-250	16	16	16
	250-500	16	16	16
Diesel	<15	3.47	3.47	3.47
	15-25	2.34	2.34	2.34
	25-50	3.27	2.86	2.72
	50-120	3.23	3.09	3.05
	120-175	2.70	2.70	2.70
	175-250	0.92	0.92	0.92
	250-500	0.92	0.92	0.92
	500-750	0.92	0.92	0.92
	750-1000	2.70	0.92	0.92
	>1000	2.70	0.92	0.92
Gasoline 2-stroke	<2	318	236	236
	2-15	274	225	225
	15-25	284	238	238
Gasoline 4-stroke	<5	318	236	236
	5-15	274	225	225
	15-25	284	238	238
	25-50	71	38	38
	50-120	38	8.76	8.76
	120-175	21	21	21
	175-250	21	21	21
	250-500	21	21	21

Fuel	HP	NOx Emission Factor (g/hp-hr)		
		2004	2010	2015+
Compressed Natural Gas 4-strokes	<15	8.44	8.44	8.44
	15-25	8.44	8.44	8.44
	25-50	5.19	1.95	1.95
	50-120	4.57	1.58	1.58
	120-175	4.56	1.58	1.58
	175-250	4.56	1.58	1.58
	250-500	4.56	1.58	1.58
Diesel	<15	6.08	4.37	4.37
	15-25	5.79	4.57	4.57
	25-50	5.10	4.88	4.80
	50-120	5.64	5.01	2.53
	120-175	4.72	4.44	2.27
	175-250	4.58	2.45	1.36
	250-500	4.29	2.45	1.36
	500-750	4.51	2.45	1.36
	750-1000	8.17	4.08	2.36
	>1000	8.17	4.08	2.36
Gasoline 2-stroke	<2	2.32	2.70	2.70
	2-15	2.84	2.90	2.90
	15-25	2.32	2.68	2.68
Gasoline 4-stroke	<5	2.32	2.70	2.70
	5-15	2.84	2.90	2.90
	15-25	2.32	2.68	2.68
	25-50	4.52	1.33	1.33
	50-120	5.06	1.78	1.78
	120-175	4.98	1.94	1.94
	175-250	4.98	1.94	1.94
	250-500	4.98	1.94	1.94

Fuel	HP	PM Emission Factor (g/hp-hr)		
		2004	2010	2015+
Compressed Natural Gas 4-strokes	<15	0.90	0.90	0.90
	15-25	0.90	0.90	0.90
	25-50	0.06	0.06	0.06
	50-120	0.06	0.06	0.06
	120-175	0.06	0.06	0.06
	175-250	0.06	0.06	0.06
	250-500	0.06	0.06	0.06
Diesel	<15	0.47	0.38	0.38
	15-25	0.38	0.38	0.38
	25-50	0.43	0.35	0.16
	50-120	0.39	0.24	0.01
	120-175	0.19	0.16	0.01
	175-250	0.11	0.11	0.01
	250-500	0.11	0.11	0.01
	500-750	0.11	0.11	0.01
	750-1000	0.38	0.11	0.06
	>1000	0.38	0.11	0.06
Gasoline 2-stroke	<2	0.74	0.74	0.74
	2-15	0.14	0.14	0.14
	15-25	0.14	0.14	0.14
Gasoline 4-stroke	<5	0.74	0.74	0.74
	5-15	0.14	0.14	0.14
	15-25	0.14	0.14	0.14
	25-50	0.06	0.06	0.06
	50-120	0.06	0.06	0.06
	120-175	0.06	0.06	0.06
	175-250	0.06	0.06	0.06
	250-500	0.06	0.06	0.06

8.1.3 Limit Construction Equipment Idling beyond Regulation Requirements

Range of Effectiveness: Varies with the amount of Project Idling occurring and the amount reduced.

Measure Description:

Heavy duty vehicles will idle during loading/unloading and during layovers or rest periods with the engine still on. Idling requires fuel use and results in emissions. The California Air Resources Board (CARB) Heavy-Duty Vehicle Idling Emission Reduction Program limits diesel-fueled commercial motor vehicles idling time to 5 minutes. There are some exceptions to the regulation such as positioning or providing a power source for equipment or operations such as lift, crane, pump, drill, hoist or other auxiliary equipment. Reduction in idling time beyond required under the regulation would further reduce fuel consumption and thus emissions. The project applicant should develop an enforceable mechanism that monitors the idling time to ensure compliance with this mitigation measure.

Measure Applicability:

- Heavy Duty Commercial Vehicles

Inputs:

The following information needs to be provided by the Project Applicant:

- Idling time of vehicle

Baseline Method:

For all pollutants, the idling emission from each idling period is calculated as follows:

$$\text{Emission} = EF \times t \times C$$

Where:

Emission = grams of pollutant per idling period
EF = Idling emission factor for diesel-fueled heavy duty vehicles obtained from EMFAC (g/idling-hour).
t = Baseline idling period (minute). This is 5 minutes for all vehicles which do not have auxiliary equipment powered by the primary engine exempted from the regulation. For exempted vehicles, the Project applicant shall determine the baseline idling period.
C = Time conversion factor = 1/60

Mitigation Method:

Mitigated emissions for this measure are calculated using the same method as baseline method, but with mitigated idling period.

Emission Reduction Ranges and Variables:

Emission reduction is calculated as follows:

$$\text{Reduction} = 1 - \frac{t_M}{t_B}$$

Where:

t_M = mitigated idling period
t_B = baseline idling period

Discussion:

If a heavy duty truck is regulated under the CARB Idling Emission Reduction Program, and the Project Applicant has committed to enforce a reduced idling period to 3 minutes, then the emissions for all pollutants from idling emissions would be reduced by:

$$1 - \frac{3}{5} = 0.4 = 40\%$$

If the Project Applicant determines that the average idling period for a heavy duty vehicle with a hoist powered by the primary engine is 20 minutes, and has committed to enforce a reduced idling time to 15 minutes, then the emissions for all pollutants would be reduced by:

$$1 - \frac{15}{20} = 0.25 = 25\%$$

Assumptions:

Data based upon the following references:

- California Air Resources Board (CARB) 2009. Heavy-Duty Vehicle Idling Emission Reduction Program. Available at: http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm
- CARB 2010. EMFAC2007 Model. Available at: http://www.arb.ca.gov/msei/onroad/latest_version.htm

Preferred Literature:

Idling of heavy duty commercial vehicles requires fuel use and results in emissions. Project Applicant can obtain the average idling emission factor for diesel-fueled heavy duty trucks in the county where the Project would be located from EMFAC. The total idling emissions can be determined by multiplying this emission factor by the total idling period. The California Air Resources Board (CARB) Heavy-Duty Vehicle Idling Emission Reduction Program limits diesel-fueled commercial motor vehicles idling time to 5 minutes, with exceptions for some vehicles with auxiliary equipment powered by the primary engine [1]. The Project Applicant has to determine the appropriate baseline idling periods for such exempted vehicles. A plan should also be developed to ensure enforcement of the reduced idling period that the Project Applicant has committed to.

Alternative Literature:

None

Notes:

[1] California Air Resources Board (CARB) 2009. Heavy-Duty Vehicle Idling Emission Reduction Program. Available at: http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm

Other Literature Reviewed:

None

8.1.4 Institute a Heavy-Duty Off-Road Vehicle Plan

Range of Effectiveness:

Not applicable on its own. This measure ensures compliances with other mitigation measures.

Measure Description:

The Project Applicant should provide a detailed plan that discusses a construction vehicle inventory tracking system to ensure compliances with construction mitigation measures. The system should include strategies such as requiring hour meters on equipment, documenting the serial number, horsepower, manufacture age, fuel, etc. of all onsite equipment and daily logging of the operating hours of the equipment.

Measure Applicability:

- This measure ensures compliances with other mitigation measures.
- Construction vehicles.

Preferred Literature:

None

Alternative Literature:

None

Literature References:

None

8.1.5 Implement a Construction Vehicle Inventory Tracking System

Range of Effectiveness:

Not applicable on its own. This measure ensures compliances with other mitigation measures.

Measure Description:

The Project Applicant should provide a detailed plan that discusses a construction vehicle inventory tracking system to ensure compliances with construction mitigation measures. The system should include strategies such as requiring engine run time meters on equipment, documenting the serial number, horsepower, manufacture age, fuel, etc. of all onsite equipment and daily logging of the operating hours of the equipment.

Measure Applicability:

- This measure ensures compliance with other mitigation measures.
- Construction vehicles.

Preferred Literature:

None

Alternative Literature:

None

Literature References:

None

9.0 Miscellaneous

9.1 Miscellaneous

9.1.1 Establish a Carbon Sequestration Project

Range of Effectiveness: Varies depending on Project Applicant and projects selected. The GHG emissions reduction is subtracted from the overall baseline project emissions inventory.

Measure Description:
The Project Applicant would establish a carbon sequestration project. This might include (a) geologic sequestration or carbon capture and storage techniques in which CO_2 from point sources such as power plants and fuel processing plants is captured and injected underground, (b) terrestrial sequestration in which ecosystems such as wetlands and forestlands are established or preserved to serve as CO_2 sinks, (c) novel techniques involving advanced chemical or biological pathways, or (d) technologies yet to be discovered. The Project Applicant would commit to a desired amount of carbon sequestration in MT per year. This amount would be subtracted from the overall baseline project emissions inventory. In order to take credit for this measure, the Project Applicant should be required to establish a reporting and verification mechanism to quantify the amount of carbon sequestered. Furthermore, the Project Applicant should be required to prove additionality.[107]

Measure Applicability:
- Overall baseline project GHG emissions inventory

Inputs:
- Amount of CO_2e sequestered (MT/year)

Baseline Method:
The Project Applicant should calculate the baseline project emissions inventory ($CO_2e_{baseline}$, the total baseline CO_2e emissions in MT per year) using the methods described in the baseline methodology document.

Mitigation Method:
The amount of CO_2e sequestered is subtracted from the overall project emissions inventory. Therefore, the percent GHG reduction is

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[107] Additionality is the reduction in emissions by sources or enhancement of removals by sinks that is additional to any that would occur in the absence of the Project. In other words, the Project should not subsidize or take credit for emissions reductions which would have occurred regardless of the Project.

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Misc-1

Carbon Sequestration

GHG emission reduction $= \dfrac{CO_2e_{sequestered}}{CO_2e_{baseline}}$

Where:

GHG emission reduction	=	Percentage reduction in overall GHG emissions from carbon sequestration project
$CO_2e_{sequestered}$	=	Amount of CO_2e sequestered (MT/year) Provided by Applicant
$CO_2e_{baseline}$	=	Total baseline CO_2e emissions (MT/year)

Assumptions:
Data based upon the following references:

- USDOE. Fossil Energy: Carbon Sequestration. Available online at: http://www.fossil.energy.gov/programs/sequestration/

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	To be determined by Applicant
All other pollutants	None

Preferred Literature:
The DOE Fossil Energy – Carbon Sequestration website describes the four core carbon sequestration technologies: geologic, carbon capture and storage, terrestrial, and novel biological and chemical pathways. The DOE website discusses current challenges and research projects associated with each of the carbon sequestration technologies, as well as the trade-offs between local environmental impacts and global environmental benefits.

Alternative Literature:
None

Other Literature Reviewed:
None

9.1.2 Establish Off-Site Mitigation

Range of Effectiveness: Varies depending on Project Applicant and projects selected. The GHG emissions reduction is subtracted from the overall baseline project emissions inventory.

Measure Description:
The Project Applicant may decide to establish GHG reduction measures similar to any of the measures discussed in this report. These reductions would take place outside of the Project Site. In order to take credit for this measure, the Project Applicant should be required to establish a method for registering and verifying the GHG emissions reduction. Furthermore, the Project Applicant should be required to prove additionality.[108]

Measure Applicability:

- Overall baseline project GHG emissions inventory

Inputs:

- Amount of CO_2e reduced off-site (MT/year)

Baseline Method:
The Project Applicant should calculate the baseline project emissions inventory ($CO_2e_{baseline}$, the total baseline CO_2e emissions in MT per year) using the methods described in the baseline methodology document.

Mitigation Method:
The amount of CO_2e reduced off-site is subtracted from the overall project emissions inventory. Therefore, the percent GHG reduction is:

$$\text{GHG emission reduction} = \frac{CO_2e_{\text{reduced off-site}}}{CO_2e_{\text{baseline}}}$$

Where:

GHG emission reduction	=	Percentage reduction in overall GHG emissions from off-site mitigation
$CO_2e_{\text{reduced off-site}}$	=	Amount of CO_2e reduced off-site (MT/year) Provided by Applicant
CO_2e_{baseline}	=	Total baseline CO_2e emissions (MT/year)

[108] Additionality is the reduction in emissions by sources or enhancement of removals by sinks that is additional to any that would occur in the absence of the Project. In other words, the Project should not subsidize or take credit for emissions reductions which would have occurred regardless of the Project.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	To be determined by Applicant
All other pollutants	To be determined by Applicant. Reductions in criteria pollutant emissions may be achieved if the off-site mitigation involves removing or retrofitting combustion sources or reducing electricity use.[109]

Preferred Literature:

None

[109] Note that the reduction in criteria pollutant emissions may not occur in the same air basin as the project.

9.1.3 Use Local and Sustainable Building Materials

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:
Using building materials which are sourced and processed locally (i.e. close to the project site, as opposed to in another state or country) reduces transportation distances and therefore reduces GHG emissions from fuel combustion. Using sustainable building materials, such as recycled concrete or sustainably harvested wood, also contributes to GHG emissions reductions due to the less carbon-intensive nature of the production and harvesting of these materials. Unlike measures which reduce GHG emissions during the operational lifetime of a project, such as reducing building electricity and water usage, these mitigation efforts are realized prior to the actual operational lifetime of a project. Therefore, these GHG emissions are best quantified in terms of a life-cycle analysis. Life cycle analyses examine all stages of the life of a product, including raw material acquisition, manufacture, transportation, installation, use, and disposal or recycling. The Project Applicant should seek local agency guidance on comparing and/or combining operational emissions inventories and life cycle emissions inventories.

Measure Applicability:
- Life cycle emissions from building materials

Inputs:
The following information needs to be provided by the Project Applicant:
- Project location
- Material transport distance
- Material type
- Building assembly type and square footage

Preferred Literature:
Several software packages and web-based tools are available which can be used to quantify the life cycle emissions from building materials.

The Building for Environmental and Economic Sustainability (BEES) software developed by the National Institute of Standards and Technology (NIST) can calculate global warming potential (in terms of CO_2 emissions in grams per product) for a variety of building products, including a multitude of cement varieties, fabrics, tiles, glass, wood, and shelving materials. Required inputs are the type of building material (e.g. generic 100% Portland cement, generic 20% limestone cement), and transportation distance. The user can compare between different types of materials and associated transportation distances.

The BEES software and user manual is available for public download here:
http://www.bfrl.nist.gov/oae/software/bees/bees.html

The Athena EcoCalculator for Assemblies software developed by the Athena Institute analyzes the environmental impacts of whole buildings in terms of global warming potential (in terms of CO_2e) from raw material extraction, final material manufacturing, transportation, on-site construction, maintenance, and demolition and disposal. Required inputs include the project location, assembly type (columns and beams, floor, exterior wall, interior wall, window, or roof), type of material, and square footage of material. The Athena EcoCalculator compares CO_2e emissions from the project-specific assembly to default assemblies of similar material and size. The Athena EcoCalculator is based on the more rigorous Athena Impact Estimator software, which requires detailed information about the building design including the number of columns and beams, supported span, wall height, and type of material used for all aspects. In contrast, the Athena EcoCalculator assumes default values for many of the architectural details.

A free public version of the Athena EcoCalculator is available for download here:
http://www.athenasmi.org/tools/ecoCalculator/index.html

Alternative Literature:
None

Other Literature Reviewed:
None

9.1.4 Require Best Management Practices in Agriculture and Animal Operations

9.1.5 Require Environmentally Responsible Purchasing

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:
Requiring environmentally responsible purchasing has the potential to have a net effect of reducing GHG emissions by reducing the life cycle emissions, operating emissions, and/or transportation emissions associated with a product. Examples of environmentally responsible purchases which reduce life cycle emissions include but are not limited to: purchasing products with sustainable packaging; purchasing post-consumer recycled copier paper, paper towels, and stationary; purchasing and stocking communal kitchens with reusable dishes and utensils; choosing sustainable cleaning supplies; and leasing equipment from manufacturers who will recycle the components at their "end of life." Examples of environmentally responsible purchases which reduce a Project's operating emissions include choosing ENERGY STAR appliances and Water Sense-certified water fixtures; choosing electronic appliances with built in sleep-mode timers; and purchasing "green power" (e.g. electricity generated from renewables or hydropower) from the utility. Choosing locally-made and distributed products reduces the transportation distances required to move the product from the distribution or manufacturing center to the Project, and therefore reduce GHG emissions associated with the transportation vehicles.

Since the magnitude of the energy and GHG reduction depends on the purchasing strategies implemented, the expected GHG reduction is not quantifiable at this time. Therefore, this mitigation measure should be incorporated as a Best Management Practice to encourage homeowners, commercial space tenants, and builders to make sustainable purchases and therefore reduce their contribution to GHG emissions. The Project Applicant could take quantitative credit for this mitigation measure if detailed and substantial evidence were provided.

Measure Applicability:
- Purchase of consumer and business goods and appliances

Assumptions:
Data based upon the following references:

- City of Chicago and ICLEI. Chicago Green Office Challenge: Waste. Available online at: http://www.chicagogreenofficechallenge.org/pages/waste/50.php
- Cool California.org. Small Business Money Saving Actions: Recycle and Cut Waste. Available online at: http://www.coolcalifornia.org/article/recycle-and-cut-waste

- Flex Your Power.org. Commercial Overview Energy Saving Tips: Office Equipment Tips. Available online at: http://www.fypower.org/com/tools/energy_tips_results.html?tips=office
- ENERGY STAR. 2007. Putting Energy into Profits: ENERGY STAR Guide for Small Businesses. Available online at: http://www.energystar.gov/ia/business/small_business/sb_guidebook/smallbizguide.pdf

Emission Reduction Ranges and Variables:
This is a Best Management Practice and therefore at this time there is no quantifiable reduction. Check with local agencies for guidance on any allowed reductions associated with implementation of best management practices.

Preferred Literature:
The Chicago Green Office Challenge, Cool California.org, and Flex Your Power.org website resources provide many examples of office and small business purchasing strategies which reduce waste and energy use. The ENERGY STAR Guide provides more details about energy-efficient appliance choices and the option to purchase renewable or clean energy from the utility for a higher cost.

Alternative Literature:
None

Other Literature Reviewed:
None

9.1.6 Implement an Innovative Strategy for GHG Mitigation

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. The GHG emissions reduction may be quantifiable. If not quantifiable, this mitigation measure should be implemented as a Best Management Practice.

Measure Description:
The Project Applicant may develop a novel strategy to reduce GHG emissions at the project site or off-site. This strategy may incorporate technologies which have yet to be developed at the time of the publication of this report. In order to take quantifiable credit for this measure, the Project Applicant must provide detailed and substantial evidence showing the quantification and verification of the GHG emissions reduction. If the GHG emissions reduction is not quantifiable, it should be implemented as a Best Management Practice.

Measure Applicability:
- To be determined by Project Applicant

Inputs:
- Amount of CO_2e reduced due to Innovative Strategy
- Baseline CO_2e for applicable inventory sector

Baseline Method:
The Project Applicant should calculate the baseline CO_2e emissions associated with the applicable GHG emissions inventory sector ($CO_2e_{baseline\text{-}sector}$, the baseline CO_2e emissions in MT per year for the applicable sector) using the methods described in the baseline methodology document. For example, if the Innovative Strategy achieves GHG reductions by reducing building energy use, $CO_2e_{baseline\text{-}sector}$ is the total CO_2e emissions associated with baseline building energy use.

Mitigation Method:
The amount of CO_2e reduced due to the Innovative Strategy is subtracted from applicable emissions inventory sector. Therefore, the percent GHG reduction is:

$$\text{GHG emission reduction} = \frac{CO_2e_{reduced\text{-}sector}}{CO_2e_{baseline\text{-}sector}}$$

Where:

GHG emission reduction	=	Percentage reduction in sector GHG emissions due to Innovative Strategy
$CO_2e_{reduced\text{-}sector}$	=	Amount of CO_2e reduced due to Innovative Strategy (MT/year) Provided by Applicant
$CO_2e_{baseline\text{-}sector}$	=	Baseline sector CO_2e emissions (MT/year)

If the GHG emissions reduction cannot be quantified and/or verified, check with local agencies for guidance on any allowed reductions associated with implementation of Best Management Practices.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	To be determined by Applicant
All other pollutants	None

Preferred Literature:
None

10.0 General Plans

In addition to fact sheets and BMPs, this document includes measures that are more applicable for General Plans. The following measures have substantial evidence of reductions when implemented at a General Plan level rather than a project level.

10.1 General Plans

10.1.1 Fund Incentives for Energy Efficiency

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:
By funding incentives for energy-efficient choices in equipment, fixtures in buildings, or energy sources, a Project Applicant can promote reductions in GHG emissions associated with fuel combustion and electricity use. The Project Applicant may choose to contribute to an existing municipal energy fund or establish a new energy fund for the Project. The Project Applicant should check with the local air district regarding participating in established programs. These energy funds may provide financial incentives or grants for any number of energy efficiency measures including but not limited to: retrofitting or designing new buildings, parking lots, streets, and public areas with energy-efficient lighting; retrofitting or designing new buildings with low-flow water fixtures and high-efficiency appliances; retrofitting or purchasing new low-emissions equipment; purchasing electric or hybrid vehicles; and investing in renewable energy systems such as photovoltaics or wind turbines. Recipients of energy fund grants could include neighborhood developers, home and commercial space builders, homeowners, and utilities. Energy funds allow recipients flexibility in choosing efficiency strategies while still achieving the desired effects of reduced energy use and associated GHG emissions.

Since the magnitude of the energy and GHG reduction depends on the strategies selected by the energy fund recipients, the expected GHG reduction is not quantifiable at this time. Therefore, this mitigation measure should be incorporated as a Best Management Practice to encourage utilities, builders, residents, and commercial tenants to reduce their energy use and/or choose cleaner energy, and therefore reduce their contribution to GHG emissions. The Project Applicant could take quantitative credit for this mitigation measure if detailed and substantial evidence were provided.

Measure Applicability:
- GHG emissions from energy use (fuel combustion and electricity use)

Assumptions:
Data based upon the following references:

- City of Ann Arbor. Energy Office: Energy Fund. Available online at: http://www.a2gov.org/government/publicservices/systems_planning/energy/Pages/EnergyFund.aspx
- Go Solar California. California Solar Initiative. Available online at: http://www.gosolarcalifornia.org/csi/index.html
- USDOE. Database of State Initiatives for Renewables and Efficiency: California. Available online at: http://www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=CA
- California Clean Energy Fund. About Us. Available online at: http://www.calcef.org/about.htm

Emission Reduction Ranges and Variables:
This is a Best Management Practice and therefore there is no quantifiable reduction at this time. Check with local agencies for guidance on any allowed reductions associated with implementation of best management practices.

Preferred Literature:
The City of Ann Arbor's Energy Fund provides a good example of a municipal general energy fund which provides grants for a wide variety of energy efficiency and renewable energy investments. The California Solar Initiative and the Energy Efficient Appliance Rebate Program (found on the DOE Database of State Initiatives for Renewables and Efficiency) are examples of California state energy funds which incentivize specific types of purchases. The DOE database provides a listing of many more California municipal and local programs.

Alternative Literature:

None

Other Literature Reviewed:
- The Energy Foundation. Programs: Power. Available online at: http://www.ef.org/programs.cfm

10.1.2 Establish a Local Farmer's Market

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:

Establishing a local farmer's market has the potential to reduce greenhouse gas emissions by providing project residents with a more local source of food, potentially resulting in a reduction in the number of trips and vehicle miles traveled by both the food and the consumers to grocery stores and supermarkets. If the food sold at the local farmer's market is produced organically, it can also contribute to greenhouse gas reductions by displacing carbon-intensive food production practices. As discussed in more detail below, these emissions reductions cannot be reasonably quantified at this time because they are based on several undefined parameters: the relative locations of the farmer's market, supermarket, and supermarket produce suppliers; the carbon intensity of food production practices; and the role of the farmer's market in a development, such as whether it supplements trips to the grocery store or completely displaces them.

Measure Applicability:

- Number of trips to supermarket and vehicle miles traveled
- Life cycle emissions of food production

Discussion:

Potential greenhouse gas emissions from establishing a local farmer's market can be divided into two types: emissions reductions from transportation and emissions reductions from food production practices. The transportation of food from a field to a store and the transportation of consumers from their homes to a store both contribute to greenhouse gas emissions. In many cases, especially in urban areas, a local farmer's market will reduce emissions associated with the distribution of food from the field to the consumer, since the farms represented at the local farmer's market are theoretically closer to the consumer than the farms which produce most of the food found at supermarkets and grocery stores. However, California has a large number of farms and orchards and in some cases the farms represented at a local farmer's market may not be different than those represented at the neighborhood grocery store. If a consumer obtains produce from a local farmer's market when they would otherwise drive a farther distance to purchase produce from a grocery store, the trip to the grocery stores is displaced, VMT is reduced, and GHG emissions reductions are achieved. However, if a consumer drives to the farmer's market and then to the grocery store (for example, to purchase food which the farmer's market cannot provide), the trip to the farmer's market is made in addition to the trip to the grocery store. Thus, an additional trip is made, VMT is added, and greenhouse gas emissions are actually increased. It is unclear how local farmer's markets affect the food purchasing behavior of consumers, and therefore the effect of a farmer's market on transportation greenhouse gas emissions is not quantifiable at this time. The carbon intensity of food production practices also contributes to greenhouse gas emissions; however, these emissions are accounted for in the life cycle analysis of the food and cannot be directly compared to a development's operational greenhouse gas emissions inventory (such as the transportation emissions detailed above). If food at a local farmer's market is produced organically, it is likely that less carbon-intensive practices were used than at the large-scale farms and orchards which produce most food found at grocery stores and supermarkets. Examples of carbon-intensive gardening practices include heated greenhouses and the heavy use of fertilizers and pesticides derived from fossil fuels. Local farms which do not practice organic or sustainable farming may employ these more carbon-intensive practices. Thus, the magnitude of the life-cycle greenhouse gas emissions is difficult to quantify and compare to operational inventories.

Preferred Literature:

None

10.1.3 Establish Community Gardens

Range of Effectiveness: Varies depending on Project Applicant and strategies selected. Best Management Practice.

Measure Description:

Establishing a community garden has the potential to reduce greenhouse gas emissions by providing project residents with a local source of food, potentially resulting in a reduction in the number of trips and vehicle miles traveled by both the food and the consumers to grocery stores and supermarkets. Community gardens can also contribute to greenhouse gas reductions by displacing carbon-intensive food production practices. As discussed in more detail below, these emissions reductions cannot be reasonably quantified at this time because they are based on several undefined parameters: the relative locations of the community garden, supermarket, and supermarket produce suppliers; the carbon intensity of gardening and farming practices; and the role of a community garden in a development, such as whether it supplements trips to the grocery store or completely displaces them.

Measure Applicability:

- Number of trips to supermarket and vehicle miles traveled
- Life cycle emissions of food production

Discussion:

Potential greenhouse gas emissions from establishing a community garden can be divided into two types: emissions reductions from transportation and emissions reductions from food production practices. The transportation of food from a field to a store and the transportation of consumers from their homes to a store both contribute to greenhouse gas emissions. In most cases a community garden will reduce emissions associated with the distribution of food from the field to the consumer, since with community gardens the food goes directly from the field to the consumer, while in grocery stores and supermarkets the path is more likely field to regional distribution center to store to consumer. If a consumer obtains produce from a community garden when they would otherwise drive a farther distance to purchase produce from a grocery store, the trip to the grocery stores is displaced, VMT is reduced, and GHG emissions reductions are achieved. However, if a consumer drives to the community garden and then to the grocery store (for example, to purchase food which the community garden cannot provide), the trip to the community garden is made in addition to the trip to the grocery store. Thus, an additional trip is made, VMT is added, and greenhouse gas emissions are actually increased. Furthermore, if community gardens displace backyard gardens, they increase transportation emissions. It is unclear how community gardens affect the food purchasing behavior of consumers, and therefore the effect of a community garden on transportation greenhouse gas emissions is not quantifiable at this time. The carbon intensity of food production practices also contributes to greenhouse gas emissions; however, these emissions are accounted for in the life cycle analysis of the food and cannot be directly compared to a development's operational greenhouse gas emissions inventory (such as the transportation emissions detailed above). Community gardens are likely to produce food using less carbon-intensive practices than the large-scale farms and orchards which produce most food found at grocery stores and supermarkets. Examples of carbon-intensive gardening practices include heated greenhouses and the heavy use of fertilizers and pesticides derived from fossil fuels; these practices are not likely to be used at community gardens. Although these qualitative conclusions can be drawn, the magnitude of the life-cycle greenhouse gas emissions is difficult to quantify and compare to operational inventories.

Preferred Literature:

None

10.1.4 Plant Urban Shade Trees

Range of Effectiveness: The reduction in GHG emissions is not quantifiable at this time, therefore this mitigation measure should be implemented as a Best Management Practice. If the study data were updated to account for Title 24 standards, the GHG emissions reductions could be quantified but would vary based on location, building type, and building size.

Measure Description:

Planting shade trees around buildings has been shown to effectively lower the electricity cooling demand of buildings by blocking incident sunlight and reducing heat gain through windows, walls, and roofs. Deciduous trees with large canopies are a desirable choice of shade tree because they provide shade in the warm months and shed their leaves in the winter months to allow sunlight to pass through and warm the building. By reducing cooling demand, shade trees help reduce electricity demand from the local utility and therefore reduce GHG emissions which would otherwise be emitted during the production of that electricity.

A study entitled "Calculating energy-saving potentials of heat-island reduction strategies" conducted by the Lawrence Berkeley National Laboratory (LBNL) Heat Island Group provides a method to quantify reductions in electricity use from planting shade trees around residences, offices, and retail stores. The electricity reductions are based on the LBNL model which assumes 4 shade trees are planted around residences, 8 trees are planted around offices, and 10 trees are planted around retail stores. The LBNL model is also based on electricity use data for two building stocks: Pre-1980 buildings (buildings constructed prior to 1980) and 1980+ buildings (buildings constructed on or after 1980). Other assumptions, including the geometry of the modeled trees and sunlight transmittance, are detailed in Section 2.5 of the study. This mitigation measure describes how to estimate greenhouse gas emissions reductions from planting shade trees based on the LBNL data. Since the model is based on electricity data for Pre-1980 and 1980+ buildings[110] it does not incorporate electricity use improvements due to the California 2001, 2005, or 2008 Title 24 measures. Given that buildings constructed in 2001 or later incorporate Title 24 electricity efficiency improvements, the electricity savings reported in the LBNL study are overestimates of the savings that would actually be achieved for these newer buildings.[111]

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[110] This data for these buildings is based on U.S. Department of Energy and California Energy Commission studies conducted in 1987 through 2001.

[111] The CEC 2003 Impact Analysis Report estimates a state-average 14.9%-26% savings in electricity use for cooling in residential buildings and 6.7% savings in electricity use for cooling in non-residential

While the electricity savings in the study overestimates savings for newer buildings, the data does show that electricity savings (and associated greenhouse gas emissions savings) from planting shade trees are real. A follow-up study which uses similar methodologies with models updated with the Title 24 standards would provide data which could be used to more accurately quantify electricity savings for new buildings.

Measure Applicability:

- Electricity use
- Limitation: It takes several years for trees to grow to the height necessary to provide shade to a building. Furthermore, without deed restrictions, the presence of shade trees around a building may not be permanent, as a new owner may decide to remove the trees or not replace them if they die.

Inputs:

The following information needs to be provided by the Project Applicant:

- Type of building (residential, office, or retail store)
- Square footage of roof
- Heating Degree Days (HDD) or Cooling Degree Days (CDD) of Project location

Baseline Method:

The CEC Residential Appliance Saturation Survey (RASS) and California Commercial Energy Use Survey (CEUS) datasets can be used to calculate the baseline electricity for building cooling. The data is available for different climate zones in California and electricity use from cooling alone can be extracted. The methodology for using RASS and CEUS to calculate $GHG_{baseline}$ is described in the baseline document.

Mitigation Method:

The electricity savings from reduced cooling demand are based on the location of the building. Table 4 of the LBNL study provides a list of cities and their HDD and CDD values. If a project's location is not listed, the Project Applicant should choose a representative city with climate similar to that of the project. Alternatively, the Project Applicant could determine the HDD and CDD of the project location from local meteorological data.

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buildings due to the 2005 update to the 2001 Title 24 standards. The CEC 2007 Impact Analysis Report estimates a state-average 19.7%-22.7% savings in overall electricity use for residential buildings and a 8.3% savings in electricity use for cooling in non-residential buildings due to the 2008 update to the 2005 Title 24 standards.

Tables 6 through 16 of the LBNL study show the expected electricity savings (in kWh per 1000 sqft of roof) based on the following parameters:

- Building type (residential, office, or retail store)
- Climate method (HDD or CDD – either can be used)
- Heating method (Gas heated-buildings or electric-heated buildings)

The Project Applicant should select data based on the appropriate parameters above. The entry corresponding to the “Shade tree savings” row and “1980+” column will provide the electricity savings in kWh per 1000 sqft of roof for the specified building type, climate method, and heating method. Note that value is an overestimate of savings for buildings which were manufactured under Title 24 standards.

Then the reduction in GHG emissions is calculated as follows:

$$GHG_{reduction} = SF \times ElecSavings \times Utility$$

Where

$GHG_{reduction}$ = Reduction in GHG emissions from planting shade trees (MT)

SF = Sqft of roof
Provided by Applicant

ElecSavings = Electricity savings (kWh / sqft roof)
From Tables 6 through 16 of LBNL study

Utility = Carbon intensity of local utility (MT CO_2e / kWh)
From Table below

Power Utility	Carbon-Intensity (lbs CO_2e/MWh)
LADW&P	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

Therefore:

$$\text{Percent reduction in GHG emissions} = GHG_{reduction} / GHG_{baseline}$$

Since the Utility term is a factor of both $GHG_{reduction}$ and $GHG_{baseline}$, the percent reduction in GHG emissions does not depend on the value of Utility.

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Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	The following emissions reductions reflect the implementation of three heat island reduction strategies (installing reflective roofs, planting shade trees, and using high-albedo pavements) for the 1980+ stock buildings. The reduction from planting shade trees around new buildings is expected to be smaller than the estimate below. Additionally, savings are expected to be smaller for new buildings due to the Title 24 standards. • 20% for residential buildings • 5-12% for office buildings • 10-17% for retail buildings
All other pollutants	Same as above[112]

Assumptions:

Data based upon the following reference:

- H. Akbari, S. Konopacki. Lawrence Berkeley National Laboratory. 2005. Calculating Energy-Saving-Potentials of Heat-Island Reduction Strategies. Journal of Energy Policy. Volume 33, p. 721-756.

Preferred Literature:

The LBNL study conducted by Akbari and Konopacki of the Heat Island Group modeled energy savings from shade trees for residential, office, and retail building types. The model accounted for differences in climate by modeling in a range of heating-degree-days and cooling-degree days, and compared a basecase (building with no external shading) to a mitigated case (building with 4, 8, and 10 shade trees, depending on the building type). However, the study is based on pre-2001 data and does not account for updates to California's Title 24 standards. Furthermore, the model assumes a specific number of shade trees planted at specific orientations.

Alternative Literature:

- CCAR. 2010. Urban Forest Project Protocol Version 1.1. Available online at: http://www.climateactionreserve.org/how/protocols/adopted/urban-forest/current-urban-forest-project-protocol/

Section D.3 of the protocol describes a method to quantify the reductions in cooling and heating demand due to the planting of shade trees. Computer simulations incorporating

[112] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

building, climate, and shading effects were used to calculate the change in unit energy consumption (UEC) on a per tree basis. Total change in energy use is calculated by multiplying the change in UEC per try by the total number of trees. Buildings were modeled in three stocks with similar building characteristics: buildings constructed prior to 1950, buildings constructed between 1950 and 1980, and buildings constructed after 1980. As with the primary reference above, the data does not account for electricity efficiency improvements due to California's Title 24 standards.

Other Literature Reviewed:

- E. G. McPherson, J. R. Simpson. USDA Forest Service. 2003. Potential Energy Savings in Buildings by an Urban Tree Planting Programme in California. Journal of Urban Forestry & Urban Greening. Volume 2, p. 73-86.
- H. Akbari. Lawrence Berkeley National Laboratory. 2002. Shade Trees Reduce Building Energy Use and CO_2 Emissions from Power Plants. Journal of Environmental Pollution. Volume 116, p. 119-126.
- J. R. Simpson. Department of Environmental Horticulture at the University of California. 2002. Improved Estimates of Tree-Shade Effects on Residential Energy Use. Journal of Energy and Buildings. Volume 34, p. 1067-1076.

10.1.5 Implement Strategies to Reduce Urban Heat-Island Effect

Range of Effectiveness: The reduction in GHG emissions is not quantifiable at this time, therefore this mitigation measure should be implemented as a Best Management Practice. If the study data were updated to account for Title 24 standards, the GHG emissions reductions could be quantified but would vary based on location, building type, and building size.

Measure Description:

The urban heat island effect is the phenomenon in which a metropolitan area is warmer than its surrounding rural areas due to increased land surface which retains heat, such as concrete, asphalt, metal, and other materials found in buildings and pavements. This warming effect causes warmer locations, such as many cities in California, to require more energy for air conditioning and refrigeration than the surrounding rural areas. Higher energy requirements in turn result in higher CO_2 emissions from the generation of this energy.

Three strategies have been shown to have a positive impact on reducing localized temperatures and reducing the electricity demand for building cooling. These strategies are planting urban shade trees, installing reflective roofs, and using light-colored or high-albedo[113] pavements and surfaces. Planting shade trees around buildings and installing reflective roofs have both been found to result in direct electricity savings for buildings. The per building direct electricity savings from planting shade trees is discussed in a separate mitigation measure. Reflective roofs are covered under Title 24 Part 6 and the electricity savings is therefore incorporated in savings due to Title 24. The combination of the three strategies, however, has been shown to have a city-wide effect: a reduction in ambient air temperature. This reduction in air temperature results in buildings requiring less electricity for cooling, and is quantified as indirect savings in electricity use. The savings can be quantified on a per-building basis or on a city-wide basis.

A study entitled “Calculating energy-saving potentials of heat-island reduction strategies” conducted by the Lawrence Berkeley National Laboratory (LBNL) Heat Island Group provides a method to quantify per-building reductions in electricity use from implementing these three strategies on a city-wide scale. In addition, the study reports modeled city-wide electricity savings. The electricity reductions are based on a LBNL model with certain assumptions about the number and orientation of shade trees

[113] The albedo ratio of a surface represents how strongly the surface reflects sunlight. Pavements with higher albedo ratios reflect more sunlight and therefore retain less heat.

and the albedo values of roofs and pavements. Per-building electricity savings are also based on for two building stocks: Pre-1980 buildings (buildings constructed prior to 1980) and 1980+ buildings (buildings constructed on or after 1980).

This mitigation measure describes how to estimate greenhouse gas emissions reductions from implementing heat-island effect reduction strategies as reported in the LBNL study. Since the LBNL model is based on electricity data for Pre-1980 and 1980+ buildings[114] it does not incorporate electricity use improvements due to the California 2001, 2005, or 2008 Title 24 measures. Given that buildings constructed in 2001 or later incorporate Title 24 electricity efficiency improvements, the electricity savings reported in the LBNL study are overestimates of the savings that would actually be achieved for these newer buildings.[115]

While the electricity savings in the study overestimates savings for newer buildings, the data does show that electricity savings (and associated greenhouse gas emissions savings) from planting shade trees are real. A follow-up study which uses similar methodologies with models updated with the Title 24 standards would provide data which could be used to more accurately quantify electricity savings for new buildings.

Measure Applicability:

- Electricity use
- Limitation: It takes several years for trees to grow to the height necessary to provide shade to a building. Furthermore, without deed restrictions, the presence of shade trees around a building may not be permanent, as a new owner may decide to remove the trees or not replace them if they die.
- Limitation: it is assumed that the heat-island effect reduction strategies are implemented on a city-wide scale.

Inputs:

The following information needs to be provided by the Project Applicant:

- Type of building (residential, office, or retail store)
- Square footage of roof

[114] This data for these buildings is based on U.S. Department of Energy and California Energy Commission studies conducted in 1987 through 2001.

[115] The CEC 2003 Impact Analysis Report estimates a state-average 14.9%-26% savings in electricity use for cooling in residential buildings and 6.7% savings in electricity use for cooling in non-residential buildings due to the 2005 update to the 2001 Title 24 standards. The CEC 2007 Impact Analysis Report estimates a state-average 19.7%-22.7% savings in overall electricity use for residential buildings and a 8.3% savings in electricity use for cooling in non-residential buildings due to the 2008 update to the 2005 Title 24 standards.

- Heating Degree Days (HDD) or Cooling Degree Days (CDD) of Project location

Baseline Method:

The CEC Residential Appliance Saturation Survey (RASS) and California Commercial Energy Use Survey (CEUS) datasets can be used to calculate the baseline electricity for building cooling. The data is available for different climate zones in California and electricity use from cooling alone can be extracted. The methodology for using RASS and CEUS to calculate $GHG_{baseline}$ is described in the baseline document.

Mitigation Method:

The electricity savings from reduced cooling demand are based on the location of the building. Table 4 of the LBNL study provides a list of cities and their HDD and CDD values. If a project's location is not listed, the Project Applicant should choose a representative city with climate similar to that of the project. Alternatively, the Project Applicant could determine the HDD and CDD of the project location from local meteorological data.

Tables 6 through 16 of the LBNL study show the expected electricity savings (in kWh per 1000 sqft of roof) based on the following parameters:

- Building type (residential, office, or retail store)
- Climate method (HDD or CDD – either can be used)
- Heating method (Gas heated-buildings or electric-heated buildings)

The Project Applicant should select data based on the appropriate parameters above. The entry corresponding to the "Indirect Savings" row and "1980+" column will provide the electricity savings in kWh per 1000 sqft of roof for the specified building type, climate method, and heating method. Note that value is an overestimate of savings for buildings which were manufactured under Title 24 standards.

Then the reduction in GHG emissions is calculated as follows:

$$GHG_{reduction} = SF \times ElecSavings \times Utility$$

Where

$GHG_{reduction}$	=	Reduction in GHG emissions from implementing heat island effect reduction strategies on a city-wide scale (MT)
SF	=	Sqft of roof Provided by Applicant
ElecSavings	=	Electricity savings (kWh / sqft roof) From Tables 6 through 16 of LBNL study
Utility	=	Carbon intensity of local utility (MT CO_2e / kWh)

General Plans

CEQA# **MM E-8 & E-12**
MP# **LU-6.1**

GP-5

From Table below

Power Utility	Carbon-Intensity (lbs CO_2e/MWh)
LADW&P	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

Therefore:

$$\text{Percent reduction in GHG emissions} = GHG_{reduction} / GHG_{baseline}$$

Since the Utility term is a factor of both $GHG_{reduction}$ and $GHG_{baseline}$, the percent reduction in GHG emissions does not depend on the value of Utility.

City-Wide GHG reductions
The LBNL study estimates that city-wide reductions in electricity use (and associated GHG emissions) range from about 10-20%. This range is based on the percent indirect savings modeled for five pilot cities: Houston, Baton Rouge, Chicago, Sacramento, and Salt Lake City, as reported in Figure 2 of the LBNL study.

Emission Reduction Ranges and Variables:

Pollutant	Category Emissions Reductions
CO_2e	The following per-building emissions reductions reflect the implementation of three heat island reduction strategies (installing reflective roofs, planting shade trees, and using high-albedo pavements) for the 1980+ stock buildings. Actual savings are expected to be lower for new buildings due to the Title 24 standards. • 20% for residential buildings • 5-12% for office buildings • 10-17% for retail buildings
All other pollutants	Same as above[116]

[116] Criteria air pollutant emissions may also be reduced due to the reduction in energy use; however, the reduction may not be in the same air basin as the project.

Assumptions:

Data based upon the following reference:

- H. Akbari, S. Konopacki. Lawrence Berkeley National Laboratory. 2005. Calculating Energy-Saving-Potentials of Heat-Island Reduction Strategies. Journal of Energy Policy. Volume 33, p. 721-756.
- S. Konopacki, H. Akbari. Lawrence Berkeley National Laboratory. 2000. Energy Savings Calculations for Heat Island Reduction Strategies in Baton Rouge, Sacramento, and Salt Lake City. LBNL 42890.

Preferred Literature:

The LBNL study conducted by Akbari and Konopacki of the Heat Island Group modeled energy savings from shade trees for residential, office, and retail building types. The model accounted for differences in climate by modeling in a range of heating-degree-days and cooling-degree days, and compared a basecase (building with no external shading) to a mitigated case (building with 4, 8, and 10 shade trees, depending on the building type). However, the study is based on pre-2001 data and does not account for updates to California's Title 24 standards. Furthermore, the model assumes a specific number of shade trees planted at specific orientations.

Alternative Literature:

None

Other Literature Reviewed:

Lawrence Berkeley National Laboratory. Heat Island Group: Benefits of Cooler Pavements. Available online at: http://eetd.lbl.gov/HeatIsland/Pavements/Overview/Pavements99-01.html. Accessed March 2010.

Lawrence Berkeley National Laboratory. Heat Island Group: The Cost of Hot Pavements. Available online at: http://heatisland.lbl.gov/Pavements/Cost.html. Accessed March 2010.

USEPA. Draft. Reducing Urban Heat Islands: Compendium of Strategies, Cool Pavements. Available online at: http://epa.gov/heatisland/resources/pdf/CoolPavesCompendium.pdf

Appendix A

List of Acronyms and Glossary of Terms

List of Acronyms

ACM	alternative calculation method
AF	acre feet
B20	biodiesel (20%)
BOD	biochemical oxygen demand
BMP	best management practice
C	carbon
CAFE	corporate average fuel economy
CAPCOA	California Air Pollution Control Officers Association
CAR	Climate Action Registry
CARB	California Air Resources Board
CCAR	California Climate Action Registry
CDWR	California Department of Water Resources
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CEUS	California Commercial End-Use Survey
CGBSC	California Green Building Standards Code
CH_4	methane
CHP	combined heat and power
CIWMB	California Integrated Waste Management Board
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DE	destruction efficiency
DEIR	Draft Environmental Impact Report
DU	dwelling unit
EF	emission factor
EIA	United States Energy Information Administration
EIR	Environmental Impact Report
EMFAC	on-road vehicle emission factors model
ET_0	reference evapotranspiration
ETWU	estimated total water use
FCZ	forecasting climate zone
GHG	greenhouse gas
GP	General Plan
GRP	General Reporting Protocol
GWP	global warming potential
HA	hydrozone area
HHV	higher heating value
hp	horsepower
HVAC	heating, ventilating, and air conditioning
IE	irrigation efficiency
IPCC	Intergovernmental Panel on Climate Change
ITE	Institute of Transportation Engineers
ITS	intelligent transportation systems
kBTU	thousand British thermal units
kW	kilowatt
kWh	kilowatt-hour
kWh/yr	kilowatt-hours/year
lbs	pounds

LA	landscape area
LADWP	Los Angeles Department of Water and Power
LCA	life cycle assessment
LDA	light-duty auto
LDT	light-duty truck
LED	light-emitting diode
LFM	landfill methane
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MAWA	maximum applied water allowance
MMBTU	million British thermal units
MSW	mixed solid waste
MTCE	metric tonnes carbon equivalent
N_2O	nitrous oxide
NOx	nitrogen oxides
NRDC	Natural Resources Defense Council
NREL	National Renewable Energy Laboratory
OLED	organic light-emitting diode
OFFROAD	off-road vehicle emission factors model
PF	plant factor
PG&E	Pacific Gas and Electric
PM	particulate matter
PUP	Power/Utility Protocol
RASS	Residential Appliance Saturation Survey
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SDGE	San Diego Gas and Electric
SLA	special landscape area
SMAQMD	Sacramento Metropolitan Air Quality Management District
SMUD	Sacramento Municipal Utility District
scf	standard cubic feet
SHP	separate heat and power
SO_2	sulfur dioxide
sqft	square feet
TDM	transportation demand management
TDV	time dependent valuation
TOD	transit-oriented development
tonnes	metric tonnes; 1,000 kilograms
TRU	truck refrigeration unit
URBEMIS	Urban Emissions Model
US	United States
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VCAPCD	Ventura County Air Pollution Control District
VTPI	Victoria Transport Policy Institute
VMT	vehicle miles traveled
VTR	vehicle trip reduction
WARM	Waste Reduction Model
WMO	World Meteorological Organization
yr	year

Glossary of Terms

Alternative Calculation Method
Software used to demonstrate compliance with the California Building Energy Efficiency Standards (Title 24). The software must comply with the requirements listed in the Alternative Calculation Method Approval Manual.

Additionality[a]
The reduction in emissions by sources or enhancement of removals by sinks that is additional to any that would occur in the absence of the project. The project should not subsidize or take credit for emissions reductions which would have occurred regardless of the project.

Albedo[a]
The fraction of solar radiation reflected by a surface or object, often expressed as a ratio or fraction. Snow covered surfaces have a high albedo; the albedo of soils ranges from high to low; vegetation covered surfaces and oceans have a low albedo. The Earth"s albedo varies mainly through varying cloudiness, snow, ice, leaf area, and land cover changes. Paved surfaces with high albedos reflect solar radiation and can help reduce the urban heat island effect.

Below Market Rate Housing
Housing rented at rates lower than the market rate. Below market rate housing is designed to assist lower-income families. When below market rate housing is provided near job centers or transit, it provides lower income families with desirable job/housing match or greater opportunities for commuting to work through public transit.

Biochemical Oxygen Demand
Represents the amount of oxygen that would be required to completely consume the organic matter contained in wastewater through aerobic decomposition processes. Under the same conditions, wastewater with higher biochemical oxygen demand (BOD) concentrations will generally yield more methane than wastewater with lower BOD concentrations. BOD_5 is a measure of BOD after five days of decomposition.

Biogenic Emissions[b]
Carbon dioxide emissions produced from combusting a variety of biofuels, such as biodiesel, ethanol, wood, wood waste and landfill gas.

Carbon Dioxide Equivalent
A measure for comparing carbon dioxide with other greenhouse gases. Tonnes carbon dioxide equivalent is calculated by multiplying the tonnes of a greenhouse gas by its associated global warming potential.

California Environmental Quality Act
A statute passed in 1970 that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.

Carbon Neutral Power
A power generation system which has net zero carbon emissions. Examples of existing carbon neutral power systems are photovoltaics, wind turbines, and hydropower systems.

Carbon Sink
Any process or mechanism that removes carbon dioxide from the atmosphere. A forest is an example of a carbon sink, because it sequesters carbon dioxide from the atmosphere.

“Carrot”
The purpose of a carrot is to provide an incentive which encourages a particular action. Parking cash-out would be considered a “carrot” since the employee receives a monetary incentive for not driving to work, but is not punished for maintaining status quo.

Combined Heat and Power
Also known as cogeneration. Combined heat and power is the generation of both heat and electricity from the same process, such as combustion of fuel, with the purpose of utilizing or selling both simultaneously. In combined heat and power systems, the thermal energy byproducts of a process are captured and used, where they would be wasted in a separate heat and power system. Examples of combined heat and power systems include gas turbines, reciprocating engines, and fuel cells.

Compact Infill
A Project which is located within or contiguous with the central city. Examples may include redevelopment areas, abandoned sites, or underutilized older buildings/sites.

Climate Zone
Geographic area of similar climatic characteristics, including temperature, weather, and other factors which affect building energy use. The California Energy Commission identified 16 Forecasting Climate Zones (FCZs) for use in the CEUS and RASS analyses. The designation of these FCZs was based in part on the utility service area.

Cordon Pricing
Tolls charged for entering a particular area (a “cordon”), such as a downtown.

Density
The amount of persons, jobs, or dwellings per unit of land area. This is an important metric for determining traffic-related parameters.

Destination Accessibility
A measure of the number of jobs or other attractions reachable within a given travel time. Destination accessibility tends to be highest at central locations and lowest at peripheral ones.

Efficacy
The capacity to produce a desired effect.

ENERGY STAR
A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy which sets national standards for energy efficient consumer products. ENERGY STAR certified products are guaranteed to meet the efficiency standards specified by the program.

Elasticity
The percentage change of one variable in response to a percentage change in another variable. Elasticity = percent change in variable A / percent change in variable B (where the

change in B leads to the change in A). For example, if the elasticity of VMT with respect to density is -0.12, this means a 100% increase in density leads to a 12% decrease in VMT.

Evapotranspiration[c]
The loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil.

General Plan
A set of long-term goals and policies that guide local land use decisions. The 2003 *General Plan Guidelines* developed by the California Office of Planning and Research provides advice on how to write a general plan that expresses a community's long-term vision, fulfills statutory requirements, and contributes to creating a great community.

Global Warming Potential[b]
The ratio of radiative forcing that would result from the emission of one kilogram of a greenhouse gas to that from the emission of one kilogram of carbon dioxide over a fixed period of time.

Graywater
Non-drinkable water that can be collected and reused onsite for irrigation, flushing toilets, and other purposes. This water has not been processed through a waste water treatment plant.

Greenhouse Gas
For the purposes of this report, greenhouse gases are the six gases identified in the Kyoto Protocol: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Headway
The amount of time (in minutes) that elapses between two public transit vehicles servicing a given route and given line. Headways for buses and rail are generally shorter during peak periods and longer during off-peak periods. Headway is the inverse of frequency (headway = 1/frequency), where frequency is the number of arrivals over a given time period (i.e. buses per hour).

Intelligent Transportation System
A broad range of communications-based information and electronics technologies integrated into transportation system infrastructure and vehicles to relieve congestion and improve travel safety.

Job Center
An area with a high degree and density of employment.

Kilowatt Hour
A unit of energy. In the U.S., the kilowatt hour is the unit of measure used by utilities to bill consumers for energy use.

Land Use Index
Measures the degree of land use mix of a development. An index of 0 indicates a single land use while 1 indicates a full mix of uses.

Lumen
A unit of luminous flux. A measure of the brilliance of a source of visible light, or the power of light perceived by the human eye.

Master Planned Community
Large communities developed specifically incorporating housing, office parks, recreational area, and commercial centers within the community. Master planned communities tend to encompass a large land area with the intent of being self-sustaining. Many master planned communities may have lakes, golf courses, and large parks.

Mixed Use
A development that incorporates more than one type of land use. For example, a small mixed use development may have buildings with ground-floor retail and housing on the floors above. A larger mixed use development will locate a variety of land uses within a short proximity of each other. This may include integrating office space, shopping, parks, and schools with residential development. The mixed-use development should encourage walking and other non-auto modes of transport from residential to office/commercial/institutional locations (and vice versa).

Ordinance
A local law usually found in municipal code.

Parking Spillover
A term used to describe the effects of implementing a parking management strategy in a sub-area that has unintended consequences of impacting the surrounding areas. For example, assume parking meters are installed on all streets in a commercial/retail block with no other parking strategies implemented. Customers will no longer park in the metered spots and will instead "spillover" to the surrounding residential neighborhoods where parking is still unrestricted.

Photovoltaic[c]
A system that converts sunlight directly into electricity using cells made of silicon or other conductive materials (solar cells). When sunlight hits the cells, a chemical reaction occurs, resulting in the release of electricity.

Recycled Water
Non-drinkable water that can be reused for irrigation, flushing toilets, and other purposes. It has been processed through a wastewater treatment plant and often needs to be redistributed.

Ride Sharing
Any form of carpooling or vanpooling where additional passengers are carried on the trip. Ride-sharing can be casual and formed independently or be part of an employer program where assistance is provided to employees to match up commuters who live in close proximity of one another.

Renewable Energy[a]
Energy sources that are, within a short time frame relative to the Earth‟s natural cycles, sustainable, and include non-carbon technologies such as solar energy, hydropower, and wind, as well as carbon-neutral technologies such as biomass.

Self Selection
When an individual selects himself into a group.

Separate Heat and Power
The typical system for acquiring heat and power. Thermal energy and electricity are generated and used separately. For example, heat is generated from a boiler while electricity is acquired from the local utility. Separate heat and power systems are used as the baseline of comparison for combined heat and power systems.

Sequestration[a]
The process of increasing the carbon content of a carbon reservoir other than the atmosphere. Biological approaches to sequestration include direct removal of carbon dioxide from the atmosphere through afforestation, reforestation, and practices that enhance soil carbon in agriculture. Physical approaches include separation and disposal of carbon dioxide from flue gases or from processing fossil fuels to produce hydrogen- and carbon dioxide-rich fractions and longterm storage in underground in depleted oil and gas reservoirs, coal seams, and saline aquifers.

"Stick"
The purpose of a stick is to establish a penalty for a status quo action. Workplace parking pricing would be considered a "stick" since the employee is now monetarily penalized for driving to work.

Suburban
An area characterized by dispersed, low-density, single-use, automobile dependent land use patterns, usually outside of the central city (a suburb).

Suburban Center
The suburban center serves the population of the suburb with office, retail and housing which is denser than the surrounding suburb.

Title 24
Title 24 Part 6 is also known as the California Building Energy Efficiency Standard, which regulates building energy efficiency standards. Regulated energy uses include space heating and cooling, ventilation, domestic hot water heating, and some hard-wired lighting. Title 24 determines compliance by comparing the modeled energy use of a „proposed home‟ to that of a minimally Title 24 compliant „standard home‟ of equal dimensions. Title 24 focuses on building energy efficiency per square foot; it places no limits upon the size of the house or the actual energy used per dwelling unit. The current Title 24 standards were published in 2008.

Transit-Oriented Development
A development located near and specifically designed around a rail or bus station. Proximity alone does not characterize a development as transit-oriented. The development and surrounding neighborhood should be designed for walking and bicycling and parking management strategies should be implemented. The development should be located within a short walking distance to a high-quality, high frequency, and reliable bus or rail service.

Transportation Demand Management
Any transportation strategy which has an intent to increase the transportation system efficiency and reduce demand on the system by discouraging single-occupancy vehicle travel and encouraging more efficient travel patterns, alternative modes of transportation such as walking, bicycling, public transit, and ridesharing. TDM measures should also shift travel patterns from peak to off-peak hours and shift travel from further to closer destinations.

Transit Ridership
The number of passengers who ride in a public transportation system, such as buses and subways.

Tree and Grid Network
Describes the layout of streets within and surrounding a project. Streets that are characterized as a tree network actually look like a tree and its branches. Streets are not laid out in any uniform pattern, intersection density is low, and the streets are less connected. In a grid network, streets are laid out in a perpendicular and parallel grid pattern. Streets tend to intersect more frequently, intersection density is higher, and the streets are more connected.

Urban
An area which is located within the central city with higher density of land uses than you would find in the suburbs. It may be characterized by multi-family housing and located near office and retail.

Urban Heat Island Effect
The phenomenon in which a metropolitan area is warmer than its surrounding rural areas due to increased land surface which retains heat, such as concrete, asphalt, metal, and other materials found in buildings and pavements.

Vehicle Miles Traveled
The number of miles driven by vehicles. This is an important traffic parameter and the basis for most traffic-related greenhouse gas emissions calculations.

Vehicle Occupancy
The number of persons in a vehicle during a trip, including the driver and passengers.

Notes:

[a] Definition adapted from: IPCC. 2001. Third Assessment Report: Climate Change 2001 (TAR). Annex B: Glossary of Terms. Available online at: http://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf

[b] Definition adapted from: CCAR. 2009. General Reporting Protocol, Version 3.1. Available online at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

[c] Definition adapted from: USEPA. 2010. Greening EPA Glossary. Available online at: http://www.epa.gov/oaintrnt/glossary.htm

CAPCOA

Appendix B

Greenhouse Gas Mitigation Measures Task 0:
Standard Approach to Calculate Unmitigated Emissions

Greenhouse Gas Mitigation Measures Task 0: Standard Approach to Calculate Unmitigated Emissions

Prepared for:
California Pollution Control Officers Association (CAPCOA)

Prepared by:
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Date:
August 2010

FEHR & PEERS TRANSPORTATION CONSULTANTS

ENVIRON

Contents

1 Introduction

ENVIRON International Corporation (ENVIRON) and Fehr & Peers worked with the California Air Pollution Control Officers Association (CAPCOA) to quantify reductions associated with greenhouse gas (GHG) mitigation measures that can be applied to California Environmental Quality Act (CEQA) Environmental Impact Report (EIR) analyses. The first part of this overall task defines a standard approach to calculate the baseline emissions before mitigation. This report contains the recommendations for methodologies and approaches to assess the baseline GHG emissions.

This report and its methodologies form the basis for the subsequent tasks associated with quantification of GHG mitigation measures. To the extent possible, default values are included with this report and in the mitigation measure Fact Sheets.

This report presents methods to be used to calculate short-term and one-time emissions sources as well as emissions that will occur annually after construction (operational emissions). The one-time emission sources include changes in carbon sequestration due to vegetation changes and emissions associated with construction. The annual operational emissions include the emissions associated with building energy use including natural gas and electricity, emissions associated with mobile sources, emissions associated with water use and wastewater treatment, emissions associated with area sources such as natural gas fired hearths , landscape maintenance equipment, swimming pools, and golf courses.

2 GHG Equivalent Emissions

The term "GHGs" includes gases that contribute to the greenhouse effect, such as carbon dioxide (CO_2,) methane (CH_4), and nitrous oxide (N_2O), as well as gases that are only man-made and that are emitted through the use of modern industrial products, such as hydrofluorocarbons (HFCs), chlorinated fluorocarbons (CFCs), and sulfurhexafluoride (SF_6). These last three families of gases, while not naturally present in the atmosphere, have properties that also cause them to trap infrared radiation when they are present in the atmosphere, thus making them GHGs. These six gases comprise the major GHGs that are recognized by the Kyoto Accords (water is not included).[1] There are other GHGs that are not recognized by the Kyoto Accords, due either to the smaller role that they play in climate change or the uncertainties surrounding their effects. Atmospheric water vapor is not recognized by the Kyoto Accords because there is not an obvious correlation between water concentrations and specific human activities. Water appears to act in a positive feedback manner; higher temperatures lead to higher water vapor concentrations in the atmosphere, which in turn can cause more global warming.[2] California has recently recognized nitrogen trifluoride as another regulated greenhouse gas.

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[1] This Kyoto Protocol sets legally binding targets and timetables for cutting the greenhouse gas emissions of industrialized countries. The US has not approved the Kyoto treaty.

[2] From the IPCC Third Assessment Report: http://www.grida.no/climate/ipcc_tar/wg1/143.htm and http://www.grida.no/climate/ipcc_tar/wg1/268.htm

Residents and the employees and patrons of commercial and municipal buildings and services use electricity, heating, water, and are transported by motor vehicles. These activities directly or indirectly emit GHGs. The most significant GHG emissions resulting from such residential and commercial developments are emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). GHG emissions are typically measured in terms of MT of CO_2 equivalents (CO_2e), calculated as the product of the mass emitted of a given GHG and its specific global warming potential (GWP).

The effect that each of these gases can have on global warming is a combination of the mass of their emissions and their global warming potential (GWP). GWP indicates, on a MT for MT basis, how much a gas is predicted to contribute to global warming relative to how much warming would be predicted to be caused by the same mass of CO_2. CH_4 and N_2O are substantially more potent GHGs than CO_2, with GWPs of 21 and 310, respectively according to the IPCC's Second Assessment Report (SAR).[3] In emissions inventories, GHG emissions are typically reported in terms of pounds (lbs) or MT[4] of CO_2 equivalents (CO_2e). CO_2e are calculated as the product of the mass emitted of a given GHG and its specific GWP. While CH_4 and N_2O have much higher GWPs than CO_2, CO_2 is emitted in such vastly higher quantities that it accounts for the majority of GHG emissions in CO_2e, both from developments and human activity in general. Since most regulatory agencies and protocols use the SAR GWP values as a basis, this assessment will also use SAR GWP values even though more recent values exist. However, SAR did not consider nitrogen trifluoride, however there are no sources of nitrogen trifluoride that would typically need to be quantified.

3 Units of measurement: MT of CO_2 and CO_2e

In many sections of this report, including the final summary sections, emissions are presented in units of CO_2e either because the GWPs of CH_4 and N_2O were accounted for explicitly, or the CH_4 and N_2O are assumed to contribute a negligible amount of GWP when compared to the CO_2 emissions from that particular emissions category.

Emissions and reductions are calculated in terms of metric tons. As such, "MT" will be used to refer to metric tons (1,000 kilograms). "Tons" will be used to refer to short tons (2,000 pounds [lbs]).

4 Indirect GHG Emissions from Electricity Use

As noted above, indirect GHG emissions are created as a result of electricity use. When electricity is used in a building, the electricity generation typically takes place offsite at the power plant; electricity use in a building generally causes emissions in an indirect manner. The project should use information specific for each local utility provider for different parts of

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3 GWP values from IPCC's Second Assessment Report (SAR, 1996) are still used by international convention and are used in this protocol, even though more recent (and slightly different) GWP values were developed in the IPCC's Fourth Assessment Report (FAR, 2007)

4 In this report, "MT" will be used to refer to metric MT (1,000 kilograms). "Tons" will be used to refer to short tons (2,000 pounds).

California. Accordingly, indirect GHG emissions from electricity usage are calculated using the utility specific carbon-intensity factor based Power/Utility Protocol (PUP) report from California Climate Action Registry (CCAR)[5] for the 2006 baseline year. ENVIRON does not recommend using the 2004 PUP reports since this year was one of the first year's utilities reported emissions, as such, the data is likely less accurate than subsequent years since utilities had a chance to refine data collection methods for the later years. Furthermore, a large coal burning power plant in Mojave was going offline in 2005 which was factored into the Scoping Plan analysis. Therefore, ENVIRON suggests using the 2006 PUP reports since it likely represents a more accurate dataset year. This emission factor takes into account the baseline year's mix of energy sources used to generate electricity for a specific utility and the relative carbon intensities of these sources. The emission factor will be determined as a CO_2e incorporating the CO_2, CH_4, and N_2O emissions.

Power Utility	Carbon-Intensity (lbs CO_2e/MWh)
LADW&P	1,238
PG&E	456
SCE	641
SDGE	781
SMUD	555

5 Short-Term Emissions

Short-term or one-time emissions from the development of a Project are associated with vegetation removal and re-vegetation on the Project site and construction-related activities.

5.1 Construction Activities

Construction activities occur during the early stage of a project. Construction activities include any demolition, site grading, building construction, and paving. These construction activities have several main sources of GHG emissions. Off-road construction equipment such as dozers, pavers, and backhoes are used on-site during construction. These pieces of equipment typically are diesel fueled although other fuels are occasionally used. Besides the off-road construction, there are on-road vehicles. These vehicles are used for worker commuting, delivering of material to the site, and hauling material away from the site. The methodology to calculate these sources of emissions is described in the next sections.

5.1.1 Estimating GHG Emissions from Off-Road Construction Equipment

This section describes how emissions from off-road equipment used during demolition, site grading, building construction and paving are calculated. This section can be used for any fuel

[5] California Climate Action Registry (CCAR) Database. PUP Report.

burning equipment such as diesel, gasoline, or compressed natural gas (CNG). For electric equipment please see the method in the next section.

First, the number and type of equipment that will be used in the construction, as well as the duration of the entire construction project, is needed. Absent other data, ENVIRON recommends that each piece of equipment will operate for 8 hours a day, five days a week throughout the construction duration. An equipment hour is defined as one hour of a piece of equipment being used. Specifications for each type of construction equipment (horsepower, load factor, and GHG emission factor) are provided by OFFROAD2007[6]. CO_2 and CH_4 emissions for each type of construction equipment are calculated as follows:

$$\text{Equipment Emissions [grams]} = \text{Total equipment hours} \times \text{emission factor [grams per brake horsepower-hour]} \times \text{equipment horsepower} \times \text{load factor}^{7}$$

The grams of CO_2 and CH_4 are multiplied by their respective GWP and then the two emissions are summed to derive the final CO_2e emissions from the piece of off-road equipment. Since OFFROAD2007 does not provide an emission factor for N_2O which is a minor subset of nitrogen oxides (NO_x) emissions and the contribution to the overall GHG emissions is likely small, it is therefore not included in calculations that used OFFROAD2007. These were accounted for with alternative fuels since they have a larger proportion of N_2O and CH_4.

5.1.2 Estimating GHG emissions from Electric Off-Road Construction Equipment

In order to estimate the indirect GHG emissions associated with electricity consumption of electrical powered equipment, the following inputs are required. First, the total operating hours of the electrical piece of equipment is needed. Secondly, the amount of kilowatts the equipment uses per time is needed. These two pieces are used along with the carbon intensity factor for the local utility provider as follows:

$$\text{Equipment Emissions} = \text{Total equipment hours} \times \text{average power draw (kW/hr)} \times \text{Utility EF (g } CO_2e \text{ per kWhr)}$$

5.1.3 GHG Emissions from On-Road Vehicles Associated with Construction

Emissions from on-road vehicles associated with construction include workers commuting to the site, vendors delivering materials, and hauling away of materials. GHGs are emitted from these vehicles in two ways: running emissions, produced by driving the vehicle, and startup emissions, produced by turning the vehicle on. Idling emissions will not be considered since

[6] OFFROAD2007 is a model developed by the Air Resources Board which contains emission factors for off-road equipment. It is available at : http://www.arb.ca.gov/msei/offroad/offroad.htm

[7] Load factor is the percentage of the maximum horsepower rating at which the equipment normally operates.

regulations exist which limit idling[8] and they would represent a small contribution to the GHG emissions. The majority of these on-road vehicle emissions are running emissions.

Running emissions are calculated using the same method for all trip types. The total Vehicle Miles Traveled (VMT) for the trip type category is estimated, and then multiplied by the representative GHG emission factors for the vehicles expected to be driven. The total VMT for a given trip type is calculated as follows:

$$VMT \quad = \quad Number\ of\ round\ trips \quad x \quad average\ round\ trip\ length\ (miles)$$

The number of trips should be based on project specific information. Default values associated with each land use type can be obtained construction cost estimators or default values in emission estimator programs. Average round trip length should be based on project specific information or county specific default values. After total VMT is calculated, GHG emissions for on-road vehicles associated with construction can be calculated from the following equation:

$$CO_2\ emissions \quad = \quad VMT \quad x \quad EF_{running}$$

Where:

VMT = vehicle miles traveled
$EF_{running}$ = running emission factor for vehicle fleet for trip type

The CO_2 calculation involves the following assumptions:

a. Vehicle Fleet Defaults:

  a. Workers commute half with light duty trucks (LDTs) and half commute in light duty autos (LDAs). Half of the LDTs are type 1 and the other half type 2.

  b. Vendors are all heavy-heavy duty vehicles.

  c. Hauling is all heavy-heavy duty vehicles.

b. The emission factor depends upon the speed of the vehicle. A default value of 35 miles per hour will be used.

c. EMFAC emission factors from the construction year will be used for $EF_{running}$.

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[8] The Air Resources Board adopted in 2004 and modified in 2005 an Air Toxic Control Measure that limits idling in diesel vehicles to 5-minutes. http://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm

The emissions associated with CH_4 and N_2O are calculated in a similar manner or assumed to represent 5% of the total CO_2e emissions. They are then converted to CO_2e by multiplying by their respective global warming potential.

Startup emissions are CO_2 emitted from starting a vehicle. For the various trips during all phases, the startup emissions are calculated using the following assumptions:

a. The same vehicle fleet assumptions as used in running emissions.

b. Two engine startups per day with a 12 hour wait before each startup.[9]

The USEPA recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their GWPs.[10] To incorporate these additional GHGs into the calculations, the total GHG footprint is calculated by dividing the CO_2 emissions by 0.95.

5.2 Vegetation Change

ENVIRON suggests following the IPCC protocol for vegetation since it has default values that work well with the information typically available for development projects. This method is similar to the CCAR Forest Protocol[11] and the Center for Urban Forest Research Tree Carbon Calculator[12], but it has more general default values available that will generally applicable to all areas of California without requiring detailed site-specific information[13].

5.2.1 Quantifying the One-Time Release by Changes in Carbon Sequestration Capacity

The one-time release of GHGs due to permanent changes in carbon sequestration capacity is calculated using the following four steps:[14]

1. *Identify and quantify the change in area of various land types due to the development (i.e. alluvial scrub, non-native grassland, agricultural, etc.).* These area changes include not only the area of land that will be converted to buildings, but also areas disrupted by the construction of utility corridors, water tank sites, and associated borrow and grading areas.

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[9] The emission factor grows with the length of time the engine is off before each ignition.

[10] USEPA. 2005. *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle.* Office of Transportation and Air Quality. February.

[11] CCAR. 2007. Forest Sector Protocol Version 2.1. September. Available at: http://www.climateregistry.org/resources/docs/protocols/industry/forest/forest_sector_protocol_version_2.1_sept2007.pdf

[12] Available at: http://www.fs.fed.us/ccrc/topics/urban-forests/ctcc/

[13] The CCAR Forest Protocol and Urban Forest Research Tree Carbon Calculator are not used since their main focus is annual emissions for carbon offset considerations. As such they are designed to work with very specific details of the vegetation that is not available at a CEQA level of analysis.

[14] This section follows the IPCC guidelines, but has been adapted for ease of use for these types of Projects.

Areas temporarily disturbed that will eventually recover to become vegetated will not be counted as vegetation removed as there is no net change in vegetation or land use.[15]

2. *Estimate the biomass associated with each land type.* For the purposes of this report, ENVIRON suggests using the available general vegetation types found in the IPCC publication Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines).[16]

   California vegetation is heavily dominated by scrub and chaparral vegetation which may not be accurately characterized by default forest land properties. Consequently, ecological zones and biomass based subdivisions identified in the IPCC Guidelines were used to sub-categorize the vegetation as scrub dominated. These subcategories should be used to determine the CO_2 emissions resulting from land use impacts.

3. *Calculate CO_2 emissions from the net change of vegetation.* When vegetation is removed, it may undergo biodegradation,[17] or it may be combusted. Either pathway results in the carbon (C) present in the plants being combined with oxygen (O_2) to form CO_2. To estimate the mass of carbon present in the biomass, biomass weight is multiplied by the mass carbon fraction, 0.5. [18] The mass of carbon is multiplied by 3.67[19] to calculate the final mass of CO_2, assuming all of this carbon is converted into CO_2.

4. Calculate the overall change in sequestered CO_2. – For all types of land that change from one type of land to another,[20] initial and final values of sequestered CO_2 are calculated using the equation below.

   Overall Change in Sequestered CO_2 [MT CO_2]

$$= \sum_i \left(SeqCO_2\right)_i \times \left(area\right)_i - \sum_j \left(SeqCO_2\right)_j \times \left(area\right)_j$$

   Where:

$SeqCO_2$	=	mass of sequestered CO_2 per unit area [MT CO_2/acre]
area	=	area of land for specific land use type [acre]
i	=	index for final land use type
j	=	index for initial land use type

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[15] This assumption facilitates the calculation as a yearly growth rate and CO_2 removal rate does not have to be calculated. As long as the disturbed land will indeed return to its original state, this assumption is valid for time periods over 20 years.

[16] Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

[17] Cleared vegetation may also be deposited in a landfill or compost area, where some anaerobic degradation which will generate CH_4 may take place. However, for the purposes of this section, we are assuming that only aerobic biodegradation will take place which will result in CO_2 emissions only.

[18] The fraction of the biomass weight that is carbon. Here, a carbon fraction of 0.5 is used for all vegetation types from CCAR Forest Sector Protocol.

[19] The ratio of the molecular mass of CO_2 to the molecular mass of carbon is 44/12 or 3.67.

[20] For example from forestland to grassland, or from cropland to permanently developed.

5.2.2 Calculating CO_2 Sequestration by Trees

Planting individual trees will sequester CO_2. Changing vegetation as described above results in a one-time carbon-stock change. Planting trees is also considered to result in a one-time carbon-stock change. Default annual CO_2 sequestration rates on a per tree basis, based on values provided by the IPCC are used[21]. An average of 0.035 MT CO_2 per year per tree can be used for trees planted, if the tree type is not known.

Urban trees are only net carbon sinks when they are actively growing. The IPCC assumes an active growing period of 20 years. Thereafter, the accumulation of carbon in biomass slows with age, and will be completely offset by losses from clipping, pruning, and occasional death. Actual active growing periods are subject to, among other things, species, climate regime, and planting density. In this report, the IPCC default value of 20 years is recommended. For large tree sequestration projects, the Project may consider using the Forest or Urban tree planting protocols developed by Climate Action Registry (CAR). These protocols have slightly different assumptions regarding steady state, tree growth, and replacement of trees..

5.3 Built Environment

The amount of energy used, and the associated GHG emissions emitted per square foot of available space vary with the type of building. For example, food stores are far more energy intensive than warehouses, which have little climate-conditioned space. Therefore, this analysis is specific to the type of building.

GHGs are emitted as a result of activities in buildings for which electricity and natural gas are used as energy sources. Combustion of any type of fuel emits CO_2 and other GHGs directly into the atmosphere; when this occurs within a building (such as by natural gas consumption) this is a direct emission source[22] associated with that building. GHGs are also emitted during the generation of electricity from fossil fuels. When electricity is used in a building, the electricity generation typically takes place offsite at the power plant; electricity use in a building generally causes emissions in an indirect manner.

Energy use in buildings is divided into energy consumed by the built environment and energy consumed by uses that are independent of the construction of the building such as plug-in appliances. In California, Title 24 part 6 governs energy consumed by the built environment, mechanical systems, and some fixed lighting. This includes the space heating, space cooling, water heating, and ventilation systems. Non-building energy use, or “plug-in” energy use can be further subdivided by specific end-use (refrigeration, cooking, office equipment, etc.). The following two steps are performed to quantify the energy use due to buildings:

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[21] The Center for Urban Forest Research Tree Carbon Calculator is not suggested since it requires knowledge on specific tree species to estimate carbon sequestered. This information is typically not available during the preparation of CEQA documents.

[22] California Climate Action Registry (CCAR) General Reporting Protocol (GRP), Version 3.1 (January). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf, Chapter 8

1. Calculate energy use from systems covered by Title 24[23] (HVAC system, water heating system, and the lighting system).
2. Calculate energy use from office equipment, plug-in lighting, and other sources not covered by Title 24.

The resulting energy use quantities are then converted to GHG emissions by multiplying by the appropriate emission factors obtained by incorporating information on local electricity providers for electricity, and by natural gas emission factors for natural gas combustion.

ENVIRON recommends using default values for Title 24 and non-Title 24 energy use for various building types. These will take into account the building size and climate zone. There are several sources of information that can be used to obtain building energy intensity. Each is described briefly below.

> The *California Commercial Energy Use Survey* (CEUS) data is provided by the California Energy Commission (CEC). It is based on a survey conducted in 2002 for existing commercial buildings in various climate zones. Electricity and natural gas use per square foot for each end use in each building type and climate zone is extracted from the CEUS data. Since the data is provided by end use, it is straightforward to calculate the Title 24 and non-Title 24 regulated energy intensity for each building type.

> *Commercial Buildings Energy Consumption Survey* (CBECS) is a survey of non-residential buildings that was conducted in 2003 by the Energy Information Administration (EIA). Electricity and natural gas use per square foot can be extracted from this data. The energy use estimates are assumed to represent 2001 Title 24 compliant buildings. Using CBECS, the percent of electricity and natural gas used for each end use can be calculated. It is then straightforward to calculate the Title 24 and non-Title 24 electricity and natural gas intensity for each building type. Similar surveys exist for manufacturing and residential energy use.

> The *Residential Appliance Saturation Survey* (RASS) refers to the California Energy Commission Consultant Report entitled "California Statewide Residential Appliance Saturday Study". Data from RASS is used to calculate the total electricity and natural gas use for residential buildings on a per dwelling unit. The RASS study estimates the unit energy consumption (UEC) values for individual households surveyed and also provides the saturation number for each type of end use. The saturation number indicates the proportion of households that have a demand for each type of end-use category. As the data is provided by end use, it is straightforward to calculate the Title 24 and non-Title 24 electricity and natural gas intensity for each building type.

> *Alternative Calculation Method* (ACM) software is available that makes estimates of the energy consumption by a model Title 24 compliant building. These programs provide

[23] Title 24, Part 6, of the California Code of Regulations: California's Energy Efficiency Standards for Residential and Nonresidential Buildings. http://www.energy.ca.gov/title24/

annual energy use for the heating, ventilation, and air conditioning (HVAC) system in each building; therefore, estimates from ACM software represent Title 24-regulated energy use. These do not calculate the non-Title 24 energy use for the buildings.

The Department of Energy produced the *Building America Research Benchmark Definition* (BARBD) technical manual, which presents empirical equations for electricity and natural gas usage. As the data is provided by end use, it is straightforward to calculate the Title 24 and non-Title 24 electricity and natural gas intensity for each building type.

Literature surveys may also be used for building and land use types not well represented by the above sources.

ENVIRON suggests using the CEUS and RASS datasets for these calculations since the data is available for several land use categories in different climate zones in California.

The Title 24 standards have been updated twice (in 2005 and 2008) since some of these data were compiled. CEC has published reports estimating the percentage deductions in energy use resulting from these new standards. Based on CEC's discussion on average savings for Title 24 improvements, these CEC savings percentages by end use can be used to account for reductions in electricity use due to updates to Title 24. Since energy use for each different system type (ie, heating, cooling, water heating, and ventilation) as well as appliances is defined, this method will easily allow for application of mitigation measures aimed at reducing the energy use of these devices in a prescriptive manner.

Based on the electricity intensity, CO_2e intensity values (CO_2e emissions per square foot or dwelling unit, as applicable, per year) for each building type can be calculated. Electricity intensity data is multiplied by an electricity emission factor to generate CO_2e intensity values. The total CO_2e emissions from each building type are calculated by multiplying the CO_2e intensity values by the appropriate metric (building square footage for non-residential buildings or number of dwelling units for residential buildings). Summing the CO_2e emissions from all building types gives the total CO_2e emissions from electricity use in Title 24 and non-Title 24 sources in buildings.

Based on the natural gas intensity, CO_2e intensity values (CO_2e emissions per square foot or dwelling unit, as applicable, per year) for each building type can be calculated. Natural gas intensity data is multiplied by a natural gas emission factor to generate CO_2e intensity values. The total CO_2e emissions from each building type are calculated by multiplying the CO_2 intensity values by the appropriate metric (building square footage for non-residential buildings or number of dwelling units for residential buildings). Summing the CO_2e emissions from all building types gives the total CO_2e emissions from natural gas use in Title 24 and non-Title 24 sources in buildings.

5.3.1 Natural Gas Boilers

GHG emissions from the combustion of natural gas are calculated as the product of natural gas consumption, natural gas heat content, and carbon-intensity factor. The Project Applicant has to determine the natural gas consumption, while the heat content and carbon-intensity factor can obtained from the CCAR General Reporting Protocol.

5.4 Area Sources

Area sources are local combustion of fuel. The area sources covered in this section include natural gas fireplaces/stoves and landscape maintenance equipment. Natural gas usage from the primary building heating is not included in this category since it is already included with building energy use. Each of these area sources is discussed further.

5.4.1 Natural Gas Fireplaces/Stoves

GHG emissions associated with natural gas fired fireplaces are calculated using emission factors from CCAR. The average BTU per hour for fireplaces in homes needs to be specified. Default values for annual fireplace usage varies for each County. Natural gas is assumed to have 1,020 BTU per standard cubic foot[24].

5.4.2 Landscape Maintenance

Landscape maintenance includes fuel combustion emissions from equipment such as lawn mowers, roto tillers, shredders/grinders, blowers, trimmers, chain saws, and hedge trimmers, as well as air compressors, generators, and pumps.

Similar to construction off-road equipment, emission factors are based on the OFFROAD2007 model. These are combined with the hours of operation for each equipment piece as well as the horsepower and load factors. The GHG emissions will be calculated based on the emission factors for the equipment and fuel reported from OFFROAD2007 and the appropriate GWP. Default usages (hours of operation) should be determined for the landscape equipment based on the Project needs.

5.5 Water

Delivering and treating water for use at the project site requires energy. This embodied energy associated with the distribution of water to the end user is associated with the electricity to pump and treat the water. GHG emissions due to water use are related to the energy used to convey, treat and distribute water. Thus, these emissions are indirect emissions from the production of electricity to power these systems.

The amount of electricity required to treat and supply water depends on the volume of water involved. Three processes are necessary to supply water to users: (1) supply and conveyance of the water from the source; (2) treatment of the water to potable standards; and (3) distribution of the water to individual users.

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[24] USEPA. 1998. AP-42 Emission Factors. Chapter 1.4 Natural Gas Combustion.

Therefore, to quantify the GHG emissions associated with the distribution of water to an end user, the carbon intensity of electricity is used along with the amount of electricity used in pumping and treating the water. Since consumption of water varies greatly for each land use type, default values need to be determined with several listed in the mitigation measure fact sheets. Since buildings may have different percentages of water associated with indoor and outdoor water usage, the water usage is quantified separately. In addition since mitigation measures associated with water use may be directed separately toward indoor and outdoor water usage, this will be beneficial for this task.

5.5.1 Indoor

Indirect emissions resulting from electricity use are determined by multiplying electricity use by the CO_2e emission factor provided by the local electricity supplier. Energy use per unit of water for different aspects of water treatment (e.g. source water pumping and conveyance, water treatment, distribution to users) is determined using the stated volumes of water and energy intensities values (i.e., energy use per unit volume of water) provided by reports from the California Energy Commission (CEC) on energy use for California's water systems.[25] The CEC report estimates the electricity required to extract and convey one million gallons of water. Using this energy intensity factor, the expected indoor water demand, and the utility-specific carbon-intensity factor, GHG emissions from indoor water supply and conveyance may be calculated.

The amount of electricity required to treat and distribute one million gallon of potable water is estimated in the CEC report. Based on the estimated indoor water demand, these energy intensity factors, and the utility-specific carbon intensity factor, GHG emissions from indoor water treatment and distribution may be calculated.

The sum of emissions due to supplying, conveying, treating, and distributing indoor water gives the total emissions due to indoor water use.

5.5.2 Outdoor

Indirect emissions resulting from electricity use are determined by multiplying electricity use by the CO_2 emission factor provided by the local electricity supplier. Energy use per unit of water for different aspects of water treatment (e.g. source water pumping and conveyance, water treatment, distribution to users) is determined using the stated volumes of water and energy intensities values (i.e., energy use per unit volume of water) provided by reports from the California Energy Commission (CEC) on energy use for California's water systems.[26] The

[25] CEC 2005. California's Water-Energy Relationship. Final Staff Report. CEC-700-2005-011-SF,

CEC 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December.

[26] CEC 2005. California's Water-Energy Relationship. Final Staff Report. CEC-700-2005-011-SF,

CEC 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December.

energy needed to supply and convey the water will be used to pump this water from the sources and distribute it throughout the development. The CEC report estimates the electricity required to extract and convey one million gallons of water. Using this energy intensity factor, the expected outdoor water demand, and the utility-specific carbon-intensity factor, GHG emissions from outdoor water supply and conveyance may be calculated.

The amount of electricity required to treat and distribute one million gallon of potable water (see recycled water for non-potable water) is estimated in the CEC report. Based on the estimated outdoor water demand, these energy intensity factors, and the utility-specific carbon intensity factor, GHG emissions from outdoor water treatment and distribution may be calculated.

The sum of emissions due to supplying, conveying, treating, and distributing outdoor water gives the total emissions due to outdoor water use.

5.5.2.1 Landscape Watering – Turf Grass

The amount of outdoor water used in the landscape watering of turf grass is calculated based on the California Department of Water Resources (CDWR) 2009 Model Water Efficient Landscape Ordinance[27] and the CDWR 2000 report "A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III."[28] Using this methodology, the amount of water required to support the baseline turf water demand ($Water_{baseline}$) is calculated as follows:

$$ETC = Kc \times ET_0$$

Where:

ETC	=	Crop Evapotranspiration, the total amount of water the baseline turf loses during a specific time period due to evapotranspiration[29] (inches water/day)
KC	=	Crop Coefficient, factor determined from field research, which compares the amount of water lost by the crop (e.g. turf) to the amount of water lost by a reference crop (unitless). Species-specific; provided in CDWR 2000
ET_0	=	Reference Evapotransporation, the amount of water lost by a reference crop (inches water/day) Region-specific; provided in Appendix A of CDWR 2009

[27] California Department of Water Resources. 2009. Model Water Efficient Landscape Ordinance. Available online at: http://www.water.ca.gov/wateruseefficiency/docs/MWELO09-10-09.pdf

[28] California Department of Water Resources. 2000. A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California: The Landscape Coefficient Method and WUCOLS III. Available online at: http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf

[29] Evapotranspiration is water lost to the atmosphere due to evaporation from soil and transpiration from plant leaves. For a more detailed definition, see this California Irrigation Management Information System (CIMIS) website: http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp;jsessionid=91682943559928B8A9A243D2A2665E19

Then:

$$Water_{baseline} = ETC \times Areabaseline \times 0.62 \times 365$$

Where:

$Water_{baseline}$	=	Volume of water required to support the baseline turf (gallons/year)
$Area_{baseline}$	=	Area of existing or standard turf (square feet)
0.62	=	conversion factor (gallons/squarefoot.inches water)
365	=	conversion factor (days/year)

Based on the estimated outdoor water demand for watering turf grass, the outdoor water energy intensity factors described above, and the utility-specific carbon intensity factor, GHG emissions from watering turf grass in lawns may be calculated.

5.5.2.2 Landscape Watering – General

The amount of outdoor water used in the landscape watering of landscapes and lawns is calculated based on the California Department of Water Resources (CDWR) 2009 Model Water Efficient Landscape Ordinance.[30] Using this methodology, the amount of water required to support the baseline lawn water demand ($Water_{baseline}$) is defined as the Maximum Applied Water Allowance (MAWA) and is calculated as follows:

$$Water_{baseline} = MAWA = ET_0 \times 0.62 \times [(0.7 \times LA) + (0.3 \times SLA)]$$

Where:

$Water_{baseline}$	=	Volume of water required to support the baseline lawn (gallons/year)
MAWA	=	Maximum Applied Water Allowance (gallons/year)
ET_0	=	Annual Reference Evapotranspiration[31] from Appendix A of CDWR 2009 (inches per year)
0.7	=	ET Adjustment Factor (ETAF)
LA	=	Landscape Area[32] includes Special Landscape Area[33] (square feet)

[30] California Department of Water Resources. 2009. Model Water Efficient Landscape Ordinance. Available online at: http://www.water.ca.gov/wateruseefficiency/docs/MWELO09-10-09.pdf

[31] Evapotranspiration is water lost to the atmosphere due to evaporation from soil and transpiration from plant leaves. For a more detailed definition, see this California Irrigation Management Information System (CIMIS) website: http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp;jsessionid=91682943559928B8A9A243D2A2665E19

[32] § 491 Definitions in CDWR 2009: "Landscape Area (LA) means all the planting areas, turf areas, and water features in a landscape design plan subject to the Maximum Applied Water Allowance calculation. The landscape area does not include footprints of buildings or structures, sidewalks, driveways, parking lots, decks, patios, gravel or stone walks, other pervious or non-pervious hardscapes, and other non-irrigated areas designed fro non-development (e.g., open spaces and existing native vegetation)."

[33] § 491 Definitions in CDWR 2009: "Special Landscape Area (SLA) means an area of the landscape dedicated

0.62	=	Conversion factor (to gallons per square foot)
SLA	=	Portion of the landscape area identified as Special Landscape Area (square feet)
0.3	=	the additional ETAF for Special Landscape Area

Based on the estimated outdoor water demand for watering lawns, the outdoor water energy intensity factors described above, and the utility-specific carbon intensity factor, GHG emissions from watering lawns may be calculated.

5.5.3 Recycled Water

After use, wastewater is treated and reused as reclaimed water. Any reclaimed water produced is generally redistributed to users via pumping. An estimate of the non-potable water demand to be met through the distribution of recycled water is needed. Estimates of the amount of energy needed to redistribute and, if necessary, treat reclaimed water is 400 kW-hr per acre foot.[34] Based on the estimated demand for reclaimed water, the estimated electricity demand and the utility-specific carbon-intensity factor, non-potable reclaimed water redistribution emissions are calculated.

5.5.4 Process

Industrial land uses can use a large amount of water for their processes. The water used for this will not be quantified since there is not sufficient water use data for this type of land use for the development of a default value. Water use is highly dependent on the specific industry..

5.6 Wastewater

Emissions associated with wastewater treatment include indirect emissions necessary to power the treatment process and direct emissions from degradation of organic material in the wastewater.

5.6.1 Direct Emissions

Direct emissions from wastewater treatment include emissions of CH_4 and biogenic CO_2. The method described by the Local Government Operations Protocol developed by the California Air Resources Board is suggested with default values assigned since detailed plant specific data will typically not be available.[35] The assumed daily 5-day carbonaceous biological oxygen

solely to edible plants, areas irrigated with recycled water, water features using recycled water and areas dedicated to active play such as parks, sports fields, golf courses, and where turf provides a playing surface."

[34] CEC 2005. California's Water-Energy Relationship. Final Staff Report. CEC-700-2005-011-SF.

[35] California Air Resources Board. 2008. *Local Government Operations Protocol - for the quantification and reporting of greenhouse gas emissions inventories*. Version 1.0. September 2008. Developed in partnership by California Air Resources Board, California Climate Action Registry, ICLEI - Local Governments for Sustainability, The Climate Registry

demand (BOD_5) of 200 mg/L-wastewater is multiplied by the protocol defaults for maximum CH_4-producing capacity (0.6 kg-CH_4/kg-BOD_5) and other default values to obtain the direct CH_4 emission. The amount of digester gas produced per volume of wastewater, and amount of N_2O per volume of wastewater needs to be determined. These values are then multiplied by the Global Warming Potential factor[36] of 21 for CH_4 or 310 for the GWP of N_2O that would be generated otherwise to obtain the annual CO_2 equivalent emissions.

5.6.2 Indirect Emissions

Indirect GHG emissions result from the electricity necessary to power the wastewater treatment process. The electricity required to operate a wastewater treatment plant is estimated to be 1,911 kW-hr per million gallons.[37] Based on the expected amount of wastewater requiring treatment, which will be assumed to be equal to the indoor potable water demand absent other data, the energy intensity factor and the utility-specific carbon-intensity factor, indirect emissions due to wastewater treatment are calculated.

5.7 Public Lighting

Lighting sources contribute to GHG emissions indirectly, via the production of the electricity that powers these lights. Lighting sources considered in this source category include streetlights, traffic lights, and parking lot lights. The annual electricity use may be estimated using the number of heads, the power requirements of each head, and the assumption that they operate for 12 hours a day on average for 365 days per year or 24 hours for traffic lights. The emission factor for public lighting is the utility-specific carbon-intensity factor. Multiplying the electricity usage by the emission factor gives an estimate of annual CO_2e emissions from public lighting.

5.8 Municipal Vehicles

GHG emissions from municipal vehicles are due to direct emissions from the burning of fossil fuels. Municipal vehicles considered in this source category include vehicles such as police cars, fire trucks, and garbage trucks. Data from reports by Medford, MA; Duluth, MN; Northampton, MA; and Santa Rosa, California[38] show that the CO_2 emissions from municipal

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[36] Intergovernmental Panel on Climate Change. IPCC Second Assessment - Climate Change 1995.

[37] CEC 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December.

[38] City of Medford. 2001. Climate Action Plan. October. http://www.massclimateaction.org/pdf/MedfordPlan2001.pdf

City of Northampton. 2006. Greenhouse Gas Emissions Inventory. Cities for Climate Protection Campaign. June. http://www.northamptonma.gov/uploads/listWidget/3208/NorthamptonInventoryClimateProtection.pdf

City of Santa Rosa. Cities for Climate Protection: Santa Rosa. http://ci.santa-rosa.ca.us/City_Hall/City_Manager/CCPFinalReport.pdf

Skoog., C. 2001. Greenhouse Gas Inventory and Forecast Report. City of Duluth Facilities Management and The International Council for Local Environmental Initiatives. October.http://www.ci.duluth.mn.us/city/information/ccp/GHGEmissions.pdf vehicles would be approximately[39] 0.05 MT per capita per year. Using these studies and the expected population, emissions from municipal vehicles may be calculated.

5.9 On-Road Mobile Sources

This section estimates GHG emissions from on-road mobile sources. The on-road mobile source emissions considered a project will be from the typical daily operation of motor vehicles by project residents and non-residents. The GHG emissions based upon all vehicle miles traveled associated with residential and non-residential trips regardless of internal or external destinations or purpose of trip are estimated. Traffic patterns, trip rates, and trip lengths are based upon the methods discussed below.

The CCAR GRP[40] recommends estimating GHG emissions from mobile sources at an individual vehicle level, assuming knowledge of the fuel consumption rate for each vehicle as well as the miles traveled per car. Since these parameters are not known for a future development, the CCAR guidance can not be used as recommended.

Estimating Trip Rates

The majority of transportation impact analysis conducted for CEQA documents in California apply trip generation rates provided by the Institute of Transportation Engineers (ITE) in their regularly updated report *Trip Generation*. The report is based on traffic counts data collected over four decades at built developments throughout the United States. This data is typically based on single-use developments, in suburban locations with ample free parking and with minimal transit service and demand management strategies in place. As a result, the ITE trip generation rates represent upper bound trip generation rates for an individual land use type. This represents a good basis against which to measure the trip-reducing effects of any one or more of the mitigation strategies that will be quantified in subsequent tasks. Therefore, we recommend ITE trip rates as the baseline condition against which the effectiveness of CAPCOA's mitigation measures is applied.

There are some CEQA traffic studies that use data other than ITE trip generation rates. Below we briefly discuss the possible use of these alternative datasets. These traffic studies typically use trip generation data from one of the following sources:

SANDAG Traffic Generators. In the San Diego region, most studies use data from the SANDAG *Traffic Generators* report. This report is similar to the ITE *Trip Generation* in that it uses primarily suburban, single use developments, except that this dataset is based on traffic counts conducted in the San Diego region rather than throughout the United States. In studies where the SANDAG data is used, CAPCOA reviewers should apply the trip reduction estimates presented in subsequent tasks directly to the SANDAG trip generation rates.

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[39] In an effort to be conservative, the largest per capita number from these four reports was used.

[40] California Climate Action Registry (CCAR). 2009. *General Reporting Protocol*. Version 3.1. January.

Travel Forecast Models. For some large development projects or general plans, the local or regional travel model is used to estimate the number of trips generated as well as trip lengths and vehicle speeds at which the individual trips occur. These models account for whether the trip segment occurs on a freeway or local streets as well as the degree of congestion. The values for trip generation rates and trip lengths using ITE and average trip lengths can be to assess the model estimates of vehicle trip generation and VMT. These comparisons should recognize that the travel models explicitly account for various factors that reduce trip-making and VMT, including the demographic characteristics of the site occupants, location and accessibility of the development site relative to other destinations in the region, the mix of land uses within the site and its surrounding area, and possibly the availability of effective transit service. When performing a comparison using the ITE trip rates and average trip lengths, the reviewer should take into consideration that these factors have already been accounted for in the modeling. Therefore, we recommend applying ITE trip rates and lengths along with the adjustments recommended elsewhere in this document (accounting for site location, design and demographics) as a means of reality-checking transportation model results.

Traffic counts at comparable developments. Some traffic assessments elect to conduct traffic counts at existing developments that are similar to the proposed development. When reviewing impact assessments produced using such information, the reviewer should take into account the extent to which the surveyed development(s) already contain trip generation and trip length reducing measures. Care needs to be used to avoid double-counting reductions.

Estimating VMT from Mobile Sources

Data on average trip lengths are used to translate trip generation rates into vehicle miles of travel (VMT). These trip lengths should be obtained from published sources of average trip lengths for different types of trip types (i.e., commute trips, shopping trips, and others) for each region within the state. Vehicle miles traveled (VMT) are calculated by multiplying ITE trip rates by the typical trip lengths.

Some mechanisms that reduce trip generation rates and trip lengths below these standard ITE-trip rates and current average trip lengths might be considered to be intrinsic parts of the development proposal rather than mitigation measures, such as project location (e.g., infill or transit oriented development [TOD]), density, mix of uses, and urban design. These are not considered part of the baseline condition, but are recognized and quantified as project design features (PDFs). This approach has the following advantages: 1) it creates a consistent basis of analysis for all development projects regardless of location and self-mitigating features already included in the project proposal, and 2) it highlights all elements of a project that reduce trip generation rates and vehicle miles traveled.

Other Factors Influencing Mobile Source GHG Emissions

Beyond trip generation, trip length and VMT, other factors that affect GHG emissions include traffic flow, vehicle fuel consumption rates, and fuel type.

Traffic speed and efficiency profiles are largely influenced by: a) the project location and degree of prevailing congestion in its vicinity, b) the degree to which the project implements traffic level-of-service mitigation measures often triggered by CEQA review, and c) actions taken by local, regional governments and Caltrans to reduce corridor or area-wide congestion.

The simplified mitigation assessment methods developed for this study use several categories of emissions factors per VMT that account for a) the generalized project location (core infill, inner ring suburbs, outer suburbs, rural), and b) and region-specific fleet and emissions rate if available.

While it is beyond the scope of this document to provide CAPCOA the ability to perform traffic speed and efficiency analysis, the study report advises CAPCOA on the type of analysis to expect to see in CEQA documents on development projects. CEQA impact and mitigation assessment methods should continue to perform air quality analysis using tools such as EMFAC that reference prevailing traffic speed profiles, especially for infill development and congested corridors, while applying appropriate credit for congestion reducing measures included in the project mitigation requirements, funded capital improvements plans, and fiscally constrained Regional Transportation Plans (RTPs.)

5.9.1 Estimating GHG Emissions from Mobile Sources

The CO_2 emissions from mobile sources were calculated with the trip rates, trip lengths and emission factors for running and starting emissions from EMFAC2007 as follows:

$$CO_2\ emissions = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled
$EF_{running}$ = emission factor for running emissions

The CO_2e calculation involves the following assumptions:

- The emission factor depends upon the speed of the vehicle.
- EMFAC emission factors from the baseline year will be used for $EF_{running}$ based on County specific fleet mix for different trip types and adjusted to account for applicable regulations that are not currently incorporated yet into EMFAC.

Startup emissions are CO_2 emitted from starting a vehicle. Startup emissions are calculated using the following assumptions:

- The number of starts is equal to the number of trips made annually.
- The breakdown in vehicles is EMFAC fleet mix for County specific fleet mix.
- The emission factor for startup is calculated based on a weighted average of time between starts for each trip type (commute trips versus all other types).

Fleet distribution types will be based on EMFAC2007 or the most recent EMFAC version available. For mobile sources, the USEPA recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their GWPs.[41] To incorporate these additional GHGs into the calculations, the total GHG footprint is calculated by dividing the CO_2 emissions by 0.95.

Emission factors for alternative fuel can be obtained from the CCAR General Reporting Protocol. For comparison with alternative fuel, N_2O and CH_4 emissions should be calculated separately as their emissions from alternative fuel are generally higher than from gasoline or diesel.

Low-emission-vehicle programs, such as neighborhood electric vehicles (NEV) or car sharing programs, will only be considered in accounting for GHG reductions if included in project-specific design or mitigation measures.

5.10 GHG Emissions from Specialized Land Uses

Below are methods to quantify GHG emissions from some additional land use categories that may be commonly found in development projects. These include golf courses and swimming pools. The methods proposed to determine GHG emissions associated with these sources is discussed in the following sections. The GHG emissions will typically fall into other categories such as landscape maintenance, water usage, and buildings, but since the data sources are different, they are explicitly described.

5.10.1 Golf Courses

Emission flux resulting from the construction of the golf course is not discussed, nor is the sequestration of CO_2 into the turf, trees, or lakes of the golf course. Operational CO_2 emissions were calculated for three areas: irrigation, maintenance (mowing), and on-site buildings' energy use. All three components are discussed in this section.

5.10.2 Calculating CO_2 Emissions from Irrigation of the Golf Course

The release of GHGs due to irrigation practices was calculated in two steps:

1. Identify the quantity of water needed.

2. Calculate the emissions associated with pumping the water.

1. *Identify the quantity of water needed.* Standard water use for an 18-hole golf course ranges from 250 to 450 acre-ft yearly. A survey of golf course superintendents conducted in the summer of 2003 by the Northern and Southern California Golf Associations revealed an annual average California usage of 345 acre-ft.[42] Numerous factors will affect the actual water usage

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[41] USEPA. 2005. *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle.* Office of Transportation and Air Quality. February.

[42] Northern California Golf Association. Improving California Golf Course Water Efficiency, pg 14. http://www.owue.water.ca.gov/docs/2004Apps/2004-079.pdf

of a specific golf course, and it is likely to vary by year. ENVIRON recommends using the average usage of 345 acre-ft per year annually.

2. Calculate the associated emissions. Using the information identified above, ENVIRON calculates total emissions from irrigation of an 18-hole golf course as follows:

Estimate total dynamic head: This is the combination of lift (300 feet) and desired pressure. Standard athletic field sprinklers require a base pressure of approximately 65 psi.[43]

60 psi x 2.31 ft/psi [44]	=	*139 ft*
+ lift	=	*300 ft*
Total dynamic head	=	*439 ft*

Identify fuel unit and multiply by head: Possible pumping fuels include electricity, natural gas, diesel, and propane. In these calculations, ENVIRON assumes that all pumps will use electricity. Based on the literature, ENVIRON recommends using a pumping energy use of 1.551 kW-hr/acre-ft/ft.[45]

$$1.551\ \text{kW-hr/acre-ft/ft} \quad x \quad 439\ \text{ft} \quad = \quad 681\ \text{kW-hr/acre-foot}$$

Multiply energy demand by emission factor and convert to MT: The energy demand per acre-ft calculated above is multiplied by the emission factor for the electricity generation source and converted to MT.

$$\frac{681\text{kW-hr/acre-ft x } 0.666\text{ lbs } CO_2\text{/kW-hr}}{2204.62\text{ lbs/ton}} = 0.21\text{ MT } CO_2\text{/acre-ft}$$

The anticipated annual water demand will be multiplied by these values and then combined this with the calculated emission factor yields total annual emissions from irrigation of the golf course. Other outdoor land uses that require irrigation can follow a similar procedure.

5.10.3 Calculating CO_2 Emissions from Maintenance of the Golf Course

Maintenance emissions include the emissions resulting from the mowing of turf grass. The release of GHGs due to mowing was calculated in three steps:

1. Identify the area of turf and frequency of mowing.
2. Identify the efficiency of a typical mower.

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[43] Full Coverage Irrigation. Partial List of Customers Using FCI Nozzles. http://www.fcinozzles.com/clients.asp.

[44] Conversion factor: 1 psi = 2.31 feet of head. Kele & Associates Technical Reference: Liquid Level Measurement. http://www.kele.com/tech/monitor/Pressure/LiqLevMs.pdf

[45] Kansas State University Irrigation Management Series. Comparing Irrigation Energy Costs. Table 4. http://www.oznet.ksu.edu/library/ageng2/mf2360.pdf

3. Calculate the emissions associated with mowing.

1. *Identify the area of turf and frequency of mowing*: An Arizona State economic analysis of golf courses reports that on average 2/3 of the land within a golf course is maintained.[46] ENVIRON suggests assuming that the course will be mowed twice weekly, although high maintenance areas such as greens will be mowed more frequently.[47] ENVIRON recommends a growing season of 52 weeks/year.[48]

2. *Identify the efficiency of a typical mower*. Typical mower calculations are based on the specifications for a lightweight fairway mower (model 3235C) reported by John Deere's Golf & Turf division.[49] A typical mower will use one tank (18 gallons) of diesel per day (assumed to be 8 hours). Given the size specifications of the mower and assuming an average speed of 5.5 mph, such a mower can cover 44 acres on 18 gallons of diesel.

3. *Calculate the emissions associated with mowing*. Using the information collected above and a CO_2 emission factor for diesel combustion[50], ENVIRON calculates the emission factor for mowing the golf course:

$$\frac{2 \text{ mowings/}}{\text{week}} \times \frac{52 \text{ weeks/}}{\text{year}} \times \frac{18 \text{ gallons diesel/}}{44 \text{ acre-mowing}} \times \frac{22.4 \text{ lbs } CO_2\text{/ gallon diesel}}{2204 \text{ lbs/ton}} = 0.43 \text{ MT } CO_2\text{/ acre-year}$$

5.10.4 Calculating CO_2 Emissions from Building Energy Use at the Golf Course

Any of the non-residential building energy use data sources described in the Buildings section may be used to estimate energy intensity at the golf course.

5.11 Pools

Recreation centers may include various pools, spas, and restroom buildings; ENVIRON assumes that pools are the main consumers of energy in recreation centers. This section describes the methods used to estimate the GHGs associated with pools in recreation centers.

The energy used to heat and maintain a swimming pool depends on several factors, including (but not limited to): whether the pool is indoors or outdoors, size of the pool (surface area and depth), water temperature, and energy efficiency of pool pump and water heater, and whether

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46 Total acreage divided by total acreage maintained. Arizona State University, Dr. Troy Schmitz. Economic Impacts and Environmental Aspects of the Arizona Golf Course Industry. http://agb.poly.asu.edu/workingpapers/0501.pdf.

47 Based on Best Practices video. http://buckeyeturf.osu.edu/podcast/?p=51

48 Based on 95% of Southern California Survey respondents report an irrigation season greater than 9-10 months. http://www.owue.water.ca.gov/docs/2004Apps/2004-079.pdf

49 John Deere Product Specifications. 3235C Lightweight Fairway Mower. http://www.deere.com/en_US/ProductCatalog/GT/series/gt_lwfm_c_series.html

50 EIA. Fuel and Energy Source Codes and Emission Coefficients. http://www.eia.doe.gov/oiaf/1605/factors.html

solar heating is used. By making assumptions for these parameters and using known or predicted values for energy use, ENVIRON estimates the electricity and natural gas use of an outdoor pool.

5.11.1 Recreation Center Characterization

In the calculations described below, ENVIRON assumes that the proposed pools will be outdoor pools with dimensions 50 meters by 22.9 meters (a typical, competition-size pool). ENVIRON bases electricity calculations on a pool that ran its standard water filter for 24 hours per day, 365 days per year. As there is little data publicly available on the energy use of commercial swimming pools, ENVIRON extrapolates energy consumption from information obtained from two sources: 1) Data on electricity used by pool pumps from Pacific Gas and Electric (PG&E),[51] and 2) Data on the annual cost to heat a commercial pool located in Carlsbad, CA.[52]

5.11.2 Electricity Use of Pools

A PG&E study on energy efficiency of a pool pump at the Lyons Pool in Oakland, CA, found an annual electricity use of 110,400 kilowatt hours per year (kWh per yr).[53] The study pool is smaller than the assumed size of the proposed pool (actual size of the Lyons Pool is 35 yards by 16 yards). Accordingly, ENVIRON scales the electricity use to reflect the larger size of the proposed pool.

5.11.3 Natural Gas Use of Pools

The estimated annual cost of heating a standard competition-size pool is $184,400 (or 72% of the total cost of pool operations).[54] ENVIRON used the average PG&E commercial rate for natural gas of $0.95 per therm to convert this cost into annual natural gas use (hundred cubic feet per year [ccf/year]).[55] The commercial rate averages the variable cost due to energy usage and time of year. This corresponds to approximately 184,400 ccf per year.[56]

This value is comparable to that obtained from the pool industry.[57] The estimated cost of heating a residential pool using a natural gas heater is about one dollar per square foot of water

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51 PG&E. 2006. Energy Efficient Commercial Pool Program, Preliminary Facility Report. Lyons Pool, "City of Oakland/Oakland Unified School District." October.

52 Mendioroz, R. 2006. Fueling Change: A Number of Design Schemes and Alternative-Energy Strategies Can Help Operators Beat the Price of Natural Gas. Athletic Business. March.

53 PG&E. 2006. Energy Efficient Commercial Pool Program, Preliminary Facility Report. Lyons Pool, "City of Oakland/Oakland Unified School District." October.

54 Mendioroz, R. 2006. Fueling Change: A Number of Design Schemes and Alternative-Energy Strategies Can Help Operators Beat the Price of Natural Gas. Athletic Business. March.

55 Pacific Gas and Electric (PG&E). 2007. Gas Rate Finder. Vol 36-G, No. 9. September. http://www.pge.com/tariffs/GRF0907.pdf

56 At the commercial rate given 1 ccf costs $1.

57 SolarCraft Services Inc. 2007. Phone conversation with Chris Bumas on September 18, 2007. Novato, CA http://www.solarcraft.com/

surface area per month ($/sqft-month) in residential therms.[58] Applying this value to a competition-size pool yields an annual natural gas use of 147,600 ccf/year.

5.11.4 Conversion of Electricity and Natural Gas Use to Greenhouse Gas Emissions

ENVIRON used utility-specific electricity and natural gas emission factors to calculate the total CO_2 emissions for each pool. A summary of the calculations is shown below:

$$Emissions\ from\ Electricity\left(\frac{Tonnes\,CO_2\ /\ yr}{1{,}000\,sqft}\right) =$$
$$\frac{Energy\,Use\,(ccf\ /\ yr) \times Emission\ Factor\ (lbs\ CO_2e\,/\,ccf\,) \times Conversion\,Factor\,(tonne\,/\,2205\,lbs)}{Surface\ Area\ of\ Pool\ (1{,}000\,sqft)}$$

$$Emissions\ from\ Natural\,Gas\left(\frac{Tonnes\,CO_2\ /\ yr}{1{,}000\,sqft}\right) =$$
$$\frac{Energy\,Use\,(ccf\ /\ yr) \times Emission\ Factor\ (lbs\ CO_2e\,/\,ccf\,) \times Conversion\,Factor\,(tonne\,/\,2205\,lbs)}{Surface\ Area\ of\ Pool\ (1{,}000\,sqft)}$$

[58] The residential price for one therm of natural gas.

Appendix C

Transportation Appendices

Appendix C.1

Transportation Calculations

Appendix C.1 – Transportation Calculations

Table C-1 provides further detail into the calculations of percent reduction in vehicle miles traveled (VMT) for each of the fact sheets (that have references to the appendix). Many of the strategies in the table below do not provide the full equations for percent reduction in vehicle miles traveled. Only the equations or variables which require further detail are outlined here. The table also provides detail on any assumptions which are made to perform the calculations and the basis of such assumptions. An additional section below Table C-1 provides a detailed discussion of the calculations made for the transit accessibility strategy.

Table C-1
Transportation Calculations

Strategy	T#	Equation	Variable	Value	Source/Notes
Increase Density (Land Use/Location)	A2	A = Percentage increase in housing units per acre = (number of housing units per acre – number of housing units per acre for typical ITE development) / (number of housing units per acre for typical ITE development)	number of housing units per acre for typical ITE development	7.6 = blended average density of residential development in the US in 2003	A.C. Nelson. "Leadership in a New Era." *Journal of the American Planning Association,* Vol. 72, Issue 4, 2006, pp. 393-407 – as cited in *Growing Cooler*
		A = Percentage increase in jobs per job acre = (number of jobs per job acre – number of jobs per job acre for typical ITE development) / (number of jobs per job acre for typical ITE development)	number of jobs per job acre for typical ITE development	20 = average jobs per job acre	Year 2005 Land Use, Sacramento County Travel Demand Model, 2008
Improve Design of Development (Land Use/Location)	A3	A = Percentage increase in intersections versus a typical ITE suburban development = (intersections per square mile of project – intersections per square mile of typical ITE suburban development) / (intersections per square mile of typical ITE suburban development)	intersections per square mile of typical ITE suburban development	36 = ITE site average intersection density	Based on Fehr & Peers methodology for analysis in the report: *Proposed Trip Generation, Distribution, and Transit Mode Split Forecasts for the Bayview Waterfront Project Transportation Study*, Fehr & Peers, 2009

Table C-1 Transportation Calculations					
Strategy	**T#**	**Equation**	**Variable**	**Value**	**Source/Notes**
Increase Diversity (Mixed Use) (Land Use/Location)	A5	A = Percentage increase in land use index versus single use development = (project land use index – single land use index) / single land use index	single land use index	0.15 = - [1*(ln 1) + 0.01*(ln 0.01)+…+0.01*(ln 0.01)]/ ln(6)	--
Increase Destination Accessibility (Land Use/Location)	A6	A = Percentage decrease in distance to downtown or major job center = (distance to downtown/job center for typical ITE development – distance to downtown/job center for project) / (distance to downtown/job center for typical ITE development)	distance to downtown/job center for typical ITE development	12 miles (average work trip length from NHTS)	2000-2001 California Statewide Travel Survey, 2001 NHTS Summary of Travel Trends, p.15 (Table 5)
Increase Transit Accessibility (Land Use/Location)	A7	A = Increase in transit mode share = % transit mode share for project - % transit mode share for typical ITE development	% transit mode share for typical ITE development	1.3%	NHTS, 2001 http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/Final2001_StwTravelSurveyWkdayRpt.pdf, p.150 (Suburban – SCAG, SANDAG, Fresno County.)
		B = Adjustment from transit mode share to VMT = 1 / average vehicle occupancy * conversion from VT to VMT = 0.67	Divide by average vehicle occupancy to translate to VT	1 / average vehicle occupancy = 1 / 1.5 = 0.67	NHTS, http://www.dot.ca.gov/hq/tsip/tab/documents/travelsurveys/2000_Household_Survey.pdf, p.iii
			conversion from VT to VMT	1	Assume all trip lengths are equal (vehicle trips to VMT) [1]

[1] To convert to vehicle miles traveled, we assume that all vehicle trips will average out to typical trip length ("assume all trip lengths are equal"). Thus, we can assume that a percentage reduction in vehicle trips will equal the same percentage reduction in vehicle miles traveled.

Table C-1
Transportation Calculations

Strategy	T#	Equation	Variable	Value	Source/Notes
Unbundle Parking Cost from Property Cost (Parking Pricing/Policy)	C3	A = Adjustment from Vehicle Ownership to VMT = average trips per 2 vehicles * 1 vehicle per average trips =(9.8 trips/ 2 vehicles) * (1 vehicle / 5.7 trips) = 0.85	Average trips per X vehicles	Households with 2 vehicles take 9.8 trips while households with 1 vehicle take 5.7 trips per day	i.e. A reduction of 1 vehicle leads to an 0.85 reduction in vehicle trips http://www.dot.ca.gov/hq /tsip/tab/documents/travel surveys/2000_Household _Survey.pdf, table 8.7
Expand Transit Network (Transit System Improvements)	D2	D = Adjustment for Transit Ridership Increase to VMT	--	0.67	see Increase Transit Accessibility
Enhance Transit Service Frequency/Speed (Transit System Improvements)	D3	E = Adjustment for Transit Ridership Increase to VMT	--	0.67	see Increase Transit Accessibility
Implement Bus Rapid Transit (Transit System Improvements)	D4	D = Adjustment for Transit Ridership Increase to VMT	--	0.67	see Increase Transit Accessibility
Implement Required Trip Reduction Programs (Trip Reduction Programs)	E2	C = Adjustment from vehicle mode share to commute VMT	--	1	Assume all trip lengths are equal (vehicle mode share to vehicle trips to VMT) [i]
Provide a Transit Fare Subsidy (Trip Reduction Programs)	E3	C = Adjustment from commute VT to commute VMT	--	1	Assume all trip lengths are equal (vehicle trips to VMT) [i]
Implement Commute Trip Reduction Marketing (Trip Reduction Programs)	E7	C = Adjustment from commute VT to commute VMT	--	1	Assume all trip lengths are equal (vehicle trips to VMT) [i]

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Table C-1
Transportation Calculations

Strategy	T#	Equation	Variable	Value	Source/Notes
Provide Employer-Sponsored Vanpool/Shuttle (Trip Reduction Programs)	E8	C = Adjustment from vanpool mode share to commute VMT	--	0.67	see Increase Transit Accessibility
Implement Bike-Sharing Programs (Trip Reduction Programs)	E10	% VMT Reduction = A * B * C = 2% * 7% * 20% = 0.03%	--	--	--
		A = 2% = Net new bicycle mode share = (existing mode share * % increase in bicycle mode share) – existing mode share	Existing mode share	Estimate at 1%	Pucher et al., 2010
			% increase in bicycle mode share	135 – 300%	Pucher et al., 2010, Table 4 (see fact sheet for calculations)
		B = % of new bicycle trips shifting from vehicles (from literature)	--	6-7%	Pucher et al., 2010 and Bike-Share in NYC, 2009, Table 4, p.45
		C = adjustments to convert from vehicle mode share to VMT * adjustment for shorter than average trip lengths = 1*20%	adjustments to convert from vehicle mode share to VMT	1	Assume all trip lengths are equal (vehicle mode share to vehicle trips to VMT) [i]
			adjustment for shorter than average trip lengths	1.94/9.9 = 20%	Adjustment to reflect ratio of bike trip length to average trip length (this strategy will only replace the shorter vehicle trips that can be reasonably replaced by a bicycle). [1.94 miles (average bike trip length from Moving Cooler Appendices B-28 referencing NHTS) / 9.9 miles (average household trip length from NHTS Transferability, 2001 NHTS, http://nhts-gis.ornl.gov/transferability/Default.aspx)]

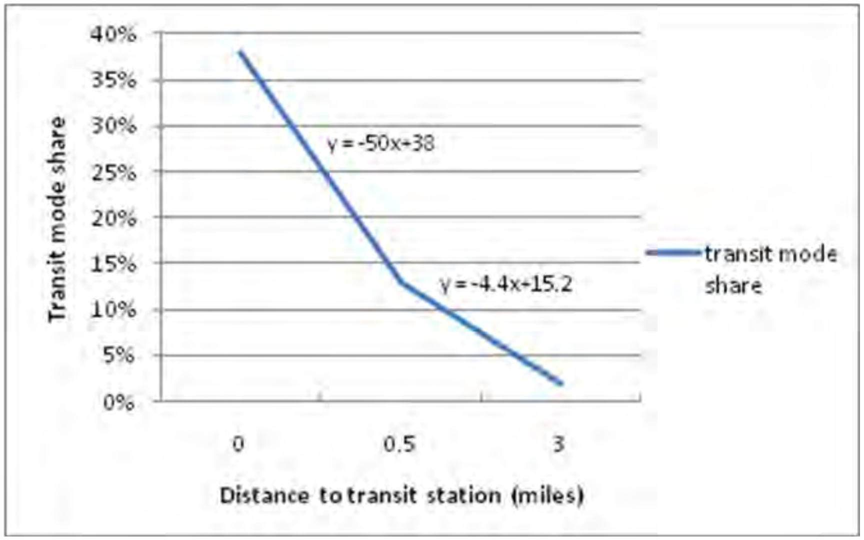
Table C-1 Transportation Calculations					
Strategy	**T#**	**Equation**	**Variable**	**Value**	**Source/Notes**
Provide End of Trip Facilities (Trip Reduction Programs)	E11	*utilizing the same equation in bike sharing program section, set A = 1.3% = (7.1% - 5.8%) % VMT Reduction = A * B * C = 1.3% * 7% * 20% = 0.02%	--	--	--
Establish Schoolpool (Trip Reduction Programs)	E13	B = Adjustments to convert from participation to daily VMT to annual school VMT = [(avg # of families per carpool - 1) / avg # of families per carpool] *% of school days	avg # of families per carpool	2.5	TDM Case Studies, DRCOG, p.13
			% of school days	75% = 39 school weeks/ 52 weeks	TDM Case Studies, DRCOG, p.13
Provide School Buses (Trip Reduction Programs)	E14	B = Adjustments to convert from participation to daily VMT to annual school VMT = % of school days	% of school days	75% = 39 school weeks/ 52 weeks	TDM Case Studies, DRCOG, p.13
Cordon Pricing (Road Pricing Management)	F2	A = % increase in pricing for passenger vehicles to cross cordon	--	100 – 500%	*Moving Cooler* uses peak hour price per mile instead of crossing price. The percentage change can still be calculated to provide a general estimate for a high range % change. Assuming a baseline of $0.10, calculated percentage increase to $0.49 - $0.65 (*Moving Cooler*) and adjusted with rounding
		C = % of VMT Impacted by Cordon Pricing and Mode Shift Adjustments = %VMT impacted by congestion pricing * Mode shift adjustment = 8.8% (peak period) and 21% (all day)	--	--	--

Table C-1 Transportation Calculations					
Strategy	**T#**	**Equation**	**Variable**	**Value**	**Source/Notes**
		Peak period = 25% * 35% = 8%	%VMT impacted by congestion pricing	25%	20% of trips are work trips (NHTS Transferability, 2001 NHTS, http://nhts-gis.ornl.gov/transferability/Default.aspx) and round up assuming other trips travel during peak periods
			Mode shift adjustment	35% = 20% + 30%/2	Of the estimated trips affected to the increase in price, assume 50% is either a time of day shift/route shift/no change, 30% convert to HOV trips (with average 2 ppl per HOV), and 20% are trip reductions/shift to transit, walk or bike
		Static all day price (London) = 60% * 35% = 21%	% VMT impacted by congestion pricing	60%	Conservatively assume 60% of trips fall in the peak periods and mid-day
			Mode shift adjustment	35%= 20% + 30%/2	Of the estimated reduced trips due to the increase in price, assume 50% is either a time of day shift/route shift/no change, 30% convert to HOV trips (with average 2 people per HOV), and 20% are trip reductions/shift to transit, walk or bike

<u>Increase Transit Accessibility (Land Use/Location)</u>

Distance to transit	Transit mode share calculation equation (where x = distance of project to transit)
0 – 0.5 miles	-50*x + 38

0.5 to 3 miles	-4.4*x + 15.2
> 3 miles	no impact
Source: Lund et al, 2004; Fehr & Peers 2010	



Data was taken from Table 5-25 of Lund et al, 2004. The table provided transit commute mode shares for those living with ½ mile of a rail station for 5 sites surveyed within California. Removing the extreme low and high percentages, this provided a range of transit commute mode share of 13% to 38%. A simple linear extrapolation was conducted to provide a relationship for distance to transit (between 0 and ½ mile) to transit mode share, via the equation: transit mode share = -50 * distance to transit + 38. The table also provided transit mode shares for those living from ½ to 3 miles from a station, a range from 2% to 13%. Using the same methodology, a relationship for distance to transit (between ½ mile and 3 miles) to transit mode share is provided via the equation: transit mode share = -4.4x + 15.2.

Appendix C.2

Trip Adjustment Factors

Appendix C.2 – Trip Adjustment Factors

The trip adjustment factors are not explicitly used for calculations of reduction in vehicle miles traveled (VMT) but serve as an added resource point for users of this document. For example, we report all commute trip reduction (CTR) program strategies as a percentage reduction in commute VMT. If the user would like to translate this to project level VMT (assuming the project is NOT an office park), and the user does not have statistics about the project area readily available, then the trip adjustment factors table can be utilized.

Example: Assume the user is providing a 15% reduction in commute VMT for a implementation of a ride share program. To calculate an estimated reduction in project level VMT, the user can multiple 15% by 20% (NHTS average % of work trips) and again multiply by 12.0 / 9.9 (average work trip length/average trip length) to adjust for both the portion of trips which are work related and that work trips tend to be longer than average trips.

TABLE C-2. TRIP ADJUSTMENT FACTORS

	NHTS[1]	Sacramento Region[2]	San Diego Region [3]	Rural (Kings County, CA) [4]
Average Work Trip Length (vehicle)	12.0	10.4	8.4	-
Average Trip Length (vehicle)	9.9	6.8	6.9	8.7
Average % of Work Trips	20%	20%	-	12%
Average % of School Trips	9.8%	-	-	-
Average Length of School Trips (Vehicle)	6.0	-	4.2	-
Average Vehicle Occupancy (All Trips)	1.5	1.4	1.5	-

Source:
1. 2000-2001 California Statewide Travel Survey, 2001 NHTS Summary of Travel Trends
2. SACMET model, Fehr & Peers, 2010.
3. SANDAG Brief Guide of Vehicular Traffic Generation Rates for the San Diego Region (April 2002)
4. NHTS Transferability, 2001 NHTS, http://nhts-gis.ornl.gov/transferability/Default.aspx

Appendix C.3

Induced Travel Memo

FEHR & PEERS
TRANSPORTATION CONSULTANTS

MEMORANDUM

Date: February 3, 2010

To: CAPCOA Team

From: Tien-Tien Chan, Jerry Walters, and Meghan Mitman

Subject:* *Induced Travel Material

SF10-0475

Induced travel is a term used to describe how travel demand responds to roadway capacity expansion and roadway improvements. Consistent with the theory of supply and demand, the general topic of research concerning induced travel is that reducing the cost of travel (i.e., reduced travel time due to a new road improvement) will increase the amount of travel. In other words, road improvements alone can prompt traffic increases. To what degree and under what circumstances these increases occur is a matter of debate and the key subject of most induced travel research. We have attached the following documents which represent research on induced travel effects:

- *Comparative Evaluations on the Elasticity of Travel Demand* – study conducted for the Utah DOT which included national literature review of induced travel studies
- *Are Induced-Travel Studies Inducing Bad Investments?* – article by Cervero in Access Magazine: Transportation Research at the University of California
- *Road Expansion, Urban Growth, Growth, and Induced Travel: A Path Analysis* – APA Journal paper by Cervero, also discusses the impacts of induced growth and induced investments

The reader should be aware that conditions may vary considerably and the extent of induced travel depends on a variety of factors, including: the degree of prior congestion in the corridor, its duration over hours of the day, its extent over lane miles of the corridor, the degree to which un-served traffic diverts to local streets and the degree of congestion on those routes, the availability of alternate modes within the corridor, whether corridor is radial and oriented toward downtown with high parking cost and limited availability or circumferential, planned level of growth in the corridor, whether the corridor is interstate or interregional, whether it is a truck route, and other factors.

GHG reduction strategies such as transportation system management (e.g. signal coordination, adaptive signal control) may also have the potential for inducing travel. For such strategies, if the estimated improvement exceeds 10% benefit in travel time reduction, we recommend conducting project specific analysis on induced travel prior to establishing GHG reduction benefits.

Appendix D

Building Mitigation Measure Quantification Methods

This Appendix summarizes the steps and assumptions used in two of the mitigation strategies – exceed Title 24 energy efficiency standards (BE-1) and installing energy efficient appliances (BE-4).

Background

GHGs are emitted as a result of activities in residential and commercial buildings when electricity and natural gas are used as energy sources. New California buildings must be designed to meet the building energy efficiency standards of Title 24, also known as the California Building Standards Code. Title 24 Part 6 regulates energy uses including space heating and cooling, hot water heating, ventilation, and hard-wired lighting. By committing to a percent improvement over Title 24, a development reduces its energy use and resulting GHG emissions.

The Title 24 standards have been updated twice (in 2005 and 2008)[1] since some of these data used to estimate energy use were compiled. California Energy Commission (CEC) has published reports estimating the percentage deductions in energy use resulting from these new standards. Based on CEC's discussion on average savings for Title 24 improvements, these CEC savings percentages by end use can be used to account for reductions in electricity and natural gas use due to the two most recent updates to Title 24. Since energy use for each different system type (ie, heating, cooling, water heating, and ventilation) as well as appliances is defined in this survey, the use of survey data with updates for Title 24 will easily allow for application of mitigation measures aimed at reducing the energy use of these devices in a prescriptive manner.

Another mitigation measure to reduce a building's energy consumption as well as the associated GHG emissions from natural gas combustion and electricity production is to use energy-efficient appliances. For residential dwellings, typical builder-supplied appliances include refrigerators and dishwashers. Clothes washers and ceiling fans would be applicable if the builder supplied them. For commercial land uses, only energy-efficient refrigerators have been evaluated for grocery stores.

1 California Energy Commission. 2003. Impact Analysis: 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings. Available at: http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/2003-07-11_400-03-014.PDF
California Energy Commission. 2006. California Commercial End-Use Survey. Prepared by Itron Inc. Available at: http://www.energy.ca.gov/ceus/

Methodology

Datasets

The Residential Appliance Saturation Survey (RASS)[2] and California Commercial Energy Use Survey (CEUS)[3] datasets were used to estimate the energy intensities of residential and non-residential buildings, respectively, since the data is available for several land use categories in different climate zones in California. The RASS dataset further differentiates the energy use intensities between single-family, multi-family and townhome residences.

The Energy Star and Other Climate Protection Partnerships 2008 Annual Report[4] and subsequent Annual Reports were reviewed for typical reductions for energy-efficient appliances. ENERGY STAR residential refrigerators, clothes washers, dishwashers, and ceiling fans use 15%, 25%, 40%, and 50% less electricity than standard appliances, respectively. ENERGY STAR commercial refrigerators use 35% less electricity than standard appliances.

Calculations

Exceeding Title 24 Energy Efficiency Standards (BE-1)

RASS and CEUS datasets were used to obtain the energy intensities of different end use categories for different building types in different climate zones. Energy intensities from CEUS are given per square foot per year and used as presented. RASS presents Unit Energy Consumption (UEC) per dwelling unit per year and saturation values; the energy intensities used in this analysis are products of the UEC and saturation values.

Data for some climate zones is not presented in the CEUS and RASS studies. However, data from adjacent climate zones is assumed to be representative and substituted as follows:

For non-residential building types:
Climate Zone 11 used Climate Zone 9 data.
Climate Zone 12 used Climate Zone 9 data.
Climate Zone 14 used Climate Zone 1 data.
Climate Zone 15 used Climate Zone 10 data.

For residential building types:
Climate Zone 6 used Climate Zone 2 data.
Climate Zone 14 used Climate Zone 1 data.
Climate Zone 15 used Climate Zone 10 data.

RASS and CEUS data are based on 2002 consumption data. Because older buildings tend to be less energy efficient, and the majority of the buildings in the survey were likely constructed

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2 California Statewide Residential Appliance Saturation Study Reporting Center. Available at: http://websafe.kemainc.com/RASSWEB/DesktopDefault.aspx

3 California Energy Commission. 2006. California Commercial End-Use Survey. Prepared by Itron Inc. Available at: http://www.energy.ca.gov/ceus/

4 United States Environmental Protection Agency 2009. ENERGY STAR and Other Climate Protection Partnerships: 2008 Annual Report. Available at: http://www.epa.gov/cpd/pdf/2008AnnualReportFinal.pdf

before 2001, the RASS and CEUS data likely overestimate energy use for a 2001 Title 24-compliant building.

To account for updates since the 2001 Title 24 standards, percentage reductions for each end use category taken directly from the CEC's "Impact Analysis for 2005 Energy Efficiency Standards" and "Impact Analysis 2008 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings" reports were applied to the CEUS and RASS datasets for improvements from 2001 to 2005, and 2005 to 2008, respectively (see Tables D-1 and D-2). For the CEUS data, exterior lighting was assumed to be covered by Title 24 lighting and therefore has the full percentage reductions taken. Interior lighting was assumed to be 50% Title 24 and 50% non-Title 24 uses. Therefore only half of the reduction for lighting was applied. The resulting 2008 numbers were then used as baseline energy intensities for this mitigation strategy. The total baseline energy intensities are calculated as follows:

$$\text{Baseline} = \sum\left[T24_{2001} \times \left(1 - R_{2001\text{-}2005}\right) \times \left(1 - R_{2005\text{-}2008}\right)\right] + \sum NT24$$

Where:

Baseline = Total baseline energy intensities of building category
$T24_{2001}$ = Energy intensities of Title 24 regulated end use from RASS or CEUS
$R_{2001\text{-}2005}$ = Reduction from 2001 to 2005
$R_{2005\text{-}2008}$ = Reduction from 2005 to 2008
NT24 = Non-Title 24 regulated end use energy intensities

Table D-1
Reduction in Title 24 Regulated End Use for Non-Residential Buildings

Energy Source	End Use	Reduction from 2001 to 2005	Reduction from 2005 to 2008
Electricity	Heating	4.9%	37.2%
	Ventilation	5.0%	1.5%
	Refrigeration	0.0%	0.0%
	Process	0.0%	0.0%
	Office Equipment	0.0%	0.0%
	Motors	0.0%	0.0%
	Miscellaneous	0.0%	0.0%
	Interior Lighting	4.9%	5.9%
	Water Heating	0.0%	0.0%
	Cooking	0.0%	0.0%
	Air Compressors	0.0%	0.0%
	Cooling	6.7%	8.3%
	Exterior Lighting	9.8%	11.7%
Natural Gas	Cooking	0.0%	0.0%
	Cooling	10.4%	9.3%
	Heating	3.1%	15.9%
	Water Heating	0.0%	0.0%
	Process	0.0%	0.0%
	Miscellaneous	0.0%	0.0%

Table D-2
Reduction in Title 24 Regulated End Use for Residential Buildings

Energy Source	End Use (As presented in RASS Dataset)	Reduction from 2001 to 2005			Reduction from 2005 to 2008		
		Multi-family	Single family	Town home	Multi-family	Single family	Town home
Electricity	Conv. Electric heat	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	HP Eheat	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	Aux Eheat	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	Furnace Fan	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	Central A/C	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	Room A/C	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	Evap Cooling	24.3%	19.8%	24.3%	19.7%	22.7%	19.7%
	Water Heat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Solar Water Heater	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Dryer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Clothes Washer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Dish Washer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	First Refrigerator	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Second Refrigerator	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Freezer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pool Pump	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Spa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Outdoor Lighting	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Range/Oven	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	TV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Spa Electric Heat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Microwave	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Home Office	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	PC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Water Bed	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Well Pump	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Miscellaneous	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Natural Gas	Primary Heat	15.7%	6.7%	15.7%	7.0%	10.0%	7.0%
	Auxiliary Heat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Conv. Gas Water Heat	15.7%	6.7%	15.7%	7.0%	10.0%	7.0%
	Solar Water Heat w/Gas Backup	15.7%	6.7%	15.7%	7.0%	10.0%	7.0%
	Dryer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Range/Oven	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pool Heat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Spa Heat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Miscellaneous	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

The same approach was used to quantify GHGs emission reduction from exceeding Title 24 energy efficiency standards by 1%. The 1% reduction was applied to only energy use intensities for Title 24 regulated end use categories. For the CEUS data, the reduction was not applied to any portion of interior lighting. The reduced energy use intensities were added to the unadjusted energy use intensities for non-Title 24 regulated end use categories to obtain the total energy use intensities for exceeding Title 24 energy efficiency standards by 1% for each building category. These were then compared to the baseline line energy intensities for the overall percentage reduction as follows:

$$\text{Percentage Reduction} = 1 - \frac{\sum\left[T24_{2001} \times \left(1 - R_{2001\text{-}2005}\right) \times \left(1 - R_{2005\text{-}2008}\right) \times 99\%\right] + \sum NT24}{\text{Baseline}}$$

Where:

- Baseline = Total baseline energy intensities of building category
- $T24_{2001}$ = Energy intensities of Title 24 regulated end use from RASS or CEUS
- $R_{2001\text{-}2005}$ = Reduction from 2001 to 2005
- $R_{2005\text{-}2008}$ = Reduction from 2005 to 2008
- NT24 = Non-Title 24 regulated end use energy intensities

Installing Energy Efficient Appliances

The same baseline line energy use intensities from the Exceeding Title 24 Energy Efficiency Standards mitigation were used for this mitigation strategy. For all appliances except ceiling fan, the reductions as presented in the ENERGY STAR 2008 annual report were applied to the energy use intensities of the corresponding energy end use categories. All other end use categories were kept unadjusted. The percentage reductions were calculated as follows:

$$\text{Percentage Reduction} = 1 - \frac{\text{Appliance Intensity} \times \left(1 - ESR\right) + \sum \text{Other End Use}}{\text{Baseline}}$$

Where:

- Baseline = Total baseline energy intensities of building category
- Appliance Intensity = 2008 baseline energy intensity of appliance in consideration
- ESR = Reduction from ENERGY STAR appliance
- Other End Use = 2008 baseline energy intensity of all other end uses

RASS does not specify a ceiling fan end-use; rather, electricity use from ceiling fans is accounted for in the “Miscellaneous” category which includes interior lighting, attic fans, and other miscellaneous plug-in loads. Since the electricity usage of ceiling fans alone is not specified, a value from the National Renewable Energy Laboratory (NREL) Building American Research Benchmark Definition (BARBD)[5] was used. BARBD reported that the average energy use per ceiling fan is 84.1 kWh per year. In this mitigation measure, it was assumed that each multi-family, single-family, and townhome residence has one ceiling fan. Therefore, the 50% reduction from ENERGY STAR for ceiling fan was applied to 84.1 kWh of the electricity attributed to the Miscellaneous RASS category. In other words, 42.05 kWh was subtracted from the electricity end use intensities of the "Miscellaneous RASS" category in evaluating the GHGs emission reduction from installing energy efficient ceiling fans.

The total energy use intensities with reduction from each appliance in consideration were then compared to the baseline line energy intensities for the overall percentage reduction as follows:

$$\text{Percentage Reduction} = 1 - \frac{(\text{Misc} - 42.05) + \sum \text{Other End Use}}{\text{Baseline}}$$

Where:

Baseline = Total baseline energy intensities of building category
Misc = 2008 energy intensity in Miscellaneous category for electricity
Other End Use = 2008 baseline energy intensity of all other end uses

5 NREL. 2010. Building America Research Benchmark Definition. Available online at: http://www.nrel.gov/docs/fy10osti/47246.pdf

Appendix E

Carbon, Water and CO_2 Sequestration Intensity Factors

Table E-1: Carbon Intensity

Utility	CO_2 intensity (lb/MWh)[1]								
	2000	2001	2002	2003	2004	2005	2006	2007	Suggested Value[2]
Anaheim Public Utilities						1,399.80	1,416.74	1,543.28	1,416.74
Austin Energy						1,127.37	1,077.97	1,117.37	1,077.97
City and County of San Francisco						76.28			76.28
City of Palo Alto Public Utilities						320.94	39.02	426.82	39.02
Glendale Water & Power						1,065.00			1,065.00
Los Angeles Department of Water & Power	1,407.44	1,403.39	1,348.48	1,360.07	1,360.60	1,303.58	1,238.52	1,227.89	1,238.52
Pacific Gas & Electric Company					566.2	489.16	455.81	635.67	455.81
PacifiCorp					1,811.00	1,812.22	1,747.30	1,775.28	1,747.30
Pasadena Water & Power						1,409.65	1664.14		1,664.14
Platte River Power Authority						1,970.93	1,955.66	1,847.88	1,955.66
Riverside Public Utilities						1,333.45	1,346.15	1,325.65	1,346.15
Roseville Electric							565.52	793.8	565.52
Sacramento Municipal Utility District					769	616.07	555.26	714.31	555.26
Salt River Project							1,546.28	1,469.90	1,546.28
San Diego Gas & Electric					613.75	546.46	780.79	806.27	780.79
Seattle City Light								17.77	17.77
Sierra Pacific Resources								1,442.78	1,442.78
Southern California Edison					678.88	665.72	641.26	630.89	641.26
Turlock Irrigation District							682.48	807	682.48

Notes:
1. Based on Table G6 of Local Government Operation Protocol version 1.1
2. The suggested values are based on 2006. If no 2006 value was available, 2005 was used followed by 2007.

Table E-2: Water Intensity

	Indoor Water Uses		Outdoor Water Uses	
	Northern California	Southern California	Northern California	Southern California
	kWh/MG			
Water Supply and Conveyance	2,117	9,727	2,117	9,727
Water Treatment	111	111	111	111
Water Distribution	1,272	1,272	1,272	1,272
Wastewater Treatment	1,911	1,911	0	0
Regional Total	5,411	13,022	3,500	11,111

Note: Based on Table ES-1 from CEC. 2006. Refining Estimates of Water-Related Energy Use in California, CEC-500-2006-118.

Table E-3: Default CO_2 Sequestration Accumulation

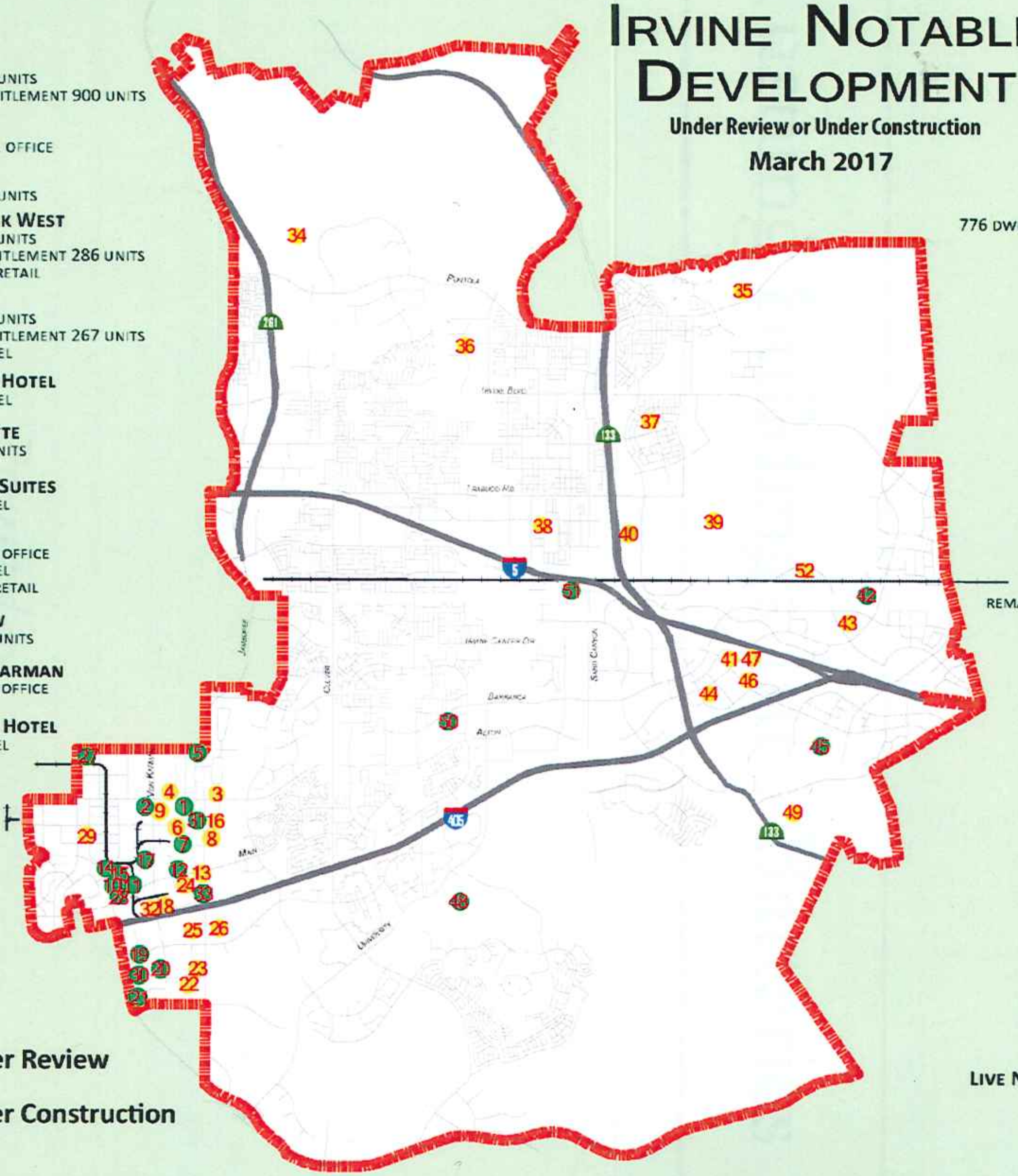
Land Use	Sub-Category	Default annual CO_2 accumulation per acre[1] (tonnes CO_2/year)
Forest Land	Scrub	14.3
	Trees	
Cropland		111
Grassland	--	6.2
Wetlands	--	4.31

Note: Based on Tables 4.3, 4.7 and 6.4 from IPCC. 2006. Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

Irvine Notable Development

Under Review or Under Construction

March 2017



1. **Diamond Jamboree Expansion** 25,000 sq. ft. retail
2. **2152-2182 Alton** 351 dwelling units
3. **2851 Alton** 170 dwelling units
4. **2501 Alton** 344 dwelling units
5. **2660 Barranca** 180 dwelling units
6. **17275 Derian** 80 dwelling units
7. **Pistoia Apts** 371 dwelling units
8. **2801 Kelvin** 372 dwelling units
9. **Irvine Gateway** 434 dwelling units
10. **17811 Gillette** 44 dwelling units
11. **2055 Main** 177 dwelling units
12. **2525 Main GPA/ZC/CUP** 150 dwelling units
13. **Main & Jamboree** 388 dwelling units
14. **17822 Gillette** 137 dwelling units
15. **17832 Gillette** 326 dwelling units
16. **360 Fusion** 280 dwelling units
17. **Desmond Ventures GPA/ZC/CUP** 115 dwelling units
18. **Hyatt House** 149 room hotel
19. **Tides Hospitality Hotel** 164 room hotel
20. **Milani Apartments** 287 dwelling units
21. **Trilogy Residential** 876 dwelling units
22. **Elements** 700 dwelling units, remaining entitlement 900 units
23. **Boardwalk** 545,000 sq. ft. office
24. **Metropolis** 457 dwelling units
25. **Central Park West** 317 dwelling units, remaining entitlement 286 units, 10,000 sq. ft. retail
26. **Park Place** 520 dwelling units, remaining entitlement 267 units, 176 room hotel
27. **Stay Bridge Hotel** 288 room hotel
28. **17821 Gillette** 43 dwelling units
29. **Homewood Suites** 161 room hotel
30. **Landmark** 448,000 sq. ft. office, 386 room hotel, 13,665 sq. ft. retail
31. **2602 McGaw** 120 dwelling units
32. **17850 Von Karman** 242,000 sq. ft. office
33. **Towneplace Hotel** 105 room hotel
34. **Orchard Hills** 288 dwelling units, remaining entitlement 2,219 units
35. **Portola Springs** 456 dwelling units, remaining entitlement 1,039 units
36. **Eastwood** 457 dwelling units, remaining entitlement 1,133 units
37. **Great Park Neighborhoods** 776 dwelling units (Pavilion Park/Beacon Park), remaining entitlement 7,082 units, 3.31 million sq. ft. non-residential
38. **Cypress Village** 16 dwelling units, remaining entitlement 32 units
39. **OC Great Park** ALA II plan 688 acres
40. **PA 40 East East** 411 dwelling units
41. **Marriot Hotel** 271 room hotel
42. **Karma Headquarters** 102,000 sq. ft. office/warehouse
43. **Broadcom Campus** 1 million sq. ft. office, remaining entitlement 1 million sq. ft. office
44. **Spectrum Residential** 584 dwelling units
45. **Los Olivos** 1,950 dwelling units
46. **200 Spectrum Center Dr** 450,000 sq. ft. office
47. **400 Spectrum Center Dr** 450,000 sq. ft. office
48. **Concordia University** campus improvements
49. **Hidden Canyon** 106 dwelling units, remaining entitlement 16 units
50. **2 Osborn** 46,800 sq. ft. medical office
51. **PA 12/40 GPA** 1,443 dwelling units
52. **Live Nation Temporary Amphitheatre** 12,000 seats

Under Review (green)

Under Construction (yellow)

James B. Hasty, Senior Vice President
Meyer Properties
4320 Von Karman Avenue
Newport Beach, CA 92660

Subject: Biological Review, PRES Office Building B

Dear Mr. Hasty,

At your request, I have reviewed environmental documentation provided by the City of Newport Beach (City) regarding a mitigated negative declaration (MND) prepared in support of a project known as the PRES Office Building B General Plan and Planned Community Text Amendments (PRES). This letter report provides the results of my review. My qualifications to conduct this review are provided in the attached biography.

Methods

I reviewed all relevant portions of the MND, provided on the City's web page. This included:

ICF Jones & Stokes. 2010. Initial Study and Mitigated Negative Declaration for the PRES Office Building B General Plan and Planned Community Text Amendments. Report dated July 2010 prepared for the City of Newport Beach Planning Department. Section IV. Biological Resources.

ICF International. 2010. Summary of Biological Literature Review and Field Visit Conducted for the PRES Office Building B General Plan and Planned Community Text Amendments. Memorandum dated June 28, 2010, from biologist Paul Schwartz to project manager Nicole Williams.

I also reviewed the letter dated June 7, 2010, from Ryan M. Easter of Palmieri, Tyler, Wiener, Wilhelm & Waldron LLP, and the City's responses.

Biologist Robert Hamilton of Hamilton Biological, Inc., visited the project site during the afternoons of July 31 and August 2, spending approximately one hour in the project vicinity during each visit. During these visits Mr. Hamilton noted plant and wildlife species present and the general condition of the project site and nearby man-made ponds on either side of Von Karman Avenue. Mr. Hamilton provided me with photographs showing the condition of the project site and the two nearby ponds.

literature search and assumptions made by the project biolog[illegible] about which species could, or could not, occur at the project site and adjacent reta[illegible]ing basin pond. The memorandum from Mr. Schwartz states:

> Prior to conducting the field survey, a California Natural Diversity Database (CNDDB) (CNDDB 2010) search was completed to detect special-status wildlife and plant species with the potential to occur within 5 miles of the project area. The species list resulting from the search is provided in Table 1.

Table 1 include entries for numerous species of plant and wildlife that do not occur within 5 miles of the project site, and have no potential to occur anywhere near the site. These include Cismontane Nolina (*Nolina cismontana*; occurs in the Santa Ana Mountains), Santa Ana River Woollystar (*Eriastrum densifolium* ssp. *sanctorum*; unrecorded south of Featherly Park near the Riverside County line), and even the Northern Leopard Frog (*Lithobates pipiens*), a species with a natural distribution that includes only the northern part of California.

Given that the project site is located near two man-made ponds that support small fish and emergent marsh vegetation, Table 1 should have included certain special-status species known from Upper Newport Bay, located only 0.8 mile southwest of the project site, and/or San Joaquin Marsh, located only 0.6 mile east of the project site. The following special-status species of potential relevance to the proposed project are not included in Table 1:

Least Bittern (*Ixobrychus exilis*). This California Species of Special Concern is known to occur in stands of cat-tails and tules at San Joaquin Marsh and other freshwater marshes in Orange County, although those stands are typically larger than those on the project site. The MND failed to mention the Least Bittern and no evaluation was made by the project biologist. However, given the relative small size and isolated, urban nature of this cat-tail habitat in the retarding basin pond, it is very unlikely that Least Bittern nests on the site, and this species would—at best—be a very irregular visitor.

American Peregrine Falcon (*Falco peregrinus anatum*). This state-endangered species is known to occur regularly at both Upper Newport Bay and San Joaquin Marsh, and Peregrine Falcons have been recorded nesting on the Marriott Hotel at Fashion Island in Newport Beach (Gallagher, S. J., and Bloom, P. H. 1997. *Atlas of Breeding Birds, Orange County, California*. Sea and Sage Audubon Press, Irvine, CA). Although this species could occur on the project site, the MND failed to mention the Peregrine Falcon and no evaluation was made by the project biologist. The Peregrine Falcon would likely be an irregular visitor, mostly in search of possible prey at the retarding basin pond—and not to the actual proposed site of the PRES building.

California Least Tern (*Sternula antillarum browni*). This species, listed as endangered by state and federal governments, nests on a sand island near the upper end of Upper Newport Bay and is "regularly encountered at golf course ponds and similar sites within a mile or two of the coast" in Orange County (Hamilton, R. A. and Willick, D. R. 1996. *The Birds of Orange County, California: Status and Distribution.* Sea and Sage Press, Sea and Sage Audubon Society, Irvine, CA) and the same is true in San Diego County (pers. obs.). Given that their nearest nesting colony is located only 1.2 miles southwest of the project site (R. A. Hamilton pers. comm.), and given the large population of small fish in the ponds adjacent to the project site (Mr. Hamilton noted that these fish are easily seen from the edges of the ponds), I believe that Least Terns might make rare or occasional summer foraging visits of these ponds during normal years. Mr. Hamilton did not see any terns at the ponds during his field visits, but the Least Terns have failed in their nesting at Upper Newport Bay this year (R. A. Hamilton pers. comm.) and Mr. Hamilton has not seen them anywhere at the bay since early July (he monitors the ongoing dredging work at the bay and inspect the terns' nesting island approximately once a week). Since July/August 2010 has not been a period of normal activity for Least Terns at Upper Newport Bay, surveys of the ponds near the project site during this period do not provide a reliable indication of the species' status there during a normal year.

Black Skimmer (*Rynchops niger*). Like the Least Tern, this California Species of Special Concern regularly nests near the upper end of Upper Newport Bay and regularly forages "within a mile or two of the coast" (Hamilton, R. A. and Willick, D. R. 1996. *The Birds of Orange County, California: Status and Distribution.* Sea and Sage Press, Sea and Sage Audubon Society, Irvine, CA). Similar to the tern, skimmers could make rare foraging visits to the ponds near the project site during normal years, probably at night. Mr. Hamilton did not see any skimmers at the ponds during his field visits, but, like the Least Terns, Black Skimmers have failed in their nesting at Upper Newport Bay this year (R. A. Hamilton pers. comm.). Mr. Hamilton has seen low numbers of skimmers at the bay since early July. Since July/August 2010 has not been a period of normal activity for skimmers at Upper Newport Bay, surveys of the ponds near the project site during this period do not provide a reliable indication of the species' status there during a normal year.

Clark's Marsh Wren *(Cistothorus palustris clarkae)*. This California Species of Special Concern is a sedentary bird that occurs in stands of cat-tails and tules at San Joaquin Marsh and Upper Newport Bay, although those stands are typically larger than those on the project site. The MND failed to mention Clark's Marsh Wren and no evaluation was made by the project biologist.

Tricolored Blackbird (*Agelaius tricolor*). This California Species of Special Concern breeds in emergent marsh vegetation and feeds in grasslands, sometimes including turf. Although it is doubtful that Tricolored Blackbirds make substantial use of this site, the MND failed to mention the Tricolored Blackbird and no evaluation was made by the project biologist.

Several other species that are not listed as threatened or endangered, or identified as California Species of Special Concern, are placed on a "Special Animals" list by the California Department of Fish and Game:

> "Special Animals" is a general term that refers to all of the taxa the California Natural Diversity Data Base is interested in tracking, regardless of their legal or protection status. This list is also referred to as the list of "species at risk" or "special status species." The Department of Fish and Game considers the taxa on this list to be those of greatest conservation need. (http://dfg.ca.gov/biogeodata/cnddb/pdfs/SPAnimals.pdf)

CEQA documents typically identify and evaluate a project's potential effects on all Special Animals that are known or expected to occur on a given site. Mr. Hamilton observed an **Allen's Hummingbird (*Selasphorus sasin*)** across the street from the project site on August 2, 2010. The **Osprey (*Pandion haliaetus*)** has been reported occasionally foraging in ponds near the project site (James Hasty pers. comm.). Other Special Animals with potential to occur on the site include **Cooper's Hawk (*Accipiter cooperii*)**, **Costa's Hummingbird (*Calypte costae*)**, and **Nuttall's Woodpecker (*Picoides nuttallii*)**. The Osprey, which has only recently recolonized Orange County, is now known to nest at both Upper Newport Bay and San Joaquin Marsh. It seems unlikely that this species occurs regularly at the ponds near the project site, but this question was not evaluated in the MND. The other species mentioned above are common across much of Orange County and the wider region, and so are not especially "sensitive," but again, it is the project biologist's responsibility to evaluate their potential for occurrence on the site and to analyze the potential significance of any impacts. None of these species was mentioned in the biological documentation for the MND.

Conclusions

The stated objective of the biological report prepared for the MND was to identify "special-status wildlife and plant species with the potential to occur within 5 miles of the project area," but evaluated a number of species that do not occur within 5 miles of the project site and/or that have no potential to occur in the project setting. More importantly, the MND did not evaluate various special-status species known to occur within a mile of the project site, at Upper Newport Bay and San Joaquin Marsh.

I cannot do more than speculate about the actual status of several of these species identified in this comment letter, but it should be stated that some of them have been reported on or near the site and others could potentially use the ponds, at least on an irregular basis. Peregrine Falcons have been recorded nesting on a building in Newport Beach. The definitive publication on the status and distribution of birds in Orange County states that both California Least Terns and Black Skimmers regularly forage at freshwater sites within a mile or two of the coast (including "golf course ponds and similar sites" for the tern). Whether either of these species forage at the two ponds adjacent to the project site is unknown because adequate surveys were not conducted during the late spring/early summer period in 2010 when these species were actively nesting at Upper Newport Bay. Now that their local nesting has failed, numbers of both of these species at the head of Newport Bay are reduced from their normal late-summer

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Paul Lehman has written many articles and papers on avian distribution and identification. Formerly a lecturer in physical geography and environmental studies at the University of California in Santa Barbara, and past editor of the American Birding Association's *Birding* magazine for nine years (1989-1997), Paul continues to give lectures on weather and bird distribution, migration, and vagrancy. He also leads bird tours throughout North America for Wings, Inc. He is an associate editor for both *North American Birds* and *Western Birds* magazines, and he has been a principal consultant on most of the popular field guides on the market today, primarily as the chief consultant and compiler for the range maps in *The Sibley Field Guides to Birds of Eastern* and *Western North America*, Roger Tory Peterson's *A Field Guide to the Birds of Eastern and Central North America* and *A Field Guide to the Birds of Western North America*, the *National Geographic Society's Field Guide to the Birds of North America* and *Complete Birds of North America*, the *Smithsonian Guide to the Birds of North America*, and the *National Wildlife Federation Guide to the Birds of North America*. He was also chief editor of the ABA/Lane birdfinding guide to North America's major metropolitan regions, and was managing editor of the recently published *Rare Birds of California* book.

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It is my conclusion that the MND is deficient in its failure to fully (1) discuss these special-status species and their known patterns of foraging in Orange County, (2) conduct surveys at appropriate times of year and appropriate times of day directed toward determining their status on the site, or (3) evaluate the potential effects of adding a tall structure along the flight-line between the Koll Center ponds and Upper Newport Bay.

I appreciate the opportunity to provide this review. If you wish to review any matters, please call me at (858) 268-1937 or send e-mail to lehman.paul@verizon.net.

Sincerely,

Paul E. Lehman

Attachment: Lehman biography

Spring Equinox

Attachment 9

Spring Equinox

Fall Equinox

Fall Equinox

Winter Solstice

Winter Solstice

All Shadow Studies