Appendix G. Waste Management

Overview

GHG emissions from waste management include:

- Solid waste management – CH_4 emissions from municipal and industrial solid waste landfills (LFs), accounting for CH_4 that is flared or captured for energy production (this includes both open and closed landfills);
- Solid waste combustion – CH_4, CO_2, and N_2O emissions from the combustion of solid waste in incinerators or waste to energy plants; and
- Wastewater management – CH_4 and N_2O from municipal wastewater and CH_4 from industrial wastewater (WW) treatment facilities.

Inventory and Reference Case Projections

Solid Waste Management
For solid waste management, CCS used the U.S. EPA SGIT and the U.S. EPA Landfill Methane Outreach Program (LMOP) landfills database[1] as starting points to estimate emissions. The LMOP data serve as input data to estimate annual waste emplacement for each landfill needed by SGIT. SGIT then estimates CH_4 generation for each landfill site. Additional post-processing outside of SGIT to account for controls is then performed to estimate CH_4 emissions.

The LMOP database contained limited information on 6 Class I landfills. CCS also contacted AKDEC staff to gather additional information on solid waste landfills and other solid waste management issues, including waste combustion.[2] AKDEC provided estimates of waste emplacement rates for 7 Class I landfills, 14 Class II landfills, and 222 Class III landfills. For the Class III sites, half of the waste accepted is assumed to be open burned (these emissions are addressed under the Solid Waste Combustion section below). Also, half of the waste estimated for Barrow (Class II landfill) was assumed to be burned at the Barrow Incinerator. The date of landfill opening was available for 5 of the Class I landfills. All other landfills were assumed to have been in operation since the 1960s, if not earlier.

Three landfills in AK are currently controlled. The Merrill Field landfill, which closed in 1987, is partially flared. The Anchorage and Juneau landfills began flaring in 2006 and 2008, respectively. The Anchorage Regional Landfill will begin a landfill gas to energy (LFGTE) project in 2015. The Class III, Class II, and remaining Class I sites were combined for the purposes of emissions modeling. The Class II and Class III disposal estimates provided by DEC were based on 2000 population data for the communities served and per capita generation rates

[1] LMOP database is available at: http://www.epa.gov/lmop/proj/index.htm. Updated version of the database provided by Rachel Goldstein, Program Manager, EPA Landfill Methane Outreach Program, October 2006. The only AK site represented in the database was the Anchorage Regional LF.
[2] Doug Buteyn and Ed Emswiler, AKDEC, Solid Waste Division, personal communications with S. Roe, CCS, December 2006 – January 2007; additional revisions to data and assumptions provided by D. Buteyn in October 2008.

(6.6 lb/person/day). These estimates were back-cast to 1960 and forecast to 2005 based on growth in rural population in AK. The table below provides a summary of the data used as input to SGIT for modeling emissions.

Table G1. Summary of Municipal Solid Waste Landfill Data

Site Name	Operating Years	Average Waste Emplacement Rate (tons/yr)	Control
Anchorage Regional LF	1987 - Present	352,203	Flare (beginning 2006)
Juneau LF[a]	2004 - Present	29,428	Flare (beginning 2008)
Anchorage Merrill Field LF	1960-1987	104,942	Flare (partial coverage)
Other Class I LFs (5 sites)	Varies - Present	197,556	None
Class II LFs (14 sites) [b]	1960's - Present	31,480	None
Class III LFs (222 sites) [b]	1960's - Present	37,004	None

[a] Prior to 2004, combustible waste was incinerated and is accounted for under the waste combustion sector. A collection and flare system is in place; however, currently the methane is mostly being vented.
[b] Waste emplacement is for 2000, rates are back-cast and forecast based on rural population growth (0.81%/year for 1960-1990, 1.89% for 1990-2000, -0.05% for 2000-2005)

The estimated average annual disposal rates for each landfill were used in SGIT for all years that the landfills were operating (Class II and III landfills were both collectively modeled as individual units at a state level). CCS performed 4 different runs of SGIT to estimate emissions from municipal solid waste (MSW) landfills: (1) Anchorage; (2) Juneau; (3) Merrill Field; (4) uncontrolled. The other landfill category that CCS commonly models is sites with landfill gas to energy (LFGTE) plants. There are none of these currently operating in Alaska.

After obtaining the methane generation data from SGIT, CCS performed post-processing of the methane emissions to account for landfill gas controls (flared sites) and to project the emissions through 2025. For Anchorage, Juneau, and Merrill Field, CCS projected uncontrolled emission levels by assuming continuation of the current emplacement rates. Controls were then applied in the appropriate year. CCS assumed that the overall methane collection and control efficiency is 75%.[3] Of the methane not captured by a landfill gas collection system, it is further assumed that 10% is oxidized before being emitted to the atmosphere (consistent with the SGIT default). This assumption for oxidation is also used for the methane emitted from uncontrolled sites. Growth rates for uncontrolled landfills were estimated using the historic (1995-2005) growth rates of emissions (4.5%/year).

For industrial waste landfills, SGIT calculates emissions based on an assumption that industrial waste is emplaced at industrial landfill sites and that the methane emissions are 7% of the methane generated at MSW sites (this default is based on national data). Due to the lack of a substantial industrial base in Alaska, CCS assumed that any industrial waste emplaced in solid waste landfills is captured in the MSW emplacement estimates described above. Hence, there are no emissions estimated specifically for the industrial waste landfills sector.

[3] As per EPA's AP-42 Section on Municipal Solid Waste Landfills: http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf.

Solid Waste Combustion
Information from AKDEC contacts was used to construct estimates from municipal solid waste combustion.[4] Solid waste combustion addressed here includes both the controlled combustion of MSW in incinerators, as well as open MSW combustion occurring at community landfills. For controlled combustion, 2002 estimates of combustion at incinerators provided by AKDEC were used to represent 2002 and 2003 activity; while 2004 and 2005 activity were estimated by subtracting the throughput for the Juneau facility, which closed in 2004. Controlled combustion estimates were back-cast from 2002 to 1990 based on AK population growth for 1990-2002 (1.4%/year). Open burning estimates were based on the assumption that half of the waste received at Class III landfills was burned on site.

The mass of controlled waste combustion was added to the estimate described under the landfills section above for open burning at Class III landfill sites to estimate total waste combustion emissions. The table below shows the total waste mass estimates per year.

Table G2. Summary of Municipal Solid Waste Combustion Data (tons)

Combustion Category	1990	1995	2000	2005
Controlled Burning	29,668	31,820	34,128	14,139
Open Burning	21,839	23,730	26,062	25,995
Totals	**51,508**	**55,550**	**60,190**	**40,133**

SGIT does not use different methods (emission factors) for open and controlled burning. Therefore, the total waste estimates above were used as input to SGIT to estimate emissions. AKDEC also provided some data for sewage sludge incineration. Most of the carbon in sewage sludge is of biological origin, and therefore the associated CO_2 emissions would not be incorporated into this GHG inventory. While CCS would expect some emissions of methane and nitrous oxide from these sources, CCS believes that the emissions would be negligible.

Emissions for the solid waste combustion sector were forecast based on Alaska's forecasted population growth from 2005-2025 (0.61%/yr).[5]

Wastewater Management
GHG emissions from municipal and industrial wastewater treatment were also estimated. For municipal wastewater treatment, emissions are calculated in EPA's SGIT based on state population, assumed biochemical oxygen demand (BOD) and protein consumption per capita, and emission factors for N_2O and CH_4. The key SGIT default values are shown in Table G3

[4] Controlled burning - Alice Edwards, AKDEC, personal communication and data file provided to S. Roe, CCS, January 2007. Open burning – Doug Buteyn, AKDEC, personal communication with S. Roe, CCS, December 2006 with additional follow-up in October 2008.
[5] Alaska Department of Labor and Workforce Development, "Workforce Information," Home, Population & Census, Estimates & Projections, Population Data Tables, "Alaska Population Projections (2005-2029)," Select "February 2005 issue of Alaska Economic Trends," in PDF file named "feb05.pdf"(Projections for Alaska population 2005–2029, Table 5. Population Growth Projections Alaska 2005–2029, Medium Population Values in Table 5 used for forecast).

below. Emissions for the municipal wastewater management sector were forecast based on Alaska's forecasted population growth from 2005-2020 (0.69%/yr).

For industrial wastewater emissions, SGIT provides default assumptions and emission factors for three industrial sectors: Fruits & Vegetables, Red Meat & Poultry, and Pulp & Paper. According to AKDEC contacts and the Dun & Bradstreet database, there aren't currently any large operations in these industry sectors that would be expected to have their own treatment systems. According to the contact at the Alyeska Valdez Marine terminal the Valdez ballast water treatment facility does not emit CH_4 emissions.[6]

Emissions of methane are also expected to occur from fish processing waste dumped at sea.[7] Again, CCS attempted to gather information on this issue; however no emissions-related information was identified. Presumably, methane emissions would also occur from waste treatment conducted on-shore; however, CCS is not aware of any data or emissions estimation methods to address this potential source category.

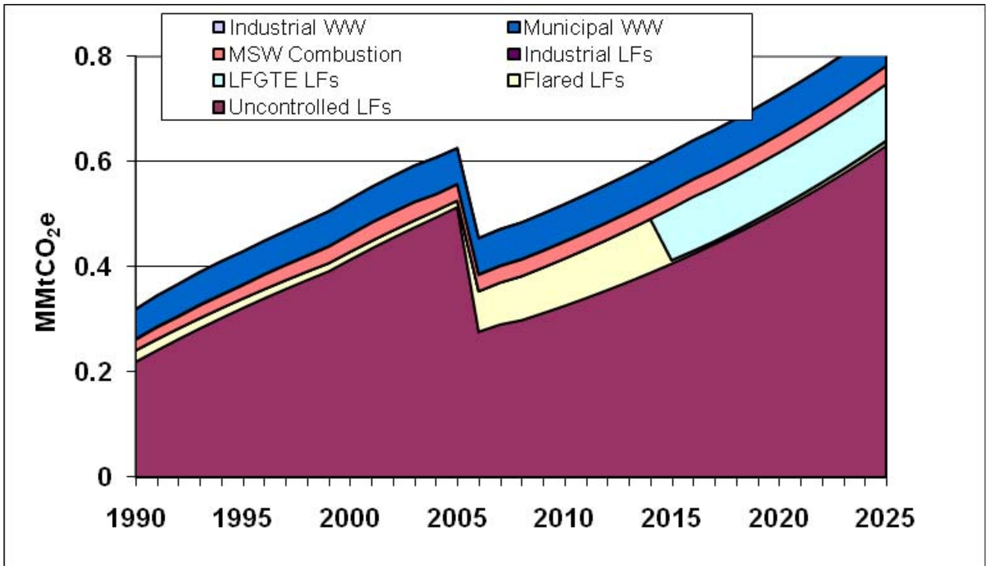
Table G3. SGIT Key Default Values for Municipal Wastewater Treatment

Variable	Value
BOD	0.065 kg /day-person
Amount of BOD anaerobically treated	16.25%
CH_4 emission factor	0.6 kg/kg BOD
Alaska residents not on septic	75%
Water treatment N_2O emission factor	4.0 g N_20/person-yr
Biosolids emission Factor	0.01 kg N_2O-N/kg sewage-N
Source: U.S. EPA State Inventory Tool – Wastewater Module; methodology and factors taken from U.S. EPA, Emission Inventory Improvement Program, Volume 8, Chapter 12, October 1999: www.epa.gov/ttn/chief/eiip/techreport/volume08/.	

Figure G1 and Table G4 show the emission estimates for the waste management sector. Overall, the sector accounts for 0.6 $MMtCO_2e$ in 2005. By 2020, emissions are expected to grow to 0.9 $MMtCO_2e$/yr. Uncontrolled landfills account for the majority of waste management emissions, accounting for an estimated 82% in 2005 and expected to account for 73% in 2025. Flared landfills accounted for an estimated 2% in 2005 and are expected to account for 1% in 2025. The significant drop in emissions seen in 2006 is due to the start of flaring at the Anchorage landfill. Before flaring began, the Anchorage landfill was the largest contributor to landfill emissions, accounting for about 12% in 2005. After flaring began in 2006, the Anchorage landfill only contributed 5% to total landfill emissions. The second drop is in 2015, when the Anchorage landfill is assumed to begin operating LFGTE technology.[8]

[6] Brad Thomas, Alyeska Valdez Marine Terminal, personal communication with Steve Roe, CCS, January, 2007. It is unclear whether this facility would also not emit any N_2O.
[7] An estimate from the early 1990's is that about 1.7 million metric tons of fish waste is generated in Alaska. The amount generated and treated on-shore versus at sea was not provided (*Pollution Prevention Opportunities in the Fish Processing Industry*, Pacific Northwest Pollution Prevention Research Center, 1993).
[8] Input from D. Mears of the FAW TWG.

Figure G1. Alaska GHG Emissions from Waste Management



Notes: LF – landfill; WW – wastewater; LFGTE – landfill gas to energy; historic and future emissions for the LFGTE landfill and industrial solid waste landfill categories were estimated to be zero in AK. Sources of information to estimate emissions for the industrial WW treatment category could not be obtained for incorporation into this assessment.

Table G4. Waste Management Emissions Inventory and Reference Case Projections (MMtCO$_2$e)

Subsector	1990	1995	2000	2005	2010	2015	2020	2025
Uncontrolled LFs	0.22	0.32	0.41	0.51	0.33	0.41	0.51	0.63
Flared LFs	0.023	0.19	0.15	0.012	0.090	0.006	0.006	0.009
LFGTE LFs	0	0	0	0	0	0.10	0.10	0.11
Industrial LFs	0	0	0	0	0	0	0	
MSW Combustion	0.020	0.025	0.033	0.031	0.032	0.033	0.034	0.35
Municipal WW	0.057	0.063	0.067	0.068	0.071	0.073	0.076	0.078
Industrial WW	0	0	0	0	0	0	0	0
Total	**0.32**	**0.43**	**0.53**	**0.63**	**0.52**	**0.62**	**0.73**	**0.86**

Source: CCS calculations based on approach described in text.

Waste combustion is estimated to contribute 6% of waste management emissions in 2005 and is expected to contribute a similar percentage in 2020. The wastewater treatment sector is estimated to contribute 14% of the sector emissions in 2005 and less than 13% of the total by 2020 (note that the wastewater estimates currently only include the municipal wastewater treatment sector). Data and methods were not identified to incorporate industrial wastewater treatment emissions into this assessment (including ballast water treatment and fish processing waste). The remaining emissions for the waste management sector emissions are contributed by solid waste landfilling – about 80% through the forecast period.

Key Uncertainties

The methods used to project landfill emissions do not account for uncontrolled sites that will need to apply controls during the period of analysis due to triggering requirements of the federal New Source Performance Standards/Emission Guidelines. As noted above, the available data do not cover all of the open and closed landfills in Alaska. Rough estimates were developed for 14 Class II and 222 Class III landfills in the state. Also, many small landfills in Alaska are frozen for as much as half the year and would not be expected to contribute emissions during that time. Hence, the estimates presented here should be viewed as order of magnitude estimates.

The waste combustion estimates should also be viewed as order of magnitude estimates given the availability of data. The estimates are based on assumptions that 50% of the waste in Class III sites is open burned. National default waste composition profiles are used to estimate the CO_2e emissions for this activity, which might not adequately reflect the types of waste being open burned (i.e. paper/wood versus plastic/other composite fractions). No significant changes in controlled waste burning (in municipal waste combustors) are assumed for the future. Growth overall in waste combustion emissions is assumed to track population growth.

For the wastewater sector, the key uncertainties are associated with the application of SGIT default values for the municipal wastewater treatment parameters listed in Table G1 above (e.g. fraction of the Alaska population on septic; fraction of BOD which is anaerobically decomposed). The SGIT defaults were derived from national data.

For industrial wastewater treatment, data and estimation methods were lacking for this assessment. Emissions are expected from ballast water treatment and the treatment of fish processing waste; however no information was identified to develop emission estimates.

Overall for the waste management sector, it is important to note that the emissions presented here are associated with the end of life waste management practices in Alaska. This is consistent with the "production-based" estimates of emissions provided for the other GHG sectors. A consumption-based approach to emissions estimation would factor in the life-cycle GHG emissions associated with the production, transport, and final waste management practice for the wastes being managed in the State. For example, the emissions associated with the production of a plastic bottle, its transport to a distributor and end user, and its final disposal method (e.g. landfill or combustion). While this method of consumption-basis emissions accounting can be useful for understanding the full impacts of GHG mitigation policies implemented in Alaska, the reductions would largely occur outside of the State.