MEMORANDUM

DATE: 11/27/2024

TO: Mohamed Otry, Environmental Protection Engineer, State/FESOPs Unit, Permits/BOA

FROM: David Coy & Rain Sevenshadows, Modeling Unit, Permits/BOA

SUBJECT: Microsoft – Hoffman Estates, Cook County, Illinois – 031449ADS, Permit Applications 23100001 & 23110003.

Microsoft Corporation's applying for a Construction Permit for the CH106 and CH107 data centers at its Hoffman Estates Data Center Complex, located at 2045 Lakewood Boulevard, Hoffman Estates, Cook County, Illinois, 60192. The complex is classified as a synthetic minor source under federal air quality regulations. Microsoft has also applied for Federally Enforceable State Operating Permit (FESOP) for the CHI05, CHI06 and CHI07 data centers.

The data center will typically draw electricity from the local power grid, but it will also be equipped with 52 emergency generators (each rated at 3 megawatts (MW)), along with three smaller generators (each 500-kilowatts (kW)). These generators will operate only during emergencies when the data center is unable to draw electricity from the local power grid or for routine monthly maintenance and testing of the generators.

Since the Microsoft facility, as of the date of this modeling memorandum, is located in an Environmental Justice (EJ) community and will have a permitted increase in emissions, the Illinois EPA asked the facility to submit an air quality analysis as part of its construction permit application. This is to ensure that the project will not violate or threaten existing National Ambient Air Quality Standards (NAAQS). In response, Microsoft contracted Stantec Consulting Services Inc. (Stantec) to conduct a detailed air quality dispersion modeling analysis to assess the potential impact of the data center on air quality from emissions of carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic compounds (VOC), and hazardous air pollutants (HAPs).

Modeling Unit Analysis

The air quality analysis was performed by Stantec, and the initial modeling report was submitted July 19, 2024. After initial review, the Illinois EPA Modeling Unit (Modeling Unit) requested a revised analysis with updated background concentrations and changes to model parameters.

Stantec submitted a revised modeling report on October 1, 2024. This final analysis depended on the implementation of several control measures as outlined below in the main dot entries:

- The emergency generators will be operated one-at-a-time monthly for short periods (less than 2 hours at a time, each) to perform required routine maintenance and reliability testing.

- The 52 3-MW emergency generators and 3 500-kW emergency generators will be limited to an equivalent of 62 hours per year at full load per generator.

- Limiting a total of 679,000 gallons of fuel per year for all 52 3-MW engines and 6,730 gallons per year limit for all 3 500-kW engines.

Stantec utilized the modeling methodology detailed in the main bullet points below:

- Stantec used AERMOD (version 23132)[1], which is a federally approved regulatory model for air quality analysis. The Modeling Unit also used this version for their audit runs.

- Modeling inputs utilized IEPA- and USEPA-recommended default regulatory options to simulate phenomena such as atmospheric stability, plume rise, and downwash. The model used five years of locally representative meteorology. The Modeling Unit obtained National Weather Service (NWS) meteorological data files for the years 2019 through 2023 from the National Centers for Environmental Information (NCEI). This data came from the National Weather Service: surface data from O'Hare International Airport in Chicago and upper air data from the National Weather Service in Davenport, IA. The applicant processed the weather data using AERMET (version 23132).[1]

- AERMOD's terrain tool, AERMAP (version 18081)[1], was used to find the elevations of receptors, sources, and buildings. It read detailed elevation maps from the National Elevation Database (NED) provided by the United States Geological Survey (USGS). The area covered by the maps matched the study area, as recommended by USEPA. The site elevation at the Microsoft – Hoffman Estates facility is about 204.8 meters above sea level.

- Stantec utilized a Cartesian grid to distribute a total of 12,055 receptors, with receptors placed every 50 meters along the facility's fence line. The following receptor grid densities in **Table 1** were applied:

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[1] A new version of AERMOD, AERMAP, and AERMET (v. 24142) has been released, but it is not expected to impact the results of this modeling analysis. Therefore, the use of AERMOD (v. 23132), AERMET (v. 23132), and AERMAP (v. 18081) was approved for this analysis since the modeling was submitted before the release of the new versions.
Tillerson, Clint (2024, November 20) *Release of the regulatory AERMOD Modeling System (AERMOD, AERMET, and AERMAP), AERSURFACE, and AERPLOT (Version 24142), and MMIF (Version 4.1.1).* USEPA https://gaftp.epa.gov/air/aqmg/scram/models/preferred/aermod/AERMOD_24142_transmittal_memo.pdf

Table 1
Receptor Grid

Discrete Cartesian Grid Format	
Spacing	**Range**
100 m	Fenceline out to 2 km.
250 m	2 km to 5 km.
500 m	5 km to 10 km.
1 km	10 km to 30 km.
2 km	30 km to 50 km

- Building downwash effects on plumes from the stacks at the facility were considered in the model using USEPA's Building Profile Input Program (BPIPRM version 04274). The dimension and locations of buildings and structures, including heights and coordinates, were provided by the facility.

- Stantec selected the rural modeling option in their analysis. The Modeling Unit conducted an Auer's Analysis as part of its review to characterize the area surrounding the Facility and determine whether the AERMOD rural option should be implemented. Stantec initially ran the model in urban mode, but the Modeling Unit's analysis determined the surrounding area was primarily rural according to Appendix W, Section 7.2.1.1 (b)(i).[2] The Modeling Unit developed its Auer's Analysis using 2021 National Land Cover Data (NLCD) within a 3-km radius of the facility. Results of the analysis showed that the surrounding area is 77.5% rural. Thus, the Modeling Unit requested Stantec revise their analysis to utilize the rural option, and the Modeling Unit audit also utilized the rural modeling option.

- The U.S. EPA's Appendix W, Section 4.2.3.4[2] outlines the three tiers for modeling the conversion of NO_x to NO_2:

    - Tier 1: Assumes that all the NO_x emitted from the source's emissions units is converted to NO_2.
    - Tier 2: Uses a representative atmospheric equilibrium default value, developed from conversion ratios based on monitored NO_x and NO_2 concentrations.
    - Tier 3: Allows for a detailed analysis using either the Ozone Limiting Method (OLM) or the Plume Volume Ratio Method (PVMRM) as regulatory screening options in AERMOD. These methods account for Ozone titration chemistry and the resulting NO_2 concentrations.

  Stantec applied a Tier 2 approach to model NO_2. Stantec used the regulatory default Ambient Ratio Method (ARM2) option in AERMOD, which utilized ambient NO_2 /NO_x ratios ranging from 0.5 (lower limit) to 0.9 (upper limit).

[2] Appendix W to Part 51, *Guideline on Air Quality Models,* 40 CFR 51 (2023).

- The modeling analysis included all 55 emergency generators operating at the same time. For testing and maintenance, the facility will not typically operate all 55 generators at once. The modeled emission rates varied depending on the pollutant and averaging period. For certain averaging periods and pollutants, the modeled emission rates followed guidance for intermittent sources as outlined in a 2011 USEPA memorandum[3] and Table 8-2 from Appendix W.

    - For 1-hour CO, 8-hour CO, and 3-hour SO_2, the maximum hourly emission rate for each engine was modeled.

    - For 24-hour PM_{10} and 24-hour $PM_{2.5}$, a daily average emission rate was modeled, which was calculated by multiplying the maximum hourly emission rate by 3 hours and dividing by 24 hours. The 3-hour estimate is a conservative representation of the typical maintenance and reliability testing of less than 2 hours per engine in a day or the maximum 5-year mean power outage duration of 157 minutes.[4]

    - For 1-hour and annual NO_2, 1-hour SO_2, and annual $PM_{2.5}$, an annualized emission rate was modeled, which was calculated by multiplying the maximum hourly emission rate by operating hours calculated from per-engine fuel use and dividing by 8,760 hours. The proposed annual operating fuel use limits are equivalent to an average of approximately 62 hours per year at full load.

Significant Impact Analysis

Stantec performed a significant impact analysis to determine whether more detailed modeling would be required for any of the criteria pollutants (NO_2, SO_2, CO, $PM_{2.5}$, and PM_{10}) associated with this project. Microsoft modeled the allowable emission rates for each pollutant and averaging period. Modeled concentrations were compared against significant impact levels (SIL) for each pollutant and averaging period. The results of this analysis are displayed in **Table 2** below.

Table 2
Significant Impact Modeling Results

Pollutant	Averaging Period	Modeled Concentration (µg/m^3)	Standard (µg/m^3)	>SIL
PM_{10}	24-hour	8.18	5	Yes
	Annual	0.12	1	No

[3] U.S. EPA (2011). *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard* https://www.epa.gov/sites/default/files/2020-10/documents/clarificationmemo_appendixw_hourly-no2-naaqs_final_06-28-2010.pdf

[4] Stantec provided historical data for the area to demonstrate that typically less than one power outage occurs annually and the outages average less than three hours per occurrence.

$PM_{2.5}$	24-hour	7.49	1.2	Yes
	Annual	0.12	0.13	No
NO_2	1-hour	69.34	7.5	Yes
	Annual	6.42	1	Yes
CO	1-hour	2174.03	2000	Yes
	8-hour	1280.78	500	Yes
SO_2	1-hour	0.1	7.9	No
	3-hr	12.02	25	No

The $PM_{2.5}$ results displayed in **Table 2** include both primary and secondary impacts. Details of the secondary $PM_{2.5}$ and Ozone (O_3) analysis are described in the following section.

Ozone and Secondary $PM_{2.5}$ Formation

Precursor emissions of NOx, SO_2, and VOC chemically react with the atmosphere to form secondary $PM_{2.5}$ and O_3. The AERMOD dispersion model cannot estimate secondary formation of pollutants due to the complex chemistry and meteorological conditions involved. Secondary formation of pollutants requires complex photochemical modeling techniques. To analyze the formation of secondarily formed $PM_{2.5}$ and O_3 on their respective NAAQS, Stantec followed the methodology outlined in the USEPA memorandum, *Clarification on the Development of Modeling Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Programs.*[5] Stantec's approach, utilizing this methodology, incorporates model results from hypothetical photochemical modeling analyses, which are available through the USEPA's MERPs View Qlik tool.[6]

Stantec utilized a hypothetical source located in Porter, Indiana as it produced the worst-case scenario estimates of secondary $PM_{2.5}$ and O_3. The hypothetical source with a stack height of 10 m, and source emissions of 500 tpy was utilized in the modeling analysis. Stantec’s results were based upon facility emissions of 64 tpy of NO_x, 1 tpy of SO_2, and 3 tpy of VOC.

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[5] USEPA (2019). *Guidance on the Use of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program*. Publication No. EPA 454/R–19–003. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[6] USEPA (2019). MERPs View Qlik. *Support Center for Regulatory Atmospheric Modeling (SCRAM).* Retrieved from: https://www.epa.gov/scram/merps-view-qlik

Ozone Impacts

Table 3 summarizes the Ozone impacts for the Hoffman Estates Complex.

Table 3
MERPs Analysis for Ozone

	Concentration (ppb)	SIL (ppb)
8-hour Ozone	0.221	1

Hoffman Estates Complex have estimated O_3 impacted below the 1 ppb SIL, which are further reflective that the emissions of NOx and VOC will not impact the O_3 NAAQS.

Secondary $PM_{2.5}$

The secondary $PM_{2.5}$ results displayed in **Table 4** summarized the MERPs calculations from Hoffman Estates Complex.

Table 4
MERPs Analysis for Secondary $PM_{2.5}$

	Concentration (µg/m^3)	SIL (µg/m^3)
24-hour $PM_{2.5}$	0.0208	1.2
Annual $PM_{2.5}$	0.0012	0.13

The total secondary $PM_{2.5}$ concentrations were added to the primary $PM_{2.5}$ impacts modeled with AERMOD for each respective averaging period for comparison to the $PM_{2.5}$ SIL. The combined primary and secondary results were 0.12 µg/m^3 for annual $PM_{2.5}$ (less than the SIL of 0.13 µg/m^3) and 7.49 µg/m^3 for 24-hour $PM_{2.5}$ (greater than the SIL of 1.2 µg/m^3). Therefore, further analysis against the NAAQS will be required for 24-hour $PM_{2.5}$.

Since pollutant concentrations exceed the SIL for 24-hour $PM_{2.5}$, 24-hour PM_{10}, 1-hour and annual NO_2, and 1-hour and 8-hour CO, further analysis was needed to demonstrate that the emissions from this facility will not exceed any of the NAAQS for these pollutants.

Cumulative Impact Analysis

The results of the significant impact analysis show further analysis is required to evaluate the project's impacts against the 1-hr and 8- hr CO; 1-hr and annual NO_2, 24-hr $PM_{2.5}$ and 24-hr PM_{10} NAAQS. Stantec developed a cumulative modeling analysis that incorporated background concentrations from monitored concentrations and nearby emission inventory sources that were not accounted for in the monitoring data.

The background monitors were selected based on their proximity and representativeness of the area surrounding the facility. The background concentrations are displayed in **Table 5** below.

Table 5
Monitored Background Concentrations

AQS ID	Location	Pollutant	Averaging Period	Modeled Statistic	Design Values				Units
					2021	2022	2023	2021-2023	
17-031-4201	Northbrook, IL	CO	1-hour	Highest 2nd High recent 3-year period.	0.964	1.286	1.147	1.286	ppm
			8-hour	Highest 2nd High recent 3-year period.	0.8	0.7	1	1	ppm
		SO_2	1-hour	3-year average of 99th percentile concentrations.	5.7	3.6	6.4	5.2	ppb
			3-hour	Highest 2nd High recent 3-year period.	6	3.2	5.2	6	ppb
		PM_{10}	24-hour	Highest 2nd High recent 3-year period.	59	40	36	59	$\mu g/m^3$
17-031-3103	Schiller Park, IL	$PM_{2.5}$	24-hour	3-year average of 98th percentile concentrations.	22.8	22.5	26.1	23.8	$\mu g/m^3$
			Annual	3-year average annual arithmetic mean	10.5	9.6	10.4	10.2	$\mu g/m^3$
17-031-0076	Chicago, IL	NO_2	1-hour	98th percentile of daily max 1-hour concentration	Varies[1]	Varies[1]	Varies[1]	Varies[1]	ppb
			Annual	98th percentile of daily max 1-hour concentration	11.9	11.5	12.5	12.5	ppb

(1) Varies by season and hour of the day.

For 1-hour NO_2, seasonal hourly background concentrations calculated from the Com Ed station were utilized in the analysis. These values were generated following USEPA guidance[7] with raw data downloaded from USEPA's Air Quality System API website[8] for years 2021 to 2023. The raw data was averaged based upon seasons and hour-of-day. The seasons were defined as December, January and February being Winter; March, April and May being Spring; June, July and August being Summer; and September, October and November being Fall.

Stantec was provided an inventory of sources from the Modeling Unit that included sources located within 10 km radius from the facility. For the 1-hour NO_2 analysis, intermittent sources were excluded from the nearby source inventory based on guidance issued by the USEPA.[9]

Table 6 shows the Stantec results for the cumulative NAAQS analysis of CO, NO_2, $PM_{2.5}$ and PM_{10}.

Table 6
NAAQS Modeling Results

Pollutant	Averaging Period	Modeled Statistic	Modeled Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	Standard ($\mu g/m^3$)	% Standard
PM_{10}	24-hour	Highest 6th High Over 5 Years	12.3	59	71.3	150	47.6%
$PM_{2.5}$	24-hour	5-Year Mean of the Annual 8th High	6.4	23.8	30.27	35	86.2%
NO_2	1-hour	5-Year Mean of the Annual 8th High	152.4	(a)	152.4	188	81.1%
	Annual	Maximum	7	23.05	30.5	100	30.1%
CO	1-hour	Highest 2nd High	2147	1479	3626	40000	9.1%
	8-hour	Highest 2nd High	1061	1150	2211	10000	22.1%

(a) Included in the model concentration0.

[7] USEPA (2011). *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard.*
[8] Air Quality System (AQS) API. Data retrieved from https://aqs.epa.gov/aqsweb/documents/data_api.html.
[9] USEPA (2011). *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO2 National Ambient Air Quality Standard.*

The Modeling Unit audit confirmed the results presented in Stantec's analysis, and all modeled concentrations for the criteria pollutants and averaging periods mentioned above were below their respective NAAQS.

Air Toxic Analysis

Stantec submitted a modeling analysis for Benzene emissions from the generators. The total annual emissions of Benzene were greater than all other HAPs. The modeled impacts were compared to reference concentrations from the California Office of Environmental Health Hazard Assessment (OEHHA).[10]

The results of Stantec's analysis are displayed in **Table 7**. All modeled concentrations were below their respective reference concentrations.

Table 7
Model Results for Benzene

Pollutant	CAS	Averaging Period	Modeled Statistic	Modeled Concentration ($\mu g/m^3$)	Risk	Standard ($\mu g/m^3$)	% OEHHA Criteria	Reference
Benzene	71-43-2	24-hour	High 1st High Over 5 Years	6.21	Acute	27	23%	OEHHA(1)
	71-43-2	Annual	High 1st High Over 5 Years	0.004	Chronic	3	0.10%	OEHHA(1)

(1) OEHHA Reference Exposure Levels (REL) are established for pollutants based on exposure durations.

Summary

Based on the applicant's submittal and the Modeling Unit's review of Stantec's air quality modeling reports, the analysis confirms that the proposed operations do not exceed the NAAQS for $PM_{2.5}$, PM_{10}, NO_2, SO_2, or CO. or the toxic-based HAP standards for Benzene. Stantec's modeling results demonstrate that the data center will meet the air quality standards for all pollutants and averaging periods evaluated.

[10]California OEHHA (2023). OEHHA Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary. Retrieved from: https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary

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