GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

Richard E. Dunn, Director

Air Protection Branch
4244 International Parkway
Suite 120
Atlanta, Georgia 30354
404-363-7000

MEMORANDUM

February 3, 2020

To: James Boylan
Thru: Byeong-Uk Kim
From: Henian Zhang
Subject: **Modeling Analysis for Ethylene Oxide**
Augusta University, Augusta, Richmond County, GA

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 Augusta University on ambient air surrounding the facility. Although this modeling is not for issuance of an air quality permit, 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). 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 EPA's Integrated Risk Information System (IRIS) database. Appendix B contains detailed calculations for the 15-min, 24-hour, and annual ethylene oxide AACs.

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 it is infeasible for the applicant to comply with the AAC, the Director at his/her 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.

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) exceeded the annual AAC at the property boundaries. However, the AAGLC at the closest residential area was below the annual AAC. The results are summarized in the following sections of this memorandum.

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

INPUT DATA

1. **Meteorological Data** – Hourly meteorological data (2014 to 2018)[2] were generated by GA EPD. Surface measurements were obtained from the Daniel Field Airport, Augusta, 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 Augusta University (see Table A1 in Appendix A for details) and reviewed by the GA EPD Stationary Source Permitting Program. The modeled ethylene oxide emission rate was 0.158 lbs/year. The source was treated as a horizontal stack with exit gas temperature of 299.5 K and exit velocity 0.001 m/s. The location of stack is 408,450.98 E and 3,704,363.22 N in the Universal Transverse Mercator (UTM) projections, Zone 17, North American Datum 1983.

3. **Receptor Locations** – Discrete receptors with 50-meter intervals were placed along the property line. Receptors extend outwards from the property line at 100-meter intervals on a Cartesian grid to approximately 3 km. This domain (approximately 6.5 km by 6.5 km) is sufficient to capture the maximum impact. All receptor locations are represented in the UTM projections, Zone 17, North American Datum 1983.

4. **Terrain Elevation** – Topography was found to be generally flat in the site vicinity. Terrain data from the USGS 1-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 building parameters submitted by Augusta University (Table A2 in Appendix A) using the BPIPPRM program (v04274). The BPIPPRM model was used to derive building dimensions for the 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 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 annual AAC derived according to the Georgia Air Toxics Guideline (see Appendix B for details). The EPA's 2014 National Air Toxic Assessment (NATA) used a higher annual 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 MGLC was below its corresponding AAC. The 24-hour averaged MGLC did not exceed the 24-hour AAC anywhere in the modeling domain (including nearby business areas). However, the annual MGLC exceeded its corresponding AAC at three receptors along the property boundary. Figure 1 shows the spatial distribution of the AAGLCs with the closest residential area labeled (R1). A site-specific risk assessment shows that the AAGLC at the closest residential area did not exceed the annual AAC (Table 2).

[2] https://epd.georgia.gov/air-protection-branch-technical-guidance-0/air-quality-modeling/georgia-aermet-meteorological-data

Table 1. Modeled MGLCs and their Respective AACs.

Averaging period	MGLC (μg/m^3)	AAC (μg/m^3)
Annual	0.00092	0.00033
15-min	0.065	900
24-hour	0.00762	1.43

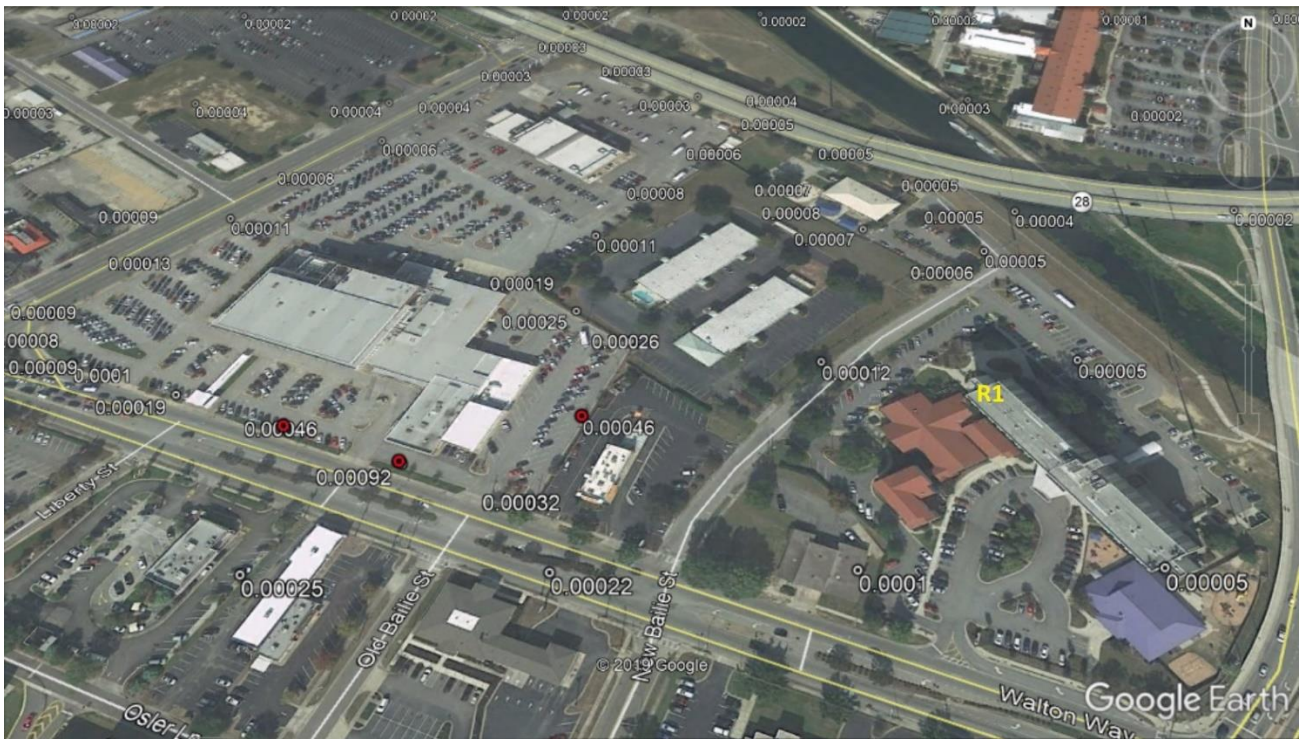

Figure 1. Modeled annual ground-level concentrations (in μg/m^3) averaged over 5 years overlaid on a Google Earth map. Receptors with AAGLCs exceeding the annual AAC are highlighted in red. The closest residential area (R1) is highlighted in yellow.

Table 2. Risk Analysis for Residential Areas with Modeled AAGLCs.

Residential Areas	Receptor UTM Zone:17		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	408,654.64	3,704,382.03	0.00007	Annual	0.00033	0.21

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

CONCLUSIONS

The dispersion modeling analysis for ethylene oxide show exceedances of the annual AAC along the property line. A site-specific risk assessment shows that the modeled annual average ground-level concentrations at the closest residential area is below the annual AAC. The modeled 15-min and 24-hour maximum ground-level concentrations did not exceed their respective AACs.

Appendix A

Emissions and Model Input Parameters

Table A1. Source Parameters

Augusta University Air Permit Ethylene Oxide Model Information Request										
Source ID	Emission Release Type	Source Description	Latitude	Longitude	Release Height	Stack Inside Diameter	Stack Exit Velocity	Stack Exit Gas Temperature	Adjusted Stack Diameter	EtO
SRC1	Point	Ethylene Oxide Sterilizer used intermittently during the year. Usage is approximately 4 times per year at 18g per use. This is a total of 72 grams per year. Each cycle exhaust slowly for two hours at the end of a 24 hour sterilization cycle. The stack exits the roof vertically and bends 90 degree at 4 feet above the roof. Two air intakes are located on this area of the roof and the stack are 30 feet from any potential air intake location and the stack opening faces away from the air intakes. The exhaust location is on side roof as the entire building has several roof elevations from additions.	33.475609	-81.986282	19 feet	0.167 feet	.91 ft/s	Varies with room temperature between 68 to 91 degrees Fahrenheit	0.053 feet	0.000079 tons per year

Augusta University Air Permit Ethylene Oxide Model Building Information Request								
Name	Address	Description	EtO Section Roof Height	EtO Section Width	EtO Section Length	Main Building Height	Main Building Length	Main Building Width
Annex Building (HS)	1499 Walton Way, Augusta, Ga 30901	A multi stories, multi sectioned building housing offices in Section A and Section B along with research laboratories in EtO Section. (See attached map for areas locations.) The sterilizer vent stack is located at the red dot on the Area C roof facing Walton Way.	19 feet	64 feet	183 Feet	52 Feet	434 Feet	300 Feet

Figure A1. Modeled Building and Stack

Table A2. Building Parameters

Augusta University EtO Building Roof Information Request				
Section Name	Roof Height with Parapet	Parapet Height	Roof Height without Parapet	Notes
A			14′ 2″	
B		21′ 7 7/32″	14′ 2″	Separated from A by an incomplete metal wall
C		18′ 3/4″	42′ 9/32″	Completely enclosed by the parapet
D	55′ 11 9/32″	2′ 8 21/32″	53′ 2 5/8″	
E	60′ 2 1/32″	1′ 2 19/32″	58′ 11 7/16″	
F	18′ 4 1/16″	1′ 5 27/32″	16′ 10 7/32″	
G	18′ 6 3/4″	4′ 4 13/32″	14′ 2 11/32″	
H	15′ 6 7/16″	1′ 8 1/32″	13′ 10 13/32″	
I	24′ 10 5/32″	2′ 2″	22′ 8 5/32″	
J	18′ 4 1/16″	4′ 3 5/8″	14′ 7/16″	
K	42′ 1/2″	2′ 10 23/32″	39′ 2 25/32″	
L			12′ 7 1/16″	
M			28′ 10 5/6″	
N			18′ 10 27/32″	

Appendix B

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

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

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

15-min AAC

The OSHA 15-min permissible exposure limit (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 25°C and 760 mmHg. After applying a safety factor of 10 for acute sensory irritants, the 15-min AAC is calculated as:

$$\text{15-min AAC} = (9 \text{ mg/m}^3 \times 1{,}000 \text{ µg/mg}) / 10 \text{ (safety factor)}$$

15-min AAC = 900 µg/m^3

24-hour AAC

The OSHA 8-hour Time Weighted Average (TWA) 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 25°C 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:

$$\text{24-hour AAC} = \frac{1.8 \text{ mg/m}^3 \times 1{,}000 \text{ µg/mg} \times (8 \text{ hours/day} \times 5 \text{ days/week})}{300 \text{ (safety factor)} \times (24 \text{ hours/day} \times 7 \text{ days/week})}$$

24-hour AAC = 1.43 µg/m^3

Annual AAC

In the EPA Integrated Risk Information System (IRIS)[3], 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[4] 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/m^3

[3] https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1025_summary.pdf
[4] 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 $\mu g/m^3$**