Draft Greenhouse Gas Emissions Inventory Report for the City of Irvine Climate Action and Adaptation Plan

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ACRONYMS AND ABBREVIATIONS

ADC	Alternative daily cover
CalRecycle	California Department of Resources Recycling and Recovery
CAP	Climate action plan
Cap-and-Trade	California Greenhouse Gas Cap-and-Trade Program
CARB	California Air Resources Board
CAAP	Climate Action and Adaptation Plan
CEC	California Energy Commission
City	City of Irvine
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Community Protocol	*U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions*
CPUC	California Public Utilities Commissions
eGRID	Emissions & Generation Resource Integrated Database
EMFAC2021	EMissions FACtor model
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
GWP	Global warming potential
HPMS	Highway Performance Monitoring System
HVAC	Heating, ventilation, and air conditioning
ICLEI	ICLEI - Local Governments for Sustainability
IRWD	Irvine Ranch Water District
IPCC	Intergovernmental Panel on Climate Change
ITAM	Irvine Transportation Analysis Model
JPA	Joint Power Authority
kWh/AF	Kilowatt-hours per acre-foot
lb/MWh	Pounds per megawatt-hour
lb/therm	Pounds per therm
LFG	Landfill gas
LPG	Liquid propane gas
Methane Regulation	Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities
MPO	Metropolitan Planning Organization
MSW	Municipal solid waste
$MTCO_2e$	Metric tons of carbon dioxide equivalent

MWh	Megawatt-hour
N_2O	Nitrous oxide
OCSan	Orange County Sanitation District
OPR	Governor's Office of Planning and Research
RTAC	Regional Targets Advisory Committee
RTDM	Regional Transportation Demand Model
RTP	Regional Transportation Plan
SB	Senate Bill
SCAQMD	Southern California Air Quality Management District
SCE	Southern California Edison
SoCalGas	Southern California Gas Company
TCR	The Climate Registry
VMT	Vehicle miles traveled
WWTP	Wastewater treatment plant

1 INTRODUCTION

This report describes the major GHG emission sources and activities for communitywide and municipal operations in the year 2019, which will inform the City's Climate Action and Adaptation Plan (CAAP).

1.1 INVENTORY PURPOSE AND DESCRIPTION

The first step in a city's climate action planning process is to develop a GHG emissions inventory, which is a snapshot of the GHG emissions associated with sources and activities within its jurisdiction in a given year. The purpose of an inventory is to:

- establish a baseline against which future emissions levels and future reduction targets can be measured,
- understand the sectors and sources generating GHG emissions and their relative contribution to total emissions, and
- monitor progress towards achievement of GHG reduction targets.

Preparing a GHG emissions inventory is a critical step in climate action planning. To develop and implement a plan that will effectively reduce GHG emissions, local governments must first have a comprehensive understanding of the emissions that are generated by activities within their jurisdictions. GHG emissions inventories not only serve to provide this knowledge, but they also act as the basis for measuring progress and provide agencies with a framework to track emissions over time and assess the effectiveness of actions taken to reduce emissions. Additionally, local governments often prepare inventories to exhibit accountability and leadership, motivate community action, and demonstrate compliance with regulations.

A GHG emissions inventory estimates emissions generated within a defined geographic boundary during a single year. It identifies the sectors, sources, and activities that are producing these emissions and the relative contribution of each, while also providing a baseline used to forecast emissions trends into the future. This information is used to set reduction targets that are consistent with State and/or local objectives and then identify local measures for reducing GHG emissions as part of the City's CAAP.

1.2 SUMMARY OF RESULTS

1.2.1 GHG Emissions from Communitywide Activities and Sources

Communitywide activities generated approximately 2,251,593 $MTCO_2e$ in 2019. The largest emissions-generating sectors include on-road transportation (51 percent), nonresidential building energy (24 percent), and residential building energy (13 percent). Collectively, on-road transportation and building energy (nonresidential and residential) account for approximately 88 percent of all emissions in 2019. The remaining 12 percent of emissions are attributable to solid waste (7 percent), off-road vehicles and equipment (3 percent), water supply (1 percent), and wastewater treatment (less than 1 percent).

The 2019 inventory will be the City's GHG emissions baseline for the CAAP and will be used to forecast emissions and set emissions reductions targets. Table 1 and Figure 1 present the results of the City's 2019 community GHG emissions inventory by sector. Descriptions of each emissions sector, including key sources of emissions, are provided in further detail in Section 3, "Data, Methods, and Assumptions."

Table 1 City of Irvine Community GHG Emissions Inventory, 2019

Sector	GHG Emissions ($MTCO_2e$)	Percent of Total
On-Road Transportation	1,144,205	51
Nonresidential Building Energy	550,138	24
Residential Building Energy	291,405	13
Solid Waste	160,626	7
Off-Road Vehicles and Equipment	68,756	3
Water Supply	30,798	1
Wastewater Treatment	5,665	<1
Total	**2,251,593**	**100**

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gases; $MTCO_2e$ = metric tons of carbon dioxide equivalent; NA = not applicable.

Source: Ascent Environmental 2022.

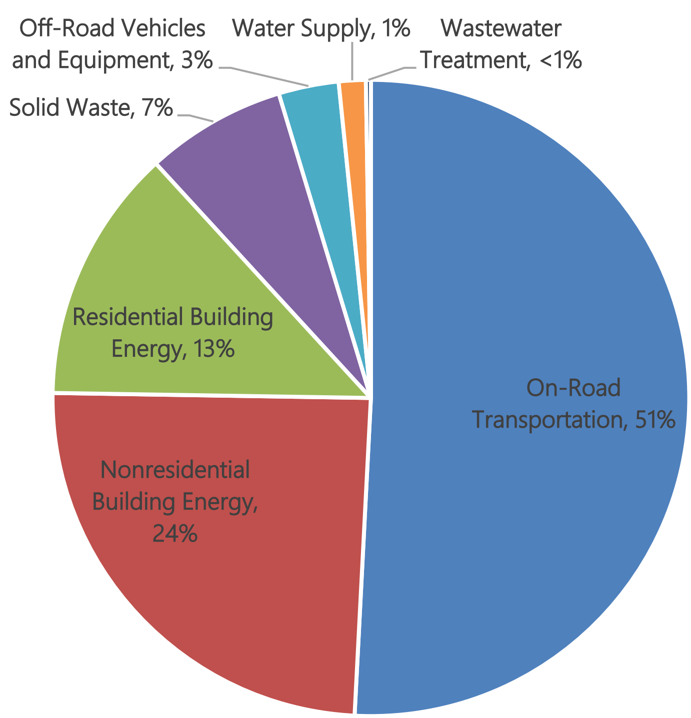

Figure 1 City of Irvine Community GHG Emissions Inventory, 2019

1.2.2 GHG Emissions from Municipal Operations

The City's municipal operations generated approximately 18,579 $MTCO_2e$ in 2019, which makes up less than one percent of the city's communitywide total emissions. Buildings and facilities (65 percent) and employee commutes (16 percent) account for approximately 81 percent of emissions of municipal operations emissions in 2019. The remaining 19 percent of emissions are attributable to wastewater treatment (6 percent), vehicle fleet (6 percent), streetlights and traffic signals (6 percent), solid waste (1 percent), and water supply (<1 percent). Table 2 presents the City's 2019 municipal operations GHG emissions inventories by sector, and Figure 2 illustrates the municipal operations inventory.

Table 2 City of Irvine Municipal Operations Greenhouse Gas Emissions Inventory, 2019

Sector	$MTCO_2e$	Percent of Total
Buildings and Facilities	12,003	65
Employee Commute	3,044	16
Wastewater Treatment	1,144	6
Vehicle Fleet	1,127	6
Streetlights and Traffic Signals	1,097	6
Solid Waste	159	1
Water Supply	4	<1
Total	**18,579**	**100**

Notes: Totals may not sum exactly due to independent rounding. $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Ascent Environmental 2022.

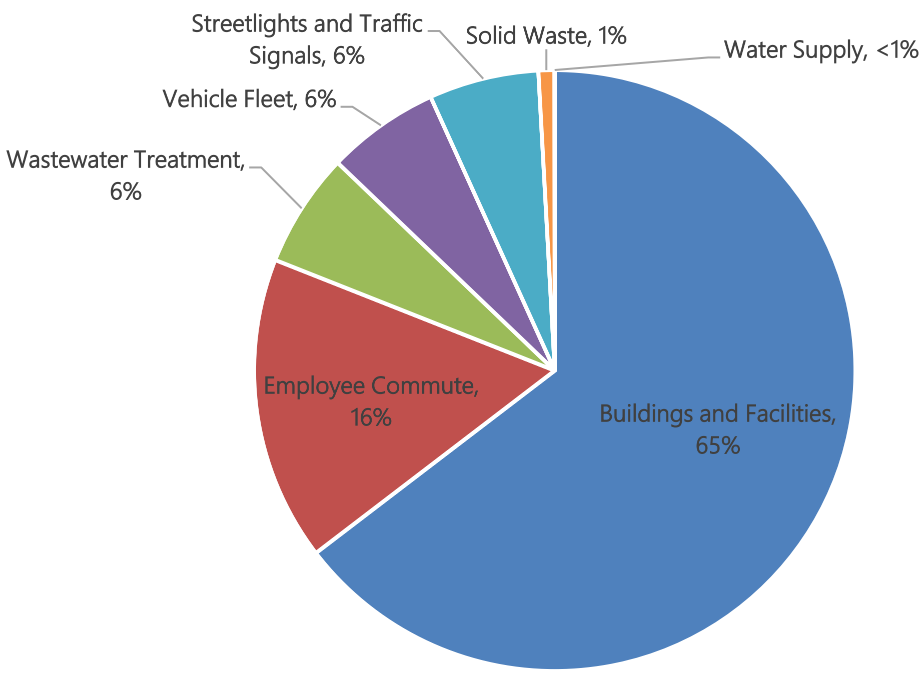

Figure 2 City of Irvine Municipal Operations GHG Emissions Inventory, 2019

1.3 ORGANIZATION OF THIS REPORT

The remainder of this report consists of the following sections:

- **Section 2: Inventory Overview** outlines considerations for preparing a community and municipal GHG emissions inventories, summarizes industry-leading protocols and methods for inventories, discusses inventory boundaries, and describes the emissions sectors and sources that are included and excluded in the community GHG emissions inventory.
- **Section 3: Data, Methods, and Assumptions** describes the data, methods, and assumptions used in the community and municipal inventories and presents GHG emissions estimates by sector.

2 INVENTORY OVERVIEW

2.1 CONSIDERATIONS FOR DEVELOPING AN INVENTORY

Nations, states, local jurisdictions, public agencies, and corporations estimate GHG emissions for different purposes. Several general approaches exist to quantify GHG emissions, and the method chosen by governments or private entities is driven by the purpose for developing an inventory. State, federal, and international agencies have developed industry protocols and recommendations for local governments preparing GHG emissions inventories at the community level.

2.1.1 Production-based Inventories

The GHG emissions inventory approach generally used by local governments in the climate action planning process, known as a “production-based” inventory, estimates GHG emissions generated by activities occurring within a defined boundary during a single year. This has become the standard approach recommended by industry protocols and includes emissions that are generated from community activities that occur within the jurisdictional boundary of the inventory, such as those emitted from natural gas furnaces used for heating buildings throughout a community. It also includes certain “trans-boundary” emissions that are associated with activities occurring within the inventory’s boundary but are released into the atmosphere outside of the boundary. For example, electricity emissions in a production-based inventory are attributed to a community based on electricity consumption within the inventory boundary, even if the electricity was generated and produced GHG emissions outside of the inventory boundary. More information regarding considerations for preparing production-based inventories is included in Sections 2.3.2 through 2.4.1.

2.1.2 Consumption-based Inventories

In addition to production-based emissions inventories, corporations, local governments, and other entities have prepared “consumption-based” emissions inventories. A consumption-based emissions inventory includes the total lifecycle GHG emissions generated by the production, shipping, use, and disposal of goods and services consumed in a community within a given year. For example, for transportation sector GHG emissions, this approach includes the emissions resulting from motor vehicle production processes, shipping the vehicle to the consumer, producing and refining fuel used in the vehicle, the combustion of the fuel used in the vehicle, and disposal of the vehicle at the end of its useful life.

This report addresses how inventories of the City’s emissions from communitywide sources and activities and municipal operations were developed using a production-based approach. This is consistent with recommendations and guidance from industry protocols (described further in Section 2.2), and State agencies, including the California Air Resources Board (CARB) and the Governor’s Office of Planning and Research (OPR). Production-based inventories provide local governments with the information needed to develop effective climate action policy within their communities; because of this, the production-based inventory method is the most common approach taken by local governments across California and nation.

2.2 PROTOCOLS AND METHODOLOGIES

2.2.1 Protocols for Accounting and Reporting of Greenhouse Gas Emissions

Several inventory protocols have been developed to provide guidance for communities and local governments to account for emissions accurately and consistently. ICLEI – Local Governments for Sustainability (ICLEI) develops protocols for local-scale accounting of emissions that have become the industry standard for local governments developing GHG emissions inventories.

The most recent guidance for community-scale emissions inventories is ICLEI's July 2019 publication *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* (Community Protocol), Version 1.2 (ICLEI 2019). State agencies, including CARB and OPR, recommend that jurisdictions prepare community GHG emissions inventories using the guidelines included in the Community Protocol (CARB 2017:100; OPR 2017:226).

The Community Protocol identifies six principles for GHG accounting and reporting. These principles were adapted from internationally recognized sources and were used to guide the development of the Community Protocol. ICLEI recommends that local governments consider the principles when preparing an inventory. The GHG accounting and reporting principles are summarized below.

- Relevance, Including Policy Relevance, and Utility for Users: The ultimate objective and intent of an inventory should be considered during the inventory development process. Inventories should be organized in a way that is understandable and useful for policy makers and the public while appropriately reflecting community GHG emissions and enabling the evaluation of emissions trends over time.
- Accuracy: The use of GHG emissions accounting methods that are expected to systematically under- or over-estimate emissions should be avoided. Decisionmakers should be able to act with reasonable assurance as to the integrity of emissions estimates.
- Completeness: Community GHG emissions inventories should be as comprehensive as possible and include all emissions associated with the community, as well as community GHG emissions "sinks" (i.e., the opposite of an emissions source; any reservoir, natural or otherwise, that accumulates and stores GHG emissions).
- Measurability: Methods used to quantify GHG emissions should be readily available, adequately substantiated and of known quality, and updated regularly as established methods evolve.
- Consistency and Comparability: Community inventories should consistently use preferred, established methods to enable tracking of emissions over time, evaluation of reduction measures effectiveness, and comparison between communities. Alternative methods should be documented and disclosed.
- Transparency: All relevant data sources, methods, and assumptions should be disclosed and described to allow for future review and replication. Similarly, all relevant issues should be documented and addressed coherently.

Consistent with the above principles as well as industry standards and best practices, the City's inventory of GHG emissions from communitywide sources and activities primarily follows methodologies provided by the Community Protocol (it also follows methodologies from CARB for certain sectors and sources not included in the Community Protocol).

ICLEI has also developed guidance to assist local governments in conducting inventories of emissions from their governmental operations. The City's municipal operations inventory follows methodologies from ICLEI's latest technical guidance in its May 2010 publication *Local Government Operations Protocol (LGOP) for the Quantification and Reporting of Greenhouse Gas Emissions Inventories* (ICLEI 2010).

2.2.2 California Air Resources Board Methods

Each year, CARB develops and publishes the California GHG Emission Inventory for emissions statewide in California. CARB follows Intergovernmental Panel on Climate Change (IPCC) guidelines for national reporting, and its overarching approach and many of its methods align with the Community Protocol. As climate change science and GHG emissions accounting practices have evolved, CARB has implemented additional methodologies for certain emissions sectors and sources that are not included in the Community Protocol.

The inventory is aligned with the CARB inventory as much as possible. Consistency with the State's methodologies and approaches will be beneficial for upcoming phases of the CAAP development process, including estimating projected GHG emissions in the future (i.e., forecasting emissions), setting GHG emissions reduction targets, and measuring progress towards established targets.

The City's inventories use methods provided by CARB and the California GHG Emission Inventory for several emissions sectors and sources. For example, although the Community Protocol recommends using the U.S. Environmental Protection Agency's (EPA's) NONROAD model, emissions from off-road vehicles and equipment in the city were obtained from CARB's OFFROAD models, which provide more geographic-specific emissions estimates for California using the best available data.

2.3 EMISSIONS SECTORS AND SOURCES

There are several approaches for categorizing and grouping GHG emissions in inventories. Generally, community GHG emissions are organized into emissions sectors, which typically include:

- Building energy
- Transportation
- Solid waste
- Water
- Wastewater

Sometimes community sectors are broken down further, such as residential building energy and nonresidential building energy, and sectors may also be combined, such as water and wastewater. Local governments may also include additional relevant sectors, such as agriculture. Municipal GHG emissions are also organized into emissions sectors, which typically include:

- Building and facilities
- Streetlights and traffic signals
- Employee commutes
- Vehicle fleets
- Solid waste
- Water supply
- Wastewater treatment

The purpose of categorizing GHG emissions into broad sectors is to provide local governments and the public with a useful organization of community emissions. Importantly, GHG emissions sectors may not align directly with economic sectors (e.g., hospitality), but there may be overlap for some communities.

Within GHG emissions sectors, emissions are generated in a variety of ways. For example, motor vehicles burn fossil fuels and emit GHGs directly into the atmosphere; the electricity used in homes and businesses produces indirect emissions from power plants; and solid waste that ends up in landfills breaks down and releases GHG emissions over time. The Community Protocol organizes different types of community GHG emissions into two general categories:

- GHG emissions **sources** are those that release emissions directly into the atmosphere as a result of any physical process that occurs within the jurisdictional boundary of the inventory. Natural gas combustion for heating in homes and diesel fuel combustion in motor vehicles within the community are examples of GHG emissions sources.
- GHG emissions **activities** are those that release emissions into the atmosphere either directly or indirectly as a result of the use of energy, materials, and/or services within the community. For example, GHG emissions from a community's electricity use are accounted for and considered GHG emissions activities, even if the burning of fossil fuels to generate the electricity occurred and produced emissions outside of the inventory boundary.

For the sake of clarity, this report uses "GHG emissions sources" to represent both direct in-boundary emissions *sources* as well as indirect emissions that are produced out-of-boundary as a result of *activities* that occur within the community. The GHG emissions sources in the City's community inventory are organized under six sectors: building energy (residential and nonresidential), on-road transportation, off-road vehicles and equipment (e.g., lawn and landscape equipment), solid waste, water supply, and wastewater treatment.

2.3.1 Community Protocol-Compliant Sources

When developing a community inventory, it is important for local governments to determine what will be included in the inventory scope. This may be influenced by factors such as the purpose and intended narrative of the inventory, the reporting framework that will be used, and the GHG emissions sources present in the community. While local governments have some flexibility in determining an inventory's scope, the Community Protocol requires the inclusion of a minimum of five emissions sources in community inventories:

1. Use of electricity by the community.
2. Use of fuel in residential and commercial stationary combustion equipment.
3. On-road passenger and freight motor vehicle travel.
4. Use of energy in potable water and wastewater treatment and distribution.
5. Generation of solid waste by the community.

The Community Protocol strongly encourages local governments to include other emissions-generating sources in accounting and reporting as well. Considerations for including additional sources are outlined in the following section.

2.3.2 Additional Sources

Many local governments go beyond the minimum requirements of the Community Protocol. Beyond the five emissions sources required by the Community Protocol, the additional GHG emissions sources included in a community inventory are determined by the jurisdiction conducting the inventory. The Community Protocol recommends the Local Government Significant Influence reporting framework, where local governments account for all emissions sources over which they have authority or significant influence. The additional source included in the community inventory is off-road vehicles and equipment.

This approach benefits the overall climate action planning process because it emphasizes the emissions sources that the local government has the greatest ability to address (ICLEI 2019:29). For example, because the City has limited control over the waste that is generated by other communities but is disposed at landfills within the city, imported waste-related emissions are excluded from the City's inventory.

2.4 BOUNDARIES

The scope and boundary chosen for estimating GHG emissions may vary depending on the focus and/or intent of the inventory. For example, while corporate inventories use the concept of ownership to guide GHG emissions accounting—where emissions generated by all sources and activities owned by the entity are accounted for, regardless of where emissions are produced—community-scale inventories serve to convey information about emissions associated with politically defined communities (ICLEI 2019:12).

As described in the previous sections, production-based community inventories include emissions that are produced within a community's geographic boundary as well as those that are produced outside the boundary but result from activities within the community. Regardless of location within or outside of a community's boundary, upstream emissions generated by the consumption of goods and services are excluded from production-based inventories. Inventories following the Community Protocol are required to include several emissions sources; however, certain emissions sources that are located within the inventory boundary may be excluded from a community inventory. The following section outlines considerations and the decision-making framework for determining what GHG emissions sources are included or excluded from an inventory.

2.4.1 Inventory Boundaries

The CAAP aims to reduce GHG emissions from sources within the city for which the City has operational control, regulatory authority, or significant influence. As a result, the City's inventories include emissions generated from sources and activities that occur within the boundaries of the city and over which the City has operational control, regulatory authority, or significant influence.

The inventories do not include emissions generated from activities located within the city's boundary but outside of its jurisdiction, as the City does not have operational control, regulatory authority, or significant influence over these emissions sources.

GHG emissions generated from the University of California, Irvine (UCI) campus, located within the City's boundaries are excluded from the community inventory because UCI is a division of the state government over which the City has no operational control, regulatory authority, or significant influence. Furthermore, one stationary source is located on the UCI campus is regulated by CARB under the California Greenhouse Gas Cap-and-Trade Program (Cap-and-Trade).

The GHG emissions sectors and sources included and excluded in the 2019 community inventories are presented in Table 3. Additionally, Table 3 identifies the protocol that provided the methodology for estimating GHG emissions from each emissions source. Emissions sources that identify multiple protocols used a combination of data and methods from multiple protocols. For example, off-road vehicles and equipment calculations used methods consistent with IPCC and the Community Protocol but substituted California-specific data obtained from CARB for less geographic-specific data provided by the protocols. More information on the protocols used for each emissions source can be found in Appendix A.

Table 3 Summary of Sectors and Sources in Community and Municipal Operations Inventories

Sector/Source	Included	Excluded	Protocol(s)
Community Inventory			
On-Road Transportation			
On-Road Transportation	Emissions from 100 percent of vehicle trips within the city (internal-internal) and 50 percent of vehicle trips starting or ending outside the city (internal-external and external-internal)	Emissions from 100 percent of pass-through vehicle trips starting and ending outside the city (external-external)	Community Protocol
Building Energy			
Electricity	Emissions associated with all electricity consumed within the city	NA	Community Protocol
Natural Gas	Emissions from natural gas consumed within the city	NA	Community Protocol
Backup Generators	Emissions from diesel, natural gas, and gasoline consumed in backup generators within the city	NA	Community Protocol
Solid Waste			
Community-Generated Solid Waste	Emissions from all waste generated within the city	Emissions from waste generated outside of the city but disposed of within the city	Community Protocol
Off-Road Vehicles and Equipment			
Off-Road Vehicles and Equipment	Emissions from off-road vehicles and equipment within the city	NA	Community Protocol/CARB
Wastewater Treatment			
Wastewater Treatment	Emissions associated with wastewater generated within the city	Emissions from wastewater generated outside of the city but treated within the city	Community Protocol
Water Supply			
Water Supply	Emissions associated with water use within the city	NA	Community Protocol

Sector/Source	Included	Excluded	Protocol(s)
Municipal Inventory			
Buildings and Facilities			
Electricity	Emissions associated with electricity consumed from municipal operations	NA	LGOP
Natural Gas	Emissions from natural gas consumed from municipal operations	NA	LGOP
Backup Generators	Emissions from diesel, natural gas, and gasoline consumed in backup generators from municipal facilities	NA	LGOP
Streetlights and Traffic Signals			
Electricity	Electricity used for streetlights and traffic signals within the city	NA	LGOP
Employee Commute			
VMT	VMT from municipal employee commute trips	NA	LGOP
Vehicle Fleet			
Fuel Use	Fuel consumption from municipal owned and operated vehicles (on-road and off-road)	NA	LGOP
Solid Waste			
Solid Waste Disposed	Emissions from all waste generated by municipal employees	NA	LGOP
Wastewater Treatment			
Wastewater Treatment	Emissions associated with wastewater generated by municipal employees	NA	LGOP
Water Supply			
Water Supply	Emissions associated with water use from municipal facilities	NA	LGOP

Notes: CARB = California Air Resources Board; Community Protocol = U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions; LGOP = Local Government Operations Protocol; NA = not applicable; VMT = vehicle miles traveled.

Source: Ascent Environmental 2022.

3 DATA, METHODS, AND ASSUMPTIONS

3.1 OVERVIEW OF ACTIVITY DATA AND EMISSIONS FACTORS

The basic calculation for estimating GHG emissions involves two primary inputs: activity data and emissions factors. Activity data refers to the relevant measurement of an activity resulting in emissions, and emissions factors represent the amount of GHGs emitted on a per unit of activity basis. Emissions factors are applied to activity data (i.e., the two values are multiplied together) to estimate GHG emissions. For example, in the community residential energy sector, activity data of annual community electricity consumption in megawatt-hours (MWh) is multiplied by an emissions factor in pounds of GHG per MWh, which results in a pounds of GHG emissions value. This calculation-based methodology is used for estimating emissions from most sources in the City's production-based inventories. An overview of activity data and emissions factors for each emissions source, along with data sources, is shown in Table 4. Detailed methods are described in the following sections.

Table 4 2019 City of Irvine Summary of Activity Data and Emissions Factors

Sector/Source	Input Type	Description and Data Sources
	Community	
On-Road Transportation		
On-Road Transportation	Activity data	VMT data from ITAM Traffic Model 2021 and SCAG RTP Model 2016.
	Emissions factor	Orange County-specific emissions factors from CARB
Building Energy		
Electricity	Activity data	Electricity consumption data from SCE
	Emissions factor	SCE Power Content Label and CARB Mandatory Reporting of Greenhouse Gases (MRR)
Natural Gas	Activity data	Natural gas consumption data from SoCalGas
	Emissions factor	Average emissions factors from TCR
Backup Generators	Activity data	Fuel consumption data estimated from SCAQMD permit data
	Emissions factor	Average emissions factors from TCR
Solid Waste		
Community-Generated Solid Waste	Activity data	Waste disposal data from CalRecycle
	Emissions factor	Mixed municipal solid waste emissions factor from EPA
Off-Road Vehicles and Equipment		
Off-Road Vehicles and Equipment	Activity data	Off-road vehicles and equipment activity and emissions factors data from CARB
	Emissions factor	
Wastewater Treatment		
Wastewater Treatment	Activity data	Wastewater generation and process-related data from IRWD and OCSan
	Emissions factor	Emissions factors based on treatment processes from IRWD, OCSan, and ICLEI
Water Supply		
Water Supply	Activity data	Water consumption data from IRWD
	Emissions factor	Energy intensity factors from CPUC
	Municipal	
Buildings and Facilities		
Electricity	Activity data	Electricity consumption data from SCE

Sector/Source	Input Type	Description and Data Sources
	Emissions factor	SCE Power Content Label and CARB Mandatory Reporting of Greenhouse Gases (MRR)
Natural Gas	Activity data	Natural gas consumption data from SoCalGas
	Emissions factor	Average emissions factors from TCR
Backup Generators	Activity data	Fuel consumption from the City
	Emissions factor	Average emissions factors from TCR
Streetlights and Traffic Signals		
Electricity	Activity data	Electricity use from streetlights and traffic signals from SCE
	Emissions factor	SCE Power Content Label and CARB Mandatory Reporting of Greenhouse Gases (MRR)
Employee Commute		
VMT	Activity data	Employee commute mileage from the City
	Emissions factor	Orange County-specific emissions factors from CARB
Vehicle Fleet		
Fuel consumption	Activity data	Fuel consumption from the City
	Emissions factor	Fuel consumption emissions factors from TCR
Solid Waste		
Solid Waste Disposed	Activity data	Waste disposal data from CalRecycle
	Emissions factor	Municipal solid waste emissions factor from EPA
Wastewater Treatment		
Wastewater Treatment	Activity data	Wastewater generation and process-related data from IRWD and OCSan
	Emissions factor	Emissions factors based on treatment processes from IRWD, OCSan, and ICLEI
Water Supply		
Water Supply	Activity data	Water consumption data from IRWD
	Emissions factor	Energy intensity factors from CPUC

Notes: CalRecycle = California Department of Resources Recycling and Recovery; CARB = California Air Resources Board; CPUC = California Public Utilities Commission; EPA = U.S. Environmental Protection Agency; ICLEI = ICLEI – Local Governments for Sustainability; IRWD = Irvine Ranch Water District; ITAM = Irvine Transportation Analysis Model; OCSan = Orange County Sanitation District; RTP = Regional Transportation Plan; SCAG = Southern California Association of Governments; SCAQMD = Southern California Air Quality Management District; SCE = Southern California Edison; SoCalGas = Southern California Gas Company; TCR = The Climate Registry; VMT = vehicle miles traveled.

Source: Ascent Environmental 2022.

3.2 GLOBAL WARMING POTENTIALS AND EMISSIONS UNITS

GHG emissions other than carbon dioxide (CO_2) generally have a stronger insulating effect and thus, a greater ability to warm the Earth's atmosphere through the greenhouse effect. This effect is measured in terms of a pollutant's GWP. CO_2 has a GWP factor of one while all other GHGs have GWP factors measured in multiples of one relative to the GWP of CO_2. This conversion of non-CO_2 gases to one unit enables the reporting of all emissions in terms of carbon dioxide equivalent (CO_2e), which allows consideration of all gases in comparable terms and makes it easier to communicate how various sources and types of GHG emissions contribute to climate change. The standard unit for reporting emissions is metric tons of carbon dioxide equivalent ($MTCO_2e$).

Consistent with the best available science, these inventories use GWP factors published in the Sixth Assessment Report from IPCC, where methane (CH_4) and nitrous oxide (N_2O) have GWP factors of 27.9 and 273, respectively (IPCC 2021). These values represent the GWP of GHG on a 100-year time horizon. This means that CH_4 is approximately 28 times stronger than CO_2 and N_2O is 273 times stronger than CO_2 in their potential to warm Earth's atmosphere over the course of 100 years. The use of 100-year GWP values is consistent with CARB methods and reflects the long-term planning horizon of the CAAP.

3.3 DATA QUALITY AND ACCURACY

When preparing a GHG emissions inventory, the goal is to use the best available data and methodologies to develop the most accurate picture of a community's emissions. However, some degree of inaccuracy is inherent to all inventories. As described by the Community Protocol, "While no community inventory is fully comprehensive (some emissions cannot be estimated due to a lack of valid methods, a lack of emissions data, or for other reasons), community inventories often aim to provide as complete a picture of GHG emissions associated with a community as is feasible" (ICLEI 2019:12). The accuracy of a GHG emissions inventory is primarily dependent on activity data (e.g., tons of solid waste generated by a community), emissions factors (e.g., grams of CO_2 per vehicle mile traveled [VMT] in a county), and scaling factors (e.g., percentage of county-level off-road vehicles and equipment emissions attributed to a local jurisdiction). The year 2019 was chosen for the inventories because it is the most recent calendar year for which representative data are available due to the changes in activity that have occurred in 2020 and 2021 due from the COVID-19 pandemic. Thus, the year 2019 is most representative year of typical conditions.

Development of the City's GHG emissions inventories was a robust and comprehensive process rooted in industry standards and best practices, and it included extensive research and consultation with City staff and departments and regional and State agencies and organizations to obtain data that are as accurate as feasible. The City recognizes that even though its inventory is consistent with all protocols previously discussed and the data used are as accurate as feasible, perfect precision in emissions estimates is not possible at this time. The following are assumptions that were made due to the unavailability of data:

- **Community and municipal wastewater activity data.** Wastewater-related data within the city was limited. The inventories assume that the Irvine Ranch Water District (IRWD) and Orange County Sanitation District (OCSan) were the two centralized wastewater treatment plants (WWTPs) serving the city. Because wastewater treated according to each entity was unable to be provided, their service boundaries within the city limits were mapped. This mapping exercise was able to determine what proportion of the city's population is serviced by each entity and was then applied to each entity's treatment types. Appendix B of this report provides the service boundary map of IRWD and OCSan within the city limits.
- **Community back-up generator activity data:** Because generator hours of operations were not able to be provided for each generator operating in 2019 from Southern California Air Quality Management District (SCAQMD), a conservative estimated number of operating hours was applied for both maintenance and emergency scenarios. Fuel consumption was also not available and was replaced using average rates using CARB's OFFROAD model.
- **Scaling factors used to attribute emissions to the city level.** Certain emissions sectors use data that are not specific to the city but Orange County as a whole, and scaling factors were used to apportion data to the city. For example, emissions data for off-road vehicles and equipment, obtained from CARB's OFFROAD models, are provided for the entire county. Population, employment, and service population factors (i.e., the proportion of the city compared to the entire county) were used to scale county-level data to the city.

3.4 COMMUNITY INVENTORY DATA AND ASSUMPTIONS

3.4.1 Sector-Specific Assumptions and Methods

The following sections describe in detail the methods, data, and assumptions that were used in estimating the City's community GHG emissions in 2019. Population and employment data were used to scale activity levels for certain emissions sources and sectors. Population and employment data for 2019 were obtained from the City's land use database and the Center for Orange County Projections. The list below summarizes this information at a high level for each sector.

- **Building Energy:** Annual electricity and natural gas usage data for the City were provided by Southern California Edison (SCE) and Southern California Gas Company (SoCalGas). Annual nonresidential backup generator usage was provided by SCAQMD. Emissions factors for nonresidential backup generator fuels were obtained from TCR.
- **On-Road Transportation:** For the on-road transportation sector, annual VMT were obtained from Iteris using the Irvine Transportation Analysis Model (ITAM) Traffic Model 2021 and Southern California Association of Governments (SCAG) Regional Transportation Plan (RTP) Model 2016. Vehicle emissions factors were derived from the 2021 EMissions FACtor (EMFAC2021) model, CARB's statewide mobile source emissions inventory model.
- **Off-Road Vehicles and Equipment**: Off-road vehicles and equipment emissions were estimated from CARB's OFFROAD2007 and OFFROAD2021 models and scaled by population, employment, or service population (i.e., the sum of population and employment) depending on the equipment type.
- **Solid Waste:** Emissions associated with waste generated by residents and businesses in the city were estimated using disposal data available from the California Department of Resources Recycling and Recovery (CalRecycle) for landfills receiving waste from the city. Landfill gas (LFG) collection information was available from EPA.
- **Water Supply:** Using guidance provided by ICLEI, water supply emissions were estimated using water consumption data from IRWD in combination with region-specific energy intensity factors obtained from the California Public Utilities Commissions (CPUC).
- **Wastewater Treatment:** Emissions from wastewater treatment depend on the types of treatment processes and equipment that centralized WWTPs use. Data regarding treatment processes, population served, digester gas combustion, and daily nitrogen load were obtained from IRWD and OCSan.

3.4.2 Utility Emissions Factors

Emissions of CO_2, CH_4, and N_2O per MWh of electricity or therm of natural gas can vary by location and from year to year depending on several factors. Utility-specific emissions factors were obtained and used throughout the 2019 inventories to estimate GHG emissions from electricity and natural gas consumption. Sources for electricity and natural gas emissions factors are shown below.

- **Electricity:** SCE's emissions factor for 2019 was derived from its Power Content Label, which shows 16.1 percent natural gas and 32.6 percent from unspecified sources of power (unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source: SCE 2019). In total, this implies that SCE's portfolio is 48.7 percent carbon-emitting power.[1] This 48.7 percent was then multiplied by the CARB emissions factor for Mandatory Reporting of Greenhouse Gases (MRR) of 0.428 MT CO2e/MWh, which reflects the emissions from unspecified power, and additionally is similar to the emission factor from an average single-cycle natural gas power plant (CARB 2018: 16).
- **Natural Gas:** Utility natural gas emissions factors for CO_2, CH_4, and N_2O were obtained from TCR's 2020 Default Emission Factors (TCR 2020).

Specific utility emissions factors used in the inventory calculations are shown in Tables 5 and 6. Emissions factors are shown in standards units for electricity (pounds of GHG per MWh) and natural gas (pounds per therm).

Table 5 2019 City of Irvine Electricity Emissions Factors

Provider	Pollutant	Emissions Factor (lb/MWh)
SCE	CO_2e	459.52

Notes: CH_4 = methane; CO_2 = carbon dioxide; lb = pounds; MWh = megawatt-hours; N_2O = nitrous oxide; SCE = Southern California Edison.
Source: Utility emissions factors provided by SCE. Table compiled by Ascent Environmental in 2022.

[1] This memorandum uses "carbon-emitting power" as a shorthand to refer to the sum of power generated by natural gas-fired generators and unspecified power.

Table 6 2019 City of Irvine Natural Gas Emissions Factors

Provider	Pollutant	Emissions Factor (lb/therm)
SoCalGas	CO_2	11.7
	CH_4	0.00104
	N_2O	0.0000220

Notes: CH_4 = methane; CO_2 = carbon dioxide; lb = pounds; MWh = megawatt-hours; N_2O = nitrous oxide; SoCalGas = Southern California Gas Company.
Source: Utility emissions factors provided by TCR. Table compiled by Ascent Environmental in 2022.

RESIDENTIAL ENERGY

Residential energy emissions in the city result indirectly from electricity consumption and directly from onsite combustion of natural gas. SCE is the provider of residential energy in the city. To calculate the $MTCO_2e$ of residential electricity consumption, the emissions factor shown in Table 5 was applied to electricity consumption data. Annual residential natural gas consumption in therms was obtained from SoCalGas. CO_2, CH_4, and N_2O emissions factors for natural gas were applied to consumption data to estimate $MTCO_2e$ from residential natural gas usage.

NONRESIDENTIAL ENERGY

Nonresidential energy emissions, which are generated by commercial and industrial uses, result indirectly from electricity consumption and directly from onsite combustion of natural gas. SCE provides nonresidential electricity in the city. Emissions associated with nonresidential energy consumption were quantified using the same methods as described above for residential energy calculations.

Data for annual nonresidential backup generators were obtained from SCAQMD, expressed as gallons for diesel fuel and standard cubic feet for propane and natural gas. Emissions factors obtained from TCR were applied to fuel consumption data to estimate GHG emissions associated with nonresidential backup generator usage.

3.4.3 Building Energy

Residential and nonresidential building energy use in the city resulted in approximately 841,543 $MTCO_2e$ in 2019. This sector generated approximately 37 percent of the city's emissions in 2019 and represents the second-largest emissions sector in the inventory. Emissions were a result of natural gas combustion for heating and cooking in homes and businesses and electricity use, primarily for lighting and heating, ventilation, and air conditioning (HVAC) and to power appliances. A marginal amount of nonresidential building energy emissions was associated with the consumption of diesel, natural gas, and gasoline in backup generators.

Nonresidential natural gas use accounted for approximately 19 percent of the city's 2019 building energy emissions, and residential natural gas use accounted for approximately 21 percent. Nonresidential electricity accounted for approximately 46 percent of the city's 2019 building energy emissions, and residential electricity use accounted for approximately 14 percent. Nonresidential backup generators accounted for 1 percent of emissions from the building sector in 2019. The GHG emissions associated with energy consumed by the All-American Asphalt facility have been included in this inventory under the nonresidential energy use category. Annual electricity, natural gas, and backup generator usage and GHG emissions are shown in Table 7, and additional information regarding each emissions source and calculations are discussed below.

Table 7 2019 City of Irvine Community Building Energy Use and GHG Emissions

Energy Type	Quantity	GHG Emissions
Electricity	MWh	$MTCO_{2e}$
Residential	559,329	116,584
Nonresidential	1,847,715	385,130

Energy Type	Quantity	GHG Emissions
Electricity Total	*2,407,044*	*501,715*
Natural Gas	therms	$MTCO_2e$
Residential	32,849,598	174,820
Nonresidential	30,158,957	160,501
Natural Gas Total	*63,008,555*	*335,322*
Backup Generators	NA	$MTCO_2e$
Nonresidential	NA	4,507
Energy Combined	NA	$MTCO_2e$
Residential	NA	291,405
Nonresidential	NA	550,139
Total	NA	841,544

Notes: Totals in columns may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; MWh = megawatt-hours; NA = not applicable.

Source: Ascent Environmental 2022.

3.4.4 On-Road Transportation

Based on modeling conducted, on-road transportation in the city resulted in approximately 1,144,205 $MTCO_2e$ in 2019, or 51 percent of the city's emissions in 2019. The on-road transportation sector represents the largest emissions sector in the city. Annual VMT and GHG emissions from on-road transportation are shown in Table 8. Additional details and calculation methodologies and assumptions are described below.

Table 8 2019 City of Irvine Community On-Road Transportation VMT and GHG Emissions

Source	Annual VMT	GHG Emissions ($MTCO_2e$)
On-Road Transportation	2,910,428,375	1,144,205

Notes: GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; VMT = vehicle miles traveled.

Source: Ascent Environmental 2022.

On-road transportation emissions are primarily the result of the combustion of gasoline and diesel fuels in passenger vehicles (i.e., cars, light-duty trucks, and motorcycles), medium- and heavy-duty trucks, and other types of vehicles permitted to operate "on road." To a smaller degree, emissions from on-road electric vehicles also result from upstream electricity generation; these emissions are represented in annual electricity emissions in the city. Due to lack of available data, emissions from the combustion of natural gas and other non-electric alternative fuels in on-road vehicles were not included in the community inventory and are assumed to have minimal contribution to total emissions.

Iteris conducted a VMT analysis that considered daily and annual VMT in the city for 2019. These VMT estimates are associated with trips that begin or end in the city. VMT estimates included 100 percent of vehicle trips that both originate from and end in the city (i.e., fully internal trips), 50 percent of trips that either end in or depart from the city (i.e., internal-external, or external-internal trips), and zero percent of vehicle trips that are simply passing through the city boundaries (i.e., external-external, or "pass-through," trips). This vehicle trip accounting method is consistent with the Regional Targets Advisory Committee (RTAC) origin-destination method established through SB 375 and CARB recommendations.

Emissions factors for on-road VMT were derived separately for light-duty vehicles and medium/heavy-duty vehicles, using Orange County-wide data from EMFAC2021. These emissions factors were combined with city-specific VMT data for these same vehicle categories provided by Iteris, and used to calculate a weighted average emissions factor for all city VMT.

3.4.5 Off-Road Vehicles and Equipment

Based on modeling conducted, off-road vehicles and equipment operating in the county emitted approximately 68,756 $MTCO_2e$ in 2019, or 3 percent of the 2019 inventory. The largest emissions-generating off-road categories include construction and mining equipment and industrial equipment. The estimated annual emissions and scaling factors used are presented in Table 9 by vehicles and equipment type. Additional details regarding calculation methods and assumptions are discussed below.

Table 9 2019 City of Irvine Community Off-Road Vehicles and Equipment GHG Emissions and Scaling Method

Off-Road Vehicles and Equipment Type	GHG Emissions ($MTCO_2e$)	Scaling Method
Construction and Mining Equipment	19,536	Service Population
Entertainment Equipment	267	Employment
Industrial Equipment	25,201	Employment
Lawn and Garden Equipment	708	Population
Light Commercial Equipment	5,330	Employment
Portable Equipment	14,647	Employment
Recreational Equipment	267	Population
Transportation Refrigeration Units	2,799	Service Population
Total	**68,756**	NA

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; NA = not applicable.

Source: Data provided by Ascent Environmental in 2022, based on modeling from CARB's OFFROAD2007 and OFFROAD2021.

Emissions from the off-road vehicles and equipment sector result from fuel combustion in off-road vehicles and equipment. Data associated with this sector were available from CARB's OFFROAD2007 and OFFROAD2021 models. These models provide emissions details at the state, air basin, or county level. Orange County emissions data from OFFROAD2007 and OFFROAD2021, which include emissions from incorporated areas of the county, were apportioned to the City of Irvine using custom scaling factors depending on the off-road vehicle and equipment type. For example, due to the likely correlation between commercial activity and employment, the city's portion of emissions from light commercial equipment in the entire county is assumed to be proportional to the number of jobs in the city as compared to the entire county.

OFFROAD2007 provides emissions details for all off-road vehicle and equipment types, but OFFROAD2021 only provides details for certain types of off-road vehicles and equipment that are relevant to the county (i.e., it does not include emissions estimates for all off-road vehicle and equipment types). CARB recommends using OFFROAD2007 where desired information is unavailable from the OFFROAD2021 model, so data from both models were used (CARB 2020). Additionally, while OFFROAD2021 provides estimates of CO_2 emissions, it does not provide estimates for CH_4 and N_2O emissions. To estimate CH_4 and N_2O emissions from the vehicle and equipment types included in OFFROAD2021, ratios of CH_4 to CO_2 and N_2O to CO_2 were obtained from OFFROAD2007 and applied to CO_2 data from OFFROAD2021 to calculate CH_4 and N_2O emissions.

3.4.6 Solid Waste

Based on modeling conducted, the solid waste sector was responsible for approximately 160,626 $MTCO_2e$ in 2019, or 7 percent of community GHG emissions. Community-generated solid waste emissions are associated primarily with the decomposition of solid waste generated by the city in landfills, while a smaller proportion of emissions are produced by the decomposition of alternative daily cover (ADC) generated by the city. Table 10 summarizes emissions from the solid waste sector. Additional details regarding calculation methods and assumptions are discussed below.

Table 10 2019 City of Irvine Community Solid Waste Quantity and GHG Emissions

Source	Quantity (tons)	GHG Emissions ($MTCO_2e$)
Community-Generated Solid Waste	389,271	160,626

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Ascent Environmental 2022.

COMMUNITY-GENERATED SOLID WASTE

CH_4 emissions generated by community-generated solid waste occur from the decay of landfill disposed waste generated annually by residences and businesses in the city. A total of 389,271 tons of landfilled waste was reported for the city in 2019. In addition to landfilled waste, communities send ADC to landfills. ADC is non-earthen material used to cover an active surface of a landfill at the end of each operating day to control for vectors, fires, odors, blowing litter, and scavenging. This material can include compost, construction and demolition waste, sludge, green material, shredded tires, spray-on cement, and fabric. Given that ADC can also include organic material, CH_4 emissions from landfills result from organic decomposition in both waste disposal and ADC. ADC from the city was reported to be 37,188 tons in 2019. Data for landfilled waste and ADC was obtained from CalRecycle (CalRecycle 2021).

The amount of CH_4 released from community-generated waste depends on the LFG management systems of the landfills at which the waste is disposed. Information regarding the use of an LFG capture system was available from EPA's Landfill Methane Outreach Program. All facilities included an LFG capture system; therefore, the default LFG collection efficiency of 0.75 was applied to adjust emissions estimates, as recommended by the Community Protocol. Default waste characterization emissions factors obtained from EPA were used in calculations.

3.4.7 Water Supply

Based on modeling conducted, water supply emissions accounted for 30,798 $MTCO_2e$ in 2019. GHG emissions associated with water supply occur from the indirect use of energy associated with water extraction, conveyance, treatment, and distribution to the point of use (e.g., residences, businesses). Energy consumption for supplying water was estimated by applying energy intensity factors (i.e., the total amount of energy required to produce a unit of water for a particular use) to water supply consumption values. Water supply emissions are estimated by applying electricity emissions factors to water consumption values. A portion of the water supply is from local sources within the city, so the inventory assumes that a majority of electricity usage associated with extracting, conveying, treating, and distributing water is captured in the buildings energy sector because these activities take place within the city. The water supply that is sourced from sources outside of the jurisdiction generated 30,798 $MTCO_2e$. Table 11 presents water supply volume, as well as associated GHG emissions for the city in 2019. The methods used are explained in more detail below.

Table 11 2019 City of Irvine Community Water Supply Quantity and GHG Emissions

Source	Quantity	GHG Emissions ($MTCO_2e$)
Water Supply (AF)	125,010	30,798

Notes: AF = acre-feet; GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Ascent Environmental 2022.

ENERGY INTENSITY FACTOR

An energy intensity factor, regarding water supply emissions, is defined by the amount of energy (e.g., electricity, natural gas) required to produce a unit of water for a particular use. Electricity is the primary source of energy used for water extraction, conveyance, treatment, and distribution in the Central Coast hydrologic region. Other energy sources may include fossil fuel-powered pumps and backup generators at treatment plants, but these sources that may be used were considered negligible. Thus, for purposes of this analysis, energy intensity is based on electricity use only and is expressed as kilowatt-hours per acre-foot (kWh/AF).

In 2015, the CPUC commissioned a study of hydrologic zones in California and their relative energy intensities for water extraction, conveyance, treatment, and distribution. The city is within the South Coast hydrologic zone, which has specific energy intensities by supply type (e.g., local surface water, imported deliveries). Using the energy intensities for the South Coast hydrologic zone, a weighted factor for water extraction, conveyance, treatment, and distribution of 1,182 kWh/AF was derived for water supply in the city.

ENERGY CONSUMPTION

To estimate water supply-related energy consumption, the energy intensity factor described above was applied to a water consumption estimate of 125,010 acre-feet per year, resulting in GHG emissions of 30,798 $MTCO_2e$.

3.4.8 Wastewater Treatment

Based on modeling conducted, wastewater treatment resulted in GHG emissions of approximately 5,665 $MTCO_2e$, which represents less than 1 percent of total emissions. Wastewater treatment emissions are summarized in Table 12, and additional details for this sector are included below.

Table 12 2019 City of Irvine Wastewater Treatment GHG Emissions

Wastewater Treatment Type	GHG Emissions ($MTCO_2e$)
Centralized WWTPs	5,665

Notes: GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; WWTP = wastewater treatment plant.

Source: Ascent Environmental 2022.

CENTRALIZED WASTEWATER TREATMENT PLANTS

Emissions associated with the treatment of sewage are highly dependent on the processes and components used by specific WWTPs such as lagoons, nitrification or denitrification, and digester gas or combustion devices. There are two centralized wastewater treatment providers for the city. IRWD and OCSan are the centralized WWTPs that collect wastewater from customers' homes and businesses. Collected wastewater enters the regional sewer system, which is operated by IRWD, and is then conveyed and pumped to either facility where it is treated before being safely reintroduced to the environment. Specific data regarding the type of WWTP and associated processes, population served, digester gas production, and daily nitrogen load were available from IRWD and OCSan. Due to lack of available data of water treatment amounts from the two providers, the proportion of the populations served by each provider was applied to the total wastewater treated in the city.

Stationary CH_4 and N_2O emissions from the combustion of digester gas were calculated based on the volume of digester gas provided by OCSan, using Community Protocol equation WW.1b. This equation accounts for the known digester gas content.

OCSan process CH_4 emissions from lagoons were calculated based on population data, using Community Protocol equation WW.6(alt) for anaerobic or facultative lagoons. Equation WW.6(alt) contains factors for the maximum CH_4 production capacity of domestic wastewater and a CH_4 correction factor for anaerobic systems. Fugitive N_2O emissions for both OCSan and IRWD were estimated based on nitrogen discharge using Community Protocol WW. 12. Process N_2O emissions were also calculated based on population data, using Community Protocol WW.7 for WWTPs with nitrification or denitrification. These equations contain nitrogen loading factors and WWTP emission factors. Fugitive N_2O emissions from effluent discharge were calculated based on average daily nitrogen load data provided by OCSan and IRWD, using Community Protocol equation WW.12.

Energy-related emissions result from the energy required for wastewater treatment operations, including the energy used in wastewater conveyance as well as energy used throughout wastewater treatment processes and to provide power to the treatment facilities. OCSan energy emissions were based on energy usage using Community Protocol equation WW.15. Because IRWD is located within the city, the inventory assumes that energy-related emissions from wastewater treatment are captured in the buildings energy sector emissions estimates.

3.4.9 Emissions Sources Excluded from the Community Inventory

Additional GHG emissions sources were evaluated for the City's community inventory. Although these sources are not included in the total community GHG emissions for the inventory, they provide additional context for understanding emissions in the city. Details regarding GHG emissions from regulated stationary sources are discussed below.

REGULATED STATIONARY SOURCES

GHG emissions are generated from a variety of regulated stationary sources operating within the city. As shown in Table 13, many facilities include two types of GHG emissions estimates: those considered "Covered" and those considered "Non-Covered." "Covered" emissions are those that are regulated by CARB under Cap-and-Trade. "Non-Covered" emissions are associated with the facilities regulated under Cap-and-Trade but are separate from the allowance budget. Cap-and-Trade establishes an aggregate GHG allowance budget on covered entities and provides a trading mechanism for compliance instruments (allowance or offset credit). Facilities regulated under Cap-and-Trade may purchase allowances to emit GHG emissions from facilities that reduce GHG emissions (e.g., solar farms) or sell emission offset credits to regulated facilities that need to reduce their emissions to meet CARB's industry-wide emissions cap. Currently, CARB gives such allowances to facilities that emit more than 25,000 $MTCO_2e$ per year. These entities primarily involve heavy industrial activities that consume large amounts of natural gas and are eligible purchasers of Cap-and-Trade emissions allowances because the facility emits more than 25,000 $MTCO_2e$ per year. Due to the involvement of facilities located in the city in Cap-and-Trade, the State, and not the City, has the regulatory authority for reducing emissions from this sector. For the purposes of developing the community inventory, emissions associated with Cap-and-Trade covered facilities, including the non-covered emissions, are excluded.

Table 13 2019 City of Irvine GHG Emissions from Regulated Stationary Sources

Facility Name	Industry Description	Covered GHG Emissions ($MTCO_2e$)	Non-Covered GHG Emissions ($MTCO_2e$)	Total GHG Emissions ($MTCO_2e$)
All American Asphalt - Irvine	Other Combustion Source	0	10,301	10,301
Allergan	Other Combustion Source	0	7,911	7,911
Bowerman Power LFG, LLC	In-State Electricity Generation	0	90,879	90,879
Braun Medical Inc	Other Combustion Source	50,645	0	50,645
Maruchan, Inc. - Laguna Canyon	Other Combustion Source	0	20,076	20,076
Petro-Diamond	Transportation Fuel Supplier	1,938,755	125,029	2,063,784
University of California, Irvine	Other Combustion Source	69,138	4	69,142
Total	**NA**	**2,007,893**	**145,109**	**2,153,002**

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gases; $MTCO_2e$ = metric tons of carbon dioxide equivalent; NA = not applicable.

Source: Data obtained from CARB; table compiled by Ascent Environmental in 2022.

UC IRVINE

UC Irvine generates GHG emissions from building and facility operations, student dormitories, student and employee commute, vehicle fleet, solid waste, water, and wastewater. UC Irvine is part of the University of California, a division of the state government and is not under the jurisdiction of the City and its emissions are not included in the City's community inventory. However, to provide context for the GHG emissions generated by UC Irvine, Table 14 shows the 2019 GHG emissions quantified by UC Irvine as part of its sustainability initiatives.

Table 14 2019 University of California Irvine Greenhouse Gas Emissions Inventory

Sector	$MTCO_2e$	Percent of Total
Stationary Combustion	77,368	82
Mobile Combustion	1,106	1
Process	90	0
Fugitive	4,812	5
Purchased Electricity – Location Based	11,413	12
Total	**94,789**	**100**

Notes: Totals may not sum exactly due to independent rounding. $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: The Climate Registry 2019

RAILWAYS

There are several train operators with routes that travel through Irvine's city limits that provide passenger and freight services. Passenger train operators with stations in the city include Amtrak and Metrolink and freight train operators traveling through the city include BNSF. BNSF does not have stations located in Irvine and simply passes through as part of its route. Because both passenger and freight rail operators are managed and owned by agencies and companies outside the city, the City does not have regulatory authority or significant influence over railway operations. Railway emissions in the city were estimated to be 2,396 $MTCO_2e$ in 2019. However, because the City does not have regulatory authority over railway emissions occurring within the City's boundaries, these emissions are excluded from the City's community inventory.

SOLID WASTE

The Frank R. Bowerman Landfill is a commercial landfill operating the city. Only municipal waste from commercial haulers and vehicles with commercial status are accepted at the landfill. Because the landfill is regulated under the County of Orange Waste and Recycling Department, the City has limited control over its operations. Thus, the waste that is generated by other communities or entities at the landfill are excluded from the City's community inventory, consistent with the Community Protocol.

3.5 MUNICIPAL OPERATIONS INVENTORIES DATA AND ASSUMPTIONS

3.5.1 Sector-Specific Assumptions and Methods

The following sections describe in detail the methods, data, and assumptions that were used in estimating the City's municipal operations GHG emissions in 2019. Employment data obtained from the City were used to scale activity levels for certain emissions sources and sectors.

The following summarizes data sources and methods used in estimating the City's municipal operations GHG emissions in 2019:

- **Buildings and Facilities:** Annual municipal electricity and natural gas usage data for the City and utility emissions factors were provided by SCE and SoCal Gas. Additional emissions factors were obtained from EPA and TCR. Annual municipal backup generator usage was provided by the City, and emissions factors for backup generators were available from TCR.
- **Streetlights and Traffic Signals:** Annual municipal electricity use for all streetlights and traffic signals was provided by the City. The SCE electricity emissions factors used in the buildings and facilities sector were used for streetlights and traffic signals.

- **Employee Commute:** Emissions associated with municipal employee commutes were calculated using employment data provided by the City, including the number of temporary and permanent employees, and average trip distances. Vehicle emissions factors were derived using EMFAC2021.
- **Vehicle Fleet:** Municipal vehicle fleet fuel consumption data was provided by the City. This fleet includes both on-road vehicles as well as off-road vehicles and equipment. Emissions factors were obtained from TCR.
- **Solid Waste:** Because annual municipal-generated solid waste data were unavailable, solid waste generation estimates were conducted using the number of municipal employees provided by the City, and average solid waste disposal per public administration employee data from CalRecycle. Emissions factors were obtained from EPA.
- **Water Supply:** Water supply data was provided by the City's water purveyors, IRWD and OCSan. Emissions were estimated by applying the region-specific energy intensity factors to the municipal water consumption volumes provided by each water purveyor. SCE utility emissions factors were used to estimate GHG emissions.
- **Wastewater Treatment:** Data regarding treatment processes, population served, digester gas production and combustion, BOD load, and nitrogen load were obtained from IRWD and OCSan.

It should be noted that the GHG emissions associated with the County's employee commute, solid waste generation, water consumption, and wastewater treatment are not additive emissions to the community inventory GHG emissions. The VMT data estimated for employee commute are already reflected in the community VMT travel model used. Municipal solid waste generation is included in community solid waste disposal tonnage data. Water and wastewater activity and emissions data do not exclude activities from municipal operations and therefore may result in overlapping emission results.

3.5.2 Buildings and Facilities

Municipal buildings and facilities accounted for approximately 12,003 $MTCO_2e$ in 2019, or 65 percent of total municipal operations emissions in 2019. This sector includes emissions from energy (i.e., electricity, natural gas, diesel) used for all City buildings and facilities, primarily for lighting, HVAC, pumps, generators, and other equipment. Electricity accounted for approximately 84 percent of emissions from this sector in 2019, while natural gas and diesel backup generators accounted for 16 percent and less than 1 percent, respectively. Buildings and facilities include City-owned and leased buildings, as well as other infrastructure such as park buildings, park lighting and irrigation controllers, and other facilities. Building energy use and emissions by source are presented in Table 15 below.

Table 15 2019 City of Irvine Municipal Operations Buildings and Facilities GHG Emissions

Source	Quantity	GHG Emissions ($MTCO_2e$)
Electricity (MWh)	48,640	10,138
Natural Gas (therms)	350,650	1,862
Backup Generators (gallons)	289	3
Total	**NA**	**12,003**

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; MWh = megawatt-hours; NA = not applicable.

Source: Ascent Environmental 2022

Buildings and facilities energy use data for 2019 was provided by SCE and SoCal Gas, and generator fuel usage was provided by the City. Municipal electricity GHG emissions were estimated using the same method described in Section 3.4.2. Municipal natural gas and backup generator GHG emissions were estimated using emissions factors from TCR.

3.5.3 Streetlights and Traffic Signals

City streetlights and traffic signals accounted for approximately 1,097 $MTCO_2e$ in 2019, or 6 percent of total municipal operations emissions in 2019. This sector includes emissions associated with electricity consumption to power City-owned streetlights and traffic signals, including road and highway lights. Electricity consumption and GHG emissions associated with streetlights and traffic signals are shown in Table 16.

Table 16 2019 City of Irvine Municipal Operations Streetlights and Traffic Signals GHG Emissions

Source	Quantity	GHG Emissions ($MTCO_2e$)
Electricity (MWh)	5,262	1,097

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; MWh = megawatt-hours.

Source: Ascent Environmental 2022

Electricity consumption from streetlights and traffic signals was provided by the City. GHG emissions were estimated using the methods and emissions factors as described in the buildings energy sector.

3.5.4 Employee Commute

Employee commute accounted for approximately 3,044 $MTCO_2e$ in 2019, approximately 16 percent of total municipal operations emissions in 2019. This sector estimates GHG emissions associated with fuel use and VMT for City of Irvine employees commuting to and from work. Table 17 shows employee commute VMT and GHG emissions.

Table 17 2019 City of Irvine Municipal Operations Employee Commute GHG Emissions

Source	VMT	GHG Emissions ($MTCO_2e$)
Employee Commute	8,541,341	3,044

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent; VMT = vehicle miles traveled.

Source: Ascent Environmental 2022

Average daily VMT were estimated based on employee survey data. This figure was applied to the number of temporary and permanent employees in 2019. The inventory assumes that temporary employees commute to work 2.5 days per week on average, while permanent employees commute 5 days per week on average. To account for holidays and vacations, an annualization factor of 48 weeks was applied to weekly employee commute VMT estimates. Emissions were estimated using emissions factors derived from EMFAC2021, as discussed in the on-road transportation sector.

3.5.5 Vehicle Fleet

City-owned vehicle fleet emissions accounted for 1,127 $MTCO_2e$ in 2019, approximately 6 percent of total municipal operations emissions in 2019. This sector includes emissions estimated from on-road and off-road vehicles and equipment owned and operated by the City. Table 18 displays vehicle fleet usage and GHG emissions.

Table 18 2019 City of Irvine Municipal Operations Vehicle Fleet GHG Emissions

Fuel Type	Fuel Use (gallons)	GHG Emissions ($MTCO_2e$)
Gasoline	107,728	954
Compressed Natural Gas	23,155	173
Total	**130,883**	**1,127**

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Ascent Environmental 2022

Vehicle fleet fuel consumption data (i.e., gallons of gasoline and diesel fuel) for 2019 were provided by the City for all City-owned vehicles and equipment. Because additional vehicle fleet data were unavailable, total emissions for gasoline and diesel fuel were estimated using emissions factors obtained from TCR. Fuel-specific CO_2 emissions factors were available for both gasoline and CNG, while the CH_4 and N_2O emissions factors were aggregated factors for both gasoline and diesel fuel in passenger cars and light-duty trucks.

3.5.6 Solid Waste

Municipal solid waste disposal accounted for approximately 159 $MTCO_2e$ in 2019, or 1 percent of total municipal operations emissions in 2019. Solid waste emissions are generated from the decomposition of organic material in landfills. Table 19 presents estimated tons of solid waste disposal and associated GHG emissions from municipal operations.

Table 19 2019 City of Irvine Municipal Operations Solid Waste GHG Emissions

Source	Quantity (tons)	GHG Emissions ($MTCO_2e$)
Landfill Disposed Waste	476	159

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Ascent Environmental 2022

Annual municipal disposed solid waste data was unavailable, so municipal-generated solid waste tonnages were estimated using an average solid waste disposal per public administration employee (tons/employee/year) figure obtained from CalRecycle (CalRecycle 2020). This figure was applied to the number of the City's municipal employees to calculate municipal tons of disposed solid waste. Methods use to estimate GHG emissions associated with solid waste disposal from municipal operations are consistent with those described in the community solid waste sector.

3.5.7 Water Supply

Water supplied for the City's municipal operations resulted in approximately 4 $MTCO_2e$ in 2019, or less than 1 percent of total municipal operations GHG emissions in 2019. For the water supply from local sources within the city, the electricity usage associated with extracting, conveying, treating, and distributing water is captured in the buildings and facilities energy sector because these activities take place within the city. Therefore, the electricity usage and emissions associated with extracting, conveying, treating, and distributing water from outside the city boundary was applied to the municipal water sector. Water usage and associated electricity consumption is provided in Table 20.

Table 20 2019 City of Irvine Municipal Operations Water Supply GHG Emissions

Source	Quantity	GHG Emissions ($MTCO_2e$)
Water consumption (MG)	44	3

Notes: GHG = greenhouse gas; MG = million gallons; MWh = megawatt-hours.

Source: Ascent Environmental 2022

Municipal water consumption volumes were provided by IRWD. To obtain municipal water supply energy use and calculate associated GHG emissions, the region-specific energy intensity factors, methods, and emissions factors described in the community water supply sector were applied.

3.5.8 Wastewater Treatment

Wastewater emissions associated with municipal operations accounted for approximately 1,144 $MTCO_2e$ in 2019, or 6 percent of total municipal operations emissions in 2019. Municipal wastewater GHG emissions associated with this sector included emissions generated by the energy used to treat municipal wastewater as well as emissions that are produced as a result as wastewater treatment processes. GHG emissions from municipal wastewater are shown in Table 21.

Table 21 2019 City of Irvine Municipal Operations Wastewater GHG Emissions

Source	GHG Emissions ($MTCO_2e$)
Wastewater Treatment	1,144

Notes: Totals may not sum exactly due to independent rounding. GHG = greenhouse gas; $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Ascent Environmental 2022

IRWD and OCSan provided wastewater-related data for the City's municipal operations. Methods for estimating emissions from these sources are based on the methodology described in the community wastewater sector and were scaled based on municipal employee population. GHG emissions were estimated using utility emissions factors provided by TCR.

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