Appendices

CONTENTS

Appendix A
Emissions Inventory and Projections Methodology

2008-2050 EMISSIONS

Ascent Environmental, Inc. (Ascent) developed a base-year (2008) greenhouse gas (GHG) emissions inventory for sources in unincorporated Yolo County (County) and future-year (i.e., 2020, 2030, 2040, and 2050) GHG emission projections. Options for the County's GHG emission reduction targets were also calculated and evaluated for consideration. This appendix presents the results of each of these tasks. For details on the historic (1990) GHG emissions inventory, please refer to the section of this appendix titled *1990 Emissions*. Also, please note that the 1990 emissions inventory contains emissions information for the University of California, Davis (UCD), tribal activities, and the incorporated cities of Davis, West Sacramento, Winters, and Woodland.

The field of emissions inventory development and available tools and methods continue to evolve in the absence of standardized guidance. State-of-the-practice methods underlain by factual historical data were used to develop the inventory, as discussed below. The 2008 base-year inventory and projections were compiled for the following emission sectors: energy use (i.e., electricity, natural gas, propane, and water consumption); transportation; solid waste; stationary sources; construction and mining; agriculture; and wastewater treatment.

The 1990 historic and 2008 base-year inventories were developed using a consistent bottom-up approach to afford an "apples-to-apples" comparison. The 1990 historic inventory is occasionally discussed in the sections that follow; however, for details on preparation of the 1990 inventory, please see the section of this appendix titled *1990 Emissions*. Future year GHG emissions projections were developed under a scenario that does not account for emission reductions that would occur associated with CAP implementation, advances in technology, or emission reductions programs initiated by the State or federal government.

Key Assumptions

Emission Factors

An emission factor is a representative constant that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant (EPA 2010); it is typically expressed as a rate of emissions per unit of the activity. Several reputable sources of information can be used to gather emissions information for use in inventory development.

Sources of GHG emission factors relied upon in preparation of the 2008 base-year inventory include the following:

- California Air Resources Board (ARB): On-Road Mobile-Source Emission Factor Model (EMFAC2007), Version 2.3., 2007.
- California Air Resources Board (ARB): Off-Road Mobile-Source Emission Factor Model (OFFROAD2007), Version 2.1., 2007.
- U.S. Environmental Protection Agency (EPA): AP-42 Compilation of Emission

Factors. Chapter 2.4 Solid Waste Disposal, 2008.

- The California Climate Action Registry (CCAR): General Reporting Protocol, Version 3.1., 2009.
- Intergovernmental Panel on Climate Change (IPCC): IPCC Guidelines for National Greenhouse Gas Inventories, 2006.

The above-mentioned emission factors represent GHG emissions from activities occurring in unincorporated Yolo County.

Consumption Data

The County's 2008 base-year inventory was prepared using consumption and generation data from the following reputable sources:

- Yolo County Central Landfill (YCCL) Joint Technical Document, 2007.
- Unincorporated Yolo County Waste Generation Study, 1991.
- Yolo-Solano Air Quality Management District (YSAQMD) Permitted Stationary Sources in Yolo County, 2008.
- Yolo County General Plan Background Report, 2005.
- Yolo County General Plan travel demand forecasting (TDF) model, Fehr & Peers, 2010.
- Community Service District Waste Discharge Requirements (Esparto, Knights Landing, Madison Waste Water Treatment Facilities data).
- California Energy Commission (CEC). Refining Estimates of Water-Related Energy Use in California. CEC-500-2006-118, 2006 (December).
- UCD. Agricultural and Resource Economics: Current Cost and Return Studies, 2010.
- Pacific Gas and Electric (PG&E). Aggregated Community-wide Natural Gas and Electricity Consumption data, 2008.
- Yolo County and Davis Public Works Department for water consumption data.
- Yolo County Agricultural Commissioner. 2008. Crop Reports.

Each of these sources includes data that are applicable to unincorporated Yolo County.

GHG emissions projections were modeled using County-specific activity data, where available, from the County's 2030 General Plan. Because full buildout of the general plan would overestimate likely growth in the unincorporated County by 2030, a more likely population of approximately 48,842 was assumed to estimate GHG emissions projections. Where County-specific activity data were not available (e.g., for years 2040 and 2050), GHG emissions projections were conducted assuming that the general plan would build out by approximately 2050.

Summary of Results

Countywide 2008 base-year emissions were calculated using a "bottom-up" approach, which involves multiplication of an emission factor for a given process by activity data describing that process. This approach ensures the highest level of control over the quality of the data used to generate the emissions inventory. Table A-1 summarizes the magnitude and relative contribution of estimated 2008 base-year emissions for each sector. Methods used to calculate each emission sector are described in the sections that follow. For detailed assumptions, please refer to the attached documentation. The results of the 1990 historic inventory are presented here for informational purposes. Please refer to the section of this appendix titled *1990 Emissions* for more detailed information.

Table A-2 summarizes the results of the 1990 historic, 2008 base-year inventory, and projections for 2020, 2030, 2040, and 2050.

Figure A-1 summarizes the relative contributions of each emissions sector to the total 1990 historic emissions in unincorporated Yolo County.

Figure A-2 summarizes the relative contributions of each emissions sector to the total 2008 base-year emissions in unincorporated Yolo County.

Figure A-3 describes the emissions growth trend in unincorporated Yolo County over the inventory and projection periods.

YOLO COUNTY GREENHOUSE GAS EMISSIONS INVENTORY METHODS

This section briefly summarizes the methods applied to each sector in the County's 2008 base-year inventory and the projections. Detailed assumptions and quantification inputs are available online and upon request from the Yolo County Planning and Public Works Department. Information on development of the 1990 inventory is provided below where pertinent to the discussion. For complete details on methods used to develop the 1990 inventory, please refer to the section of this appendix titled *1990 Emissions*.

Table A-1:
Unincorporated Yolo County Greenhouse Gas Emissions Inventory

Emissions Sector	1990 Historic Inventory		2008 Base-Year Inventory		
	MT CO_2e	%	MT CO_2e	%	% Change from 1990
Energy Consumption[1]	131,652	21.5%	181,447	27.8%	37.8%
Transportation	155,577	25.4%	105,253	16.1%	-32.3%
Solid Waste	1,654	0.3%	6,871	1.1%	315.5%
Agriculture	292,032	47.6%	297,341	45.6%	1.8%
Residue Burning	14,669	5.0%	13,917	4.7%	-5.1%
Livestock	30,000	10.3%	45,257	15.2%	50.9%
Rice Cultivation	28,389	9.7%	34,131	11.5%	20.2%
Farm Equipment	72,170	24.7%	71,667	24.1%	-0.7%
Agricultural Irrigation Pumps	39,231	13.4%	39,231	13.2%	0.0%
Pesticide Application	83	0.0%	35	0.0%	-58.4%
Fertilizer Application	98,982	33.9%	79,966	26.9%	-19.2%
Lime Application	4,344	1.5%	11,774	4.0%	171.0%
Urea Application	4,164	1.4%	1,362	0.5%	-67.3%
Wastewater Treatment	256	0.0%	974	0.1%	281.1%
Construction & Mining	14,954	2.4%	29,271	4.5%	95.7%
Stationary Sources	17,526	2.9%	30,583	4.7%	74.5%
Facilities	3,974	22.7%	8,220	26.9%	106.9%
Agricultural Processing	10,905	62.2%	16,483	53.9%	51.1%
Equipment	2,647	15.1%	5,880	19.2%	122.2%
Total[2]	613,651	100%	651,740	100%	6.2%

Notes: CO_2e = carbon dioxide equivalent; MT= metric tons.
[1] The energy consumption sector includes emissions from electricity production, natural gas and propane combustion, and water consumption.
[2] Totals may not match exactly the sum of the numbers in the applicable column due to rounding.
Source: Data compiled by Ascent Environmental, Inc. and AECOM in 2010.

Energy Consumption

Inventory Methods

For the 1990 historic inventory, electricity, natural gas, and propane consumption data for residential and non-residential land uses were based on data from the 1982 *Yolo County Energy Plan*. Consumption rates were extrapolated to 1990 using population growth estimates from the DOF (DOF 2010a). Consumption data for the 2008 base-year was obtained directly from PG&E for accounts located within the unincorporated County. Emission factors from the CCAR General Reporting Protocol were used to calculate carbon dioxide equivalent (CO_2e) emissions from these fuel types.

GHG emissions associated with water consumption (i.e., conveyance, treatment, and distribution) were estimated using water consumption data obtained from the County and the City of Davis (for Royal

Table A-2: Unincorporated Yolo County 1990 Historic and 2008 Base-Year Greenhouse Gas Emissions Inventory and Future-Year Projections						
Emissions Sector	Unincorporated Yolo County (MT of CO_2e)					
	1990	2008	2020	2030	2040	2050
Energy Consumption[1]	131,652	181,447	404,929	628,444	689,093	748,757
Transportation	155,577	105,253	285,492	465,731	510,677	554,733
Solid Waste	1,654	6,871	12,660	18,449	20,230	21,975
Agriculture	292,032	297,341	289,482	281,624	281,624	281,624
Wastewater Treatment	256	974	974	709	709	709
Construction & Mining	14,954	29,271	34,414	39,558	39,558	39,558
Stationary Sources	17,526	30,583	37,068	43,588	43,588	43,588
Total [2]	613,651	651,740	1,065,038	1,478,103	1,585,478	1,690,944

Notes: CO_2e = carbon dioxide equivalent; MT= metric tons.
[1] Energy consumption includes emissions from electricity production, from natural gas and propane combustion, and domestic water consumption.
[2] Totals may not match exactly the sum of the numbers in the applicable column due to rounding.
Source: Data compiled by Ascent Environmental, Inc. in 2010.

Figure A-1

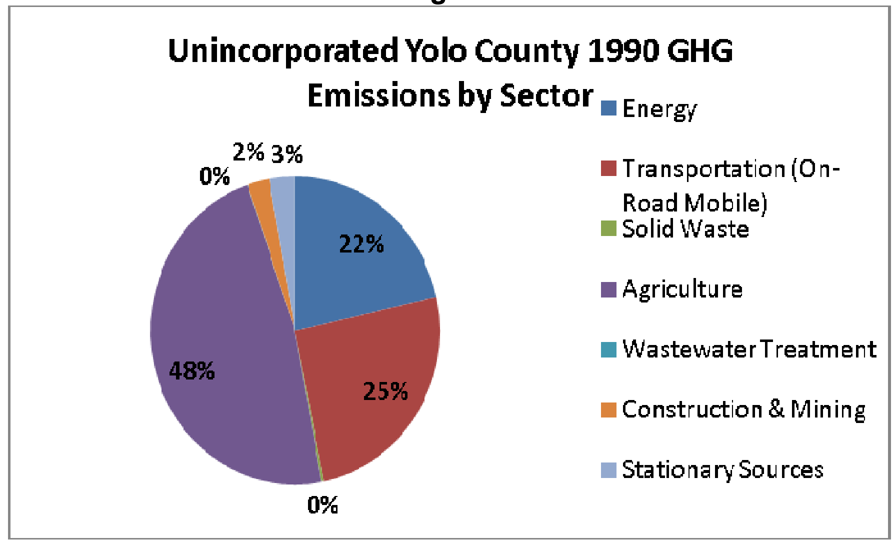
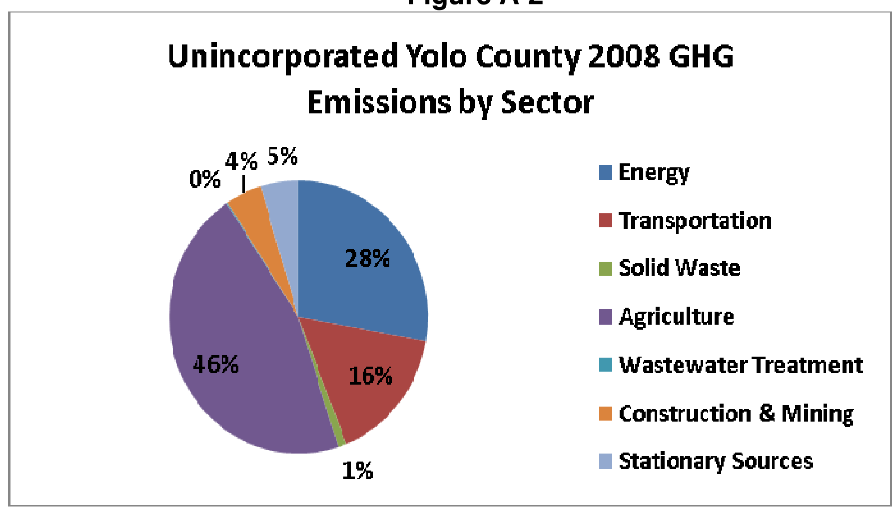


Figure A-2



Oaks and El Macero, which are located in the unincorporated County, but are provided water by the City of Davis). Emission factors from CCAR for electricity consumption were used to calculate CO_2e. Water consumption-related CO_2e emissions were included within the energy sector, because electricity is used to convey, treat, and pump water. Agriculture related water consumption is included as a sub-sector under agricultural emissions as agricultural irrigation pumps.

Projection Methods

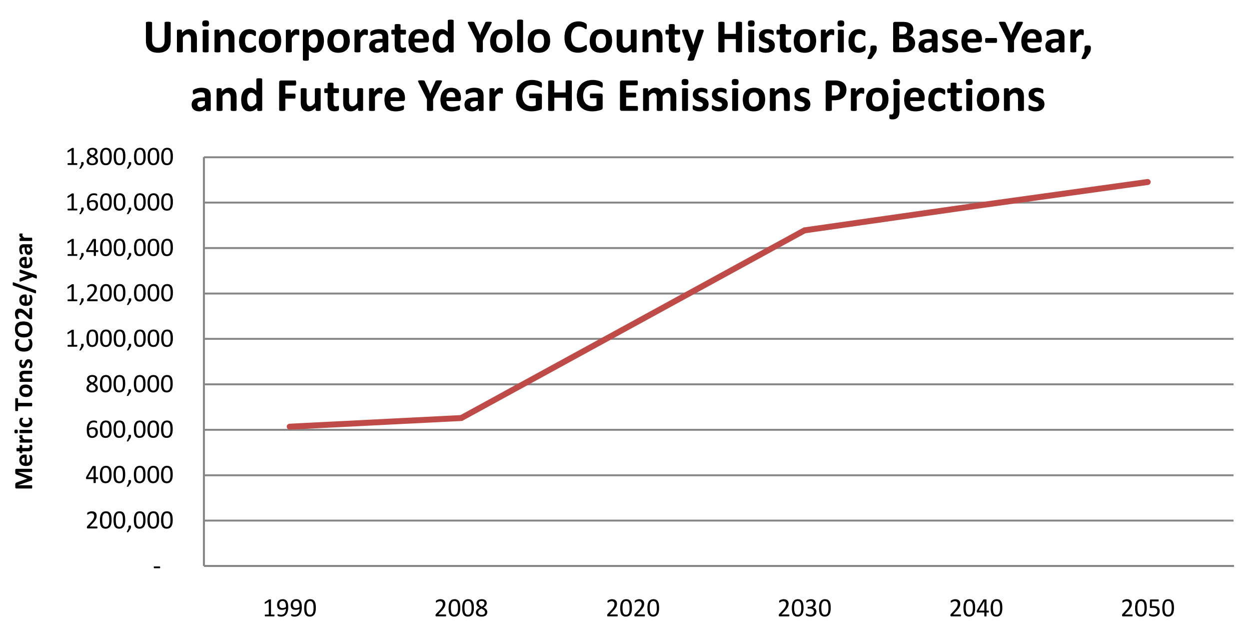
Energy-related GHG emissions for the 2030 projection were based on data from the Public Utilities section of the Yolo County General Plan EIR and fuel consumption growth rates from the U.S. Department of Energy, Energy Information Administration (2010) for the Pacific Region (which includes California). These projected 2030 energy consumption values were scaled down proportionally because it was assumed that only approximately 50% of the general plan would build out by 2030. Energy-related GHG emissions for the 2020 projection were interpolated between 2008 and 2030. Energy consumption growth rates were not available for the 2040 and 2050 projections; thus, population growth rates in Yolo County were used as an indicator of growth in energy consumption for those years assuming that the general plan would build out by approximately 2050. No emission reductions from statewide energy conservation programs or renewable energy requirements were accounted for in GHG emissions projections in Table A-2. See Table A-8 for estimates of reductions that may occur associated with State and federal GHG reduction programs and legislation.

Transportation

Inventory Methods

On-road mobile-source emissions for the 1990 historic inventory were calculated using Caltrans Highway Performance Monitoring System (HPMS) data for roadways in the unincorporated County, along with emission factors from EMFAC 2007 by speed bin (i.e., portion of vehicle miles traveled [VMT] that would occur within a range of 5-mile-per-hour increments). HPMS data for 1990 was used in combination with data prepared by Fehr & Peers (2010) from the Yolo County General Plan Traffic Demand Forecasting (TDF) model, which included 2005 VMT data by speed bin. The dataset obtained from Fehr & Peers accounted for trips that did not originate or terminate in the County by apportioning 50% of VMT and

Figure A-3



associated GHG emissions to Yolo County for internal-to-external trips, and external-to-internal trips. VMT and associated GHG emissions resulting from internal-to-internal trips were allocated 100% to Yolo County. This methodology is consistent with the Regional Target Advisory Committee (RTAC) recommendations in response to Senate Bill (SB) 375.

These data were used to derive a correction factor to apply to the 1990 Caltrans dataset to achieve a more accurate 1990 VMT number. Another correction was applied to the Caltrans dataset in order to allocate a percentage of the VMT that occurs on state highways to origins and/or destinations within the unincorporated County, based on 1990 population.

Transportation-related GHG emissions for the 2008 base-year inventory were calculated using emission factors from EMFAC 2007 by speed bin, and 2005 VMT data from the Yolo County General Plan TDF model. According to Caltrans HPMS traffic counts, VMT did not change significantly between 2005 and 2008, so 2005 VMT is treated as representative of 2008 conditions.

Projection Methods

Mobile-source-related GHG emissions were modeled for 2030 with the same method used to calculate 2008 mobile-source emissions. 2030 VMT data was obtained from Fehr & Peers by speed bin for the full general plan build-out. This value was scaled down proportionally because it was assumed that approximately 50% of the general plan would build out by 2030. 2020 mobile-source GHG emissions were interpolated between 2008 and 2030 emissions, and 2040 and 2050 emissions were projected using population growth rates for Yolo County that assume full general plan buildout by approximately 2050. Table A-2 does not account for reductions in emissions from statewide programs related to mobile sources (e.g., Pavley emission standards, low carbon fuel standard, or SB 375). See Table A-8 for estimates of reductions that may occur associated with State and federal GHG reduction programs and legislation.

Solid Waste

Inventory Methods

GHG emissions related to solid waste disposal were calculated using methods from EPA for the Yolo County Central Landfill (YCCL), which describes exponential decay of solid waste proportionate to the quantity of waste in place. Waste generation data for the 2008 base-year inventory were obtained from YCCL's Joint Technical Document (2007), from the Yolo County General Plan EIR, and from Yolo County Department of Public Works staff.

Projection Methods

Solid waste-related GHG emissions were modeled for the 2030 projection using waste generation data provided in the Yolo County General Plan EIR, scaled down proportionally assuming that approximately 50% of the general plan would build out by 2030. The same emissions modeling techniques were used for the YCCL as described above. Solid waste-related GHG emissions for the 2020 projection were interpolated between 2008 and 2030, and emissions for the 2040 and 2050 projections were derived using population growth rates for Yolo County that assume full general plan buildout by approximately 2050. Projected solid waste disposal data accounts for the County's 75% waste diversion requirement.

Agriculture

Inventory Methods

Agricultural sources of GHG emissions include off-road farm equipment, irrigation pumps, residue burning, livestock, pesticide application, rice cultivation, lime and urea application, and fertilizer volatilization. The process data for Yolo County's agricultural sector were obtained from a variety of sources, as discussed in detail below. GHG emission factors associated with farming equipment were obtained from OFFROAD2007. The GHG emission factor for agricultural irrigation pumps and the number of pumps in the county were obtained from ARB's GHG emissions inventory (ARB 2006, ARB 2003). Fertilizer application data were obtained from UCD, Agriculture and Resource Economics Department *Current*

Cost and Return Studies (UCD 2010). Emission factors and methods to quantify GHG emissions associated with fertilizer application were obtained from ARB's GHG emissions inventory (ARB 2007). Calendar year 1990 and 2008 process data for acres of rice and other crops cultivated and livestock populations in Yolo County were obtained from Yolo County's 1990 and 2008 *Annual Crop Reports* (Yolo County 1990, 2008). Emission factors and quantification methods for enteric fermentation and manure management were obtained from the ARB's GHG emissions inventory (ARB 2007). GHG emissions associated with lime and urea application were obtained from UCD. Agricultural GHG emissions by source type are available online and by request from the Yolo County Planning and Public Works Department.

Projection Methods

Agricultural emissions were not anticipated to increase between the 2008 base-year and 2020 and beyond, because the total amount of agricultural land within Yolo County is not expected to increase above existing conditions. Planned growth in agricultural processing facilities is discussed further under Stationary Sources. Unlike other sectors, agriculture has a high potential for annual emissions variability, because the emission rates for crop types, fertilizer application requirements, and other practices can be considerably different. According to the Land Use and Housing section of the County's 2030 General Plan EIR, approximately 58,821 acres of land would be redesignated from agricultural purposes to other purposes under the 2030 General Plan, as compared with the County's 1983 General Plan (Yolo County 2009). However, it is important to note that much of the land that would be redesignated from agricultural purposes to other purposes was being operated as open space, forest, or public, and was not being actively farmed. Thus, the change in land use designation may not actually represent a change in active land use type for many parcels in Yolo County. Farmers and ranchers will likely change their crops, activities, and practices multiple times within the 60-year timeframe of these emissions estimates and projections in response to market demand, weather, water availability, and other unpredictable factors. These changes could either increase or decrease GHG emissions. Also, although the total amount of agricultural land is expected to decrease according to the General Plan, this does not necessarily translate to a decrease in GHG emissions, because the variability in GHG-emissions intensity of different crop types can be greater than the predicted acreage decrease. Other factors such as change in livestock populations (e.g., increase in dairy cattle population) change in fertilizer application practices, growth in organic crop production, and change in pesticide application practices in Yolo County between 1990 and 2008 have historically contributed to changes in overall agricultural-related GHG emissions, and would be expected to continue to do so in the future. For these reasons, it is difficult to project GHG emissions changes over time using agricultural activities. Therefore, reasonable assumptions were made by County staff based on current trends in Yolo County. In general, slight trends away from field crops (e.g., tomatoes, corn, and wheat) and toward perennial and orchard crops (e.g., wine grapes, almonds, and olives) were assumed to occur by 2030 based on input from the Agricultural Commissioner's office and from planning staff. In addition, specific anticipated agricultural acreage that would be taken out of production and converted to development was also removed from 2030 agricultural GHG emissions. Beyond 2030, the approach to project future agricultural emissions was to keep the 2030 estimates constant into the future. Refer to Table A-3 for the 1990 and 2008 GHG inventories and 2030 projections by sub-sector.

In addition, Ascent calculated GHG emissions by crop type per 100 acres in 2008. The estimates in Table A-4 include GHG emissions from fertilizer application, residue burning, and rice cultivation only. Please note that there are other types of emissions associated these crops and the data provided herein is for information purposes only.

Wastewater Treatment

Inventory Methods

Methane emissions from wastewater treatment facilities were calculated using process data (e.g., treatment capacity, biological oxygen demand) for the three wastewater treatment facilities that serve unincorporated Yolo County. Ascent obtained this information from Esparto, Knights Landing, and Madison Community Service District Waste Discharge Requirements facility permit records from the Central Valley Regional Water Quality Control Board. Base year influent data were obtained from the Public Utilities section of the Yolo County General Plan EIR.

Table A-3
Unincorporated Yolo County 1990 Historic and 2008 Base-Year Greenhouse Gas Emissions Inventory and Future-Year Projections for Agricultural Subsectors

Emissions Subsector	Unincorporated Yolo County (MT of CO_2e)		
	1990	2008	2030
Residue Burning	14,669	13,917	11,366
Livestock	30,000	45,257	38,877
Rice Cultivation	28,389	34,131	38,686
Farm Equipment	72,170	71,667	71,667
Agricultural Irrigation Pumps	39,231	39,231	39,231
Pesticide Application	83	35	35
Fertilizer Application	98,982	79,966	68,625
Lime Application	4,344	11,774	11,774
Urea Application	4,164	1,362	1,362
Total [1]	292,032	297,341	281,624

Notes: CO_2e = carbon dioxide equivalent; MT= metric tons.
[1] Totals may not match exactly the sum of the numbers in the applicable column due to rounding.
Source: Data compiled by Ascent Environmental, Inc. in 2010.

The GHG emissions associated with secondary wastewater treatment processes were quantified using methods and emission factors from IPCC for centralized, aerobic wastewater treatment plants, which are representative of processes at these facilities (IPCC 2006b). GHG emissions from tertiary treatment plants are contained in the PG&E dataset and are included in the energy sector.

Projection Methods

It was assumed that wastewater treatment facilities within Yolo County would transition from secondary to tertiary treatment processes between 2008 and 2030, with the exception of Esparto's plant. The Esparto plant was assumed to operate at capacity in 2030, as described within the Public Utilities section of the Yolo County General Plan EIR. Additional capacity would likely be needed beyond 2030; however, any new facilities would be packaged tertiary treatment plants, which do not generate methane. Instead, GHG emissions from tertiary treatment facilities would be included in the energy sector.

Anticipated tertiary facilities would be associated with the Dunnigan Specific Plan and Elkhorn developments, and the Madison and Knights Landing districts. A tertiary wastewater treatment plant is already serving the Wild Wings development.

Other Sources

Construction & Mining

Ascent calculated 1990 historic and 2008 base-year GHG emissions from construction and mining activities within unincorporated Yolo County using emission factors and inventory data from the OFFROAD model. It was not possible to allocate emissions to the respective activities because the OFFROAD model is equipment-based, rather than activity-based. Thus, it was not possible to determine which pieces of equipment in the OFFROAD model were used for construction and which were used for mining. Please note that this sector only includes emissions associated with the on-site use of heavy-duty equipment. Emissions associated with the land uses themselves (e.g., off-site transportation and energy use) are included in the other sectors as applicable. Also, for the sake of clarification, the issue of fugitive particulate matter dust emissions, which is typically associated with mining activities, is not addressed in this inventory as such are not classified as GHGs. It is unknown whether construction and mining-related GHG emissions would increase beyond 2030, and thus, were held constant after 2030.

Table A-4
Year 2008 Greenhouse Gas Emissions by Crop Type

Crop Type	MT CO_2e/100 acres/year	Crop Type	MT CO_2e/100 acres/year
Almonds	74	Pistachio Nuts	34
Wine Grapes/Kiwi	3	Plums	21
Walnuts	93	Tangerines	18
Prunes	25	Tomatoes	34
Pears, Bartlett	34	Asparagus	15
Pears, Others/Persimmons	34	Misc Vegetables	17
Apples	4	Misc Fruits	20
Apricots	21	Barley	14
Cherries	26	Beans	18
Figs	13	Corn (and Milo)	19
Kiwi	20	Hay - Alfalfa	1
Nectarines	25	Hay - Grain	7
Olives	15	Oat and Misc Field Crop	10
Peaches (Freestone)	25	Pasture	15
Pluots/Apricots	21	Propogative and Nursery	3
Rice	142	Wheat	39

Notes: CO_2e = carbon dioxide equivalent; MT= metric tons.
Source: Data compiled by Ascent Environmental, Inc. in 2010.

Stationary Sources
GHG emissions from stationary sources within the County were calculated in the 1990 historic and 2008 base-year inventories using facility permit data obtained from YSAQMD. The permit data contained fuel consumption activity information from which GHG emissions were calculated using CCAR emission factors. In addition, the OFFROAD model was used to obtain heavy-duty equipment emissions associated with industrial land uses within the County in both years. In 2008, the pesticide sulfuryl fluoride, which has a high GWP, was applied to commodities during agricultural processing. This was not a common practice in 1990. GHG emissions associated with the application of sulfuryl fluoride during processing are reported in the stationary source sector, under agricultural processing. According to the County's General Plan, agricultural commercial and industrial processing facilities are anticipated to increase during build-out. It was assumed that approximately 264 acres of additional agricultural industrial or agricultural commercial land uses would be built out by 2030; about an 82% increase from 324 acres in 2008. Thus, stationary-source emissions within the County would increase through 2030. It was unknown whether stationary-source emissions within

the County would increase or decrease beyond 2030, and thus, these were held constant after 2030.

Wetlands

According to the Global Climate Change section of the Yolo County General Plan EIR, there are approximately 14,855 acres of wetlands currently in Yolo County. Significant areas of seasonal wetland and marsh communities are found in the Yolo Basin, including the Vic Fazio Yolo Bypass Wildlife (Yolo Bypass) Area, private lands in the southern panhandle, the Conaway Ranch north of Interstate 80, and the City of Davis. Additional wetlands are found at the recently restored Roosevelt Ranch Preserve east of Zamora and in several other locations throughout the central and eastern portions of the County.

It is important to note that nearly all of this wetland development has occurred over the past 20 years. In fact, in recent years the pace of wetland creation has occurred at a faster rate than has urbanization. Between 2000 and 2008, about 1,371 acres of farmland were lost to community development in the unincorporated area. During this same time, approximately 4,225 acres of farmland were converted to wetlands. Since 2008, several significant new projects have been approved, primarily adjoining the Sacramento River and in the lower Yolo Bypass. Consequently, wetlands are playing an increasing role related to GHG emissions and climate change.

The Yolo Bypass Area is a public and private restoration project managed by the California Department of Fish and Game in consultation with the Yolo Basin Foundation. Managed wetlands in the Yolo Bypass Area are currently enclosed by levees and berms, and flooded with water from irrigation systems. The Yolo Bypass provides flood conveyance for the high flows from several northern California waterways to the Sacramento-San Joaquin River Delta. Whereas natural wetland hydrology is very dynamic, flooding cycles for managed wetlands can be made predictable through strategic and innovative management. Permanent wetlands are flooded year round; seasonal wetlands are drained the first of April and flooded the first of September each year. The management of productive wetlands requires not only water management, but also periodic soil and vegetation disturbances. In addition to seasonal and permanent wetlands, the Yolo Bypass Area includes annual grasslands, riparian scrub and woodlands, vernal pools, and row crop/seasonal wetlands. The primary row crop is rice, but other crops, including grains, are also produced across the northern and central portions of the Yolo Bypass Wildlife Area. Please note that emissions associated with these row crops are accounted for in the agricultural sector.

Wetlands sequester carbon in vegetation and inundated soils through the process of CO_2 uptake from the atmosphere, photosynthesis, and decomposition. On the other hand, wetlands result in the generation of GHGs including methane (CH_4), which has global warming potential 21 times that of CO_2, from the anaerobic decomposition of biomass (e.g., bacteria); nitrous oxide (N_2O) from nitrification and denitrification processes; and CO_2, CH_4, and N_2O from peat soil subsidence and oxidation associated with draining activities.

Wetlands are dynamic ecosystems, constantly changing due to the physical, chemical, and biological processes associated with floods, drought, and fire. More specifically, carbon and nitrogen cycling along with decomposition vary considerable based on location and time of year. Thus, there is currently a substantial amount of uncertainty involved with quantifying GHG emissions from wetlands unless site-specific information is available, which is not the case for Yolo County. For these reasons coupled with the fact that ARB does not include such sources in the statewide GHG emissions inventory, wetlands were not included in base-year emissions inventory.

However, it is important to note that even though site-specific research for wetlands located in Yolo County is not available, wetland-related GHG sequestration and generation rates have been developed in research and literature. These are summarized below for informational purposes only (e.g., to assist with the further understanding of policy change and/or mitigation strategy implications), but please note that given the uncertainty in the research and substantial variability in location conditions these should not be considered precise or it some cases even applicable to Yolo County.

Studies have shown that freshwater marshes, a type of wetland, can sequester up to 25 metric tons of carbon per acre per year; saline marches, another type of wetland, from approximately 0.8 to 5.7 metric tons of carbon per acre per year; and freshwater wetlands approximately 0.3 metric tons per acre per year. Please note that results within these studies varied greatly depending on numerous factors (e.g., temperature, inundation regime, and plant species).

With respect to the generation of CH_4 from decomposition, studies have shown saline marshes release less CH_4 than their fresh water counterparts, tidal brackish wetlands can release approximately 0.5 to 1.9 metric tons of CO_2e per acre per year, and freshwater wetlands can release 1.6 to 7.8 metric tons of CO_2e per acre per year. The results of these studies varied greatly depending on numerous factors (e.g., evapotranspiration). Research concerning the generation of N_2O from nitrification and denitrification processes is very limited and has an extremely high degree of uncertainty because of the compound's complex chemistry, unknown strength of nitrifying and denitrifying processes in certain environments, and variability depending on biogeochemical characteristics of a wetland (e.g. labile carbon availability, nitrate availability, and redox potential).

Lastly, CO_2, and to a lesser extent CH_4 and N_2O emissions, from peat soil subsidence and oxidation associated with draining activities can result in carbon losses from approximately 2.02 to 6.07 metric tons per acre per year. The results of these studies also varied greatly depending on soil organic content, carbon content, temperature, and other factors.

In general, the majority of wetlands created in Yolo County are freshwater wetlands, fed by irrigation return water, groundwater, and/or surface flows. Broadly speaking, using the variable ranges cited above, these freshwater wetlands may contribute net GHG emissions of between 1.3 and 7.5 metric tons per acre of CO_2e per year. Depending on how they are managed (e.g., annually draining), the net impact may be as much as 3.3 to 13.6 metric tons. This is comparable to the emission rates for field crops such as hay, oats, barley, asparagus, and pasture; or orchard crops such as apples, olives, and figs. Although wetlands are estimated to account for less than 1% of all GHG emissions nationwide, they are an expanding part of the landscape that deserves more detailed study and consideration in the future.

Discussion

GHG emissions from most sectors increased between 1990 and 2008, except for transportation-related emissions. The reduction in transportation emissions is attributable to reductions in VMT and a reduction in CO_2 emission factors associated with improved vehicle fuel economy and fleet turnover during this 18-year time frame. Another factor is the historically low rate of growth and development allowed in the unincorporated area allowed under the 1983 General Plan. The reduction in VMT is also likely attributable to the method by which trips and VMT are allocated to the unincorporated County and to cities. Trips that may have originated or terminated in the unincorporated County in 1990 may have been from land annexed into cities prior to 2008 (e.g., Gibson Ranch [480 acres to City of Woodland in 1992] and Wildhorse [419 acres to City of Davis in 1995]). Thus, associated VMT would be allocated to the respective city per the methodology employed by Fehr & Peers and recommended by the RTAC.

Energy-related GHG emissions were estimated to increase at a higher rate than estimated population growth, despite factors such as annexation of land from County to city jurisdictions; the reduction in GHG emission factors from increased renewable energy in the State's electricity portfolio; and the affect of California energy conservation standards (Title 24) on the

County's new building stock. The discrepancy can be explained by the difference in datasets used to derive 1990 and 2008 energy-related GHG emissions. 1990 data was extrapolated from Yolo County's 1982 Energy Plan, whereas 2008 data was obtained directly from PG&E accounts. Nonetheless, these two datasets are applicable to the County, yield reasonable results, and represent the best available data. In addition, the higher rate of energy use is also attributable to changing consumer patterns over the past 20 years. The number of home computers, kitchen appliances, chargers, televisions, and other electronics has grown significantly between 1990 and 2008.

GHG emissions associated with agricultural activity in the unincorporated County increased overall between 1990 and 2008, but decreased within the sub-sectors associated with agricultural equipment, residue burning, pesticide application, and fertilizer application. The heavy-duty agricultural equipment fleet has become more efficient and currently includes better emission controls than in 1990, which explains the decline in emissions from agricultural equipment. Emissions from residue burning decreased, despite an increase in the number of acres of rice harvested, which is explained by implementation of regulations that limit residue burning. Pesticide application to commodities by farmers decreased from 1990 to 2008 because application of GHG-emitting pesticides became more prevalent at the agricultural processing stage, compared to the rate of application directly to crops (the application of pesticides as a part of processing operations is reported under stationary sources). Fertilizer application decreased between 1990 and 2008, in part, due to increased use of drip irrigation systems, the growth in organic crop production, and use of cover crops. Because water used to irrigate crops contains nitrates, farmers began monitoring nitrate content and decreased direct fertilizer application accordingly (Young, pers. comm., 2010). Please note that even though Yolo County has one of the largest percentages of agricultural acres on which organic practices occur, the development of these emission inventories were not able to be performed at a resolution to derive organic- specific information.

Agricultural GHG emissions from, livestock, rice cultivation, urea and lime application all increased from 1990 to 2008. According to County staff, dairy cattle population increased dramatically from 1990 to 2008, approximately 50 head to 2,200 head, respectively. Dairy cattle generate greater GHG emissions per head than beef cattle.

Stationary-source GHG emissions also increased between 1990 and 2008. Notably, GHG emissions from pesticide application increased considerably from 1990 to 2008, due to increased application of the pesticide sulfuryl fluoride, a GHG with high GWP.

Projected GHG emissions in energy, transportation, solid waste, and wastewater treatment sectors are attributable to population growth, as described in the projection methodology discussion of each sector. It is worth noting that a sizable portion of the incremental increase in GHG emissions projections from 2008 and 2030 would be attributable to the Dunnigan Specific Plan development, as will a sizable portion of the County's GHG emission reduction potential.

JURISDICTIONAL CONTROL

Of the sectors studied in the emission inventories, the sectors (and portions thereof) over which the County has jurisdiction are somewhat limited. For example, the County retains discretionary authority over land use decisions in its jurisdiction, which are known to influence VMT, but has no jurisdiction over fuel economy standards, which are controlled by the federal government. Similarly, the County has the ability to implement energy efficiency standards for buildings constructed in the unincorporated County, but it does not control the composition of PG&E's energy portfolio, which is regulated at the State level. The degree to which State and federal regulations may influence GHG emissions within the County is discussed later in this report.

Sectors over which the County has no control include the construction and mining equipment fleet and stationary source process emissions (e.g., although authority over these is regulated through the permitting process, the County does not have jurisdiction over equipment emission rates from the tail pipe, and stationary sources are essentially being addressed through the State Cap-and-Trade regulation). For these reasons, these sectors were removed from the inventory for purposes of GHG emissions reduction target development. The GHG emissions over which the County has some jurisdiction are reported in Table A-5.

Table A-5
Unincorporated Yolo County Jurisdictional Greenhouse Gas Emissions Inventory and Future-Year Projections

Emissions Sector	Unincorporated Yolo County (MT of CO_2e)					
	1990	2008	2020	2030	2040	2050
Energy Consumption [1]	131,652	181,447	404,929	628,444	689,093	748,757
Transportation	155,577	105,253	285,492	465,731	510,677	554,733
Solid Waste	1,654	6,871	12,660	18,449	20,230	21,975
Agriculture	292,032	297,341	289,482	281,624	281,624	281,624
Wastewater Treatment	256	974	974	709	709	709
Total [2]	581,171	591,886	993,537	1,394,957	1,502,332	1,607,798

Notes: CO_2e = carbon dioxide equivalent; MT= metric tons.
[1] Energy consumption includes emissions from electricity production, from natural gas and propane combustion, and water consumption.
[2] Totals may not match exactly the sum of the numbers in the applicable column due to rounding.
Source: Data compiled by Ascent Environmental, Inc. in 2010.

1990 EMISSIONS

Ascent developed a historic GHG emissions inventory for sources in Yolo County for the year 1990 (County 1990 inventory). The County's 1990 inventory was compiled for the following emission sectors: energy use (i.e., electricity, natural gas, propane, and water consumption); transportation; solid waste; stationary sources; construction and mining; agriculture; and waste water treatment. This memorandum presents the results of the County 1990 inventory.

There is currently no agency-adopted or recommended protocol for preparation of community-wide GHG emissions inventories. The field of practice and available tools and methods continue to evolve in absence of standardized guidance. State-of-the-practice methods applied to factual historical data were used to develop the inventory, as discussed below.

Key Assumptions

Emission Factors

An emission factor is a representative constant that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant (EPA 2010); it is typically expressed as a rate of emissions per unit of the activity. For example, the number of tons of CO_2e generated by an automobile per mile traveled is an emission factor. Several reputable sources of information can be used to gather emissions information for use in inventory development.

Sources of GHG emission factors relied upon in preparation of the County's 1990 inventory include the following:

- California Air Resources Board (ARB): On-Road Mobile-Source Emission Factor Model (EMFAC2007), Version 2.3., 2007.
- California Air Resources Board (ARB): Off-Road Mobile-Source Emission Factor Model (OFFROAD2007), Version 2.1., 2007.
- U.S. Environmental Protection Agency (EPA): AP-42 Compilation of Emission Factors. Chapter 2.4 Solid Waste Disposal, 2008.

- The California Climate Action Registry (CCAR): General Reporting Protocol, Version 3.1., 2009.
- Intergovernmental Panel on Climate Change (IPCC): IPCC Guidelines for National Greenhouse Gas Inventories, 2006.

The above-mentioned emission factors represent GHG emissions from activities occurring in Yolo County.

Demographic Data
1990 GHG emissions inventory data for certain sectors were either back-calculated or forecasted from the closest available data point using population data from the California Department of Finance (DOF 2010).

Consumption Data
The inventory was prepared using consumption and generation data from the following reputable sources:

- Yolo County Energy Plan, 1982.
- Yolo County Central Landfill (YCCL) Joint Technical Document, 2007.
- Unincorporated Yolo County Waste Generation Study, 1991.
- Yolo-Solano Air Quality Management District (YSAQMD) Permitted Stationary Sources in Yolo County, 1990.
- California Department of Transportation (Caltrans) Highway Performance Monitoring System (HPMS) California Public Road Data, 1990.
- Community Service District Waste Discharge Requirements (Esparto, Knights Landing, Madison Waste Water Treatment Facilities data).
- California Energy Commission (CEC). Refining Estimates of Water-Related Energy Use in California. CEC-500-2006-118, 2006 (December).
- University of California, Davis (UCD). Agricultural and Resource Economics: Current Cost and Return Studies, 2010.

Each of these sources includes data that are applicable to Yolo County.

Summary of Results

Countywide 1990 emissions were calculated using a "bottom-up" approach, which involves multiplication of an emission factor for a given process by activity data describing that process. For example, the emission factor for household energy use would be multiplied by the number of households within a jurisdiction at a specific time. This approach ensures the highest level of control over the quality of the data used to generate the emissions inventory. Where data were available, 1990 GHG inventories were prepared for the incorporated cities of Davis, West Sacramento, Winters, and Woodland. Emissions were also shown for UCD and tribal lands. However, these were kept separate from the unincorporated community emissions as they are distinct in terms of area, location, and operations. These inventories were not prepared with the same level of precision as the unincorporated County inventory, but are useful for comparison purposes.

Table A-6 summarizes the scale and relative contribution of estimated 1990 GHG emissions for each sector. Methods used to calculate each emission sector are described in the sections that follow. Detailed assumptions are available online and by request from the Yolo County Planning and Public Works Department.

Figure A-5 summarizes the relative contributions of each GHG emissions sector to the total 1990 GHG emissions in unincorporated Yolo County.

Figure A-6 summarizes the relative contributors of each jurisdiction to the total 1990 GHG emissions in Yolo County (i.e., unincorporated plus incorporated).

YOLO COUNTY HISTORIC GREENHOUSE GAS EMISSIONS INVENTORY METHODS

This section briefly summarizes emissions inventory methods applied for each sector in the historic (1990) inventory. Detailed assumptions and quantification inputs, are available online and by request from the Yolo County Planning and Public Works Department.

Energy Consumption

Electricity, natural gas, and propane consumption data for residential and non-residential land uses were based on data

Table A-6
Yolo County Historic Greenhouse Gas Emissions Inventory (1990)

Emissions Sector	Unincorporated Yolo County		Davis		West Sacramento		Winters		Woodland		UCD	Tribal Activities	Total Yolo County	
	MT CO_2e	%	MT CO_2e	%	MT CO_2e	%	MT CO_2e	%	MT CO_2e	%	MT CO_2e	MT CO_2e	MT CO_2e	%
Energy Consumption[1]	131,652	21.5%	268,791	56.6%	162,132	54.9%	26,962	63.0%	236,082	41.4%			825,618	39.0%
Transportation	155,577	25.4%	187,629	39.5%	122,107	41.4%	14,005	32.7%	166,341	29.2%			645,659	30.5%
Solid Waste	1,654	0.3%	11,264	2.4%	6,794	2.3%	1,130	2.6%	9,893	1.7%			30,735	1.5%
Agriculture	292,032	47.6%	-	-	-	-	-	-	-	-			292,032	13.8%
Wastewater Treatment	256	0.0%	7,013	1.4%	4,230	1.4%	703	1.6%	6,159	1.1%	-	-	18,361	0.9%
Construction & Mining	14,954	2.4%	-	-	-	-	-	-	-	-			14,954	0.7%
Stationary Sources	17,526	2.9%	<0.1	-	<0.1	-	<0.1	-	151,211	26.5%[3]			168,737	8.0%
UCD											120,991		120,991	5.7%
Tribal Activities												439	439	0.0%
Total[2]	613,651		474,696		295,262		42,800		569,686		120,991	439	2,117,525	

Notes: CO_2e = carbon dioxide equivalent; MT= metric tons; UCD = University of California, Davis.
[1] The energy consumption sector includes emissions from electricity production, natural gas and propane combustion, and water consumption.
[2] Totals may not match exactly the sum of the numbers in the applicable column due to rounding.
[3] The stationary source sector for the City of Woodland comprises a larger portion of the emission inventory in comparison to the other incorporated and other unincorporated areas due to the fact more industry is located there.
Source: Data compiled by Ascent and AECOM in 2010.

from the 1982 *Yolo County Energy Plan*. Consumption rates were extrapolated to 1990 using population growth estimates from the California Department of Finance (DOF 2010). Emission factors from the CCAR General Reporting Protocol were used to calculate carbon dioxide equivalent (CO_2e) emissions from these fuel types.

GHG emissions associated with water consumption (i.e., conveyance, treatment, and distribution) were estimated using water demand rates from CEC for domestic uses and emission factors from CCAR for electricity consumption. Water consumption-related CO_2e emissions were included within the energy sector because electricity is used to convey, treat, and pump water.

Transportation

On-road mobile-source emissions for 1990 were calculated using Caltrans HPMS data

Figure A-5

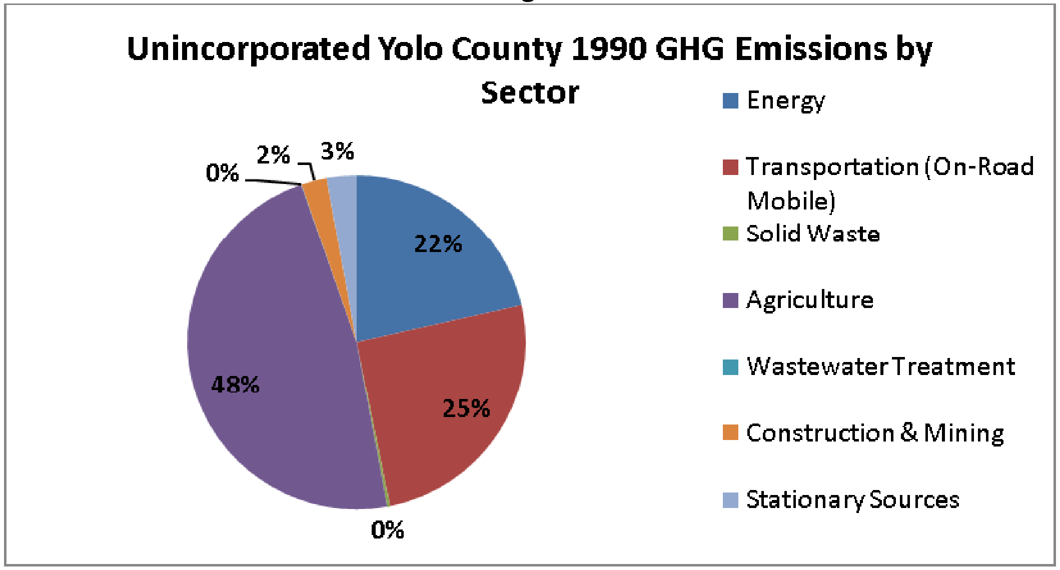
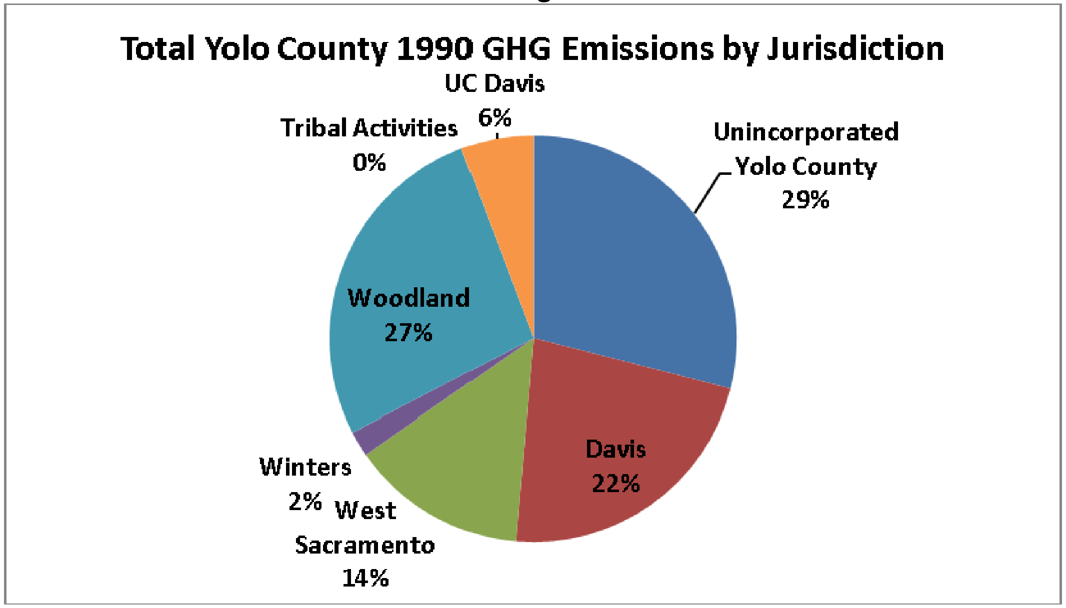


Figure A-6



for roadways in the unincorporated County, along with emission factors from EMFAC2007 by speed bin (i.e., portion of vehicle miles traveled [VMT] that would occur within a range of 5 mile per hour increments). HPMS data for 1990 was used in combination with data prepared by Fehr & Peers (2010) from the Yolo County General Plan Traffic Demand Forecasting (TDF) model, which included 2005 VMT data by speed bin. The dataset obtained from Fehr & Peers accounted for trips that did not originate or terminate in the county by apportioning 50% of VMT and associated GHG emissions to Yolo County for internal-to-external trips, and external-to-internal trips. VMT, and associated GHG emissions, resulting from internal-to-internal trips were allocated 100% to Yolo County. This methodology is consistent with the Regional Target Advisory Committee (RTAC) recommendations in response to Senate Bill (SB) 375.

These data were used to develop a correction factor that was then applied to the 1990 Caltrans dataset to achieve a more accurate 1990 VMT number. Another correction was applied to the Caltrans dataset in order to allocate a percentage of VMT that would occur on state highways where the origin and destination were both located within the unincorporated County, based on 1990 population.

Solid Waste

GHG emissions related to solid waste disposal were calculated using a first-order decay modeling method from EPA for the Yolo County Central Landfill (YCCL). Waste characterization data for the unincorporated County and for the UCD landfill were obtained from the 1991 *Yolo County Waste Generation Study*. Solid waste disposal-related emissions were apportioned to the incorporated areas using population data contained in the solid waste disposal study.

Agriculture

Agricultural sources of GHG emissions include off-road farm equipment, irrigation pumps, residue burning, livestock, pesticide application, rice cultivation, and fertilizer volatilization. The activity data for Yolo County's agricultural sector were obtained from a variety of sources as discussed in detail below. GHG emission factors associated with farming equipment in 1990 were obtained from OFFROAD2007. The GHG emission factor for agricultural irrigation pumps and the number of pumps in the county were obtained from ARB's GHG emissions inventory (ARB 2006, ARB 2003). Fertilizer application data for 1990 were obtained from the University of California, Davis, Agriculture and Resource Economics Department *Current Cost and Return Studies* (UCD 2010a). Emission factors and methods to quantify GHG emissions associated with fertilizer application were obtained from ARB's GHG emissions inventory (ARB 2007). Calendar year 1990 activity data for acres of rice and other crops cultivated and livestock populations in Yolo County were obtained from Yolo County's 1990 *Annual Crop Report* (Yolo County 1990). GHG emissions associated with lime and urea application were obtained from UCD. Emission factors and quantification methodologies for enteric fermentation (i.e., livestock digestive processes) and manure management were obtained from the ARB's GHG emissions inventory (ARB 2007). Documentation of agricultural-related GHG emissions by source type is available online and by request from the Yolo County Planning and Public Works Department.

Wastewater Treatment

Methane emissions from wastewater treatment facilities were calculated using process data (e.g., treatment capacity, biological oxygen demand) for the three wastewater treatment facilities that serve unincorporated Yolo County. Ascent obtained this information from Esparto, Knights Landing, and Madison Community Service District Waste Discharge Requirements facility permit records from the Central Valley Regional Water Quality Control Board, based on documents in effect in 1990.

The GHG emissions associated with wastewater treatment processes were quantified using methods and emission factors from IPCC for centralized, aerobic wastewater treatment plants, which is representative of processes at these facilities in 1990 (IPCC 2006b).

Other Sources

Construction & Mining

Ascent calculated 1990 GHG emissions from construction and mining activities within unincorporated Yolo County in the historic inventory using emission factors and inventory data from the OFFROAD model. It was not possible to allocate emissions to the respective activities because the OFFROAD model is equipment-based, rather than activity-based. Thus, it was not possible to determine which pieces of equipment in the OFFROAD model were used for construction and which were used for mining. Please note that this sector only includes emissions associated with the on-site use of heavy-duty equipment. Emissions associated with the land uses themselves (e.g., off-site transportation and energy use) are included in the other sectors as applicable. Also, for the sake of clarification, the issue of fugitive particulate matter dust emissions, which is typically associated with mining activities, is not addressed in this inventory as such are not classified as GHGs.

Stationary Sources

GHG emissions from stationary sources within the County in 1990 were calculated using facility permit data obtained from YSAQMD. The permit data contained fuel consumption activity information from which GHG emissions were calculated using CCAR emission factors. Stationary-source emissions were heavily influenced by permitted facilities that burned wood/biomass in 1990. CCAR recommends treatment of wood combustion sources as biogenic (i.e., originating from living organisms) emissions and are included in the historic inventory for informational purposes. GHG emissions associated with agricultural processing facilities were itemized separately within this sector.

In addition, the OFFROAD model was used to obtain heavy-duty equipment emissions associated with industrial land uses within the County in 1990.

University of California, Davis
Emissions from UCD (for the Davis campus) were calculated for 1990 in the *2009-2010 Climate Action Plan* and were estimated at 120,991 MT CO_2e/year (UCD 2010b). Emissions for the Davis campus in 2008 were estimated at 162,775 MT CO_2e/year. In addition, Ascent calculated GHG emissions from the UCD landfill in 1990 (4,725 MT CO_2e/year) using the same methods described above for the 1990 solid waste sector for the historic inventory.

Tribal Activities
GHG emissions associated with activities on tribal trust land for the Yocha Dehe Wintun Nation were modeled using the Urban Emissions Model (URBEMIS 2007 version 9.2.4) and population data obtained from County staff. Emissions from tribal activities were estimated to be 439 MT CO_2e/year in 1990.

Port of Sacramento
The GHG emissions inventory for West Sacramento is currently in the preparation process, and is anticipated to include GHG emissions from activities at the Port of Sacramento. However, emissions estimates for the Port were not available at this time.

Yolo Bypass
GHG emissions from agricultural production in the Bypass were included in the Agricultural sector. The Yolo Bypass was federally designated in 1997, therefore, GHG emissions that occurred in this area in during 1990 were under the County's jurisdiction, and were included in the County's 1990 Historic inventory.

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