SECTION 7.4 GREENHOUSE GAS EMISSIONS

Introduction

This section provides a discussion of existing global climate conditions, climate change science, and greenhouse gas (GHG) emissions sources in California, the San Francisco Bay Area, and the city of Hayward. This section also provides a summary of applicable regulations with respect to local, regional and statewide GHG emission sources. A discussion of the impacts caused by global climate change within the Planning Area is included in the Hazards chapter of this Background Report in Section 9.6 (Climate Change Impacts).

GHG emissions have the potential to adversely affect the environment because, on a cumulative basis, they contribute to global climate change. In turn, global climate change has the potential to result in rising sea levels, which can inundate low-lying areas; affect rain and snow fall, leading to changes in water supply; and to affect habitat, leading to adverse effects on biological and other resources. Because GHG emissions come from many different sources in both current and expected future activities in a growing community, identification and reduction of GHG emissions is an important consideration in long-range planning efforts.

Major Findings

- Total GHG emissions in Hayward were approximately 1,183,279 metric tons of CO_2 equivalent in 2005. The primary source of GHG emissions in Hayward is the transportation sector, comprising about 62 percent of all GHG emissions in the city. Residential and commercial building energy consumption comprises nearly 34 percent of local emissions.
- In 2010, total GHG emissions decreased in certain sectors compared to 2005 levels. Residential and commercial energy usage in building each decreased by 3 percent during this period, while transportation GHG emissions from on-road sources (including passenger vehicles, commercial vehicles, and buses) decreased significantly by a total of 8 percent between 2005 and 2010. Waste-related GHG emissions experienced the most significant decline, approximately 54 percent, between 2005 and 2010.
- The City of Hayward has an adopted Climate Action Plan (CAP) that includes the 2005 GHG emission inventory, forecasts future emissions, and sets reduction targets. The City's GHG reduction targets are as follows:
    - 6 percent below 2005 levels by 2013
    - 12.5 percent below 2005 levels by 2020
    - 82.5 percent below 2005 levels by 2050
- The CAP's forecasted GHG emission scenarios for 2020 and 2050 take into account "business of usual" growth in emissions without any local, State or federal actions, as

well as future emissions with key assumptions regarding State and federal actions. Projected growth in GHG emissions was indexed to generalized growth factors, and may not be consistent with General Plan build-out conditions. Any changes in assumed growth in the current General Plan Update will need to be applied to revised GHG emission forecasts.

- The CAP includes nine GHG reduction strategies that apply to all sectors in the GHG inventory. Within these strategies, there are approximately 40 specific communitywide actions and 20 specific municipal actions that implement the strategies. Full implementation of all quantitative actions according to the implementation plan in the CAP will result in meeting the City's GHG reduction targets by 2020 and 2050.

Existing Conditions

Climate is the accumulation of daily and seasonal weather events over a long period of time, whereas weather is defined as the condition of the atmosphere at any particular time and place (Ahrens 2003). The climate of the Planning Area is characterized as Mediterranean, and is strongly influenced by proximity to the Pacific Ocean.

Certain gases in the earth's atmosphere, classified as GHGs, play a critical role in determining the earth's surface temperature. Solar radiation enters the earth's atmosphere from space. A portion of the radiation is absorbed by the earth's surface, and a smaller portion of this radiation is reflected back toward space. This absorbed radiation is then emitted from the earth as low-frequency infrared radiation. The frequencies at which bodies emit radiation are proportional to temperature. The earth has a much lower temperature than the sun; therefore, the earth emits lower frequency radiation. Most solar radiation passes through GHGs; however, infrared radiation is absorbed by these gases. As a result, radiation that otherwise would have escaped back into space is instead "trapped," resulting in a warming of the atmosphere. This phenomenon, known as the greenhouse effect, is responsible for maintaining a habitable climate on Earth. Without the greenhouse effect, Earth would not be able to support life as we know it.

Prominent GHGs contributing to the greenhouse effect are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). CO_2 is the most prevalent of all GHG emissions. All GHG's are classified in terms of their global warming potential (GWP). GWP is a simplified index that uses the warming potential of carbon dioxide as the base unit of measurement. For example, CO_2 has a GWP of 1, but methane (CH_4) has a GWP of 21 because methane has approximately 21 times more warming potential than CO_2. Since there are numerous GHG's with varying degrees of GWP, GHG's are frequently expressed in a unit known as carbon dioxide equivalent (CO_2e), which normalizes all GHG's to equivalent CO_2 levels. This allows varying types and amounts of GHG emissions to be expressed in the same unit of measurement.

Human-caused emissions of these GHGs in excess of natural ambient concentrations are responsible for intensifying the greenhouse effect and have led to a trend of unnatural warming of the earth's climate, known as global warming or global climate change . It is extremely

unlikely that global climate change of the past 50 years can be explained without taking into consideration the contribution of GHG emissions from human activities (IPCC 2007).

Climate change is a global problem. GHGs originate from local and regional sources all over the world, but they are global pollutants. GHGs differ from criteria air pollutants and toxic air contaminants, which are mostly generated locally and regionally, have mostly localized air quality effects and have relatively short atmospheric lifetimes (about 1 day). GHGs have long atmospheric lifetimes (1 year to several thousand years), and thus GHGs persist in the atmosphere for long enough time periods to be dispersed around the globe. Although the exact lifetime of any particular GHG molecule is dependent on multiple variables and cannot be pinpointed, it is understood that more CO_2 is emitted into the atmosphere than is sequestered by ocean uptake, vegetation, and other forms of sequestration. Of the total annual human-caused CO_2 emissions, approximately 54 percent is sequestered through ocean uptake, uptake by northern hemisphere forest regrowth, and other terrestrial sinks within a year, whereas the remaining 46 percent of human-caused CO_2 emissions remains stored in the atmosphere (Seinfeld and Pandis 1998).

Statewide GHG Emissions

Emissions of GHGs contributing to global climate change are attributable in large part to human activities associated with the transportation, industrial/manufacturing, utility, residential, commercial and agricultural sectors (ARB 2011a). In California, the transportation sector is the largest emitter of GHGs, followed by electricity generation (ARB 2011b). California produced 478 million gross metric tons of CO_2e in 2008 (ARB 2011a).

Combustion of fossil fuel in the transportation sector was the single largest source of California's GHG emissions in 2008, accounting for 37 percent of total GHG emissions in the state (ARB 2011b). This sector was followed by the electric power sector (including both in-state and out-of-state sources) (24 percent) and the industrial sector (19 percent) (ARB 2011a). California GHG emissions inventory and projections are summarized in Table 7.4-1 below.

TABLE 7.4-1
CALIFORNIA GHG EMISSIONS INVENTORY AND PROJECTIONS

	MMT CO_2e/yr				
Emissions Sector	**1990**	**2000**	**2005**	**2008**	**2020**
Electrical Generation[1]	110.6	103.9	111.0	116.4	110.4
Residential/Commercial	44.1	42.9	40.8	43.1	45.3
Transportation	150.7	171.1	184.3	175.0	183.9
Industrial	103.0	97.3	90.7	92.7	91.5
High GWP Gases	-[2]	11.0	14.2	15.7	37.9
Agriculture	23.4	25.4	29.0	28.1	29.1
Waste Management	-[2]	6.2	6.5	6.7	8.5
Forestry	0.2	0.2	0.2	0.2	0.2
Gross Total Emissions[3]	**433**	**458.0**	**476.7**	**477.7**	**506.8**

TABLE 7.4-1 CALIFORNIA GHG EMISSIONS INVENTORY AND PROJECTIONS					
Carbon Sequestration	-6.7	-4.7	-4.2	-4.0	0.0
Total Net Emissions[3]	**427**	**453.3**	**472.6**	**473.8**	**506.8**

Notes: GWP = global warming potential; MMT CO_2e/yr = million metric tons carbon dioxide equivalent per year.
[1] Includes in-state-generated and imported electricity production.
[2] Contained within Industrial Sector emissions.
[3] Totals may not sum exactly due to rounding.
Source: ARB 2007:6, 2011b, 2011c.

Regional and Local GHG Emissions

San Francisco Bay Area

The Bay Area Air Quality Management District (BAAQMD) conducts periodic inventories of GHG emissions within the San Francisco Bay Area Air Basin. In 2010, BAAQMD updated its regional GHG emissions inventory (originally conducted for the baseline year of 2002) to the base year 2007. In 2007, 95.8 million metric tons of CO_2 equivalent ($MMTCO_2e$) were emitted as a result of activities in the San Francisco Bay Area. Of these, 88.7 $MMTCO_2e$ were emitted within the Air Basin and 7.1 $MMTCO_2e$ were indirect emissions from imported electricity. The Transportation sector contributed approximately 36 percent of total GHG emissions in the Bay Area, including on-road motor vehicles, locomotives, ships and boats, and aircraft. The Industrial/Commercial also contributed about 36 percent of regional GHG emissions, with primary sources including oil refining, natural gas and other fuel combustion, waste management, cement manufacturing, and other sources (BAAQMD 2010a).

A summary of the 2007 regional GHG emissions inventory, by sector and County, is shown in Table 7.4-2. Alameda County, in which the City of Hayward is located, emitted approximately 15.9 $MMTCO_2e$, or about 16 percent of total regional emissions.

TABLE 7.4-2 2007 BAY AREA GHG EMISSIONS, BY SECTOR AND COUNTY ($MMTCO_2E$)										
	Alameda	**Contra Costa**	**Marin**	**Napa**	**San Francisco**	**San Mateo**	**Santa Clara**	**Solano***	**Sonoma***	**Total SF Bay Area**
Industrial/ Commercial	3.3	19.2	0.5	0.3	1.9	1.6	4.7	2.9	0.6	35.0
Residential Fuel	1.3	1.1	0.4	0.1	0.9	0.8	1.6	0.3	0.4	6.9
Electricity/Co-Generation	2.0	5.7	0.3	0.2	1.3	1.0	3.6	0.4	0.6	15.1
Off-Road Equipment	0.6	0.4	0.1	0.0	0.4	0.3	0.8	0.1	0.2	2.9
Transportation	8.4	5.0	1.3	0.9	2.7	4.8	7.9	1.8	2.1	34.9
Agriculture/ Farming	0.1	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.2	1.1
TOTAL (All Sectors)	**15.7**	**31.5**	**2.7**	**1.6**	**7.1**	**8.5**	**18.8**	**5.7**	**4.1**	**95.8**

Notes: $MMTCO_2e$ = million metric tons of carbon dioxide equivalent. Totals may not be completely accurate, due to rounding of figures. * = Portion within BAAQMD.
Source: BAAQMD 2010a.

The 2007 Regional GHG Emissions Inventory also includes a list of the "Top 200" major GHG emitting point source facilities in the region. Four of the facilities on the list are located within the City of Hayward, as shown in Table 7.4-3.

TABLE 7.4-3
2007 BAY AREA "TOP 200" MAJOR GHG EMITTING FACILITIES LOCATED IN HAYWARD.

Rank in Top 200	Facility Name	Address	Total GHG Emissions in 2007 ($MTCO_2e$)
49	American Lithographers & Business Forms	21062 Forbes Street	45,790
93	Morgan Advanced Ceramics	2425 Whipple Road	16,071
177	Mission Foods	23423 Cabot Blvd	4,594
187	Hayward Waste Water Treatment Plant	3700 Enterprise Ave	4,053

Source: BAAQMD 2010a.

City of Hayward

The City of Hayward adopted a CAP in 2009. Included in the City's CAP is a summary of a community GHG emissions inventory prepared for the City of Hayward by International Council for Local Environmental Initiatives (ICLEI) USA – Local Governments for Sustainability in 2006, and subsequently updated in 2008, for the baseline year of 2005. The 2005 inventory is summarized below in Table 7.4-4. Total GHG emissions in Hayward were approximately 1,183,279 $MTCO_2e$ in 2005. The transportation sector was the single largest source of emissions in 2005, contributing 62 percent of total emissions. Approximately 61 percent of transportation emissions were generated on State highways, compared to 39 percent on local roads. Energy consumption in the form of natural gas and electricity accounted for nearly 34 percent of Hayward's total emissions, about 60 percent of which is in the commercial/industry sector and 40 percent in the residential sector. In 2005, Hayward consumed a total of 922 million kilowatt hours (kWh) of electricity and 36 million therms of natural gas. Solid waste emissions from community-generated and landfilled waste (approximately 158,000 metric tons of waste in 2005) constituted over 4 percent of total GHG emissions (City of Hayward 2009).

TABLE 7.4-4
CITY OF HAYWARD 2005 GHG EMISSIONS

Emissions Sector	$MTCO_2e$/yr	
	2005	% of total
Residential Energy	158,528	13.4%
Commercial/Industrial Energy	238,226	20.1%
Transportation[1]	734,087	62.0%
Waste	52,438	4.4%
Water/Wastewater[2]	n/a	-
Total Emissions	**1,183,279**	**100%**

Notes: $MTCO_2e$/yr = metric tons carbon dioxide equivalent per year. Totals may not be completely accurate, due

TABLE 7.4-4
CITY OF HAYWARD 2005 GHG EMISSIONS

to rounding of figures.
[1] Includes on-road transportation sources only (off-road sources, certain transit (e.g. Bay Area Rapid Transit (BART)) sources, and air travel related to Hayward Executive Airport, were not included)
[2] Water/Wastewater emissions were not included in the 2005 inventory.
Source: City of Hayward Climate Action Plan, 2009.

In January 2013, a new GHG emissions inventory for the year 2010 was completed for the City of Hayward, using methods similar, but not identical to the 2005 inventory (StopWaste.org 2013). In 2010, community emissions for the city of Hayward were estimated to be 1,118,560 $MTCO_2e$. Transportation continued to be the largest emitting sector in the inventory, with nearly 63 percent of total emissions, while Residential and Commercial/Industrial sector energy consumption comprised nearly 35 percent of total emissions. The 2010 inventory is summarized below in Table 7.4-5.

TABLE 7.4-5
CITY OF HAYWARD 2010 GHG EMISSIONS

Emissions Sector	$MTCO_2e/yr$	
	2010	% of total
Residential Energy	154,423	13.8%
Commercial/Industrial Energy	235,693	21.1%
Transportation[1]	700,310	62.6%
Waste	24,048	2.1%
Water/Wastewater[2]	4,087	0.4%
Total Emissions	**1,118,560**	**100%**

Notes: $MTCO_2e/yr$ = metric tons carbon dioxide equivalent per year. Totals may not be completely accurate, due to rounding of figures.
[1] Includes both on-road and off-road sources, as well as BART and air travel related to Hayward Executive Airport.
[2] Includes apportioned emissions from wastewater discharge activities only. Process and fugitive emissions related to the Hayward Water Pollution Control Plant are included in Commercial/Industrial Energy Sector.
Source: StopWaste.org, 2013.

It is important to note here that the 2005 and 2010 GHG inventories **cannot** be directly compared because calculation methodologies used for some inventory sectors were inconsistent between the two inventory years, and also because some emissions sources were inconsistently reported between the two inventories. Key differences between the 2005 and 2010 inventories are summarized below:

- On-road transportation emissions were calculated using different methodologies between the two inventory years. The 2005 inventory calculated transportation emissions based on total vehicle miles traveled (VMT) within the city limits using what is sometimes referred to as the "boundary method". However, the 2010 inventory utilized VMT data obtained from activity-based modeling, as provided by the Metropolitan Transportation Commission, which takes into account origin/destination

of trips beginning and ending in Hayward, screens out pass-through trips, and takes other factors into consideration. Therefore on-road transportation emissions between the two inventory years cannot be directly compared.

- Off-road transportation, other transit emissions (e.g. Bay Area Rapid Transit (BART)), and air travel emissions related to Hayward Executive Airport were not included in the 2005, but were included in the 2010 inventory.
- Water/Wastewater sector emissions were not included in the 2005 inventory, but were included in the 2010 inventory.
- Hayward Water Pollution Control Plant Process and Fugitive Emissions data were included in the 2010 inventory's Commercial/Industrial sector emissions, but not in the 2005 inventory (StopWaste.org 2013).

In order to provide meaningful and accurate comparisons between 2005 and 2010, StopWaste.org provided adjustments to certain 2005 transportation emissions subsectors using the same methods used to prepare the 2010 transportation emissions, and determined which sectors and subsectors can be directly compared. These are summarized below in Table 7.4-6. Key highlights of comparable changes between 2005 and 2010 include:

- Residential energy sector emissions showed a decrease of over 3 percent. This occurred despite a small increase in residential electricity consumption between 2005 and 2010. Increasing renewable energy sources in Pacific Gas & Electric Company's (PG&E) electricity supply portfolio likely resulted in lower GHG emission factors which, when combined with annual variations in weather and precipitation levels (which can also lead to some variation in the amount of hydropower generation, which also impacts GHG emission factors), may have been enough to offset the net increase in usage during this time period.
- Commercial/Industrial energy sector emissions also decreased by 3 percent. There were no net increases in energy consumption in this sector.
- Transportation emissions from on-road sources (including passenger vehicles, commercial vehicles, and buses) decreased significantly by a total of 8 percent between 2005 and 2010. Commercial vehicle emissions decreased by over 12 percent, and emissions from buses declined by 15 percent. Passenger vehicle emissions, the largest share of all on-road travel, declined by 6 percent.
- Waste emissions from landfilled waste were reduced by more than half, or approximately 54 percent. Total landfilled waste, expressed in metric tons, decreased by over 31 percent during this time period. Changes in the community waste stream profile as a result of increased recycling and other efforts also likely contributed to this major reduction in emissions in the waste sector.

TABLE 7.4-6
DIRECTLY COMPARABLE GHG EMISSION SECTORS IN HAYWARD, 2005 TO 2010

Sector	2005 Activity Data	2010 Activity Data	2005 $MTCO_2e$	2010 $MTCO_2e$	Percent Change $MTCO_2e$	Notes
Residential						
Electricity	242,674,455 kWh	252,427,371 kWh	54,252	51,297	-5%	All 2005 activity data were found in "City of Hayward Baseline Greenhouse Gas Emissions Inventory Report, November 2006." All 2005 emissions estimates were found in Appendix A: Baseline Emissions Detailed Reports, 1/30/2009 in "Hayward Climate Action Plan, October 8, 2009." Data and methodologies are consistent across inventory years.
Natural Gas	19,496,859 Therms	19,400,629 Therms	104,277	103,126	-1%	
Total			**158,529**	**154,423**	**-3%**	
Commercial/Industrial						
Electricity	678,989,309 kWh	657,204,663 kWh	151,793	146,446	-4%	
Natural Gas	16,160,661 Therms	16,041,943 Therms	86,434	85,273	-1%	
Total			**238,227**	**231,719**	**-3%**	
Transportation						
Commercial Vehicles	182,760,367 VMT	162,121,413 VMT	239,600	210,934	-12%	Transportation emissions estimates were recalculated for year 2005 using data and methodologies consistent with 2010 calculations.
Passenger Vehicles	1,030,891,165 VMT	968,074,654 VMT	430,413	405,267	-6%	
Buses	6,535,790 VMT	5,549,659 VMT	11,025	9,375	-15%	
Total	1,220,187,322 VMT	1,135,745,726 VMT	**681,038**	**625,577**	**-8%**	
Waste						
Total Landfilled Waste	173,509 tons	119,483 tons	**52,319**	**24,048**	**-54%**	2005 emissions reported here excluded ADC waste, which was excluded from 2010 calculations as well.
TOTAL Comparable Emissions			**1,130,113**	**1,035,766**	**-8%**	

Source: StopWaste.org 2013

Regulatory Setting

This report has been prepared at a time where accepted practice and legislation regarding how government agencies should address climate change continues to evolve. This section summarizes the current and relevant federal, State, and local regulatory programs, plans, and policies that apply to GHG emissions and land use planning.

Federal

Supreme Court Ruling

The U.S. Environmental Protection Agency (EPA) is the federal agency responsible for implementing the Federal Clean Air Act (CAA). The Supreme Court of the United States ruled on April 2, 2007 that CO_2 is an air pollutant as defined under the CAA, and that EPA has the authority to regulate emissions of GHGs.

Mandatory GHG Reporting Rule

On September 22, 2009, EPA issued a final rule for mandatory reporting of GHGs from large GHG emissions sources in the United States. In general, this national reporting requirement will provide EPA with accurate and timely GHG emissions data from facilities that emit 25,000 metric tons (MT) or more of CO_2 per year. This publicly available data will allow the reporters to track their own emissions, compare them to similar facilities, and aid in identifying cost-effective opportunities to reduce emissions in the future. Reporting is at the facility level, except that certain suppliers of fossil fuels and industrial GHGs along with vehicle and engine manufacturers will report at the corporate level. An estimated 85 percent of the total U.S. GHG emissions, from approximately 10,000 facilities, are subject to this final rule.

Proposed GHG Permitting Requirements on Large Industrial Facilities

On May 13, 2010, EPA issued the Prevention of Significant Deterioration and Title V Greenhouse Gas Tailor Rule (EPA 2010). This final rule sets thresholds for GHG emissions that define when permits under the New Source Review Prevention of Significant Deterioration (PSD) and Title V Operating Permit programs are required for new and existing industrial facilities.

Endangerment and Cause or Contribute Findings

On December 7, 2009, EPA adopted its Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases under the CAA (Endangerment Finding). The Administrator (of EPA) found that atmospheric concentrations of GHGs endanger the public health and welfare within the meaning of Section 202(a) of the CAA. The evidence supporting this finding consists of human activity resulting in "high atmospheric levels" of GHG emissions, which are very likely responsible for increases in average temperatures and other climatic changes. Furthermore, the observed and projected results of climate change (e.g., higher likelihood of

heat waves, wild fires, droughts, sea level rise, higher-intensity storms) are a threat to the public health and welfare. Therefore, GHGs were found to endanger the public health and welfare of current and future generations. The Administrator also found that GHG emissions from new motor vehicles and motor vehicle engines are contributing to air pollution, which is endangering public health and welfare. EPA's final findings respond to the 2007 U.S. Supreme Court decision that GHGs fit within the CAA definition of air pollutants.

National Program to Cut GHG Emissions and Improve Fuel Economy for Cars and Trucks

On August 28, 2012 EPA and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) issued joint Final Rules for Corporate Average Fuel Economy (CAFE) standards for vehicle model years 2017 and beyond (NHTSA 2012). These first-ever national GHG emissions standards will increase fuel economy to the equivalent of 54.5 miles per gallon (mpg) for cars and light-duty trucks by model year 2025. EPA approved these standards under the CAA, and NHTSA approved them under the Energy Policy and Conservation Act.

Climate Change Adaptation

Activities are already underway across the federal government to build adaptive capacity and increase resilience to climate change. These activities include efforts to improve understanding of climate science and impacts, to incorporate climate change considerations into policies and practices, and to strengthen technical support and capacity for adaptation decision making. Some efforts are large collaborative undertakings involving federal and non-federal partners while others are smaller and at the program-level. The Climate Change Adaptation Task Force, co-chaired by the White House Council on Environmental Quality (CEQ), the Office of Science and Technology Policy (OSTP), and the National Oceanic and Atmospheric Administration (NOAA), makes recommendations to President Obama for how Federal Agency policies and programs can better prepare the United States to respond to the impacts of climate change (CEQ 2011).

State

The California Air Resources Board (ARB) is the agency responsible for coordination and oversight of state and local air pollution control programs in California and for implementing the California Clean Air Act (CCAA), which was adopted in 1988. Various statewide and local initiatives to reduce the state's contribution to GHG emissions have raised awareness that, even though the various contributors to and consequences of global climate change are not yet fully understood, global climate change is under way, and there is a real potential for severe adverse environmental, social, and economic effects in the long term. Because every nation emits GHGs and therefore makes an incremental cumulative contribution to global climate change, cooperation on a global scale will be required to reduce the rate of GHG emissions to a level that can help to slow or stop the human-caused increase in average global temperatures and associated changes in climatic conditions.

Executive Order S-3-05

Executive Order S-3-05, which was signed by Governor Schwarzenegger in 2005, proclaims that California is vulnerable to the impacts of climate change. It declares that increased temperatures could reduce the Sierra Nevada snowpack, further exacerbate California's air quality problems, and potentially cause a rise in sea level. To combat those concerns, the Executive Order established total GHG emission targets. Specifically, emissions are to be reduced to the 2000 level by 2010, the 1990 level by 2020, and to 80 percent below the 1990 level by 2050. This Executive Order is binding only on state agencies, and has no force of law for local governments; however, the signing of S-3-05 sent a clear signal to the California Legislature about the framework and content for legislation to reduce GHG emissions.

Assembly Bill 32, The California Global Warming Solutions Action of 2006

In September 2006, Governor Arnold Schwarzenegger signed Assembly Bill (AB) 32, the California Global Warming Solutions Act of 2006. AB 32 establishes regulatory, reporting, and market mechanisms to achieve quantifiable reductions in GHG emissions and a cap on statewide GHG emissions. AB 32 requires that statewide GHG emissions be reduced to 1990 levels by 2020. This reduction will be accomplished through an enforceable statewide cap on GHG emissions that will be phased in starting in 2012. To effectively implement the cap, AB 32 directs the ARB to develop and implement regulations to reduce statewide GHG emissions from stationary sources.

Assembly Bill 32 Climate Change Scoping Plan

In December 2008, ARB adopted its Climate Change Scoping Plan, which contains the main strategies California will implement to achieve reduction of approximately 118 million metric tons (MMT) CO_2e, or approximately 22 percent from the state's projected 2020 emission level of 545 MMT of CO_2e under a business-as-usual scenario (this is a reduction of 47 MMT CO_2e, or almost 10 percent, from 2008 emissions). ARB's original 2020 projection was 596 MMT CO_2e, but this revised 2020 projection takes into account the economic downturn that occurred in 2008 (ARB 2011b). The Scoping Plan reapproved by ARB in August 2011 includes the Final Supplement to the Scoping Plan Functional Equivalent Document (FED), which further examined various alternatives to Scoping Plan measures. The Scoping Plan also includes ARB-recommended GHG reductions for each emissions sector of the state's GHG inventory. ARB estimates the largest reductions in GHG emissions to be achieved by implementing the following measures and standards (ARB 2011b):

- improved emissions standards for light-duty vehicles (26.1 MMT CO_2e),
- the Low-Carbon Fuel Standard (LCFS) (15.0 MMT CO_2e),
- energy efficiency measures in buildings and appliances (11.9 MMT CO_2e), and
- renewable portfolio and electricity standards for electricity production (23.4 MMT CO_2e).

In 2011, ARB adopted the cap-and-trade regulation. The cap-and-trade program covers major sources of GHG emissions in the state such as refineries, power plants, industrial facilities, and transportation fuels. The cap-and-trade program includes an enforceable emissions cap that will decline over time. The State distributes allowances, which are tradable permits, equal to the emissions allowed under the cap. Sources under the cap are required to surrender allowances and offsets equal to their emissions at the end of each compliance period (ARB 2012a).

With regard to land use planning, the Scoping Plan expects that reductions of approximately 3.0 MMT CO_2e will be achieved through implementation of Senate Bill (SB) 375, which is discussed further below (ARB 2011b).

AB 32 also requires that the Scoping Plan be updated every five years. ARB began efforts to update the Scoping Plan in 2012, and the update is scheduled to be adopted by December 2013. ARB expects that the 2013 Update to the AB 32 Scoping Plan will: summarize the scientific advancements concerning the understanding of climate change and its impacts, highlight California's accomplishments to date (including State, regional and local climate initiatives), quantify progress toward meeting the 2020 GHG emissions goal, examine the economic impacts of actions taken to support that goal, identify opportunities to pursue additional measures as appropriate (such as uncovered sectors or short-lived climate pollutants), and lay the foundation for the research and policy work needed to map the path to the post-2020 goals. (ARB 2013).

Senate Bill 375

SB 375, signed in September 2008, aligns regional transportation planning efforts, regional GHG emission reduction targets for cars and light trucks, and land use and housing allocation. SB 375 requires Metropolitan Planning Organizations (MPOs) to adopt a Sustainable Communities Strategy (SCS) or Alternative Planning Strategy (APS), which integrate regional land use planning within an MPO's Regional Transportation Plan (RTP). The Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG) are jointly responsible for developing the SCS for the Bay Area. Known as Plan Bay Area, this SCS is the successor to Transportation 2035, the long-range RTP adopted by MTC in 2009. Plan Bay Area is scheduled for adoption in summer 2013 and covers the time period through 2040 (One Bay Area 2013).

ARB, in consultation with MPOs, will provide each affected region with reduction targets for GHGs emitted by passenger cars and light trucks in the region for the years 2020 and 2035. These reduction targets will be updated every 8 years, but can be updated every 4 years if advancements in emissions technologies affect the reduction strategies to achieve the targets. The specific GHG reduction targets to be used by MTC and ABAG in Plan Bay Area include 7 percent below 2005 emissions levels by 2020, and 15 percent below 2005 levels by 2035 (ARB 2012b). ARB is also charged with reviewing each MPO's SCS or APS for consistency with its assigned targets. If MPOs do not meet the GHG emission reduction targets, transportation projects would not be eligible for funding programmed after January 1, 2012.

Senate Bill 97

As directed by SB 97, the California Natural Resources Agency (CNRA) adopted Amendments to the California Environmental Quality Act (CEQA) Guidelines for GHG emissions on December 30, 2009. On February 16, 2010, the Office of Administrative Law approved the Amendments, and filed them with the Secretary of State for inclusion in the California Code of Regulations. The Amendments became effective on March 18, 2010.

CEQA allows lead agencies to analyze and mitigate the significant effects of GHG emissions at a programmatic level, such as in a general plan, or as part of a separate plan (e.g., a climate action plan) to reduce GHG emissions (CEQA 15183.5).

Renewable Electricity (or Renewable Portfolio) Standard

SB 1078 (Chapter 516, Statutes of 2002) requires retail sellers of electricity, including investor-owned utilities and community choice aggregators, to provide at least 20 percent of their supply from renewable sources by 2017. SB 107 (Chapter 464, Statutes of 2006) changed the target date to 2010. On November 17, 2008, Governor Schwarzenegger signed Executive Order S-14-08 requiring all retail sellers of electricity to serve 33 percent of their load with renewable energy by 2020. The following year, Executive Order S-21-09 directed the California Air Resources Board, under its Assembly Bill 32 authority, to enact regulations to achieve the goal of 33 percent renewables by 2020. In 2011, Governor Brown signed SB X1-2 codified the 33 percent by 2020 standard into law.

The California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) jointly implement the statewide Renewable Portfolio Standard (RPS) program through rulemakings and monitoring the activities of electric energy utilities in the state (CPUC 2012a).

Executive Order S-1-07, Low-Carbon Fuel Standard

Executive Order S-1-07, which was signed by Governor Schwarzenegger in 2007, proclaims that the transportation sector is the main source of GHG emissions in California, at over 40 percent of statewide emissions. It establishes a goal that the carbon intensity of transportation fuels sold in California should be reduced by a minimum of 10 percent by 2020. This order also directed ARB to determine if this Low Carbon Fuel Standard (LCFS) could be adopted as a discrete early action measure after meeting the mandates in AB 32. ARB adopted the LCFS on April 23, 2009.

Advanced Clean Cars Program

In January 2012, ARB approved a new emissions-control program for model years 2017 through 2025 of passenger vehicles and light-duty trucks that addresses emissions from passenger vehicles and light-duty trucks. In addition to establishing more stringent emission standards for both GHGs and criteria air pollutants (and precursors), the program increases requirements of manufacturers to produce more Zero Emission Vehicles, including battery electric vehicles, hydrogen fuel cell vehicles, and plug-in hybrid electric vehicles. The program also includes a

Clean Fuels Outlet regulation that helps make sure that fuels such as electricity and hydrogen are available to meet the fueling needs of the new advanced technology vehicles as they come to market. More specifically, it requires major refiners/importers of gasoline to develop hydrogen fueling stations to meet demand for hydrogen fuel (ARB 2012c).

California Building Codes, Title 24

Title 24 of the California Code of Regulations (CCR) regulates how each new home and business is built or altered in California. It includes requirements for the structural, plumbing, electrical, and mechanical systems of buildings, and for fire and life safety, energy conservation, green design, and accessibility in and about buildings. Two sections of Title 24 – Part 6, the California Energy Code, and Part 11, the California Green Building Standards Code or CalGreen Code – contain standards that address GHG emissions related to new construction. These two sections require direct electricity, natural gas, and water savings for every new home or business built in California. Part 6, which was last updated in January 2011, also includes requirements for lighting, insulation and equipment upgrades to residential and nonresidential buildings undergoing additions, alterations or repairs. CCR Title 24 codes are statewide codes and standards that must be enforced by local agencies through the construction application process.

The California Green Building Standards Code, or CalGreen, became a mandatory code beginning January 1, 2011. The code takes a holistic approach to green building by including minimum requirements in the areas of planning and design, energy efficiency, water efficiency and conservation, material conservation and resource efficiency, and environmental quality. The CalGreen code has minimum mandatory standards and two additional tiers of voluntary measures intended to achieve greater levels of efficiency that result in lower levels of GHG emissions. Local governments must enforce the minimum standards and can choose to adopt either Tier 1 or Tier 2 standards to achieve greater positive environmental impacts.

Mandatory CalGreen standards do not require explicit reductions in energy consumption beyond the minimum Title 24 Part 6 standards. However, if a local agency elects to adopt either of the optional tiers of CalGreen, additional prerequisites and electives must be implemented by new development projects. For the voluntary energy efficiency prerequisites, Tier 1 is a 15 percent and Tier 2 is a 30 percent improvement over minimum Title 24 Part 6 requirements.

California Solar Initiative

The California Solar Initiative (CSI) was authorized in 2006 under SB 1 and allows the California Public Utilities Commission (CPUC) to provide incentives to install solar technology on existing residential, commercial, nonprofit, and governmental buildings if they are customers of the State's investor-owned utilities (IOUs), including Pacific Gas & Electric (PG&E). The CSI program has a budget of nearly $2.2 billion to be expended by 2016 with a goal to reach 1,940 megawatts (MW) of installed solar power throughout the state by that time (CPUC 2012b). The CSI program has several components, including the Research and Development, Single-family

Affordable Solar Housing (SASH), Multi-family Affordable Solar Housing (MASH), and Solar Water Heating Pilot Program, each of which provides incentives to further the installation of solar technology on California's buildings.

California Climate Adaptation Strategy

In 2009, California adopted a statewide Climate Adaptation Strategy (CAS) that summarizes climate change impacts and recommends adaptation strategies across seven sectors: public health; biodiversity and habitat; oceans and coastal resources; water; agriculture; forestry; and transportation and energy. The 2009 CAS was the first of its kind in the usage of downscaled climate models to more accurately assess statewide climate impacts as a basis for providing guidance for establishing actions that prepare, prevent, and respond to the effects of climate change (CNRA 2009). The California Natural Resources Agency, in coordination with other state agencies, began updating the Climate Adaptation Strategy in 2012, and a draft is planned for release for public review and comment in early 2013 (CNRA 2013).

Model Policies for Greenhouse Gases in General Plans

In June 2009 the California Air Pollution Control Officers Association (CAPCOA) prepared a white paper that presents model policies for addressing GHG emissions in general plans. CAPCOA intends this paper to be a resource rather than a guidance document intended to dictate how local communities should address GHG emission in their general plans. Model language is provided in nine major categories: GHG reduction planning (overall); land use and urban design; transportation; energy efficiency; alternative energy; municipal operations; waste reduction and diversion; conservation and open space; and education (CAPCOA 2009).

Regional and Local

Bay Area Air Quality Management District

The Bay Area Air Quality Management District (BAAQMD) is the lead air quality regulatory agency for the San Francisco Bay Area Air Basin. BAAQMD maintains air quality conditions through comprehensive programs of planning, regulation, enforcement, technical innovation, and promotion of the understanding of air quality issues, as well as reducing GHG emissions. A number of BAAQMD programs related to GHG emissions are addressed below.

Climate Protection Program

On June 1, 2005 the Air District Board of Directors adopted a resolution establishing a Climate Protection Program and acknowledging the link between climate protection and programs to reduce air pollution in the Bay Area. The Board of Directors also formed a standing Committee on Climate Protection to provide direction on District climate protection activities.

A central element of the District's climate protection program is the integration of climate protection activities into existing District programs. The District is continually seeking ways to

integrate climate protection into current District functions, including grant programs, CEQA commenting, regulations, inventory development, and outreach. In addition, the District's climate protection program emphasizes collaboration with ongoing climate protection efforts at the local and State level, public education and outreach and technical assistance to cities and counties (BAAQMD 2012a).

Greenhouse Gas Fee for Stationary Sources

On May 21, 2008, the District's Board of Directors approved a new fee on air pollution sources in the region to help defray the costs associated with the District's climate protection activities and programs, including environmental review, air pollution regulations and emissions inventory development. Industrial facilities and businesses that are currently required to submit an air quality permit to operate are required to pay a fee of 4.4 cents per metric ton of GHG emissions added to their permit bill. The fee will apply to climate protection program activities related to stationary sources, such as developing emission inventories (BAAQMD 2012a).

Bay Area 2010 Clean Air Plan

The Bay Area 2010 Clean Air Plan provides a comprehensive plan to improve Bay Area air quality and protect public health. The Clean Air Plan defines a control strategy that the BAAQMD and its partners will implement to: (1) reduce emissions and decrease ambient concentrations of harmful pollutants; (2) safeguard public health by reducing exposure to air pollutants that pose the greatest health risk, with an emphasis on protecting the communities most heavily impacted by air pollution; and (3) reduce GHG emissions to protect the climate. In its dual roles as an update to the Bay Area state ozone plan and a multi-pollutant plan, the 2010 Clean Air Plan addresses four categories of pollutants: ground-level ozone and its key precursors (ROG and NO_X), particulate matter ($PM_{2.5}$ as well as precursors secondary to $PM_{2.5}$), air toxics, and greenhouse gases (BAAQMD 2010b).

The 2010 Clean Air Plan provides a control strategy containing over 55 control measures applicable to a number of different sources, including:

- 18 Stationary Source Measures,
- 10 Mobile Source Measures,
- 17 Transportation Control Measures,
- 6 Land Use and Local Impact Measures, and
- 4 Energy and Climate Measures.

California Environmental Quality Act Guidelines

The BAAQMD CEQA Guidelines are developed to assist local jurisdictions and lead agencies in complying with the requirements of CEQA regarding potentially adverse impacts related to both air quality and climate change. These CEQA Guidelines were updated in June 2010 to

include reference to thresholds of significance ("Thresholds") adopted by the Air District Board on June 2, 2010. The Guidelines were further updated in May 2011. On March 5, 2012 the Alameda County Superior Court issued a judgment finding that the BAAQMD had failed to comply with CEQA when it adopted the Thresholds. The court did not determine whether the Thresholds were valid on the merits, but found that the adoption of the Thresholds was a project under CEQA. The court issued a writ of mandate ordering BAAQMD to set aside the Thresholds and cease dissemination of them until the Air District had complied with CEQA. The BAAQMD has appealed the Alameda County Superior Court's decision. The appeal is currently pending in the Court of Appeal of the State of California, First Appellate District.

In view of the court's order, BAAQMD is no longer recommending that the Thresholds be used as a generally applicable measure of a project's significant air quality or climate change impacts. Lead agencies will need to determine appropriate thresholds of significance based on substantial evidence in the record. Although lead agencies may rely on the District's CEQA Guidelines (updated May 2011) for assistance in calculating air pollution and GHG emissions, obtaining information regarding the health impacts of air pollutants, and identifying potential mitigation measures, BAAQMD has been ordered to set aside the Thresholds and is no longer recommending that these Thresholds be used as a general measure of a project's significant impacts. Lead agencies may continue to rely on the BAAQMD's 1999 Thresholds of Significance and they may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project (BAAQMD 2012b).

Tables 7.3-5 and 7.3-6 in the Air Quality section (7.3) of this Report contain both the 1999 and proposed 2010 Thresholds related to both Air Quality and Climate Change impacts, including GHG emissions, for both project-level and plan-level analysis. The 1999 Thresholds do not address GHG emissions. The proposed 2010 Thresholds related to GHG emissions are as follows:

- Project Level
  - Stationary Sources: 10,000 $MTCO_2e$/year
  - Projects Other than Stationary Sources: a.) Compliance with Qualified GHG Reduction Strategy, OR b.) 1,100 $MTCO_2e$/yr, OR c.) 4.6 $MTCO_2e$ per service population per year (sp/yr). Service population is defined as total residents and employees.
- Plan-Level
  - Compliance with Qualified GHG Reduction Strategy (or similar criteria included in a General Plan), OR
  - 6.6 $MTCO_2e$/ sp/yr (residents + employees)

Greenhouse Gas Plan Level Guidance

In May 2012, the BAAQMD issued GHG Plan Level Guidance to assist local governments in developing community scale GHG emission inventories and projections, quantifying emission reductions from various policies and mitigation measures, and developing effective climate protection strategies. The Guidance is based on established methodologies and practices, and is intended to be a set of recommended approaches rather than formal protocol.

Included within the Guidance are qualitative criteria that the BAAQMD will use to judge whether a climate action plan (CAP) or other plan designed to reduce communitywide GHG emissions (e.g. sustainability plan or general plan) will meet the criteria established by the Governor's Office of Planning and Research (OPR) per CEQA Guidelines Section 15183.5. These qualitative criteria are as follows:

- GHG emissions inventory should be complete and comprehensive,
- calculations and assumptions should be transparent,
- GHG reduction strategies should rely primarily on mandatory measures,
- build in a margin of safety,
- measures should address existing as well as new development, and
- implementation and monitoring should be clearly defined.

The Guidance document also provides guidance on developing the quantitative sections of a local CAP, including development of GHG emission inventories, projections, mitigation measures, and implementation and monitoring procedures (BAAQMD 2012c).

Alameda County Climate Protection Project

In 2006, the City of Hayward joined other local governments in Alameda County participating in the Alameda County Climate Protection Project (ACCPP). ACCPP was launched by the Alameda County Waste Management Authority & Recycling Board (also known as StopWaste.org) in partnership with the Alameda County Conference of Mayors and ICLEI USA – Local Governments for Sustainability. All participating jurisdictions agreed to join ICLEI's Cities for Climate Protection Program. ICLEI and StopWaste.Org have provided assistance to each participating jurisdiction in various aspects of the 5-step climate action planning process outlined in this program, which includes conducting a baseline greenhouse gas emissions inventory and forecasts; setting a community-wide GHG emissions reduction target; developing a CAP that consists of polices and measures to meet the GHG reduction target; implementing the CAP; and monitoring and verification of results (StopWaste.org 2013b).

Hayward Climate Action Plan

The City of Hayward adopted a CAP in 2009. The CAP was developed in accordance with ICLEI's Cities for Climate Protection Program 5-step process referenced above. The CAP's primary components are summarized below.

Baseline GHG Inventory and Projections

A GHG emissions inventory was conducted by ICLEI on behalf of the City for the baseline year 2005. Total annual emissions in 2005 were estimated to be approximately 1.18 $MMTCO_2e$ (see Existing Conditions above for a more detailed breakdown and discussion of the inventory). Projections of future emission growth are provided for two scenarios, both of which were based on ICLEI growth rates related to population and employment growth, by sector, for the years 2020 and 2050:

- Scenario 1 estimated that emissions would increase by approximately 0.28 $MMTCO_2e$ (nearly 24 percent) by 2020 and 0.95 $MMTCO_2e$ (over 80 percent) by 2050. This scenario assumed no changes in vehicle fuel economy or statewide renewable portfolio standard (RPS), and is commensurate with projected growth in population and employment by these respective years, therefore representing a truly "business-as-usual" projection.
- Scenario 2 estimated that emissions would increase by a much lower 30,000 $MTCO_2e$ by 2020 (less than 1 percent) and about 80,000 $MTCO_2e$ by 2050 (about 7 percent). This scenario assumed the same base growth rates as Scenario 1, however legislative changes to improve vehicle fuel economy and the statewide RPS over time were also assumed, therefore leading to much lower projected emissions in 2020 and 2050.

Scenario 2 was selected as the basis for estimated future GHG emissions for the CAP, based on legislative changes to State and federal policy related to vehicle fuel economy and RPS (City of Hayward 2009).

Greenhouse Gas Reduction Targets

The CAP sets a series of GHG emission reduction targets for both communitywide and City operations-specific emissions, expressed as a percentage by which emissions must be reduced below the 2005 baseline, by the target years of 2013, 2020 and 2050. The City aims to reduce emissions by the following amounts:

- 6 percent below 2005 levels by 2013,
- 12.5 percent below 2005 levels by 2020, and
- 82.5 percent below 2005 levels by 2050.

These targets, when viewed against Scenario 2 projections, require that emissions be reduced communitywide by a total of 154,642 $MTCO_2e$ by 2020, and 1.07 $MMTCO_2e$ by 2050 (City of Hayward 2009).

Greenhouse Gas Emission Reduction Plan

The CAP includes nine strategies to guide the City's effort in reducing GHG emissions and addressing climate adaptation issues. Each of these strategies includes a number of specific implementing actions in order to achieve GHG emission reductions and/or other co- benefits. Many of the actions have quantifiable GHG reduction benefits; however some of the actions could not be quantified but are supportive of the overall strategies they support. The nine strategies are:

- Strategy 1 – Transportation and Land Use: Reduce Vehicle Miles Traveled
- Strategy 2 – Transportation: Decrease the Carbon-Intensity of Vehicles
- Strategy 3 – Energy: Improve Energy Performance of Existing Buildings
- Strategy 4 – Energy: Improve Energy Performance of New Buildings
- Strategy 5 – Energy: Use Renewable Energy
- Strategy 6 – Solid Waste: Increase Waste Reduction and Recycling
- Strategy 7 – Sequester Carbon
- Strategy 8 – Climate Change Adaptation
- Strategy 9 – Engage and Educate Community

The CAP estimates that full implementation of all strategies and associated actions would result in reductions of about 189,000 $MTCO_2e$ by 2020, and 1.084 $MMTCO_2e$ by 2050, thereby meeting the 2020 and 2050 GHG reduction targets (City of Hayward 2009).

Implementation of the Climate Action Plan

The CAP includes a section that sets up various implementation mechanisms and approaches to ensure that meeting the targets under the plan's strategies and numerous actions is successful. These include a number of specific programs and activities, such as management of staff resources (i.e. setting up a Climate Action Management Team, appointing a staff Sustainability Coordinator), ensuring citizen and business participation, prioritization of actions across all strategies, and the creation of a financial plan and development of funding sources to support CAP implementation.

Ongoing Measurement and Verification

The CAP includes a final section that establishes a framework for monitoring progress in meeting the CAP's targets and performance goals, to enable informed decisions about specific CAP-related programs, provide credible and defensible data, and prepare for future reporting requirements. A number of key monitoring and verification programs and activities are recommended, including:

- Completion of a full GHG emissions inventory every three to five years to measure and verify that emissions are actually decreasing over time
- Documentation and evaluation of the effectiveness of the City's climate programs on a regular basis. This includes tracking key indicators relative to each of the GHG emission sectors and GHG Reductions Strategies in the CAP.

In 2012, a full GHG emissions inventory for both communitywide and municipal operations was prepared by StopWaste.org for the year 2010 (see Existing Conditions above in this section for a more detailed discussion and breakdown of the 2010 inventory).

Key Terms

The following key terms used in this chapter are defined as follows:

Carbon dioxide (CO_2). Carbon dioxide is an odorless and colorless GHG. CO_2 is emitted from natural sources, such as the decomposition of dead organic matter; respiration of bacteria, plants, animals, and fungus; evaporation from oceans; and volcanic out-gassing. Anthropogenic (man-made) sources include the burning of fossil and other fuels (e.g., coal, oil, natural gas, wood).

Carbon dioxide equivalent (CO_2e). A unit for describing how much global warming a given type and amount of GHG may cause, normalized to a functionally equivalent amount or concentration of CO_2 as the reference. See Global Warming Potential.

Carbon Sequestration. Carbon storage (sequestration) occurs in forests and soils, primarily through the natural process of photosynthesis. Atmospheric CO_2 is taken up through leaves and becomes carbon in the woody biomass of trees and other vegetation where it is stored.

Climate Action Plan (CAP). A Climate Action Plan is a planning document that lays out a set of strategies and policy recommendations intended to reduce GHG emissions associated with a given entity, agency, or jurisdiction.

Climate Change. Climate change refers to long-term changes in temperature, precipitation, and other elements of the earth's climate system. An ever-increasing body of scientific research attributes these climatological changes to GHGs, particularly those generated from the human production and use of fossil fuels.

Global Warming Potential (GWP). GWP is one type of simplified index based upon properties of the GHG that can be used to estimate the effect on the climate system with reference to CO_2. For example, one ton of methane is as potent a GHG as 21 tons of CO_2. Methane has GWP of 21 CO_2e. See also Carbon Dioxide Equivalent.

Greenhouse Effect. The earth's natural warming process is known as the "greenhouse effect." Certain atmospheric gases that trap heat in the atmosphere, causing the greenhouse effect, are referred to as GHGs.

Greenhouse Gases (GHG). Gases that contribute to the greenhouse effect. Some GHGs such as carbon dioxide (CO_2) occur naturally, and are emitted to the atmosphere through natural processes and human activities. Other GHGs (e.g., fluorinated gases) are created and emitted solely through human activities. The principal GHGs that enter the atmosphere because of human activities include: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Chlorofluorocarbons (CFCs), and fluorinated gases (hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Greenhouse Gas (GHG) Inventory. A greenhouse gas (GHG) inventory is an accounting of the amount of GHGs emitted to or removed from the atmosphere over a specific period of time (e.g., one year) for a specified area. A GHG inventory also provides information on the activities that cause emissions, as well as background on the methods used to make the calculations. Policy makers use GHG inventories to track emission trends, develop strategies and policies, and assess progress in reducing GHG emissions.

Methane (CH_4). Methane is a GHG with GWP of 21. Anthropogenic (human-caused) sources of methane emissions include agricultural activities, natural gas consumption, landfills, wastewater treatment plants, and mobile sources.

Nitrous oxide (N_2O). N_2O is a GHG with GWP of 310. Nitrous oxide sources include wastewater treatment plants, fertilizer application and soil management in agricultural activities, and mobile sources.

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