Appendix C:
Analysis of Criteria Pollutant Emissions from Landfill Gas Control Devices

Proposed Amendments to the Regulation on Methane Emissions from Municipal Solid Waste Landfills

Release Date: September 23, 2025

I. Introduction

The Proposed Amendments are expected to increase the quantity of landfill gas captured and controlled at landfills subject to the LMR. This appendix includes the methods and results of an analysis to determine the potential additional emissions of oxides of nitrogen (NO_x), carbon monoxide (CO), particulate matter (PM), and sulfur dioxide (SO_2) from gas control devices as a result of capture and combustion of additional landfill gas. This analysis also supports the analysis in Chapters V and VI of the Initial Statement of Reasons (ISOR).

II. Methods

Staff used the estimated increase in gas collection resulting from the Proposed Amendments calculated in Chapter V of the ISOR as the basis for these calculations. CARB staff calculated estimates of the amount of potential additional methane collected and controlled from landfills in each air district to estimate potential additional emissions from combustion.

When landfill gas is combusted in a control device, that device destroys methane, volatile organic compounds, and other gas species that may be present in landfill gas, while producing some pollutants including NO_x, CO, PM, and SO_2. Staff used emissions factors from U.S. EPA's AP-42 Table 2.4-5 (U.S. EPA, 2025) to convert the amount of additional methane collected into potential emissions of NO_x, CO, PM, and SO_2. Table C-1 shows the emissions factors from AP-42 for flares ("Enclosed Combustor/Flare" as listed in AP-42).

Table C-1. Emissions Factors for Flares from AP-42

Pollutant	**Emissions Factor (lb/mmscf methane)**[a]
NO_x	38
CO	58
PM	17
SO_2	15.6[b]

[a] lb = pounds; mmscf = million standard cubic feet

[b] AP-42's approach to calculating SO_2 emissions is dependent on the concentration of reduced sulfur compounds in the landfill gas. Staff used equations (3), (4), and (7) in AP-42 Chapter 2.4 along with default values of 46.9 ppmv concentration of total sulfur compounds and 50% methane composition by volume in landfill gas (defaults provided in AP-42 Chapter 2.4). Staff also used a collection system efficiency of 100% in equation (7) of AP-42 Chapter 2.4 to produce an emissions factor based on methane collected (rather than methane generated) and used a standard temperature of 20 degrees Celsius.

Staff assumed that all additional methane collected will be directed to enclosed flares, which is the most common type of device used to control landfill gas in California. Some of the additional gas might instead be controlled in energy recovery devices such as engines, gas turbines, or boilers. In these cases, combustion of the gas is performing a useful purpose (production of electricity or heat), which is considered to offset fossil natural gas combustion elsewhere that would be needed to produce the same energy in the absence of the increased landfill gas combustion. Thus, assuming that all additional collected landfill gas is combusted in a flare, rather than for a useful purpose, results in higher additional emissions estimates than calculating the net emissions from a mix of control device types partly offset by reduced emissions from reduced fossil natural gas use.

III. Results

Table C-2 shows the estimated increase in gas collection and emissions of NO_x, CO, PM, and SO_2 in each local air district resulting from the Proposed Amendments. The table shows that the maximum potential emissions increase calculated for any air district is 5.88 tons per year of NO_x, 8.97 tons per year of CO, 2.63 tons per year of PM, and 2.41 tons per year of SO_2.

Table C-2. Estimated Potential Increase in Methane Collection and Emissions of NO_x, CO, PM, and SO_2 by Air District

Air District	**Increase in Methane Input (mmscf/yr)**	**Increase in NO_x Emissions (tons/yr)**	**Increase in CO Emissions (tons/yr)**	**Increase in PM Emissions (tons/yr)**	**Increase In SO_2 Emissions (tons/yr)**
Antelope Valley AQMD	10.9	0.21	0.32	0.09	0.09
Bay Area AQMD	309.4	5.88	8.97	2.63	2.41
Butte County AQMD	10.4	0.20	0.30	0.09	0.08
Calaveras County APCD	2.0	0.04	0.06	0.02	0.02
Eastern Kern County APCD	2.6	0.05	0.08	0.02	0.02
El Dorado County AQMD	3.5	0.07	0.10	0.03	0.03
Feather River AQMD	7.0	0.13	0.20	0.06	0.05
Imperial County APCD	0.5	0.01	0.01	0.00	0.00
Lake County AQMD	3.3	0.06	0.10	0.03	0.03
Mojave Desert AQMD	4.3	0.08	0.12	0.04	0.03
Monterey Bay ARD	11.5	0.22	0.33	0.10	0.09
Placer County APCD	30.1	0.57	0.87	0.26	0.24
Sacramento Metro AQMD	21.9	0.42	0.64	0.19	0.17
San Diego County APCD	56.0	1.06	1.62	0.48	0.44
San Joaquin Valley APCD	209.0	3.97	6.06	1.78	1.63
San Luis Obispo County APCD	9.5	0.18	0.27	0.08	0.07
Santa Barbara County APCD	15.6	0.30	0.45	0.13	0.12
Shasta County AQMD	8.6	0.16	0.25	0.07	0.07
South Coast AQMD	168.8	3.21	4.89	1.43	1.32
Tehama County APCD	3.9	0.07	0.11	0.03	0.03
Ventura County APCD	0.7	0.01	0.02	0.01	0.01

Note: Air districts without any additional estimated gas capture are not included in the table. AQMD=Air Quality Management District; APCD=Air Pollution Control District; ARD=Air Resources District.

Air district significance thresholds for NO_x vary from 4.6 tons per year (tpy) (calculated from daily rate threshold) to 40 tpy (Table C-3). Of the four air districts with estimated potential increases above 1 tpy in Table C-2, all have a NO_x significance threshold of 10 tpy or higher. As shown in Table C-2, the projected potential emissions increases would be very small, and would not exceed the significance threshold in any air district, for NO_x or any other pollutant.

As a secondary check, for the district with the highest potential additional increase in NO_x, staff utilized actual emissions data to confirm that emissions would not exceed the threshold of significance. Staff used the most recent landfill gas recovery data and source tests available from 2020-2023 LMR annual reports from landfills in the Bay Area AQMD,[1] for devices controlling 70% of overall gas (the remaining 30% of gas is directed to third-party operated devices for which source tests are not available). Staff found that 83% of the gas across these landfills would be directed to enclosed flares, with a methane flow-weighted average[2] NO_x emissions factor of 34.4 lb NO_x/mmscf methane. This would result in potential additional NO_x emissions of 5.74 tons/yr (34.4 lb NO_x/mmscf methane x 309.4 mmscf methane/yr x 83% x 1 ton/2,000 lb) in the Bay Area AQMD. As discussed in the Methods section of this appendix, the remaining additional gas combusted for a useful purpose would displace other forms of energy generation, resulting in no net increase to emissions.

[1] Included in references as Best Environmental, 2023a-b; Blue Sky Environmental, Inc., 2023a-m; Blue Sky Environmental, Inc., 2022a-b, Blue Sky Environmental, Inc., 2021a-e; and Blue Sky Environmental, Inc., 2020.

[2] Weighted by actual throughput to each control device from 2023 annual reports.

Table C-3. Air District Thresholds of Significance

Air District	**NO_x**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**
Antelope Valley AQMD[3]	25 tpy	100 tpy	15 tpy	12 tpy	25 tpy
Bay Area AQMD[4]	10 tpy	No adopted mass-based threshold	15 tpy	10 tpy	No adopted mass-based threshold
Butte County AQMD[5]	25 lbs/day	No adopted mass-based threshold	80 lbs/day	No adopted mass-based threshold	No adopted mass-based threshold
Calaveras County APCD[6]	150 lbs/day	No adopted mass-based threshold	150 lbs/day	No adopted mass-based threshold	No adopted mass-based threshold
Eastern Kern County APCD[7]	25 tpy	No adopted mass-based threshold	15 tpy	No adopted mass-based threshold	27 tpy
El Dorado County AQMD[8]	82 lbs/day	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold
Feather River AQMD[9]	25 lbs/day	No adopted mass-based threshold	80 lbs/day	No adopted mass-based threshold	No adopted mass-based threshold
Imperial County APCD[10]	137 lbs/day	550 lbs/day	150 lbs/day	550 lbs/day	150 lbs/day
Lake County AQMD	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold
Mojave Desert AQMD[11]	25 tpy	100 tpy	15 tpy	12 tpy	25 tpy
Monterey Bay ARD[12]	137 lbs/day	550 lbs/day	82 lbs/day	No adopted mass-based threshold	150 lbs/day
Placer County APCD[13]	55 lbs/day	No adopted mass-based threshold	82 lbs/day	No adopted mass-based threshold	No adopted mass-based threshold

[3] (AVAQMD, 2016)
[4] (BAAQMD, 2022)
[5] (BCAQMD, 2024)
[6] (Calaveras County, 2018)
[7] (KCAPCD, 1999; KCAPCD, 2000)
[8] (EDCAPCD, 2002)
[9] (FRAQMD, 2010)
[10] (ICAPCD, 2017)
[11] (MDAQMD, 2020)
[12] (MBUAPCD, 2008)
[13] (PCAPCD, 2017)

Sacramento Metro AQMD[14]	65 lbs/day	No adopted mass-based threshold	Zero (0); 80 lbs/day and 14.6 tpy if BACT/BMPs applied[b]	Zero (0); 82 lbs/day and 15 tpy if BACT/BMPs applied[b]	No adopted mass-based threshold
San Diego County APCD[15]	40 tpy	100 tpy	15 tpy	10 tpy	40 tpy
San Joaquin Valley APCD[16]	10 tpy	100 tpy	15 tpy	15 tpy	27 tpy
San Luis Obispo County APCD[17]	25 lbs/day	550 lbs/day	25 lbs/day	No adopted mass-based threshold	No adopted mass-based threshold
Santa Barbara County APCD[18]	120 lbs/day	500 lbs/day	80 lbs/day	55 lbs/day	120 lbs/day
Shasta County AQMD[19]	25 tpy	No adopted mass-based threshold	25 tpy	No adopted mass-based threshold	No adopted mass-based threshold
South Coast AQMD[20]	55 lbs/day	550 lbs/day	150 lbs/day	55 lbs/day	150 lbs/day
Tehama County APCD[21]	>25 lbs/day with feasible mitigation	No adopted mass-based threshold	>80 lbs/day with feasible mitigation	No adopted mass-based threshold	No adopted mass-based threshold
Ventura County APCD[22]	25 lbs/day[a]	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold	No adopted mass-based threshold

[a] 5 lbs/day in the Ojai Planning Area, however there are no landfills subject to the LMR within that area.
[b] CARB sees no reason why activities undertaken as compliance responses to the Proposed Amendments would not incorporate best management practices (BMPs). Construction BMPs include compliance with District dust control requirements, limiting vehicle speeds, minimizing idling time consistent with requirements, and complying with other equipment-related requirements.[23] Operational BMPs are: compliance with District rules, compliance with mandatory Title 24 requirements, and compliance with anti-idling requirements for diesel-powered equipment.[24]

[14] (SMAQMD, 2020a)
[15] (SDCAPCD, 2020)
[16] (SJVAPCD, 2015)
[17] (SLOCAPCD, 2023)
[18] (SBCAPCD, 2016)
[19] (Shasta County AQMD, 2003)
[20] (South Coast AQMD, 2023)
[21] (TCAPCD, 2015)
[22] (VCAPCD, 2003)
[23] (SMAQMD, 2019)
[24] (SMAQMD, 2020b)

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