2.5 Cumulative Impacts

2.5.1 Regulatory Setting

Cumulative impacts are those that result from past, present, and reasonably foreseeable future actions, combined with the potential impacts of this project. A cumulative effect assessment looks at the collective impacts posed by individual land use plans and projects. Cumulative impacts can result from individually minor, but collectively substantial impacts taking place over a period of time.

Cumulative impacts to resources in the project area may result from residential, commercial, industrial, and highway development, as well as from agricultural development and the conversion to more intensive types of agricultural cultivation. These land use activities can degrade habitat and species diversity through consequences such as displacement and fragmentation of habitats and populations, alteration of hydrology, contamination, erosion, sedimentation, disruption of migration corridors, changes in water quality, and introduction or promotion of predators. They can also contribute to potential community impacts identified for the project, such as changes in community character, traffic patterns, housing availability, and employment.

California Environmental Quality Act (CEQA) Guidelines, Section 15130, describes when a cumulative impact analysis is warranted and what elements are necessary for an adequate discussion of cumulative impacts. The definition of cumulative impacts, under CEQA, can be found in Section 15355 of the CEQA Guidelines. A definition of cumulative impacts, under the National Environmental Policy Act (NEPA), can be found in 40 CFR, Section 1508.7 of the Council on Environmental Quality (CEQ) Regulations.

Cumulative Analysis

This cumulative analysis determines whether the Highway 101 Greenbrae/Twin Cities Corridor Improvement project in combination with other approved or foreseeable projects will result in a cumulative impact, and, if so, whether the Build Alternative's contribution to the cumulative impact will be cumulatively considerable. Reasonably foreseeable future projects are described in **Section 1.3.2, Planned Development**, and include land use developments and other transportation improvements that are planned and funded and will be located in the immediate vicinity of the Greenbrae/Twin Cities Corridor. The planned and funded transportation projects located near the proposed project are anticipated to be constructed and operational by the year 2035.

Planned land use developments:

- Twin Cities Police Authority: public facility (Larkspur)
- The Rose Garden: 85 residential units (Larkspur)
- Drake's Way: 24 residential units (Larkspur)
- Drake's Cove (also known as Larkspur Landing Circle): mixed-use development, hotel and 126 multi-family residential units (Larkspur)
- 195-205 Tamal Vista residences (also known as the WinCup development) – mixed-use development, commercial and 180 multi-family residential units (Corte Madera)

Planned transportation improvements:

- US 101 Gap Closure Project
- US 101/Marin City interchange modification
- Tiburon interchange improvements
- US 101/I-580 interchange improvements
- I-580 to Shoreline Parkway/Andersen Drive connection
- Bel Marin Keys Boulevard and Atherton Avenue capacity improvements
- US 101 southbound auxiliary lane between Miller Creek and N. San Pedro Road
- South Novato Road improvements (four lanes from Center Road to US 101)
- McInnis Parkway extension from current terminus to Miller Creek
- Central Marin Ferry Connection
- Sonoma-Marin Area Rail Transit (SMART)
- Doherty Drive Bridge Replacement
- Bon Air Bridge Replacement
- North-South Greenway bicycle transportation corridor

2.5.1.1 Issues with No Adverse Effect

If the project will not result in a direct or indirect impact on a resource, then it will not contribute to a cumulative impact on that resource. The impact used in the cumulative impact analysis is the net impact (i.e. project impact minus proposed minimization and/or mitigation measures). For resource areas where the impact will be fully offset by the proposed minimization and/or mitigation measures, there is no contribution to cumulative impacts from the project. The environmental analysis conducted for the project has determined that the project will not result in a net impact on any resource, with the exception of noise, threatened and endangered species, and visual resources.

The environmental resource areas for which the project has been found to have no adverse effect include[1]:

- Land Use
- Growth
- Farmlands and Timberlands
- Community Impacts
- Utilities/Emergency Services
- Traffic
- Cultural Resources
- Hydrology and Floodplains

[1] The Build Alternative has been found to either have no effect or no adverse effect after implementation of Caltrans' Standard Provisions and/or compliance with required regulations on the resources identified. Therefore, the Build Alternative will not contribute to a cumulative impact on these resources.

- Water Quality and Storm Water Runoff
- Geology/Soils/Seismicity/Topography
- Paleontology
- Hazardous Waste/Materials
- Air Quality
- Natural Communities
- Floodplains and Wetlands

The potential for the project to contribute to effects on noise and threatened and endangered species are discussed in more detail below.

2.5.1.2 Noise

The resources study area for noise is equivalent to the noise study area evaluated in **Section 2.3.7, Noise**, and encompasses all developed land uses surrounding the proposed Build Alternative improvements, with a focus on noise-sensitive receptors. Sensitive receptors in close proximity to the Build Alternative include residential, hotel, and parks and recreational land uses, some of which will experience noise levels that exceed the NAC thresholds due to traffic noise from US 101 under cumulative conditions (year 2035). The future 2035 noise levels account for residential and employment growth in the surrounding areas as well as recently completed infrastructure projects in the project vicinity. There are no existing noise barriers (e.g., sound walls or berms) in the resource study area to reduce traffic noise.

Implementation of the Build Alternative will result in an increase in noise levels between 0 and 2 dBA above future 2035 cumulative noise levels under the No Build condition, which is not considered a substantial change.[2] However, because the cumulative noise conditions of the study area will exceed the NAC threshold, noise abatement options were considered. Noise abatement was evaluated at impacted areas and a total of eleven potential barriers were investigated. With the exception of one barrier, which is located within the state right-of-way, all barriers evaluated were located at the edge of pavement of the highway and/or ramps near each impacted area. **Section 2.3.7.4** presents the preliminary noise abatement analysis and decision. The implementation of the noise abatement options determined to be feasible will effectively reduce noise levels below the NAC thresholds. The final noise abatement decision will be made and indicated in the final environmental document.

2.5.1.3 Threatened and Endangered Species

The resource study area, with regards to cumulative impacts, for threatened and endangered species includes Corte Madera Creek and the existing salt marsh habitat located along the banks of the creek both upstream and downstream.. The following eight threatened and endangered species were identified as potentially occurring within the resource study area:

- Tidewater goby [TWG] (Eucyclogobius newberryi),
- Central California Coast steelhead [CCCS] (Oncorhynchus mykiss),

[2] In typically noisy environments, changes in noise of 1 dBA to 2 dBA are generally not perceptible. People are generally able to detect sound level increases of 3 dBA in typically noisy environments; thus, 3 dBA is the threshold for perceptible change in a noisy environment.

- Central California Coast coho salmon [CCC coho] (Oncorhynchus kisutch),
- Central Valley (Sacramento River winter-run) chinook salmon [CVCH] (Oncorhynchus tshawytscha),
- North American green sturgeon [NAGS] (Acipenser medirostris),
- California clapper rail [CCR] (Rallus longirostris obsoletus),
- California black rail [CBR] (Laterallus jamaicensis coturniculus), and
- Salt marsh harvest mouse [SMHM] (Reithrodontomys raviventris).

Implementation of the Build Alternative will impact Corte Madera Creek (fish habitat), California clapper rail and California black rail dispersal habitat (0.02 acre [776 ft^2]), and salt marsh harvest mouse habitat (0.02 acre [776 ft^2]). Direct impacts to fish may occur as a result of distress from underwater noise created by impact pile driving. Temporary impacts to California clapper rail and California black rail may also result from construction related noise. Indirect impacts from implementing the Build Alternative may result from additional shading over Corte Madera Creek (0.02 acre [657 ft^2]). Pursuant to CEQA and NEPA, Caltrans has proposed a number of reasonable and prudent measures to minimize and reduce impacts to threatened and endangered animal species. These measures are described in **Section 2.4.5.4**. Further, impacts resulting from the Build Alternative will be mitigated during Section 7 consultation with the USFWS.

Two projects, the Central Marin Ferry Connection Multi-use Pathway Phase I Project (CMFC) and the Bon Air Bridge Replacement Project (Bon Air) have recently completed environmental approval and are slated for construction in the next few years. Both projects impact salt marsh habitat and portions of Corte Madera Creek that fall within the resource study area.

The CMFC will be constructed in the immediate vicinity of the Build Alternative's biological study area. The CMFC biological study area overlaps with the Build Alternative's study area directly north of Corte Madera Creek and east of US 101. It is estimated that CMFC will permanently impact 0.02 acre of fish habitat and 0.4 acres of California clapper rail, California black rail, and salt marsh harvest mouse habitat along the northern bank of Corte Madera Creek. CMFC habitat impacts to these species will be offset by improving species habitat upstream, at Creekside Park, which will create a larger contiguous area of habitat of higher value. Fish habitat impacts from CMFC will be offset by implementing minimization measures that will be defined during Section 7 consultation with the USFWS.

The Bon Air project is located approximately 1.2 miles upstream of the proposed Build Alternative improvement, across Corte Madera Creek. The Bon Air project will involve the use of heavy equipment (excavator, pile driver, *etc.*) to construct a new bridge and temporary trestle foundations and superstructure, and demolish an existing bridge. Habitat supporting salt marsh harvest mouse, California clapper rail, Central California Coast steelhead, and North American green sturgeon is located in the area of the Bon Air improvements. It is anticipated that the Bon Air project will permanently impact 0.153 acre of salt marsh harvest mouse and California clapper rail habitat. Impacts to these species will be offset by restoring 0.459 acre of habitat upstream, at Creekside Park. Construction activities associated with the Bon Air project are expected to temporarily affect salt marsh harvest mouse, California clapper rail, Central California Coast steelhead, and North American green sturgeon, and their critical habitats, but is not likely to jeopardize the continued existence of any of the species.

Measures are incorporated into the Build Alternative and these two nearby projects in order to avoid and minimize impacts to special-status species to the extent feasible. Measures required as a result of Section 7 consultation include, but are not limited to the following: protocol-level California clapper rail surveys and/or avoiding impact pile driving in the California clapper rail breeding season; removing vegetation by hand to avoid impacts to salt marsh harvest mouse; and bioacoustic monitoring to prevent impacts to fish. Due to the avoidance and minimization measures incorporated for all the projects, the relatively minor impacts to marginal habitat, and the compensatory mitigation that restores higher quality habitat upstream, no cumulative impacts are anticipated to occur to any of the threatened or endangered species in the resource study area.

2.5.1.4 Visual Resources

The resources study area for visual resources is equivalent to the visual resources defined in **Section 2.2.6, Visual/Aesthetics** and includes the US 101 corridor and immediately surrounding land uses from the Tamalpais Drive interchange to the Sir Francis Drake Boulevard interchange. Local roadways and intersections where new transit, bicycle, and pedestrian facilities will be constructed as part of the Build Alternative are also included in the visual study area. The visual resources study area is highly urbanized along highway 101 with some residential and commercial uses. Although highway 101 is not a designated scenic highway, regional landmarks, such as Mt. Tamalpais, San Francisco Bay, Shorebird Marsh/Corte Madera Ecological Preserve, and Corte Madera Creek, are within site of the resources study area. Seven viewpoints have been identified as representative views of the visual study area that may be seen or valued by viewer groups in the area. Overall, the existing visual quality for the study area is moderate/average.

The Build Alternative would decrease the visual quality for two viewpoints, two viewpoints would remain unchanged, and three viewpoints would have an improved rating. With the implementation of Caltrans' design standards, aesthetic treatments, and **Mitigation Measure VIS-1**, visual impacts resulting from construction of the Build Alternative will be reduced from a moderately high impact to a moderate impact, and the Build Alternative will generally maintain the overall visual quality of the study area. There are no other major transportation projects planned within the visual resources study area that would contribute to a cumulative visual impact. Past, present, and reasonably foreseeable land use development projects, would be subject to the local design review process to ensure consistency with the local design guidelines, which stipulates the design treatment and relationship of buildings to the surrounding built environment, and ensures adverse aesthetic impacts would be minimized. Thus, construction of the Build Alternative would not combine with, or augment, any potential adverse visual impacts that may be associated with other cumulative development.

2.5.2 Avoidance, Minimization and/or Mitigation Measures

The avoidance, minimization and/or mitigation measures included in **Sections 2.2, Human Environment**; **2.3, Physical Environment**; and **2.4, Biological Environment**, are expected to fully offset potential adverse effects of the Build Alternative resulting in no contribution to cumulative impacts.

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2.6 Climate Change (CEQA)

Climate change refers to long-term changes in temperature, precipitation, wind patterns, and other elements of the earth's climate system. An ever-increasing body of scientific research attributes these climatological changes to greenhouse gas (GHG)emissions, particularly those generated from the production and use of fossil fuels.

While climate change has been a concern for several decades, the establishment of the Intergovernmental Panel on Climate Change (IPCC) by the United Nations and World Meteorological Organization's in 1988, has led to increased efforts devoted to greenhouse gas (GHG) emissions reduction and climate change research and policy. These efforts are primarily concerned with the emissions of GHGs generated by human activity including carbon dioxide (CO_2), methane(CH_4), nitrous oxide(N_2O), tetrafluoromethane, hexafluoroethane, sulfur hexafluoride, HFC-23 (fluoroform), HFC-134a (s, s, s, 2 – tetrafluoroethane), and HFC-152a (difluoroethane).

In the U.S, the main source of GHG emissions is electricity generation, followed by transportation. In California, however, transportation sources (including passenger cars, light duty trucks, other trucks, buses and motorcycles) make-up the largest source (second to electricity generation) of GHG emitting sources. The dominant GHG emitted is CO_2, mostly from fossil fuel combustion.

There are typically two terms used when discussing the impacts of climate change. "Greenhouse Gas (GHG) Mitigation" is a term for reducing GHG emissions in order to reduce or "mitigate" the impacts of climate change. "Adaptation," refers to the effort of planning for and adapting to impacts due to climate change (such as adjusting transportation design standards to withstand more intense storms and higher sea levels).[3]

There are four primary strategies for reducing GHG emissions from transportation sources: 1) improve system and operation efficiencies, 2) reduce growth of vehicle miles traveled (VMT) 3) transition to lower GHG fuels and 4) improve vehicle technologies. To be most effective all four should be pursued collectively. The following regulatory setting section outlines state and federal efforts to comprehensively reduce GHG emissions from transportation sources.

2.6.1 Regulatory Setting

State

With the passage of several pieces of legislation including State Senate and Assembly Bills and Executive Orders, California launched an innovative and pro-active approach to dealing with GHG emissions and climate change.

Assembly Bill 1493 (AB 1493), Pavley. Vehicular Emissions: Greenhouse Gases (AB 1493), 2002: requires the California Air Resources Board (ARB) to develop and implement regulations to reduce automobile and light truck greenhouse gas emissions. These stricter emissions standards were designed to apply to automobiles and light trucks beginning with the 2009-model year. In June 2009, the U.S. Environmental Protection Agency (U.S. EPA) Administrator granted a Clean Air Act waiver of

[3] http://climatechange.transportation.org/ghg_mitigation/

preemption to California. This waiver allowed California to implement its own GHG emission standards for motor vehicles beginning with model year 2009. California agencies will be working with Federal agencies to conduct joint rulemaking to reduce GHG emissions for passenger cars model years 2017-2025.

Executive Order S-3-05: (signed on June 1, 2005, by Governor Arnold Schwarzenegger) the goal of this Executive Order is to reduce California's GHG emissions to: 1) 2000 levels by 2010, 2) 1990 levels by the 2020 and 3) 80 percent below the 1990 levels by the year 2050. In 2006, this goal was further reinforced with the passage of Assembly Bill 32.

AB32 (AB 32), the Global Warming Solutions Act of 2006: AB 32 sets the same overall GHG emissions reduction goals as outlined in Executive Order S-3-05, while further mandating that ARB create a scoping plan(which includes market mechanisms) and implement rules to achieve "real, quantifiable, cost-effective reductions of greenhouse gases."

Executive Order S-20-06 further directs state agencies to begin implementing AB 32, including the recommendations made by the State's Climate Action Team.

Executive Order S-01-07: Governor Schwarzenegger set forth the low carbon fuel standard for California. Under this Executive Order, the carbon intensity of California's transportation fuels is to be reduced by at least ten percent by 2020.

Senate Bill 97 (Chapter 185, 2007): required the Governor's Office of Planning and Research (OPR) to develop recommended amendments to the State CEQA Guidelines for addressing greenhouse gas emissions. The Amendments became effective on March 18, 2010.

Caltrans Director's Policy 30 (DP-30) Climate change (approved June 22, 2012): is intended to establish a Department policy that will ensure coordinated efforts to incorporate climate change into Departmental decisions and activities. This policy contributes to the Department's stewardship goal to preserve and enhance California's resources and assets.

Federal

Although climate change and GHG reduction is a concern at the federal level; currently there are, no regulations or legislation that have been enacted specifically addressing GHG emissions reductions and climate change at the project level. Neither the United States Environmental Protection Agency (U.S. EPA) nor Federal Highway Administration (FHWA) has promulgated explicit guidance or methodology to conduct project-level greenhouse gas analysis. As stated on FHWA's climate change website (http://www.fhwa.dot.gov/hep/climate/index.htm), climate change considerations should be integrated throughout the transportation decision-making process–from planning through project development and delivery. Addressing climate change mitigation and adaptation up front in the planning process will facilitate decision-making and improve efficiency at the program level, and will inform the analysis and stewardship needs of project level decision-making. Climate change considerations can easily be integrated into many planning factors, such as supporting economic vitality and global efficiency, increasing safety and mobility, enhancing the environment, promoting energy conservation, and improving the quality of life.

The four strategies set forth by FHWA to lessen climate change impacts do correlate with efforts that the State has undertaken and is undertaking to deal with transportation and climate change; the strategies include improved transportation system efficiency, cleaner fuels, cleaner vehicles, and reduction in the growth of vehicle hours travelled.

Climate change and its associated effects are also being addressed through various efforts at the federal level to improve fuel economy and energy efficiency, such as the "National Clean Car Program" and Executive Order 13514–*Federal Leadership in Environmental, Energy and Economic Performance*.

Executive Order 13514 is focused on reducing greenhouse gases internally in federal agency missions, programs and operations, but also direct federal agencies to participate in the interagency Climate Change Adaptation Task Force, which is engaged in developing a U.S. strategy for adaptation to climate change.

On April 2, 2007, in *Massachusetts v. EPA*, 549 U.S. 497 (2007), the Supreme Court found that greenhouse gases are air pollutants covered by the Clean Air Act and that the U.S. EPA has the authority to regulate GHG. The Court held that the U.S. EPA Administrator must determine whether or not emissions of greenhouse gases from new motor vehicles cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, or whether the science is too uncertain to make a reasoned decision.

On December 7, 2009, the U.S. EPA Administrator signed two distinct findings regarding greenhouse gases under section 202(a) of the Clean Air Act:

- **Endangerment Finding**: The Administrator found that the current and projected concentrations of the six key well-mixed greenhouse gases--carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)--in the atmosphere threaten the public health and welfare of current and future generations.
- **Cause or Contribute Finding**: The Administrator found that the combined emissions of these well-mixed greenhouse gases from new motor vehicles and new motor vehicle engines contribute to the greenhouse gas pollution which threatens public health and welfare.

Although these findings did not themselves impose any requirements on industry or other entities, this action was a prerequisite to finalizing the U.S. EPA's *Proposed Greenhouse Gas Emission Standards for Light-Duty Vehicles*, which was published on September 15, 2009.[4] On May 7, 2010 the final *Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards* was published in the Federal Register.

U.S. EPA and the National Highway Traffic Safety Administration (NHTSA) are taking coordinated steps to enable the production of a new generation of clean vehicles with reduced GHG emissions and improved fuel efficiency from on-road vehicles and engines. These next steps include developing the first-ever GHG regulations for heavy-duty engines and vehicles, as well as additional light-duty vehicle GHG regulations. These steps were outlined by President Obama in a memorandum on May 21, 2010.[5]

[4] http://www.epa.gov/climatechange/endangerment.html

[5] http://epa.gov/otaq/climate/regulations.htm

The final combined U.S. EPA and NHTSA standards that make up the first phase of this national program apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years 2012 through 2016. The standards require these vehicles to meet an estimated combined average emissions level of 250 grams of carbon dioxide per mile, equivalent to 35.5 miles per gallon (MPG) if the automobile industry were to meet this carbon dioxide level solely through fuel economy improvements. Together, these standards will cut GHG emissions by an estimated 960 million metric tons and 1.8 billion barrels of oil over the lifetime of the vehicles sold under the program (model years 2012-2016).

On November 16, 2011, U.S. EPA and NHTSA issued their joint proposal to extend this national program of coordinated greenhouse gas and fuel economy standards to model years 2017 through 2025 passenger vehicles.

2.6.2 Project Analysis

An individual project does not generate enough GHG emissions to significantly influence global climate change. Rather, global climate change is a cumulative impact. This means that a project may participate in a potential impact through its incremental contribution combined with the contributions of all other sources of GHG.[6] In assessing cumulative impacts, it must be determined if a project's incremental effect is "cumulatively considerable." See California Environmental Quality Act (CEQA) Guidelines sections 15064(h)(1) and 15130. To make this determination the incremental impacts of the project must be compared with the effects of past, current, and probable future projects. To gather sufficient information on a global scale of all past, current, and future projects in order to make this determination is a difficult if not impossible task.

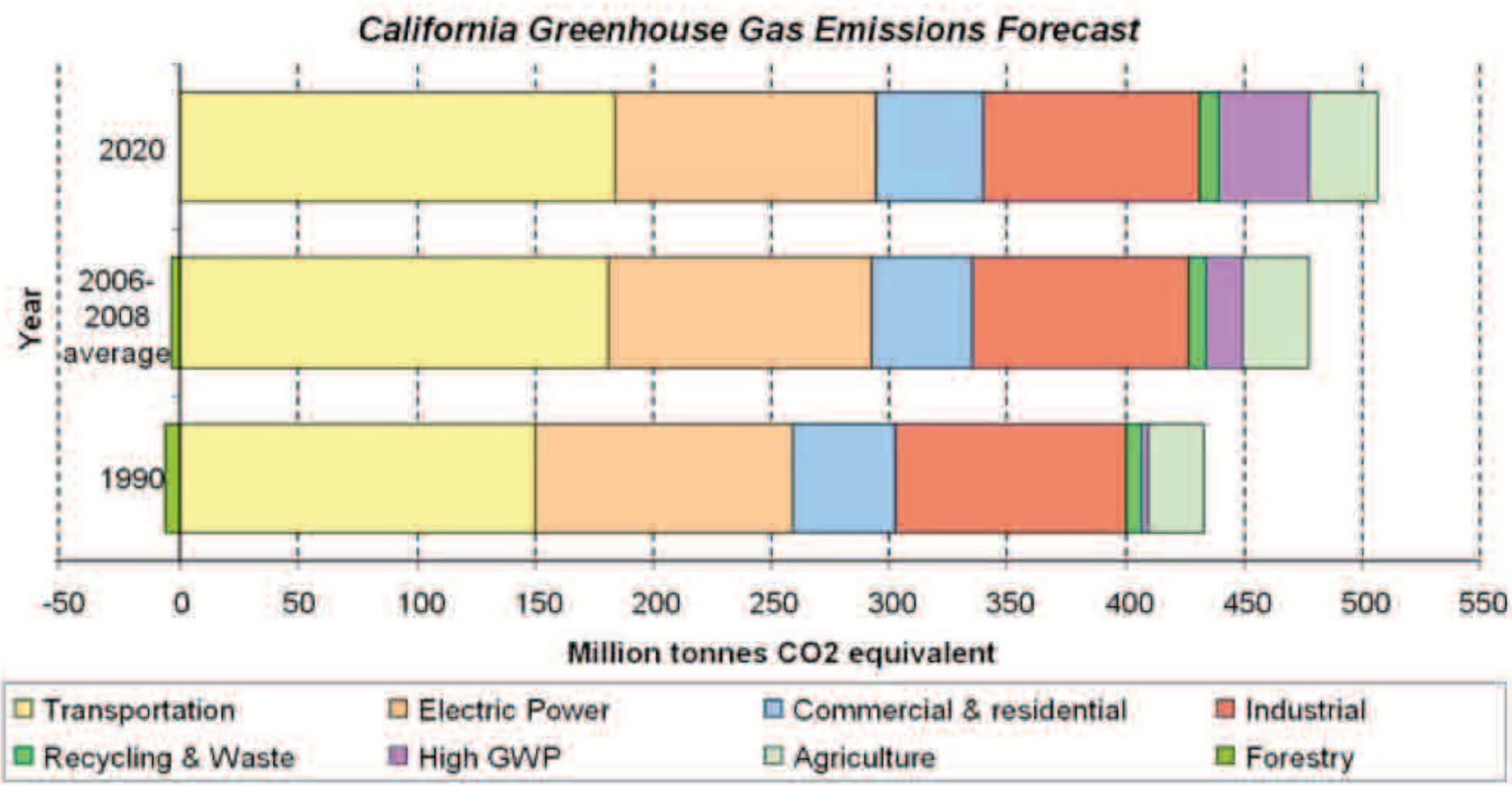
The AB 32 Scoping Plan contains the main strategies California will use to reduce GHG. As part of its supporting documentation for the Draft Scoping Plan, ARB released the GHG inventory for California (Forecast last updated: 28 October 2010). The forecast is an estimate of the emissions expected to occur in the year 2020 if none of the foreseeable measures included in the Scoping Plan were implemented. See **Figure 2-18**. The base year used for forecasting emissions is the average of statewide emissions in the GHG inventory for 2006, 2007, and 2008.

Caltrans and its parent agency, the Business, Transportation, and Housing Agency, have taken an active role in addressing GHG emission reduction and climate change. Recognizing that 98 percent of California's GHG emissions are from the burning of fossil fuels and 40 percent of all human made GHG emissions are from transportation, Caltrans has created and is implementing the Climate Action Program at Caltrans that was published in December 2006 (see Climate Action Program at Caltrans (December 2006).[7]

One of the main strategies in Caltrans' Climate Action Program to reduce GHG emissions is to make California's transportation system more efficient. As shown in **Figure 2-19**, the highest levels of carbon dioxide from automobiles occur at stop-and-go speeds (0-25 miles per hour). To the extent that a project relieves congestion in highly travelled corridors, GHG emissions, particularly CO_2, may be reduced.

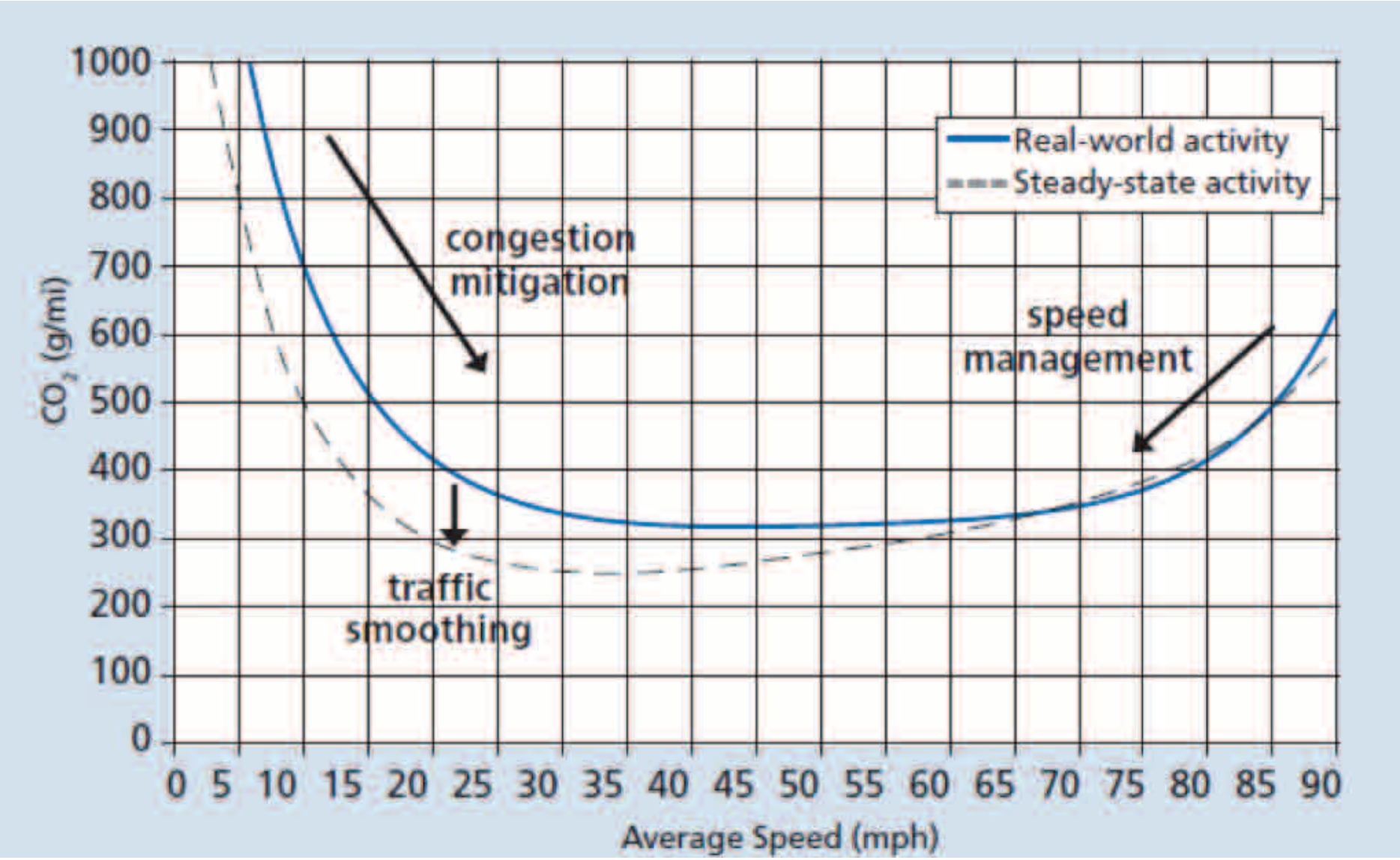
[6] This approach is supported by the AEP: *Recommendations by the Association of Environmental Professionals on How to Analyze GHG Emissions and Global Climate Change in CEQA Documents* (March 5, 2007), as well as the SCAQMD (Chapter 6: The CEQA Guide, April 2011) and the US Forest Service (Climate Change Considerations in Project Level NEPA Analysis, July 13, 2009).

[7] Caltrans' Climate Action Program is located at the following web address:
http://www.dot.ca.gov/hq/tpp/offices/ogm/key_reports_files/State_Wide_Strategy/Caltrans_Climate_Action_Program.pdf



California Greenhouse Gas Forecast Figure **2-18**

Source: California Air Resources Board, 2008.



Possible Effects of Traffic Operation Strategies in Reducing On-road CO_2 Emissions

Figure **2-19**

Source: Caltrans, 2011c.

The MTC, the Bay Area Air Quality Management District (BAAQMD), the Bay Conservation and Development Commission, and the Association of Bay Area Governments are working to reduce GHGs by sponsoring a five-year, Transportation Climate Action Campaign. The Campaign focuses on public outreach and education efforts that enable individuals to develop climate friendly behaviors, reduce the San Francisco Bay Area's carbon footprint, and form the groundwork for ongoing climate change initiatives.

The proposed project is designed to improve traffic operations, reduce traffic congestion, and improve bicycle and pedestrian access along U.S. Highway 101. The improvements implemented as part of the proposed project will help to alleviate traffic congestion, enhance local traffic circulation, and provide interregional connectivity. Congestion relief achieved as a result of the proposed project will help to reduce idling times, acceleration, and braking, which have all been established as contributors to air pollution.

Pedestrian and bicycle improvements proposed as part of the Build Alternative will connect to existing and planned pedestrian and bicycle facilities to the north (e.g., Central Marin Ferry Connection Multi-Use Pathway) and existing pedestrian and bicycle facilities to the south, effectively closing a gap in these facilities along the US 101 corridor. Facilitating connections to these transit alternatives is expected to reduce the number of personal vehicles on the highway and connecting arterials, thereby reducing the amount of GHG emissions. The U.S. EPA estimates that an individual who leaves their car at home for just two days a week will reduce GHG emissions by an average 1,600 pounds per year.[8] There are a number of transit services expansion projects in the areas surrounding the US 101 corridor that are being studied or have been approved. These transit services expansion projects are being pursued by other agencies and organizations, but are not part of the proposed Build Alternative.

Operational Emissions

The analysis in this section is based on the *Climate Change Technical Memorandum* completed in June 2011 (Caltrans, 2011c). CO_2 emissions associated with implementation of the proposed project were modeled using EMFAC 2007 to compare existing baseline conditions (year 2009) to Future with Build Alternative emissions as well as Future without Build Alternative emissions for both the construction (2015) and design (2035) years. **Table 2.6-1** presents project-level emissions and indicates that CO_2 associated with

the Build Alternative under future conditions will result in a slight increase in comparison to the anticipated regional emissions, which directly correlates to the increase in VMT associated with the Build Alternative.

It is important to note that CO_2 emissions calculated here are useful only for a comparison between scenarios. The numbers are not necessarily an accurate reflection of what the true CO_2 emissions will be because CO_2 emissions are dependent on factors that are not a part of the emissions model, such as the fuel mix, rate of acceleration, and the aerodynamics and efficiency of the vehicles on the roadway. These modeling results also do not account for the congestion relief associated with the Build Alternative, since the EMFAC BURDEN mode averages speed rather than making it project specific. Bike, pedestrian, and

[8] USEPA Climate Change: What You Can Do on the Road (web site).

transit access improvements as discussed above will also reduce future CO_2 emissions associated with the Build Alternative and are not accounted for in the EMFAC results. In addition, the model was developed prior to current California legislation that will further reduce CO_2 emissions. Therefore, future CO_2 estimates with the proposed project are likely to be lower than shown in **Table 2.6-1**.

Table 2.6-1: Existing and Build Alternative Greenbrae/Twin Cities Corridor CO_2 Emissions in Tons Per Day

Roadway Segment	2009 Existing	2015 No-Build	2015 Build	2035 No-Build	2035 Build
US 101 Greenbrae/Twin Cities Corridor	3,560	3,730	3,850	4,710	4,900

Source: Caltrans, 2011c.

Limitations and Uncertainties with Modeling

EMFAC

Although EMFAC can calculate CO_2 emissions from mobile sources, the model does have limitations when it comes to accurately reflecting CO_2 emissions. According to the National Cooperative Highway Research Program report, *Development of a Comprehensive Modal Emission Model* (April 2008), studies have revealed that brief but rapid accelerations can contribute significantly to a vehicle's carbon monoxide and hydrocarbon emissions during a typical urban trip. Current emission-factor models are insensitive to the distribution of such modal events (i.e., cruise, acceleration, deceleration, and idle) in the operation of a vehicle and instead estimate emissions by average trip speed. This limitation creates an uncertainty in the model's results when compared to the estimated emissions of the various alternatives with baseline in an attempt to determine impacts. Although work by EPA and the CARB is underway on modal-emission models, neither agency has yet approved a modal emissions model that can be used to conduct this more accurate modeling. In addition, EMFAC does not include speed corrections for most vehicle classes for CO_2; for most vehicle classes emission factors are held constant which means that EMFAC is not sensitive to the decreased emissions associated with improved traffic flows for most vehicle classes. Therefore, unless a project involves a large number of heavy-duty vehicles, the difference in modeled CO_2 emissions due to speed change will be slight.

CARB is currently not using EMFAC to create its inventory of greenhouse gas emissions. It is unclear why the CARB has made this decision. Their website only states:

> *REVISION: Both the EMFAC and OFFROAD Models develop CO_2 and CH_4 [methane] emission estimates; however, they are not currently used as the basis for [CARB's] official [greenhouse gas] inventory which is based on fuel usage information. However, ARB is working towards reconciling the emission estimates from the fuel usage approach and the models.*

Other Variables

With the current science, project-level analysis of greenhouse gas emissions is limited. Although a greenhouse gas analysis is included for this project, there are numerous key greenhouse gas variables that

are likely to change dramatically during the design life of the proposed project and will thus dramatically change the projected CO_2 emissions.

First, vehicle fuel economy is increasing. The EPA's annual report, "Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2008," which provides data on the fuel economy and technology characteristics of new light-duty vehicles including cars, minivans, sport utility vehicles, and pickup trucks, confirms that average fuel economy has improved each year beginning in 2005, and is now the highest since 1993.[9] Most of the increase since 2004 is due to higher fuel economy for light trucks, following a long-term trend of slightly declining overall fuel economy that peaked in 1987. These vehicles also have a slightly lower market share, peaking at 52 percent in 2004 with projections at 48 percent in 2008. **Table 2.6-2** shows the alternatives for vehicle fuel economy increases studied by the National Highway Traffic Safety Administration in its Final Environmental Impact Statement (EIS) for New Corporate Average Fuel Economy (CAFE) Standards (October 2008).

Table 2.6-2: Model Year 2015 Required Miles Per Gallon (mpg) by Alternative

	No Action	25% Below Optimized	Optimized (Preferred)	25% Above Optimized	50% Above Optimized	Total Costs Equal Total Benefits	Technology Exhaustion
Cars	27.5	33.9	35.7	37.5	39.5	43.3	52.6
Trucks	23.5	27.5	28.6	29.8	30.9	33.1	34.7

Second, near zero carbon vehicles will come into the market during the design life of this project. According to a March 2008 report released by University of California Davis (UC Davis), Institute of Transportation Studies:

> *Large advancements have occurred in fuel cell vehicle and hydrogen infrastructure technology over the past 15 years. Fuel cell technology has progressed substantially resulting in power density, efficiency, range, cost, and durability all improving each year. In another sign of progress, automotive developers are now demonstrating over 100 fuel cell vehicles (FCVs) in California—several in the hands of the general public—with configurations designed to be attractive to buyers. Cold-weather operation and vehicle range challenges are close to being solved, although vehicle cost and durability improvements are required before a commercial vehicle can be successful without incentives. The pace of development is on track to approach pre-commercialization within the next decade.*
>
> *A number of the U.S. DOE 2010 milestones for FCV development and commercialization are expected to be met by 2010. Accounting for a five to six year production development cycle, the scenarios developed by the U.S. DOE suggest that 10,000s of vehicles per year from 2015 to 2017 will be possible in a federal demonstration program, assuming large cost share grants by the government and industry are available to reduce the cost of production vehicles.*[10]

[9] http://www.epa.gov/oms/fetrends.htm

[10] Cunningham, Joshua, Sig Cronich, Michael A. Nicholas. March 2008. Why Hydrogen and Fuel Cells are Needed to Support California Climate Policy, UC Davis, Institute of Transportation Studies, pp. 9-10.

Third and as previously stated, in 2009, California adopted a low-carbon transportation fuel standard to reduce the carbon intensity of transportation fuels by 10 percent by 2020. The regulation became effective on January 12, 2010 (codified in title 17, California Code of Regulations, Sections 95480-95490). Beginning January 1, 2011, transportation fuel producers and importers must meet specified average carbon intensity requirements for fuel in each calendar year.

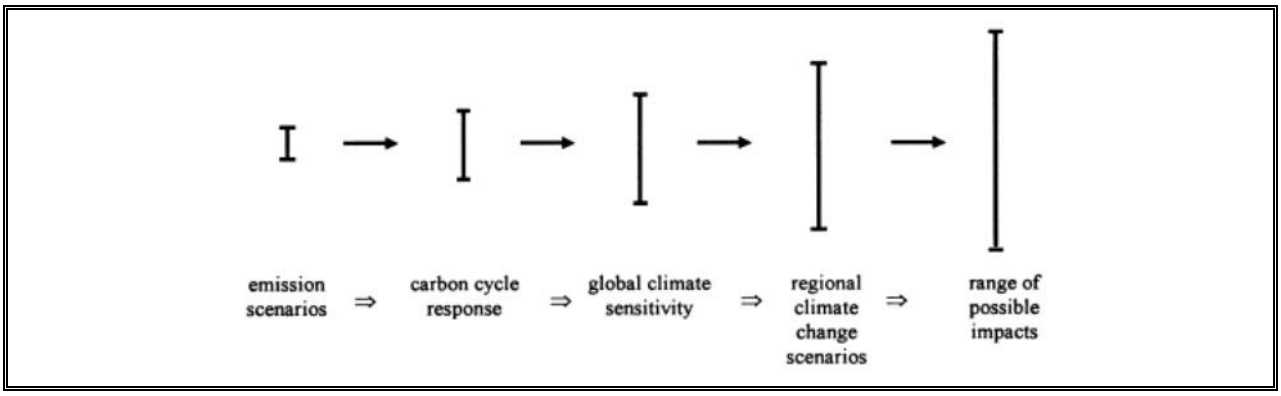
Fourth, driver behavior has been changing as the U.S. economy and oil prices have changed. In its January 2008 report, "Effects of Gasoline Prices on Driving Behavior and Vehicle Market," (http://www.cbo.gov/ftpdocs/88xx/doc8893/01-14-GasolinePrices.pdf) the Congressional Budget Office found the following results based on data collected from California: 1) highway motorists have adjusted to higher gas prices by making fewer trips and driving more slowly; 2) the market share of sports utility vehicles is declining; and 3) the average prices for larger, less-fuel-efficient models have declined over the past five years as average prices for the most-fuel-efficient automobiles have risen, showing an increase in demand for the more fuel efficient vehicles.

Limitations and Uncertainties with Impact Assessment

Taken from page 3-70 of the National Highway Traffic Safety Administration Final EIS for New CAFE Standards (October 2008), **Figure 2-20** illustrates how the range of uncertainties in assessing greenhouse gas impacts grows with each step of the analysis:

> *"Cascade of uncertainties typical in impact assessments showing the "uncertainty explosion" as these ranges are multiplied to encompass a comprehensive range of future consequences, including physical, economic, social, and political impacts and policy responses."*

Figure 2-20 Cascades of Uncertainties



Much of the uncertainty in assessing an individual project's impact on climate change surrounds the global nature of the climate change. Even assuming that the target of meeting the 1990 levels of emissions is met, there is no regulatory or other framework in place that will allow for a ready assessment of what any modeled increase in CO_2 emissions will mean for climate change given the overall California greenhouse gas emissions inventory of approximately 430 million tons of CO_2 equivalent. This uncertainty only increases when viewed globally. The IPCC has created multiple scenarios to project potential future global greenhouse gas emissions as well as to evaluate potential changes in global temperature, other climate changes, and their effect on human and natural systems. These scenarios vary

in terms of the type of economic development, the amount of overall growth, and the steps taken to reduce greenhouse gas emissions. Non-mitigation IPCC scenarios project an increase in global greenhouse gas emissions by 9.7 up to 36.7 billion metric tons CO_2 from 2000 to 2030, which represents an increase of between 25 and 90 percent.[11]

The assessment is further complicated by the fact that changes in greenhouse gas emissions can be difficult to attribute to a particular project because the projects often cause shifts in the locale for some type of greenhouse gas emissions, rather than causing "new" greenhouse gas emissions. It is difficult to assess the extent to which any project level increase in CO_2 emissions represents a net global increase, reduction, or no change; there are no models approved by regulatory agencies that operate at the global or even statewide scale.

The complexities and uncertainties associated with project level impact analysis are further borne out in the recently released Final EIS completed by the National Highway Traffic Safety Administration CAFE standards, October 2008. As the text quoted below shows, even when dealing with greenhouse gas emission scenarios on a national scale for the entire passenger car and light truck fleet, the numerical differences among alternatives is very small and well within the error sensitivity of the model.

> *In analyzing across the CAFE 30 alternatives, the mean change in the global mean surface temperature, as a ratio of the increase in warming between the B1 (low) to A1B (medium) scenarios, ranges from 0.5 percent to 1.1 percent. The resulting change in sea level rise (compared to the No Action Alternative) ranges, across the alternatives, from 0.04 centimeter to 0.07 centimeter. In summary, the impacts of the model year 2011-2015 CAFE alternatives on global mean surface temperature, sea level rise, and precipitation are relatively small in the context of the expected changes associated with the emission trajectories. This is due primarily to the global and multi-sectoral nature of the climate problem. Emissions of CO_2, the primary gas driving the climate effects, from the United States automobile and light truck fleet represented about 2.5 percent of total global emissions of all greenhouse gases in the year 2000 (EPA, 2008; CAIT, 2008). While a significant source, this is a still small percentage of global emissions, and the relative contribution of CO_2 emissions from the United States light vehicle fleet is expected to decline in the future, due primarily to rapid growth of emissions from developing economies (which are due in part to growth in global transportation sector emissions). [NHTSA Draft EIS for New CAFE Standards, June 2008, pp.3-77 to 3-78].*

Construction Emissions

Greenhouse gas emissions for transportation projects can be divided into those produced during construction and those produced during operations. Construction GHG emissions include emissions produced as a result of material processing, emissions produced by onsite construction equipment, and emissions arising from traffic delays due to construction. These emissions will be produced at different levels throughout the construction phase; their frequency and occurrence can be reduced through innovations in plans and specifications and by implementing better traffic management during construction phases.

[11] Intergovernmental Panel on Climate Change (IPCC). February 2007. Climate Change 2007: The Physical Science Basis: Summary for Policy Makers. http://www.ipcc.ch/SPM2feb07.pdf.

In addition, with innovations such as longer pavement lives, improved traffic management plans, and changes in materials, the GHG emissions produced during construction can be mitigated to some degree by longer intervals between maintenance and rehabilitation events. Although compliance with Caltrans' Standard Specifications will be expected to minimize construction-related emissions, the Build Alternative will result in a temporary increase in GHG emissions during construction. Although construction emissions will be unavoidable, the project will result in long-term GHG reduction benefits, as described above.

CEQA Conclusion

As discussed above, both the future with project and future no build show increases in CO_2 emissions over the existing levels; the future build CO_2 emissions are higher than the future no build emissions. In addition, as discussed above, there are also limitations with EMFAC and with assessing what a given CO_2 emissions increase means for climate change. However, Caltrans is firmly committed to implementing measures to help reduce greenhouse gas emissions. These measures are outlined in the following section.

Greenhouse Gas Reduction Strategies

AB 32 Compliance

Caltrans continues to be actively involved on the Governor's Climate Action Team as ARB works to implement the Executive Orders S-3-05 and S-01-07 and help achieve the targets set forth in AB 32. Many of the strategies Caltrans is using to help meet the targets in AB 32 come from the California Strategic Growth Plan, which is updated each year. Former Governor Arnold Schwarzenegger's Strategic Growth Plan calls for a $222 billion infrastructure improvement program to fortify the state's transportation system, education, housing, and waterways, including $100.7 billion in transportation funding during the next decade. The Strategic Growth Plan targets a significant decrease in traffic congestion below today's level and a corresponding reduction in GHG emissions. The Strategic Growth Plan proposes to do this while accommodating growth in population and the economy. A suite of investment options has been created that combined together are expected to reduce congestion. The Strategic Growth Plan relies on a complete systems approach to attain CO_2 reduction goals: system monitoring and evaluation, maintenance and preservation, smart land use and demand management, and operational improvements as depicted in **Figure 2-21**.

Caltrans is supporting efforts to reduce vehicle miles traveled by planning and implementing smart land use strategies: job/housing proximity, developing transit-oriented communities, and high density housing along transit corridors. Caltrans is working closely with local jurisdictions on planning activities; however, Caltrans does not have local land use planning authority. Caltrans is also supporting efforts to improve the energy efficiency of the transportation sector by increasing vehicle fuel economy in new cars, light and heavy-duty trucks; Caltrans is doing this by supporting on-going research efforts at universities, by supporting legislative efforts to increase fuel economy, and by its participation on the Climate Action Team. It is important to note, however, that the control of the fuel economy standards is held by U.S. EPA and ARB.**Table 2.6-3** summarizes statewide efforts that Caltrans is implementing in order to reduce GHG emissions. More detailed information about each strategy is included in the Climate Action Program at Caltrans (December 2006).

Mobility Pyramid Figure **2-21**

Source: Caltrans, 2007a.

Table 2.6-3: Climate Change/CO_2 Reduction Strategies

Strategy	Program	Partnership		Method/Process	Estimated CO_2 Savings (MMT)	
		Lead	Agency		2010	2020
Smart Land Use	Intergovernmental Review (IGR)	Caltrans	Local Governments	Review and seek to mitigate development proposals	Not Estimated	Not Estimated
	Planning Grants	Caltrans	Local and regional agencies & other stakeholders	Competitive selection process	Not Estimated	Not Estimated
	Regional Plans and Blueprint Planning	Regional Agencies	Caltrans	Regional plans and application process	0.975	7.8
Operational Improvements & Intelligent Trans. System (ITS) Deployment	Strategic Growth Plan	Caltrans	Regions	State ITS; Congestion Management Plan	0.007	2.17
Mainstream Energy & GHG into Plans and Projects	Office of Policy Analysis & Research; Division of Environmental Analysis	Interdepartmental effort		Policy establishment, guidelines, technical assistance	Not Estimated	Not Estimated
Educational & Information Program	Office of Policy Analysis & Research	Interdepartmental, CalEPA, CARB, CEC		Analytical report, data collection, publication, workshops, outreach	Not Estimated	Not Estimated
Fleet Greening & Fuel Diversification	Division of Equipment	Department of General Services		Fleet Replacement B20 B100	0.0045	0.0065 0.045 0.0225
Non-vehicular Conservation Measures	Energy Conservation Program	Green Action Team		Energy Conservation Opportunities	0.117	.34
Portland Cement	Office of Rigid Pavement	Cement and Construction Industries		2.5 % limestone cement mix 25% fly ash cement mix > 50% fly ash/slag mix	1.2 0.36	4.2 3.6
Goods Movement	Office of Goods Movement	Cal EPA, CARB, BT&H, MPOs		Goods Movement Action Plan	Not Estimated	Not Estimated
Total					2.72	18.18

To the extent that it is applicable or feasible for the project and through coordination with the project development team, the following measures discussed on the pages following will also be included in the project to reduce the GHG emissions and potential climate change impacts from the project.

The policies and BMPs that will be incorporated into the proposed project operations will include:

- Installing energy-efficient traffic lights;
- Installing energy-efficient street lights (e.g., light emitting diode (LED) street lights); and
- Expanding community bicycle infrastructure (e.g., dedicated bicycle lanes, additional bicycle parking).

Adaptation Strategies

”Adaptation strategies” refer to how the Department and others can plan for the effects of climate change on the state’s transportation infrastructure and strengthen or protect the facilities from damage. Climate change is expected to produce increased variability in precipitation, rising temperatures, rising sea levels, variability in storm surges and intensity, and the frequency and intensity of wildfires. These changes may affect transportation infrastructure in various ways, such as damaging roadbeds by longer periods of intense heat, increasing storm damage from flooding and erosion, and inundating infrastructure from rising sea levels. These effects will vary by location and may, in the most extreme cases, require that a facility be relocated or redesigned. There may also be economic and strategic ramifications as a result of these types of impacts to the transportation infrastructure.

At the federal level, the Climate change Adaptation Task Force, co-chaired by the White House Council on Environmental Quality (CEQ), the Office of Science and Technology Poliscy (OSTP), and the National Oceanic and Atmospheric Administration (NOAA), released its interagency report on October 14, 2010 outlining recommendations to President Obama for how Federal Agency policies and programs can better prepare the U.S. to respond to the impacts of climate change. The Progress Report of the Interagency Climate Change Adaptation Task Force recommends that the federal government implement actions to expand and strengthen the nation’s capacity to better understand, prepare for, and respond to climate change.

Climate change adaption must also involve the natural environment as well. Efforts are underway on a statewide level to develop strategies to cope with impacts to habitat and biodiversity through planning and conservation. The results of these efforts will help California agencies plan and implement mitigation strategies for programs and projects.

On November 14, 2008, former Governor Arnold Schwarzenegger signed EO S-13-08 which directed a number of state agencies to address California’s vulnerability to sea level rise caused by climate change. This EO set in motion several agencies and actions to address the concern of sea level rise.

The California Natural Resources Agency (Resources Agency) was directed to coordinate with local, regional, state and federal public and private entities to develop. The California Climate Adaptation Strategy (Dec 2009)[12], which summarizes the best known science on climate change impacts to

[12] http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF

California, assesses California's vulnerability to the identified impacts, and then outlines solutions that can be implemented within and across state agencies to promote resiliency.

The strategy outline is in direct response to EO S-13-08 that specifically asked the Resources Agency to identify how state agencies can respond to rising temperatures, changing precipitation patterns, sea level rise, and extreme natural events. Numerous other state agencies were involved in the creation of the Adaptation Strategy document, including the California Environmental Protection Agency; Business, Transportation and Housing; Health and Human Services; and the Department of Agriculture. The document is broken down into strategies for different sectors that include: Public Health; Biodiversity and Habitat; Ocean and Coastal Resources; Water Management; Agriculture; Forestry; and Transportation and Energy Infrastructure. As data continues to be developed and collected, the state's adaptation strategy will be updated to reflect current findings.

The Resources Agency was also directed to request the National Academy of Science to prepare a Sea Level Rise Assessment Report by December 2010[13] to advise how California should plan for future sea level rise. The report is to include:

- Relative sea level rise projections for California, Oregon and Washington taking into account coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates.
- The range of uncertainty in selected sea level rise projections.
- A synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems.
- A discussion of future research needs regarding sea level rise.

Prior to the release of the final Sea Level Rise Assessment Report, all state agencies that are planning to construct projects in areas vulnerable to future sea level rise were directed to consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. Sea level rise estimates should also be used in conjunction with information regarding local uplift and subsidence, coastal erosion rates, predicted higher high water levels, storm surge and storm wave data.

Interim guidance has been released by The Coastal Ocean Climate Action Team (CO-CAT) as well as the Department as a method to initiate action and discussion of potential risks to the states infrastructure due to projected sea level rise.

Because of the requirements set forth for State agencies in EO-S-13-08, as well as an increased interest by the public and regulatory agencies, Caltrans took a proactive approach in addressing sea level rise impacts on existing infrastructure and for future projects with the development of the department's *Guidance on Incorporating Sea-Level Rise (May 2011).*

[13] Pre-publication copies of the report, *Sea Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*, were made available from the National Academies Press on June 22, 2012. For more information, please see http://www.nap.edu/catalog.php?record_id=13389.

The following analysis was conducted prior to the *National Research council publication of the Sea-Level Rise for the Coast of California, Oregon and Washington: Past, Present and Future* study release and uses projections adopted by the Ocean Protection council in March 2011.

According to the Guidance, to assess whether an individual project will potentially be impacted by sea level rise, a three-part screening criteria has been developed. The screening involves examination for the following three questions:

1. Is the project located on the coast or in an area vulnerable to sea level rise?
2. Will the project be impacted by the stated sea level rise?
3. Is the design life of the project beyond year 2030?

Determination of whether or not a project will be impacted by sea level rise is based on the projections included in **Table 2.6-4**. Until the year 2050, there is strong agreement among the various climate models for the amount of sea level rise that is likely to occur. After mid-century, projections of sea level rise become more uncertain because the modeling results diverge and the sea level rise projections vary depending upon how quickly the international community reduces greenhouse gas emissions (Caltrans, 2011i).

Table 2.6-4: Sea-Level Rise Projections Using Year 2000 as the Baseline

Year		Average of Models	Range of Models
2030		7 in (18 cm)	5-8 in (9-17 cm)
2050		14 in (36 cm)	10-17 in (26-43 cm)
2070	Low	23 in (59 cm)	17-27 in (43-70 cm)
	Medium	24 in (62 cm)	18-29 in (46-74 cm)
	High	27 in (69 cm)	20-32 in (51-81 cm)
2100	Low	40 in (97 cm)	31-50 in (78-128 cm)
	Medium	47 in (121 cm)	37-60 in (95-152 cm)
	High	55 in (140 cm)	43-69 in (110-176 cm)

Source: Caltrans, 2011a.
Notes: in=inches, cm=centimeters

All projects that have filed a Notice of Preparation as of the date of EO-S-13-08, and/or are programmed for construction funding from 2008 through 2013, or are routine maintenance projects may, but are not required to, consider these planning guidelines. Although the proposed project is exempt from sea level rise analysis as directed in EO S-13-08 since the Notice of Preparation for the proposed project was filed in September 2009, the proposed Greenbrae/Twin Cities Corridor is located in an area vulnerable to sea level rise because it is in close proximity to San Francisco Bay. In addition, the design life of the proposed project is the year 2035, which is beyond the year 2030 screening criteria. As a result, it is appropriate to evaluate the effect of sea level rise on the proposed project.

Executive Order S-13-08 also directed the Business, Transportation, and Housing Agency to prepare a report to assess vulnerability of transportation systems to sea level rise affecting safety, maintenance and

operational improvements of the system, and economy of the state. The Department continues to work on assessing the transportation system vulnerability to climate change, including the effect of sea level rise.

Currently, the Department is working to assess which transportation facilities are at greatest risk from climate change effects. However, without statewide planning scenarios for relative sea level rise and other climate change effects, the Department has not been able to determine what change, if any, may be made to its design standards for its transportation facilities. Once statewide planning scenarios become available, the Department will be able review its current design standards to determine what changes, if any, may be warranted in order to protect the transportation system from sea level rise.

Climate change adaptation for transportation infrastructure involves long-term planning and risk management to address vulnerabilities in the transportation system from increased precipitation and flooding; the increased frequency and intensity of storms and wildfires; rising temperatures; and rising sea levels. The Department is an active participant in the efforts being conducted in response to EO S-13-08 and is mobilizing to be able to respond to the National Academy of Science Sea Level Rise Assessment Report.

Figure 2-22 shows a map of shoreline areas vulnerable to sea level rise in the years 2050 and 2100 according to the San Francisco Bay Conservation and Development Commission (BCDC). As shown, the proposed project will be subject to sea level rise in both the years 2050 and 2100. Impacts of a 16 inch sea level rise (conditions anticipated in the year 2050) will include inundation of most of the proposed project area.[14] Impacts of a 55 inch sea level rise (possible year 2100 conditions) will continue to extend inundation within the proposed Greenbrae/Twin Cities Corridor and may make the ponding deeper in the existing floodplains.

Adaptation to sea level rise at the regional level is a broad-based planning activity that will be implemented by Caltrans. As stated above, adaptation for transportation infrastructure involves long-term planning and risk management in the transportation system. As such, the 2009 California Climate Change Adaptation Strategy Report suggests that Caltrans employ the following Adaptation Strategies for projects subject to sea level rise:

- **Develop a transportation use "hot-spot" map.** Research and identify transportation "hot spots" using updated National Research Council and other appropriate study efforts to identify across the State where the mixture of climate change impacts, population increases, and transportation demand increases will make communities most vulnerable to climate change.
- **Transportation Infrastructure Assessment.** Assess existing transportation design standards as to their adequacy to withstand climate forces from sea level rise and extreme weather events beyond those considered.
- **Buffer Zone Guidelines.** Develop guidelines to establish buffer areas and setbacks to avoid risks to structures within projected "high" future sea level rise or flooding inundation zones.
- **Stormwater Quality.** Assess how climate changes could alter size and design requirements for stormwater quality best management practices (BMPs) (CNRA, 2009).

[14] According to the location hydraulic study report, 118 of the 120 acres of the proposed project site are presently located within the floodplain. Therefore, the proposed project is already subject to flooding risk prior to the potential effects of sea level rise.

Legend

- Area vulnerable to an approximate 16-inch sea level rise
- Area vulnerable to an approximate 55-inch sea level rise

N

0 .75 1.5 3
MILE

Shoreline Areas Vulnerable to Sea Level Rise: Central Bay North

Figure **2-22**

Source: Caltrans, 2011a.

These strategies are general in nature and intended to be carried out by Caltrans during the planning and programming of transportation projects across the entire transportation network. Incorporating these strategies early into the planning and programming of transportation improvements will allow transportation planners over time to design new facilities and incorporate measures into near-term transportation projects that will avoid, reduce, and address sea level rise across the transportation network.

In addition, since sea level rise will further increase flooding at the project level, the most appropriate approach for the project proponent is the development of proactive strategies in anticipation of change. As a result, the following factors should be considered during proposed project design whenever feasible.

- **Alternative route(s).** In the event that US 101 is inundated, alternate routes were analyzed during the proposed project feasibility process. These routes will consist primarily of local north-south routes that could be used if US 101 is closed at the Greenbrae Interchange. Possible routes include:
  - US 101 at Corte Madera to San Rafael via Fifer Avenue - Lucky Drive, Doherty Drive, Magnolia Avenue, Bon Air Road, Sir Francis Drake Boulevard, Wolfe Grade/ D Street, and Second Street.
  - US 101 at Corte Madera to San Rafael via Tamalpais Drive - Magnolia Avenue, College Avenue, and Red Hill Avenue/Second Street to U.S. Highway 101; and
  - US 101 at Mill Valley to San Rafael via State Route 1- Sir Francis Drake Boulevard and Red Hill Avenue/Second Street to US 101;
- Given existing traffic patterns, there is little opportunity to develop an adequate alternative route that could accommodate traffic volumes associated with the proposed project or avoid substantial residential and business relocations and impacts to environmentally sensitive areas. These local road alternatives could not handle the necessary volumes because most of the routes are partially residential and significantly out of direction.
- **Emergency/Evacuation Plans.** Traveler safety: Local police, fire, and public works departments conduct annual emergency response training exercises to prepare for catastrophic events such as flooding. Recently a common radio frequency was established to allow communication between various departments and jurisdictions.
- **Anticipated travel delays for goods movement/interstate commerce.** The proposed Greenbrae/Twin Cities Corridor allows for movement of people and goods along its 180 mile length. According to analysis completed during the proposed project feasibility process, there are no viable highway alternatives to this route for goods movement and truck traffic because of topographical, environmental, and development constraints. Therefore, in the case of roadway inundation, delays will be anticipated. However, the alternative routes discussed above could help to relieve some of the pressures of local traffic.

- **Roadway Elevation.** During the design phase of the proposed project, the possibility of raising a portion of the highway was analyzed. The option studied included raising the roadway profile of U.S. Highway 101 by 20 feet and reconstructing 0.8 mile of the highway. The estimated cost associated with this design will be $86 million. Raising the roadway in order to fix the flooding issue in the area will involve elevating an even larger portion of the highway. Any reconstruction of the highway to avoid flooding by raising the highway will most likely require a complete reconstruction of the Sir Francis Drake Interchange, which will mean additional costs. Based on all of the above, this option was considered infeasible due to cost.

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