Memorandum

To: Jared Patton, Chicago Metropolitan Agency for Planning (CMAP)

From: Emily Golla, Elliott Wezerek, Cory Matsui, Lynn Socha, Ajo Rabemiarisoa, Rahul Dagli, Neha Vaingankar, and Alex Da Silva, ICF

Date: June 24, 2022

Re: CMAP 2019 Regional Greenhouse Gas Inventory Methodology

Methodology Overview

The purpose of this memorandum is to document the methodology used to develop the 2019 greenhouse gas (GHG) emissions inventory and updated 2010 and 2015 emissions inventories for northeastern Illinois, defined as the seven counties of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will. The inventory that ICF prepared is compliant with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) BASIC level requirements.

For each sub-sector, this document describes the methodologies used to develop the inventory estimates, updates made to the inventory methods since development of the 2015 regional inventory, and limitations and uncertainties. A list of the data sources used to prepare the inventories is also provided.

Stationary Energy Sector Emissions

Residential Buildings

Methodology. Stationary Energy emissions from residential buildings were calculated using electricity and natural gas data specific to each jurisdiction as provided by the utilities that serve northeastern Illinois (ComEd 2022, 2021a, 2018, 2012; Nicor Gas 2022, 2021, 2017, 2011; People's Gas 2022, 2018, 2012) and obtained from the U.S. Energy Information Administration (U.S. EIA 2021). Utilities that serve the region include Commonwealth Edison (ComEd), Illinois Municipal Electric Agency (IMEA), Nicor Gas, and People's Gas. Electricity use from residential charging of on-road electric vehicles was subtracted from the electricity consumption total provided by ComEd to avoid double-counting, as this consumption is included in the On-road Transportation sub-sector.

To estimate emissions from electricity and natural gas provided by the utilities, ICF multiplied the adjusted consumption data by the following emission factors:

- **ComEd:** Utility-specific CO_2 emission factors (ComEd 2021b; EEI 2021) and CH_4, and N_2O emission factors for the RFC West region obtained from EPA's Emissions & Generation Resource Integrated Database (eGRID) (U.S. EPA 2021a, 2017, 2014).
- **IMEA:** Derived CO_2, CH_4, and N_2O emission factors for IMEA based on the utility's fuel mix (IMEA 2021, 2020, 2017, 2016, 2011) and using fuel-specific emission factors for the RFC West region obtained from EPA's eGRID (U.S. EPA 2021a, 2018, 2017, 2014).
- **Nicor Gas and People's Gas:** CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

Updates relative to the 2015 Inventory Report

- For the 2019 inventory report, ICF used utility-specific emission factors from ComEd and derived emission factors for IMEA. For the 2015 inventory report, average eGRID emission factors for the RFC West region were used to estimate emissions from electricity use.

Limitations and Uncertainties

The 2019 CO_2 emissions factor provided by ComEd accounts for renewable energy credits (RECs) for the entire load supplied by ComEd, including the load from Alternative Retail Electric Suppliers (ARES), because ComEd procured RECs for the entire electric load supplied by both ComEd and the ARES in 2019. However, in 2010 and 2015, ARES in the ComEd territory procured their own RECs, and thus ComEd could not provide information on the quantity of renewables procured by ARES and was unable to account for those RECs in the CO_2 emission factors for those years. Consequently, the CO_2 emissions factors provided by ComEd for 2010 and 2015 may differ from the actual emissions rate that incorporates the RECs procured by the ARES. Based on a reasonable estimated range of renewables in 2010 and 2015 procured by the ARES, the emissions factors provided by ComEd and used in the inventory could range from 5% lower to 2% higher than the actual emissions rate.

Commercial and Institutional Buildings and Facilities

Methodology. Stationary Energy emissions from commercial and institutional buildings and facilities were calculated using electricity and natural gas data specific to each jurisdiction as provided by the utilities that serve northeastern Illinois (ComEd 2022, 2021a, 2018, 2012; Nicor Gas 2022, 2021, 2017, 2011; People's Gas 2022, 2018, 2012) and obtained from U.S. EIA (2021). Utilities that serve the region include ComEd, IMEA, Nicor Gas, and People's Gas. The following adjustments were then made to the consumption totals to avoid double-counting:

- **On-Road Electricity:** Electricity use from commercial charging of on-road electric vehicles was subtracted from the electricity consumption total provided by ComEd, as this consumption is included in the On-road Transportation sub-sector.
- **Rail Electricity:** Electricity use from railways was subtracted from the electricity consumption total provided by ComEd for 2019, as this consumption is included in the

On-road Transportation sub-sector. Rail electricity consumption was not subtracted from ComEd totals for 2010 and 2015 because rail consumption was not included in the values provided.

- **On-Road CNG:** Compressed natural gas (CNG) consumption associated with buses was subtracted from the natural gas consumption total, as this consumption is included in the On-road Transportation sub-sector.
- **Off-Road CNG:** CNG consumption for off-road equipment was subtracted from the natural gas consumption total, as this consumption is included in the Off-road Transportation sub-sector.
- **Wastewater:** Electricity and natural gas consumed at wastewater treatment facilities was subtracted from the electricity and natural gas consumption totals, as this consumption is included in the Non-Specified Sources - Wastewater Treatment sub-sector.

To estimate emissions from electricity and natural gas provided by the utilities, ICF multiplied the adjusted consumption data by the following emission factors:

- **ComEd:** Utility-specific CO_2 emission factors (ComEd 2021b; EEI 2021) and CH_4, and N_2O emission factors for the RFC West region obtained from EPA's Emissions & Generation Resource Integrated Database (eGRID) (U.S. EPA 2021a, 2017, 2014).
- **IMEA:** Derived CO_2, CH_4, and N_2O emission factors for IMEA based on the utility's fuel mix (IMEA 2021, 2020, 2017, 2016, 2011) and using fuel-specific emission factors for the RFC West region obtained from EPA's eGRID (U.S. EPA 2021a, 2018, 2017, 2014).
- **Nicor Gas and People's Gas:** CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

ICF also obtained facility-level stationary combustion data on emissions by fuel type reported under EPA's Greenhouse Gas Reporting Program (GHGRP) to estimate stationary combustion emissions from the consumption of other fuels reported by commercial and institutional buildings and facilities (U.S. EPA 2021c). Emissions from the combustion of natural gas in commercial and institutional buildings and facilities that were reported under EPA's GHGRP were excluded from the totals to avoid double-counting with the natural gas consumption data provided by the utilities.

Updates relative to the 2015 Inventory Report.

- For the 2019 inventory report, ICF used utility-specific emission factors from ComEd and derived emission factors for IMEA. For the 2015 inventory report, average eGRID emission factors for the RFC West region were used to estimate emissions from electricity use.

- For the 2019 inventory report, natural gas consumed by buses was subtracted from the consumption totals for the Commercial and Institutional Buildings and Facilities sub-sector. For the 2015 inventory report, this adjustment was not made to the totals.
- For the 2019 inventory report, electricity and natural gas consumed at wastewater treatment facilities was subtracted from the consumption totals for the Commercial and Institutional Buildings and Facilities sub-sector and instead included under the Non-Specified Sources - Wastewater Treatment sub-sector under the Stationary Energy sector. For the 2015 inventory report, emissions associated with energy consumed at wastewater treatment facilities were included under the Commercial and Institutional Buildings and Facilities sub-sector.

Limitations and Uncertainties.

- As discussed under the Residential Buildings section above, the CO_2 emissions factors provided by ComEd for 2010 and 2015 may differ from the actual emissions rate that incorporates the RECs procured by the ARES. Based on a reasonable estimated range of renewables in 2010 and 2015 procured by the ARES, the emissions factors provided by ComEd and used in the inventory could range from 5% lower to 2% higher than the actual emissions rate.
- The non-residential electricity data provided by ComEd for 2019 is broken out into sub-sectors (i.e., commercial/institutional and manufacturing/construction) based on Standard Industrial Classification (SIC) codes. For 2010 and 2015, non-residential electricity data are broken out into sub-sectors based on building size as information is not available to map the data based on SIC codes.

Manufacturing Industries and Construction

Methodology. Stationary Energy emissions from manufacturing and construction were calculated using electricity and natural gas data specific to each jurisdiction as provided by the utilities that serve northeastern Illinois (ComEd 2022, 2021a, 2018, 2012; Nicor Gas 2022, 2021, 2017, 2011; People's Gas 2022, 2018, 2012) and obtained from U.S. EIA (2021). Utilities that serve the region include ComEd, IMEA, Nicor Gas, and People's Gas. To estimate emissions from electricity and natural gas provided by the utilities, ICF multiplied the adjusted consumption data by the following emission factors:

- **ComEd:** Utility-specific CO_2 emission factors (ComEd 2021b; EEI 2021) and CH_4, and N_2O emission factors for the RFC West region obtained from EPA's Emissions & Generation Resource Integrated Database (eGRID) (U.S. EPA 2021a, 2017, 2014).
- **IMEA:** Derived CO_2, CH_4, and N_2O emission factors for IMEA based on the utility's fuel mix (IMEA 2021, 2020, 2017, 2016, 2011) and using fuel-specific emission factors for the RFC West region obtained from EPA's eGRID (U.S. EPA 2021a, 2018, 2017, 2014).

- **Nicor Gas and People's Gas:** CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

ICF also obtained facility-level stationary combustion data on emissions by fuel type reported under EPA's GHGRP to estimate stationary combustion emissions from the consumption of other fuels by manufacturing industries and construction (U.S. EPA 2021c). Emissions from the combustion of natural gas in manufacturing industries and construction that were reported under EPA's GHGRP were excluded from the totals to avoid double-counting with the natural gas consumption data provided by the utilities.

Updates relative to the 2015 Inventory Report.

- For the 2019 inventory report, ICF used utility-specific emission factors from ComEd and derived emission factors for IMEA. For the 2015 inventory report, average eGRID emission factors for the RFC West region were used to estimate emissions from electricity use.

Limitations and Recommendations.

- As discussed under the Residential Buildings section above, the CO_2 emissions factors provided by ComEd for 2010 and 2015 may differ from the actual emissions rate that incorporates the RECs procured by the ARES. Based on a reasonable estimated range of renewables in 2010 and 2015 procured by the ARES, the emissions factors provided by ComEd and used in the inventory could range from 5% lower to 2% higher than the actual emissions rate.
- The non-residential electricity data provided by ComEd for 2019 is broken out into sub-sectors (i.e., commercial/institutional and manufacturing/construction) based on Standard Industrial Classification (SIC) codes. For 2010 and 2015, non-residential electricity data are broken out into sub-sectors based on building size as information is not available to map the data based on SIC codes.

Energy Industries

Methodology. Stationary Energy emissions from energy industries were taken directly from EPA's GHGRP (U.S. EPA 2021c). These estimates include facility-level stationary combustion emissions from power plants and refineries in northeastern Illinois.

Updates relative to the 2015 Inventory Report In the 2015 inventory report, emissions in this sub-sector only included stationary combustion emissions from power plants and did not include other types of facilities that result in other fuel production (e.g., refineries). For the 2019 inventory, this sub-sector was updated to also include stationary combustion emissions from refineries.

Limitations and Uncertainties. No notable limitations or uncertainties.

Non-Specified Sources – Wastewater Treatment

Methodology. Emissions associated with energy consumed at wastewater treatment facilities were estimated based on electricity and natural gas consumption and biogas combustion emissions at the wastewater treatment plants in the region, as provided directly by the Metropolitan Water Reclamation District (MWRD) wastewater treatment plants in the region (MWRD 2021, 2018, 2011).

Given that data from all wastewater treatment plants in the region were not available, this information was used to calculate electricity and natural gas consumption per million gallons of wastewater treated. The per gallon consumption estimates were then multiplied by the total quantity of wastewater generated, as obtained from EPA's Integrated Compliance Information System (ICIS), to calculate total electricity and natural gas consumption at wastewater treatment facilities in the region (U.S. EPA 2021d). To estimate emissions from total electricity and natural gas consumption, ICF multiplied the consumption data by the following emission factors:

- **Electricity:** ComEd CO_2 emission factors (ComEd 2021b; EEI 2021) and CH_4, and N_2O emission factors for the RFC West region obtained from EPA's eGRID (U.S. EPA 2021a, 2017, 2014).
- **Natural Gas:** CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

For biogas emissions, CH_4 and N_2O emissions data provided by MWRD was similarly used to calculate emissions per million gallons of wastewater treated and then scaled based on the total quantity of wastewater generated in the region, as obtained from EPA's ICIS, to calculate total emissions from the combustion of biogas at wastewater treatment facilities in the region (U.S. EPA 2021e).

Updates relative to the 2015 Inventory Report. For the 2015 inventory report, emissions associated with energy consumed at wastewater treatment facilities were included under the Commercial and Institutional Buildings and Facilities sub-sector. For the 2019 inventory report, ICF quantified and reported separately emissions associated with energy consumed at wastewater treatment facilities.

Limitations and Uncertainties.

- Energy consumption data were not available for non-MWRD wastewater treatment plants in northeastern Illinois. Therefore, the energy intensity of MWRD plants was used a proxy for other wastewater treatment plants in the region.
- The estimations of electricity and natural gas consumption per million gallons of wastewater treated were calculated based on data available from MWRD for 2016 and 2019. Consumption estimates for 2010 and 2015 were therefore derived using the 2016 MWRD energy intensity estimates for electricity and natural gas.

- Based on the information available from MWRD and in the EPA ICIS database, it is assumed that all wastewater generated in the region is treated at plants within the regional boundary.

Non-Specified Sources – Water Conveyance[1]

Emissions associated with water conveyance result from the use of electricity consumption used to supply water in the region. To quantify these emissions, ICF multiplied the energy intensity values for conveying water by the total water consumption for each county in the region. Water consumption estimates are available from CMAP for each municipality in the region, by sector (i.e., residential and non-residential), and by water source, including Lake Michigan Fox River, Kankakee River, other surface water, shallow aquifer, and sandstone aquifer (CMAP 2019). The water conveyance energy intensity values were obtained from a 2012 study conducted by the Illinois Section American Water Works Association (ISAWWA) Water Efficiency Committee (ISAWWA 2012). Total water conveyance energy values from electricity were calculated by multiplying the water consumption from each source (e.g., Lake Michigan) by the corresponding energy intensity factor from the 2012 ISAWWA report.

Updates relative to the 2015 Inventory Report. Under the previous inventory, emissions associated with water conveyance energy were not calculated separately. The energy used for water conveyance and the corresponding emissions are likely partially included in the Commercial and Institutional Buildings and Facilities sub-sector, because electricity consumption by the water pumping equipment is assumed to be reflected in the datasets provided by ComEd and IMEA. Some water pumping equipment may be located outside of the CMAP region, however, and energy from that equipment would not be included in the energy datasets provided by the utilities. For the 2019 inventory, ICF quantified energy use associated with water conveyance, but the corresponding emissions are not shown as a separate sector due to uncertainties and data limitations (as discussed below).

Limitations and Uncertainties. Although there is a robust dataset available for water conveyance, there are still considerable data limitations and uncertainties that necessitate excluding water conveyance emissions as a separate sector of the inventory. Specifically:

- The consumption of the energy to convey the water in the region occurs throughout the water supply chain, and a precise accounting of the energy consumption locations cannot be determined. To avoid double counting emissions, the calculated water conveyance energy would need to be subtracted from the energy dataset provided by the utilities; however, subtracting to avoid double counting is not a straightforward exercise. For instance, water may be extracted from a well in one city, consuming energy in that city, while the water is sent for use in a second city. The water conveyance sector

[1] Energy consumption from water conveyance was estimated for the first time as part of the 2019 inventory. However, due to the uncertainties and data limitations discussed in this section, the results were not incorporated into the 2019 inventory report.

attributes the energy use to the second city, because that is where the water consumption occurs; however, for the Commercial and Institutional Buildings and Facilities sector, the energy consumption may be attributed to the first city, because that is where the equipment is located and would thus be included in the dataset for the first city provided by ComEd.

- The ISAWWA study only provides energy intensity estimates for water supplied with electricity and does not include estimates for water supplied with natural gas. Consequently, ICF was unable to estimate how much water is conveyed using natural gas-powered equipment. Although such equipment is less common than electric-powered conveyance equipment, the extent of natural gas energy consumption for water conveyance is not known at this time.
- The ISAWWA study only provides energy intensity estimates for water supplied for 2010. Year-specific factors for 2015 and 2019 are not available.

Fugitive Emissions from Oil and Natural Gas Systems

Methodology. Fugitive emissions from oil and natural gas systems were taken directly from EPA's GHGRP (U.S. EPA 2021d). These estimates include facility-level fugitive emissions from petroleum refining, natural gas systems for refineries, and natural gas transmission and distribution facilities in northeastern Illinois.

Updates relative to the 2015 Inventory Report. In the 2015 inventory report, emissions from hydrogen production at petroleum refineries were not included. For the 2019 inventory, emissions from hydrogen production were incorporated into this sub-sector.

Limitations and Uncertainties. No notable limitations or uncertainties.

Transportation Sector Emissions

On-Road

Methodology. On-road transportation emissions are based on output from customized runs of EPA's Motor Vehicle Emissions Simulator (MOVES) model (U.S. EPA 2018a, U.S. EPA 2021f) and estimates of vehicle miles traveled (VMT) by vehicle type, as derived from CMAP's travel demand model. Since the MOVES runs assume a national default fraction of 0% for electric vehicle (EV) VMT, ICF estimated emissions from EVs (including battery electric vehicles and plug-in hybrid electric vehicles [PHEVs]) separately, and then adjusted the MOVES emissions output to avoid double counting. ICF estimated EV emissions by following the steps outlined below.

- **EV VMT (2019):** To estimate total EV VMT, ICF obtained data on the number of EVs and hybrid vehicles registered in each county in 2019 from the Illinois Secretary of State (2021). ICF divided the number of registered EVs and hybrid vehicles by the total

number of registered passenger vehicles and light-duty trucks to estimate the portion of VMT associated with each vehicle type. ICF assumed the portion of hybrid vehicles represented by PHEVs based on sales estimates of PHEV and hybrid electric vehicles (HEV) in the State of Illinois (Alliance for Automotive Innovation 2021). The resulting percentages were then multiplied by total VMT estimates to calculate EV VMT by vehicle type. No EV buses were assumed to operate in the region, based on the Federal Transit Administration's (FTA's) National Transit Database (NTD) (FTA 2019a.).

- **EV VMT (2010 and 2015):** Registration data for EVs were not available for 2010 and 2015; therefore, ICF scaled the 2019 EV VMT percentages based on the change in national EV VMT, as obtained from the U.S. National GHG Inventory (U.S. EPA 2021b.).
- **EV Electricity Consumption:** Electricity consumption associated with EV VMT was quantified by multiplying EV VMT by EV kilowatt hour-per-mile engine efficiency factors from the Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) Model (ANL 2021).
- **EV Emissions:** To calculate emissions, EV electricity consumption was multiplied by ComEd CO_2 emission factors (ComEd 2021b; EEI 2021) and CH_4, and N_2O emission factors for the RFC West region from EPA's eGRID (U.S. EPA 2021a, 2017, 2014).

On-road CNG fuel consumption was additionally quantified for the purposes of subtracting consumption from the Stationary Energy sector to avoid double counting. Fuel consumption data (gallons) associated with the Pace suburban bus fleet were obtained from FTA's NTD (2019a), and then allocated to each county in which Pace operates based on population. Gallons were converted to therms using a CNG bus fuel efficiency factor from the 2019 NTD Policy Manual (FTA 2019b).

Updates relative to the 2015 Inventory Report.

- For the 2019 inventory report, ICF used utility-specific emission factors from ComEd. For the 2015 inventory report, average eGRID emission factors for the RFC West region were used to estimate emissions from electricity use.
- For the 2019 inventory report, vehicle registration data were used to calculate EV VMT. For the 2015 inventory report, EV VMT was estimated by scaling national EV VMT data to the region based on population.

Limitations and Uncertainties.

- The latest version of the MOVES model (MOVES3) was used to estimate 2019 emissions from on-road transportation, while emission estimates for 2010 and 2015 were generated using MOVES2014b. The inconsistency in the version of the model used to generate emissions may impact the trends observed across the timeseries.
- Data on VMT or fuel consumption by county for the Pace bus fleet were unavailable. As a result, population data was used as a proxy to allocate CNG bus fuel consumption to each county in which Pace operated in 2019.

- The Illinois Secretary of State vehicle registration data (vehicle count by category and technology) was used to inform the 2019 inventory calculations for the on-road alternative fuel vehicles (and resulting emissions). Year-specific registration data for 2010 and 2015 are not available.

Railways

Methodology. Transportation emissions from passenger transit rail (i.e., CTA, Metra Rail, NICTD) were calculated using fuel consumption and electric propulsion data from the FTA NTD (2019a). Fuel and electricity consumption from the three transit agencies were apportioned to the counties using each county's share of rail VMT, as provided by CMAP (2017, 2022). Emissions from electricity use were calculated using the ComEd CO_2 emission factors (ComEd 2021b; EEI 2021) and CH_4, and N_2O emission factors for the RFC West region from EPA's eGRID (U.S. EPA 2021a, 2017, 2014). Emissions from diesel were calculated by multiplying consumption data by CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

Emissions from other passenger train activity (i.e., Amtrak trains) were calculated using train route and frequency information from Amtrak (Amtrak 2015). The length of each route was determined from the U.S. Department of Transportation's (DOT's) Amtrack shapefile by using the county boundaries to calculate the length of the route in each county (USDOT/BTS 2021). Fuel efficiency for Amtrak trains was calculated using total train miles and total fuel consumption for the entire Amtrak system as obtained from the Bureau of Transportation Statistics (BTS 2021). The track miles were then multiplied by system fuel efficiency to estimate fuel consumption. Finally, emissions were calculated by multiplying consumption data by diesel fuel CO2, CH4, and N2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

Transportation emissions from freight rail were calculated using ton-mile data for the region provided by Oak Ridge National Laboratory (ORNL), which included the length, distance, carloads, and tonnage for each rail segment in each county (ORNL 2022, 2018). ORNL sourced the geographic component (segment length, distance) from the Transportation Routing Analysis Geographic Information System (TRAGIS) model, and carload and tonnage from the Surface Transportation Board. Fuel consumption was then derived by multiplying ton-mile data by the miles-per-gallon efficiency from two of the largest Class I freight rail operators that serve the region: Union Pacific (Union Pacific 2021) and Burlington Northern Santa Fe (BNSF 2021). Finally, emissions were calculated by multiplying consumption data by diesel fuel CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

Updates relative to the 2015 Inventory Report.

- For the 2019 inventory report, ICF used utility-specific emission factors from ComEd. For the 2015 inventory report, average eGRID emission factors for the RFC West region were used to estimate emissions from electricity use.

- For the 2019 inventory report, Amtrak route lengths were updated using a U.S. DOT shapefile with route information. For the 2015 inventory report, route lengths were estimated using Google Earth.

Limitations and Uncertainties.

- No notable limitations or uncertainties.

Waterborne Navigation

Methodology. Emissions from waterborne navigation were calculated by using fuel consumption data for recreational (i.e., pleasure craft) and commercial boats. Fuel consumption data for recreational boats were sourced from the NONROAD component of the MOVES3 model (U.S. EPA 2018a, U.S. EPA 2021f). Fuel consumption data for commercial boats were taken from the 2015 Chicago inventory (City of Chicago 2017) and collected directly from commercial tour boat operators in the region, such as tour companies and water ferries (ICF 2021a, 2017a). In cases when data were not provided for all inventory years, regional gross domestic product was used to proxy consumption across the time series. Emissions were quantified by multiplying the diesel and gasoline consumption data by emission factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

Updates relative to the 2015 Inventory Report. For the 2019 inventory report, the NONROAD component of the MOVES3 was used to estimate fuels consumption from pleasure crafts. For the 2015 inventory report, an earlier version of the model, MOVES2014a, was used to estimate consumption.

Limitations and Uncertainties. The companies contacted to collect fuel consumption data for commercial boats do not represent all of the commercial boat operators in the region. In addition, some companies that were contacted were unresponsive or unable to provide data or neglected to provide data for all inventory years.

Aviation

Methodology. Emissions from the direct combustion of fuel for aviation trips that occur within the region (i.e., trips that depart and land within the region) were quantified using fuel consumption data obtained from regional fuel service providers (ICF 2021b, 2017b). In cases when data were not provided for all inventory years, regional gross domestic product was used to proxy consumption across the time series. Emissions were calculated by multiplying consumption data by fuel-specific emissions factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b).

Emissions from the direct combustion of fuel consumed during landing and takeoff (LTO) at airports that serve the region (e.g., O'Hare and Chicago Midway International) were similarly calculated by multiplying the fuel consumed during LTO by fuel-specific emissions factors from EPA's GHG Emission Factors Hub (U.S. EPA 2021b). LTO fuel consumption estimates were based on a 2015 Environmental Impact Study conducted for the O'Hare airport (FAA 2015). ICF used

trip data from the Federal Aviation Administration (FAA)'s Air Traffic Activity System to scale consumption estimates for other years and airports (FAA 2021).

Updates relative to the 2015 Inventory Report. This inventory includes emissions from landings and takeoffs at the two major airports that serve the region. The 2015 inventory report did not include emissions from landings and takeoffs.

Limitations and Uncertainties.

- The companies contacted to collect fuel consumption data for intra-regional flights do not represent all of the aviation fuel service providers in the region. In addition, most companies that were contacted were unresponsive or unable to provide data or neglected to provide data for all inventory years.
- Landing and take-off data were only available for the O'Hare airport for the year 2015. Emissions associated with Midway and for the other inventory years were estimated by scaling the 2015 LTO emission for O'Hare.

Off-Road

Methodology. Emissions from off-road vehicles and equipment were quantified using emissions and fuel consumption data by equipment type from the NONROAD component of EPA's MOVES3 model (U.S. EPA 2021f). Carbon dioxide and CH_4 emissions were taken directly from the MOVES3 model, while N_2O emissions were calculated by multiplying consumption data by fuel- and equipment-specific emission factors from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (U.S. EPA 2021b).

Updates relative to the 2015 Inventory Report. For the 2019 inventory report, the NONROAD component of the MOVES3 was used to estimate fuel consumption and emissions from off-road vehicles and equipment. For the 2015 inventory report, an earlier version of the model, MOVES2014a, was used to estimate fuel consumption and emissions. The MOVES3 model generates off-road emissions outputs for both CO_2 and CH_4, whereas previous versions of MOVES only quantify CO_2 emissions. Thus, for the 2019 inventory report, off-road CH_4 emissions were directly taken from MOVES, whereas for the 2015 inventory report, off-road CH_4 emissions were calculated based on fuel consumption values from MOVES and emission factors obtained from the U.S. EPA (E.S. EPA 2021b) for nonroad equipment.

Limitations and Uncertainties.

- Only emissions by county are available from the NONROAD component of MOVES. Therefore, to estimate emissions for Chicago, proxy data (including population, land area, and sales data from the U.S. Census Bureau) were used to allocate emissions from Cook County to the City.

Waste Sector Emissions

Disposal of Solid Waste Generated in the Region

Methodology. Emissions from waste generated in the region were calculated using the methane commitment method, which calculates downstream emissions associated with solid waste sent to landfills during each inventory year. The methane commitment method takes a lifecycle approach, calculating landfill emissions based on the amount of waste disposed in a given year and assigning emissions to the year of waste generation under the assumption that the emissions will actually occur in future years as waste decays and produces methane. The methane commitment estimates for solid waste sent to landfill is calculated based on the mass of solid waste sent to landfill during the inventory year, the methane generation potential of waste based on the waste composition, the fraction of methane recovered at the landfill, and the oxidation factor for the landfill.

Activity data on the amount of waste generated and disposed of in landfills each year were obtained from county solid waste reports and direct communication with county officials (City of Chicago 2017; Cook County 2017; Delta Institute 2018, 2021; DuPage County 2019, 2017; Kane 2020; Kendall County 2020; SWALCO 2019, 2014; Will County 2021, 2018, 2017a). For counties for which data were not available, disposal amounts were calculated based on the per capita waste generation rate for Illinois Region 2 and adjusted to account for the average recovery rate (CDM Smith 2015).

Data for the waste composition in the region was retrieved from the *2015 Illinois Commodity/Waste Generation and Characterization Update* (CDM Smith 2015). Information on landfill characteristics such as oxidation factor, methane fraction in landfill gas, and the fraction of methane recovered were obtained from EPA's GHGRP (U.S. EPA 2021c). For instances where information on the destination landfill was not available, a standard value for the methane recovery rate, oxidation factor, and amount of methane contained in landfill gas was applied, based on the characteristics of other landfills where waste is disposed in the region.

Updates relative to the 2015 Inventory Report.

- In the prior inventory report, in cases when the destination landfill was unknown, landfill characteristics were estimated based on destination landfills for waste generated in the City of Chicago. For the 2019 inventory report, landfill characteristics were for unknown landfills were based on the characteristics of all known landfills where waste is disposed in the region.
- Updates were made to historical assumptions regarding the amount and where waste is disposed based on the availability of new data.

Limitations and Uncertainties. Some county solid waste agencies report incomplete waste disposal data (e.g., the data represents a limited number of municipalities within the county). In

addition, the methods used to track and estimate waste generation varies by county. In many cases, it is also not known where the waste that is generated in a given county is landfilled (e.g., within the regional boundary or outside the regional boundary).

Biological Treatment of Waste Generated in the Region

Methodology. Emissions from the biological treatment of waste generated in the region were calculated using data on the amount of waste diverted for composting. Estimates of mass of solid waste sent to composting facilities were gathered from county solid waste agency reports and direct communication with county officials (City of Chicago 2017; Delta Institute 2021; DuPage County 2019, 2016; Kane County 2020, 2017; Kendal County 2017; McHenry County 2021; SWALCO 2019; Will County 2017b). For counties for which data was not available, the amount of waste composted was estimated based on the average per capita composting rate reported for all other counties in the region. Emissions were then calculated by multiplying composting data by emission factors by CH_4 and N_2O emission factors from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006).

Updates relative to the 2015 Inventory Report. Updates were made to historical assumptions regarding the amount of compost treated based on the availability of new data.

Limitations and Uncertainties. Composting data was not available for all counties. In addition, based on the information provided by county solid waste agencies, all composting is assumed to occur at facilities outside the region.

Wastewater Generated in the Region

Methodology. Wastewater emissions were calculated based on the quantity of wastewater generated and fugitive emissions measurements from plants treating wastewater generated in the region. The quantity of wastewater generated was obtained from the U.S. EPA Integrated Compliance Information System (ICIS) (U.S. EPA 2021d). Wastewater flow for all treatment plants in the region were apportioned to each county based on data provided by CMAP (2011). Emission measurements from plants treating wastewater generated in the region were provided by the Metropolitan Water Reclamation District (MWRD), including N_2O emissions from wastewater treatment and discharge, CH_4 emissions from incomplete biogas combustion, CH_4 emissions from Imhoff tank operation, and nonbiogenic CH_4 and N_2O emissions from biogas combustion (MWRD 2021, 2018). This information was used to calculate average emissions per million gallons of wastewater treated at MWRD plants. The MWRD emission factors were then multiplied by the total quantity of wastewater generated to calculate total emissions from wastewater generated in the region.

Updates relative to the 2015 Inventory Report. Updated plant flow data were obtained from the ICIS for historical inventory years. The updated flow data differed marginally from the values previously obtained from the ICIS.

Limitations and Uncertainties.

- Although outreach was conducted, activity data were not available for non-MWRD wastewater treatment plants in the region. Therefore, the MWRD emission factors were assumed to be representative of all wastewater treatment plants in the region.
- The generation source of wastewater treated in the region is based on apportionment data provided by CMAP in 2011.

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