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ENVIRONMENTAL PROTECTION DIVISION

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MEMORANDUM

December 30, 2020

To: James Boylan
Thru: Byeong-Uk Kim
From: Yan Huang
Subject: **Modeling Analysis for Ethylene Oxide**
Sterigenics U.S., LLC, Atlanta, Cobb County, GA (Permit Application #27153)

GENERAL INFORMATION

Air dispersion modeling of ethylene oxide was conducted by the Georgia Environmental Protection Division (GA EPD) to assess the impacts of ethylene oxide emissions from sources at Sterigenics U.S., LLC (hereafter, Sterigenics) on ambient air surrounding the facility. GA EPD followed the procedures described in GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*[1] (hereafter, "Georgia Air Toxics Guideline").

Computer models are used to predict the concentrations of toxic air pollutants (TAPs) being analyzed using facility information provided by the source and other information developed by GA EPD staff. The modeling results are compared to the 15-min, 24-hour, and annual Acceptable Ambient Concentrations (AACs).[2] GA EPD's 15-min and 24-hour AACs are derived from Occupational Safety and Health Administration (OSHA) permissible exposure limits. GA EPD's annual AACs are derived from U.S. EPA's risk values which are found in U.S. EPA's Integrated Risk Information System (IRIS) database.

GA EPD uses AACs as a screening tool to ensure that public health is protected. No further evaluation is needed if the modeled concentrations are below the corresponding AACs. If the modeled concentration is above the AAC, GA EPD requires the company to consider a reduction in pollutant emission rates, additional controls, and/or an increase in stack heights, followed by a site-specific risk assessment.

After performing a site-specific risk assessment, if the modeled concentrations are still above the corresponding AAC and it is infeasible for the applicant to comply with the AAC, the Director at his discretion may approve control technology which reflects the maximum degree of reduction in emissions of hazardous air pollutants that the Director determines is achievable by the source, provided that such control technology is no less effective than the level of emission control which is achieved in practice by the best controlled similar source.

[1] https://epd.georgia.gov/air-protection-branch-technical-guidance-0/toxic-impact-assessment-guideline

[2] The AAC is set at a concentration that is estimated to result in as many as one person in a million people, if exposed to that concentration continuously for a lifetime, developing cancer as a result of that exposure. This would be in addition to a person's overall risk of developing cancer. For American's, the overall risk of developing cancer is one in three as shown at https://www.cancer.org/cancer/cancer-basics/lifetime-probability-of-developing-or-dying-from-cancer.html.

This memo discusses modeling results and the input data used to perform the ethylene oxide dispersion modeling. The modeled maximum ground-level concentrations (MGLCs) for the 15-min and 24-hour averaging periods were below their corresponding AACs. The modeled annual averaged ground-level concentrations across the 5-year period (AAGLCs) at the four closest residential areas exceeded the annual AAC.[3] The results are summarized in the following sections of this memorandum.

INPUT DATA

1. **Meteorological Data** – Hourly meteorological data (2014 to 2018)[4] used in this review were generated by GA EPD. Surface measurements were obtained from the Cartersville Airport, Cartersville, GA. Upper air observations were obtained from the Atlanta Regional Airport – Falcon Field, Peachtree City, GA. These measurements were processed using the AERSURFACE (v13016), AERMINUTE (v15272), and AERMET (v18081) with the adjusted surface friction velocity option (ADJ_U*).

2. **Source Data** – Emission release parameters and emission rates were provided by the company and reviewed by the GA EPD Stationary Source Permitting Program (see Appendix A for details). The facility-wide modeled ethylene oxide emission rate was 84 lbs/year including sterilization, aeration, back vents, and indoor air emissions.

3. **Receptor Locations** – Discrete receptors with 50-meter intervals were placed along the property boundary and from the property boundary to approximately 500 m. Discrete receptors were placed at 100-meter intervals from 500 m to approximately 2.0 km to the west and to the north, 100-meter intervals from 500 m to approximately 1.0 km to the east and to the south, and 250-meter intervals for an additional 3 km from the edge of 100-meter interval receptor grid at each direction. Additional receptors were placed at the four closest residential areas. This domain (approximately 9 km by 9 km) is sufficient to capture the maximum impact. All receptor locations are on a Cartesian grid and are represented in the Universal Transverse Mercator (UTM) projections, Zone 16, North American Datum 1983.

4. **Terrain Elevation** – Topography was found to be generally flat in the site vicinity. Terrain data from the USGS 1/3-sec National Elevation Dataset (NED) were extracted to obtain the elevations of all sources, buildings, and receptors by the AERMAP terrain processor (v18081).

5. **Building Downwash** – The potential effect for building downwash was evaluated via the "Good Engineering Practice (GEP)" stack height analysis and was based on the scaled site plan submitted by Sterigenics using the BPIPPRM program (v04274). The BPIPPRM model was used to derive building dimensions for downwash assessment and the assessment of cavity-region concentrations.

AIR TOXICS ASSESSMENT

The impacts of facility-wide ethylene oxide emissions were evaluated according to the Georgia Air Toxics Guideline. The 15-min, 24-hour, and annual AACs were reviewed based on OSHA Permissible Exposure

[3] The Georgia AAC is sixty times more protective than US EPA's acceptable concentration (see Appendix B and Appendix C). The Georgia AAC is 0.00033 $\mu g/m^3$ versus EPA's acceptable concentration of 0.02 $\mu g/m^3$.
[4] The 2014-2018 meteorological data was used to be consistent with the previous modeling performed for this facility in 2019.

Limit (PEL), OSHA Total Weight Average (TWA) PEL, and U.S. EPA IRIS Risk Based Air Concentration (RBAC) according to the Georgia Air Toxics Guideline. For this assessment, GA EPD used the 15-min, 24-hour, and annual AAC derived according to the Georgia Air Toxics Guideline (see Appendix B for details). The U.S. EPA's 2014 National Air Toxic Assessment (NATA)[5] used a much higher (far less stringent) annual concentration threshold than the Georgia AAC value (see Appendix C for details). The modeled 1-hour, 24-hour, and annual ground-level concentrations were calculated using the AERMOD dispersion model (v19191).

Table 1 summarizes the MGLCs and the AAC levels. The 15-min MGLC is based on the 1-hour MGLC multiplied by a factor of 1.32. The 15-min and 24-hour MGLCs were below their corresponding AACs. However, the AAGLC exceeded its corresponding AAC with the maximum concentration located at the southeast side of the property boundary. Figure 1 shows the spatial distribution of the AAGLCs. Figure 2 shows a zoomed-in version of Figure 1 with the closest four residential areas labeled (R1, R2, R3, and R4). R1, R2, R3, and R4 represent the closest residential home within a group of homes or subdivisions. A site-specific risk assessment shows that the AAGLCs at the four closest residential areas exceeded the annual AAC (Table 2).

Table 1. Modeled MGLCs and the Respective AACs.

Averaging period	MGLC (μg/m^3)	AAC (μg/m^3)
Annual	0.00518*	0.00033
15-min	0.12	900
24-hour	0.04	1.43

*Modeled annual averaged ground-level concentrations across the 5-year period (i.e., AAGLC).

Table 2. Risk Analysis for Residential Areas with Modeled 5-year Average Concentrations.

Residential Areas	Receptor UTM Zone:16		AAGLC* (μg/m^3)	Averaging Period	AAC (μg/m^3)	Ratio of AAGLC (μg/m^3) to AAC (μg/m^3)
	Easting (meter)	Northing (meter)				
R1	734,456.40	3,746,827.10	0.00151	Annual	0.00033	4.6
R2	734,349.30	3,746,923.70	0.00149			4.5
R3	734,073.40	3,746,829.10	0.00147			4.5
R4	733,449.70	3,746,572.40	0.00133			4.0

*AAGLC is the annual averaged ground-level concentrations across the 5-year period.

CONCLUSIONS

The dispersion modeling analysis for ethylene oxide shows exceedances at the annual AAC level. The risk assessment indicates that nearby residential areas are above the annual Georgia AAC (4.0-4.6 times) but these same areas are more than 92% lower than the U.S. EPA's acceptable risk threshold[6]. The 15-min and 24-hour Georgia AAC levels were not exceeded.

[5] The National Air Toxics Assessment (NATA) is a screening tool developed by U.S. EPA to help identify pollutants, emission sources, and places that warrant further study to better understand risks.

[6] Annual modeled concentrations at nearby residential areas are well below the 0.02 microgram per cubic meter value used in EPA's 2014 NATA to determine areas that required further study.

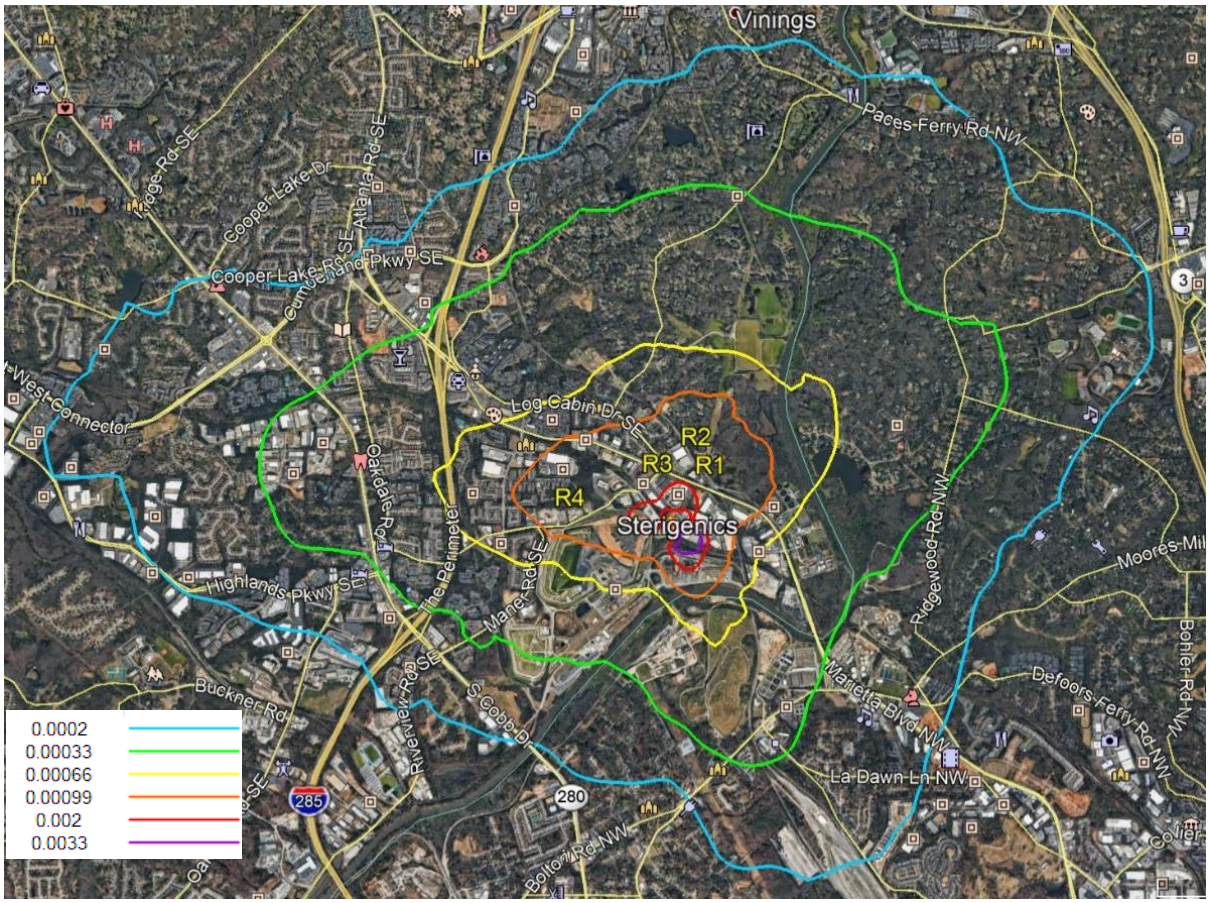

Figure 1. Contours of modeled annual ground-level concentrations (in μg/m^3) averaged over 5 years overlaid on a Google Earth map.

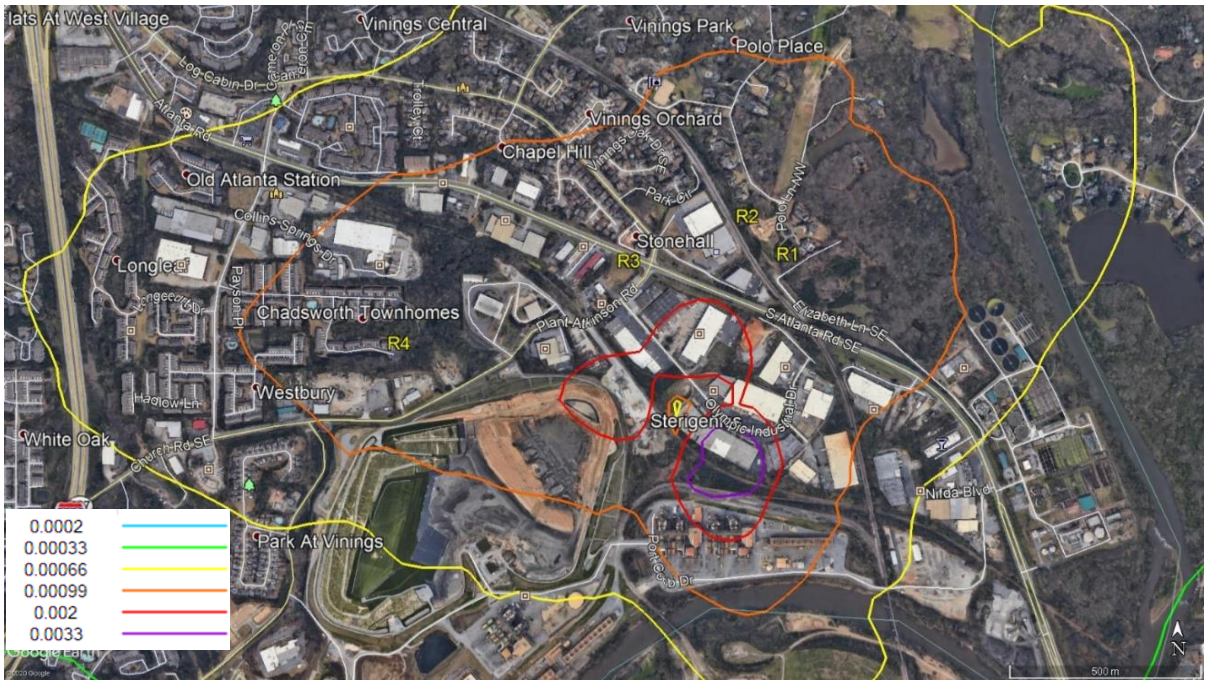

Figure 2. Zoomed-in version of Figure 1 with the four closest residential areas labeled (R1, R2, R3, and R4).

Appendix A

Emissions and Model Input Parameters

Ethylene Oxide (EtO) Emissions

Emission Source	EtO Emission (lb/yr)	Total (lb/yr)
Sterilization	8	53
Aeration	37	
Backvents	8	
Indoor Air	31	31
		84

Model Input Parameters for EtO Emissions Sources

Model ID	Stack Description	Source Type	UTM E[1] (m)	UTM N[1] (m)	Elevation[2] (m)	Modeled EtO Emissions[3] (g/s)	Exhaust Gas Flow Rate (scfm)	Exhaust Gas Flow Rate (acfm)
STK1	AAT Scrubber	POINT	734,200	3,746,411	250.92	7.62E-04	12,000	13,052.00
STK2	Indoor Air	POINT	734,194	3,746,406	250.58	4.46E-04	18,000	18,576.00

Model ID	Stack Height		Stack Temperature		Exit Velocity		Stack Diameter	
	(ft)	(m)	(°F)	(K)	(ft/s)	(m/s)	(ft)	(m)
STK1	80.0	24.38	98	309.82	155.8	47.4869	1.3	0.406
STK2	80.0	24.38	70	294.26	98.5	30.0377	2.0	0.610

Notes:
1. Coordinates are based on UTM NAD83, Zone 16.
2. Modeled elevations were incorporated using AERMAP version 18081. Terrain elevation data was obtained using the National Elevation Data (NED) files from the USGS Multi-Resolution Land Characteristics Consortium (MRLC).
3. AERMOD version 19191 was used for this analysis.

Appendix B

GA EPD Calculation of the 15-min, 24-hour, and Annual AAC for Ethylene Oxide

GA EPD Calculation of the 15-min, 24-hour, and Annual AAC for Ethylene Oxide

According to the GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*, the annual, 24-hour, and 15-min AAC for ethylene oxide are calculated as following:

15-min AAC

The OSHA 15-min PEL for ethylene oxide is 5 ppm. To convert the PEL from ppm to mg/m^3, the following conversion formula from the guidance is used:

$$(5 \text{ ppm} \times 44.05 \text{ g/mol}) / (24.45 \text{ L/mol}) = 9 \text{ mg/m}^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at 25ºC and 760 mmHg. After applying a safety factor of 10 for acute sensory irritants, the 15-min AAC is calculated as:

$$\text{15-min AAC} = (9 \text{ mg/m}^3 \times 1000 \text{ µg/mg}) / 10 \text{ (safety factor)}$$

15-min AAC = 900 µg/m³

24-hour AAC

The OSHA 8-hour Time Weighted Average (TWA) permissible exposure limit (PEL) for ethylene oxide is 1 ppm. To convert the TWA PEL from ppm to mg/m^3, the following conversion formula from the guidance is used:

$$(1 \text{ ppm} \times 44.05 \text{ g/mol}) / (24.45 \text{ L/mol}) = 1.8 \text{ mg/m}^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at 25ºC and 760 mmHg. After converting the 8-hour average weekly exposure to a 24-hour average weekly exposure and applying a safety factor of 300 for known human carcinogens, the 24-hour AAC is calculated as:

$$\text{24-hour AAC} = \frac{1.8 \text{ mg/m}^3 \times 1000 \text{ µg/mg} \times (8 \text{ hours/day} \times 5 \text{ days/week})}{300 \text{ (safety factor)} \times (24 \text{ hours/day} \times 7 \text{ days/week})}$$

24-hour AAC = 1.43 µg/m³

Annual AAC

In the EPA Integrated Risk Information System (IRIS)[7], the Inhalation Unit Risk (IUR) for ethylene oxide is 3×10^{-3} per $\mu g/m^3$. Since ethylene oxide is carcinogenic to humans, it belongs to Group A[8] with a cancer risk of 1/1,000,000. Therefore, the annual AAC is calculated as:

$$\text{Annual AAC} = \text{Cancer Risk} / \text{IUR} = (1/1{,}000{,}000)/(0.003/\mu g/m^3)$$

Annual AAC = 0.00033 µg/m³

[7] https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1025_summary.pdf

[8] https://www.epa.gov/fera/risk-assessment-carcinogenic-effects

Appendix C

EPA Calculation of the Annual AAC for Ethylene Oxide

EPA Calculation of the Annual AAC for Ethylene Oxide

According to EPA's IRIS, inhalation unit risk (IUR) for ethylene oxide (EtO) is $3x10^{-3}$ per $\mu g/m^3$ (as discussed in Appendix B). However, because of the elevated risk due to the mutagenic mode of action through early-life exposures, EPA multiplied the IUR by 1.6:

Modified IUR for EtO = $3x10^{-3}$ per $\mu g/m^3$ x 1.6 = $0.005/\mu g/m^3$

EPA's NATA used (100/1,000,000) individual risk for the purpose of determining "acceptable risk" (AR) in their national assessment.

AR Exposure Concentration = Cancer Risk / IUR = $(100/1{,}000{,}000)/(0.005/\mu g/m^3)$ **= 0.02 µg/m^3**