



## Memorandum

<b>Date:</b>	January 21, 2015
<b>To:</b>	Cal Broomhead, Pansy Gee, Donnie Oliveira, Sachiko Tanikawa San Francisco Department of the Environment
<b>From:</b>	Brian Schuster, Rich Walter, Rahul Young ICF International
<b>Subject:</b>	<b>Technical Review of the 2012 Community-wide GHG Inventory for the City and County of San Francisco</b>

This memo provides a summary of key findings from ICF International’s review of the community-wide greenhouse gas (GHG) inventory for the City and County of San Francisco for calendar year 2012 (hereafter referred to as the “2012 community-wide GHG inventory”) prepared by the San Francisco Department of the Environment (SFE).

This memo is organized into the following sections:

Section 1 — Background

Section 2 — Methodology

Section 3 — Key Findings

Section 4 — Inventory Limitations and Suggestions for Future Improvement

Section 5 — Conclusion and Summary Statement

### 1. Background

ICF International (hereafter referred to as “ICF”), a publicly-traded technical, management and strategy consulting firm with expertise in climate change, energy, transportation, waste, and other issues,<sup>1</sup> was hired by the San Francisco Department of the Environment (SFE) in September 2014 to undertake an independent, third-party review of the 2012 community-wide GHG inventory. ICF has prepared numerous GHG inventories for companies, cities, counties, states, and countries including preparation of the U.S. national GHG inventory since the late 1980s. This current effort represents the third time that ICF has provided technical review of San Francisco’s community inventory, having conducted such an exercise in 2008 for the community-wide GHG emissions for San Francisco for 1990, 2000 and 2005 years and in 2012 for the community-wide GHG emissions for

---

<sup>1</sup> Please refer to ICF’s website ([www.icfi.com](http://www.icfi.com)) for further info. ICF’s NASDAQ symbol is “ICFI”

San Francisco for the year 2010. Since then, SFE has produced a 2012 Community-wide GHG Inventory and has also taken the opportunity to review and improve methodologies and data used in earlier inventories (affecting 1990, 2000 and 2005 inventories across some sectors).

## 2. Methodology

ICF's technical review of SFE's 2012 community-wide GHG inventory consisted primarily of a desk review of (a) the GHG Inventory; (b) inventory guidance documents and; (c) approximately 60 supporting documents (back-up records, raw data, PDF files of relevant reports, and email correspondence). Other than a visit to the SFE, our review did not include site visits to specific community-wide emissions producing entities. The focus of our review has been primarily on the activity data, emissions factors, overall approaches and methods as well as documentation for the 2012 community-wide GHG inventory.

ICF's review consisted of the following key components:

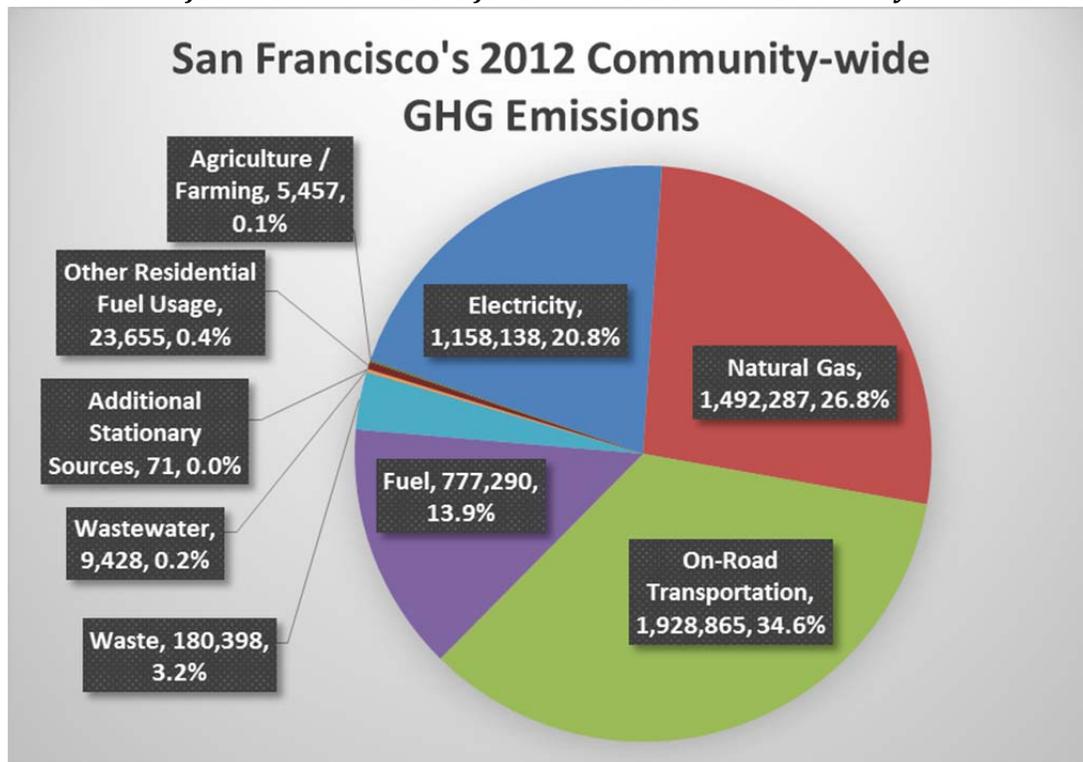
- **Kick-off meeting:** A kick-off meeting between ICF and SFE was held in person in October 2014. Subsequent discussions took place via telephone and in person.
- **Review of GHG Inventory and supporting calculations:** ICF's review consisted of checking the methods and accuracy of quantification approaches, with a focus on transparency and completeness of calculations, as well as clear and verifiable references and assumptions for key parameters, with a focus on activity data, emissions factors and calculation approaches applied for the 2012 inventory. Numerical checks of the inventory numbers, both in terms of activity data as well as tons CO<sub>2</sub> equivalent (tons CO<sub>2</sub>e) by sector and in aggregate, were performed by ICF. In addition, a review of any methodological changes in the 2012 inventory (in relation to earlier years) and a consistent application of those changes to earlier years' inventories were also reviewed.
- **Check of requested activity data and emissions factors calculations against inventory:** ICF requested original activity data from relevant agencies to double-check the accuracy of such numbers used by SFE in its community-wide GHG inventory. Given that electricity and natural gas usage (primarily for buildings, as well as for some transportation) as well on-road transportation in aggregate accounted for approximately 82% of total community-wide GHG emissions in 2012 (please see Figure 1), ICF focused on these sectors by obtaining and reviewing electricity and natural gas consumption totals for the City and County of San Francisco from Pacific Gas & Electric (PG&E), electricity breakouts from the San Francisco Public Utilities Commission (SFPUC), and on-road vehicle miles travelled (VMT) data from the San Francisco County Transportation Agency's (SFCTA) SF-CHAMP model. In addition, ICF reviewed individual emissions factors for electricity (pounds of CO<sub>2</sub> per megawatt-hour, or lbs CO<sub>2</sub>/MWh) for 2012 from PG&E (third-party verified) and SFPUC, as well as an emissions factor for on-road vehicles (grams of CO<sub>2</sub>e per mile travelled) from the Bay Area Air Quality Management District (BAAQMD).

- **Consistency with the ICLEI 2012 U.S. Community Protocol Version 1.0.** The ICLEI 2012 U.S. Community Protocol Version 1.0 (hereafter referred to as the “ICLEI 2012 Protocol”), is the current and latest protocol for generating community GHG emissions inventories. As such, the 2012 community-wide GHG inventory was reviewed to confirm that all sectors, methods, and emissions sources were consistent with the ICLEI 2012 Protocol. ICF has noted instances where certain sectors, methods, and emissions sources were not consistent with the ICLEI 2012 Protocol and provided reasons for these inconsistencies as well as recommendations for future inventory updates.
- **Interim findings by ICF:** Following the above steps, ICF produced interim findings and submitted them to SFE in October 2014. Periodic updates were also communicated to SFE from November 2014 up to completion of the review.
- **Revisions by SFE and Final Review by ICF:** Based on ICF’s findings, SFE revised the 2012 community-wide GHG inventory. ICF reviewed the revised 2012 inventory by conducting a final check on methods, calculations and overall conclusions.

### 3. Key Findings

San Francisco's 2012 community-wide GHG emissions inventory is comprised of nine key components. The amount of GHG emissions and the percentage they comprised of the total 2012 inventory are shown in Figure 1.

*Figure 1: Breakout of Sources and Emissions for San Francisco's 2012 Community-wide GHG Emissions*



- **Electricity:** Consumption in both buildings (broken out by residential, commercial and municipal categories) as well as for transportation uses (BART and MUNI). In 2012, this was comprised of electricity from PG&E (general grid electricity), SFPUC, and Direct Access providers. Emissions from electric power transmission and distribution were also estimated using values from the U.S. Environmental Protection Agency's (U.S. EPA) Emissions & Generation Resource Integrated Database (eGRID) database. This category also includes some electricity consumed outside of city boundaries at facilities which distribute and treat potable water used within the City. Electricity for water-related activities was provided by SFPUC.
- **Natural Gas:** Consumption for residential, commercial and industrial use. PG&E supplied natural gas and emissions factor.
- **On-Road Transportation:** On-road vehicles (e.g., on highways, city streets and other paved roads) comprising vehicle usage within San Francisco's boundaries as well as on-road travel into

and out of the city, without any pass-through travel, were estimated using the SF-CHAMP model run by SFCTA. Emissions factors (grams CO<sub>2</sub>e/mile) were derived from BAAQMD.

- **Fuel Usage:** This category consisted of fuel usage for a portion of Caltrain locomotives, ferry usage (commuter and leisure ferries), and non-ferry ships and boats, attributable to San Francisco, along with fuel usage for diesel MUNI buses and off-road equipment. Fuels include diesel, gasoline, and compressed natural gas (CNG). SFE relied on emission factors and methods from the ICLEI 2012 Protocol for GHG emissions estimates.
- **Waste:** This category consisted of GHG emissions arising from waste sent to landfills (after accounting for diversion of waste that was recycled and composted) following a “methane commitment” approach.<sup>2</sup> SFE relied on emission factors and methods from the ICLEI 2012 Protocol for GHG emissions estimates.
- **Wastewater:** This sector includes emissions from the wastewater treatment plants (WWTP) within the city, including emissions from digester gas combustion along with process and fugitive emissions of N<sub>2</sub>O from the wastewater treatment process. Electricity used at the WWTPs was included in the building energy sector. SFE relied on emission factors and methods from the ICLEI 2012 Protocol for process and fugitive GHG emissions estimates
- **Additional Stationary Sources:** This includes emissions from fuel oil combustion from stationary sources (natural gas emissions from these sources are included in the building energy category). Data for these emissions was provided by the U.S. EPA.
- **Other Residential Fuel use:** This includes emissions from residential fuel combustion of wood, propane/LPG, kerosene, and other liquid and solid fuels. Data for these emissions was provided by the BAAQMD.
- **Agriculture/Farming:** This includes emissions from agricultural equipment, animal waste, soil management, and biomass burning. Emissions were provided by the BAAQMD.

Here are the key findings from ICF’s review of San Francisco’s 2012 community-wide GHG emissions inventory:

1. **Clear accounting of boundaries, emissions sectors and key sources of emissions:** The documentation and quantification of activity levels from all major sources of emissions that fall within a community’s boundaries is generally more complicated than a smaller range or subset, such as for an industrial or a purely municipal inventory. San Francisco’s 2012 community-wide GHG inventory represents an appropriate attempt at capturing major emission sources and calculating resultant activity levels. It appears that all of the major stationary and mobile categories have been accounted for and appropriately quantified, which at a community-wide level can be a challenging task.

---

<sup>2</sup> The “methane commitment” approach is an IPCC method in which landfill methane emissions are quantified based on the current year’s waste generation. Since waste in a landfill takes many years to decay and thus takes many years to emit all of its associated methane, this approach in essence is quantifying the future emissions of today’s waste. Alternatively, this approach is assuming that waste generation doesn’t change from current levels and thus uses the emissions of today’s waste as a proxy for all waste in the landfill.

2. **Original source documents for key sectors match activity levels:** ICF requested original source documents documenting 2012 activity levels for electricity and natural gas consumption (with a focus on PG&E and SFPUC), on-road transportation (SFCTA on-road vehicles VMT data based on the SF-CHAMP model), fuel usage (from the San Francisco Municipal Transportation Agency, SFPUC, and the National Transit Database), and waste tonnages (from CalRecycle), wastewater treatment data (from SFPUC). The activity data were available and matched SFE's 2012 community-wide inventory data.
3. **Key emissions factors (EFs) have been reviewed and validated in consultation with relevant agencies and organizations:**
  - a. Revised PG&E and SFPUC 2012 electricity EFs: The 2012 PG&E electricity EF completed third-party verification on March 19, 2012. In addition, the SFPUC has achieved a net zero EF for 2012, which has been verified. SFE has reflected both of these revised numbers in its 2012 community-wide inventory. ICF also recommended that for direct access electricity, SFE use the latest (year 2010) emission factor from the U.S. EPA's eGRID system for the CAMX sub-region. SFE subsequently made this revision.
  - b. Natural gas EF: The natural gas EF that SFE applied matched the value recommended by PG&E. This factor was consistently applied in the community-wide GHG inventory.
4. **Updated emission factors using the latest protocol.** Upon recommendation from ICF, SFE updated their emission calculations to use the latest emission factors from the Climate Registry for 2014. These emission factors are updated by the Climate Registry on a regular basis and were last updated in April 2014.
5. **Inclusion of CH<sub>4</sub> and N<sub>2</sub>O emissions.** SFE has included emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) in the 2012 community-wide inventory. These emissions were not previously included. The emission factors for CH<sub>4</sub> and N<sub>2</sub>O used by SFE are the latest available from the Climate Registry, the ICLEI 2012 Protocol, and the U.S. EPA.
6. **Update to Global Warming Potential (GWP) factors.** SFE was previously using GWPs from IPCC's Second Assessment Report (21 for CH<sub>4</sub> and 310 for N<sub>2</sub>O), but has subsequently updated their GWPs to use the latest values from IPCC's Forth Assessment Report (28 for CH<sub>4</sub> and 265 for N<sub>2</sub>O). These GWPs reflect the latest science on radiative forcing for GHGs.
7. **Inclusion of additional emission sources.** ICF identified a number of emissions sources that SFE did not originally include in its 2012 community-wide inventory, but are required or recommended for community inventories by the ICLEI 2012 Protocol. These sectors include wastewater, stationary sources, residential fuel use, water-related electricity use (for energy use outside of city boundaries), ships and boats, off-road equipment, and agriculture/farming. Based on ICF's recommendations, SFE has included these emissions using the best available data and methods in the 2012 community-wide inventory.
8. **Inclusion of transmission and distribution loss electricity and emissions.** SFE did not originally include emissions from transmission and distribution (T&D) loss electricity in the inventory. ICLEI recommends that these emissions are included, since the electricity transmission system is not 100% efficient. SFE subsequently updated the 2012 community-wide

GHG inventory to account for T&D losses using factors from the U.S. EPA as recommended by ICLEI.

9. **Use of appropriate CO<sub>2</sub> emission factor for BART electricity.** ICF identified some inconsistencies with how SFE applied emission factors to BART electricity. SFE subsequently updated the 2012 community-wide GHG inventory to use a weighted emission factor for BART using the amount of electricity that Northern California Power Agency (NCPA) and PG&E each supplied to BART trains in 2012. ICF has verified and approved this approach.
10. **Proper accounting of municipal energy use.** SFE originally included energy use from a number of municipal facilities located outside of city boundaries. Since the boundaries of a community inventory are generally geographic and not operational, ICF recommended that these facilities be excluded from the community inventory with the exception of the SFO airport. SFE subsequently updated the 2012 community-wide GHG inventory to include only municipal facilities located inside city boundaries along with SFO.
11. **Reporting of biogenic emissions of CO<sub>2</sub> from biodiesel combustion as an informational item.** The ICLEI 2012 Protocol does not require community inventories to include biogenic GHG emissions, but it recommends that communities include these emissions as informational items when the data are available. SFE has biodiesel fuel consumption data along with biogenic CO<sub>2</sub> emission factors, and included an estimate of biogenic CO<sub>2</sub> emissions as an informational line-item in the inventory. These biogenic emissions amount to 8,538 MTCO<sub>2</sub>e and are not included in the inventory total for 2012.
12. **Clear links to data sources:** SFE prepared a *single* Excel file that clearly contains all information for key inventory segments in a referenced and linked manner. The organization of the 2012 inventory represents an improvement over the 2010 inventory and earlier year inventory files that ICF reviewed in 2012. Clearly laid-out components and sub-components of the inventory which are linked to each other, as SFE has done, helps ensure full transparency and credibility, improves the ability to track emissions in the future, and makes it easier for third-party verifiers to corroborate calculations.

## 4. Inventory Limitations and Suggestions for Future Improvement

The following are limitations of the inventory and suggested areas for future improvement for SFE's consideration in relation to the development of San Francisco community-wide GHG inventories:

1. **Disaggregation of BAAQMD EFs between different types of vehicles:** SFE has employed BAAQMD's blended emissions factor for VMT for 2012, weighted across gas and diesel as well as across all vehicle classes. As EFs will vary between different types of vehicles (i.e., passenger vehicles and trucks) and fuels used, disaggregation to the extent possible between these two broad categories as well as within them (i.e., different classes of light duty and heavy duty vehicles) could improve transparency, accuracy and tracking of CO<sub>2</sub>e calculations for on-road transportation especially for different vehicle classes. In addition, the blended emission factor

used by SFE for vehicles includes freight trucks and buses, while the VMT used in the inventory from the SF-CHAMP model (to which SFE applied the emission factor) does not include freight trucks and buses. This produces a mismatch between the EF and the activity data, and should be rectified in future inventories.

2. **Use of CH<sub>4</sub> and N<sub>2</sub>O EFs for vehicles.** SFE used a scaling factor, provided by BAAQMD, to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions from on-road vehicles. The scaling factor was applied to CO<sub>2</sub> emissions. While this is a reasonably accurate method of estimating approximate emissions of CH<sub>4</sub> and N<sub>2</sub>O for vehicles, the inventory could be improved by using actual disaggregated CH<sub>4</sub> and N<sub>2</sub>O emission factors by vehicle and fuel type. These emission factors can be generated by the using CARB's EMFAC2014 emissions model. Using this method is the state of practice for community GHG Inventories, and it would improve the accuracy of the transportation sector of the inventory.
3. **Include on-road vehicle emissions for B20, B5, CNG, and propane fuel use.** The current on-road vehicle sector includes emissions from gasoline and diesel vehicles only. Emissions from vehicles consuming biodiesel (such as B20 and B5), CNG, and propane were not included in the inventory. Including all vehicle fuel use in the inventory would provide a broader and more accurate picture of all transportation-related emissions in the city. SFE plans to search for an accurate source of data for all vehicle fuel usage for future inventories.
4. **Include emissions from freight trucks and buses.** The current on-road transportation sector of the inventory does not include emissions from freight trucks or buses, because the SF-CHAMP model from SFCTA does not include these vehicle types. SFE is currently working with SFCTA and BAAQMD to determine the appropriate method for estimating emissions from buses or freight within the city. These emissions could constitute a meaningful portion of transportation-related emissions within the City: according to BAAQMD's emissions inventory for 2011, buses alone produced nearly 170,000 MT CO<sub>2</sub>e within the City of San Francisco. As such, buses and freight trucks should be included in future inventories if the data and methods are available to support such an analysis. Emissions from buses (both public and private) traveling into and out of the City is a regional issue that SFE hopes to discuss and address with BAAQMD and hopes to include in future inventories. Adequate information regarding ridership allocation and fuel usage for these buses is currently not available.
5. **Calculate CH<sub>4</sub> and N<sub>2</sub>O emissions from MUNI buses using actual mileage data.** CH<sub>4</sub> and N<sub>2</sub>O emission factors for on-road vehicles are typically in units of emissions per mile, as opposed to emissions per gallon fuel. In order to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions from MUNI buses, SFE used a fleet average fuel efficiency value to estimate VMT first, and then applied the CH<sub>4</sub> and N<sub>2</sub>O emission factors. SFE conducted this analysis because VMT data for MUNI buses were not available. While this is a reasonable method for estimating CH<sub>4</sub> and N<sub>2</sub>O emissions when mileage data are unavailable, using actual mileage data for MUNI buses would greatly improve the accuracy of the CH<sub>4</sub> and N<sub>2</sub>O emissions for MUNI buses.
6. **Site-based emissions from the four landfills located within city boundaries are not included.** According to CalRecycle, there are 4 closed landfills that are located within city boundaries: SF Pier 98 India Basin, Hunters Point, City College of San Francisco, and Treasure Island Naval Station, Site 12. ICLEI recommends that communities disclose site-based emissions

from landfills located within a community's boundaries in addition to generation-based emissions. SFE was unable to collect the data necessary to estimate site-based emissions from these landfills, such as waste-in-place tonnage, methane capture rates, and other site characteristics. Consequently, these emissions were not included in the 2012 community-wide GHG inventory. SFE has apparently exercised due diligence to locate data on the waste profile and waste tonnages for the closed landfills, but data have not been located. Thus this is a limitation on the inventory due to inadequate data and will likely not be included in future inventories.

7. **Verify the methane capture rate.** SFE used a weighted average methane capture rate of 59% to estimate waste emissions. This figure was derived from a 2012 study by CalRecycle titled, "CalRecycle Review of Waste-to-Energy and Avoided Landfill Methane Emissions." SFE's Zero Waste Team determined that the 59% capture rate represented the most realistic projections for the landfills that San Francisco uses. However, ICF found conflicting information from different reporting entities regarding the methane capture rate for landfills accepting the majority of waste generated by the city. For example, Altamont Landfill reported a 76.3% methane capture rate to the U.S. EPA. ICF recommends that SFE contact CalRecycle and the authors of the study to confirm that the 59% methane capture rate is appropriate to use as an average methane capture rate for all landfills serving the city.
8. **Improve the fugitive and process wastewater emissions using actual activity data from the WWTPs.** Per recommendation from ICF, SFE updated the 2012 community-wide GHG inventory to include fugitive and process emissions from wastewater treatment. However, these emissions were estimated using service population and not actual activity data at the WWTPs (which include the North Point Wet-Weather Facility, the Oceanside Treatment Plant, and the Southeast Treatment Plant). Although the population method is supported by ICLEI, the inventory could be improved by using actual data from these plants, such as measured average total nitrogen discharge values (kg N/day). The ICLEI 2012 Protocol recommends that wastewater treatment emissions are estimated using actual activity data if available (over the population-based approach used by SFE).
9. **Include fugitive septic emissions in the wastewater sector.** SFE did not include fugitive emissions from septic systems in the 2012 community-wide GHG inventory. SFE indicated that there are likely very few septic systems within the city and emissions from these systems would therefore be minimal. However, emissions from septic systems can be much higher on a per-capita basis than emissions from central WWTPs (as was included in the inventory). Consequently, ICF encourages SFE to collect data on septic systems within the city and include these emissions in future inventories, as recommended by ICLEI.
10. **Update additional emissions sources with 2012 year emissions.** Upon recommendation from ICF, SFE expanded the 2012 community-wide GHG inventory to include additional emissions sources such as residential fuel use, off-road vehicles and equipment, marine vessels, and agriculture/farming. SFE obtained emissions from these sources from the BAAQMD's Bay Area Emissions Inventory for 2011. At the time of the completion of the 2012 community-wide GHG inventory, a 2012 Bay Area inventory was not available from BAAQMD; 2011 was the latest

year. ICF understands that 2012 emissions were not available, but SFE should attempt to update these emissions sectors with data for 2012 as soon as they become available.

11. **Inclusion of additional non-CO<sub>2</sub> gases:** SFE's inventory guidance document mentions the difficulty in accurately quantifying non-CO<sub>2</sub> emissions for most non-waste and transportation sectors, as well as the insignificant role that these gases are expected to contribute to overall GHG emissions in comparison to CO<sub>2</sub>. Although CH<sub>4</sub> and N<sub>2</sub>O have been included in the 2012 community-wide inventory, hydrofluorocarbons (HFCs), (e.g., from building chillers and refrigerators and vehicle air conditioners) have not been included. Fugitive emissions from refrigerant leakage and other substitutes for ozone-depleting substances (ODS) could be added to future inventories if the data are available. These GHGs are often called "high-GWP GHGs" because they typically have high GWP values, ranging anywhere from 100 to 20,000. BAAQMD's current estimate of ODS emissions for the city are based on adjusted State-level estimates; SFE determined that these estimates were too speculative and uncertain to include in the 2012 community-wide GHG inventory. No further information was available on refrigerants or ODS substitutes for the City. If data are available in the future, including these gases in future inventory updates could further improve the scope of the inventory.

## 5. Conclusion and Summary Statement

Based on its review of SFE's 2012 community-wide GHG emissions inventory, ICF International has verified the information submitted by SFE as being consistent with existing emissions methodologies. The emission estimates were calculated in a consistent and transparent manner and were found to be a fair and appropriate representation of SFE's community-wide GHG emissions and were free from material misstatement. ICF identified several minor, immaterial discrepancies in the greenhouse gas inventory which were corrected by SFE during the course of the verification. ICF has verified a total of **5,575,588 metric tons of CO<sub>2</sub> equivalent (CO<sub>2</sub>e) emissions for the 2012 community-wide GHG inventory.**

Since the 1990 inventory does not have all the same sectors as the 2012 inventory, some emissions must be removed from the 2012 inventory in order to compare the 2012 emissions to 1990 emissions. Emissions for electricity, natural gas, on-road transportation, fuel, and waste are 4,754,976 metric tons of CO<sub>2</sub>e emissions in 2012. This number represents a reduction of approximately 23.3% in relation to the revised 1990 community-wide GHG emissions of 6,201,949 metric tons of CO<sub>2</sub>e emissions for the same emissions sectors. However, it should be noted that the 1990 inventory includes some differences in methodology when compared to the 2012 inventory, resulting in minor limitations in comparability between the two inventories.

ICF has made several suggestions that could further enhance the scope, rigor and transparency for future inventory efforts.



January 21, 2015

---

Rich Walter, ICF International

---

Date