

MEMORANDUM

To: Jeff Weber, Chief Real Estate Development Officer, Shadowbox Studios

From: Sophia La Herran, Technical Lead
Heidi Rous, CPP, Sr. Reviewer

Date: April 3, 2026

Subject: Shadowbox Data Center Project – Air Quality Comparison

PURPOSE

The purpose of this memorandum is to provide a basis for understanding the magnitude of air quality impacts associated with the Shadowbox Data Center Project (Project) located in DeKalb County, Georgia. Specifically, this analysis documents the air impacts associated with the Project and compares them with the impacts of a hypothetical high industrial distribution center, another a permitted use on the Project site. This assessment has been prepared for reference only and contains no actual project information or permitting determinations.

AIR QUALITY

Pollutants of Concern

The air pollutants emitted into ambient air by stationary and mobile sources are regulated by State and federal laws. These regulated air pollutants are known as “criteria air pollutants” and are categorized into primary and secondary pollutants.

Primary air pollutants are emitted directly from sources. Carbon monoxide (CO), reactive organic gases (ROG), nitrogen oxide (NO_x), sulfur dioxide (SO₂), coarse particulate matter (PM₁₀), fine particulate matter (PM_{2.5}), and lead are primary air pollutants. Of these, CO, NO_x, SO₂, PM₁₀, and PM_{2.5} are primary criteria pollutants. ROG and NO_x are criteria pollutant precursors and form secondary criteria pollutants through chemical and photochemical reactions in the atmosphere. For example, the criteria pollutant ozone (O₃) is formed by a chemical reaction between ROG and NO_x in the presence of sunlight. O₃ and nitrogen dioxide (NO₂) are the principal secondary pollutants. Sources and health effects commonly associated with criteria pollutants are summarized in **Table 1**.

Table 1: Air Contaminants and Associated Public Health Concerns		
Pollutant	Major Man-Made Sources	Human Health Effects
Particulate Matter (PM ₁₀ and PM _{2.5})	Sources include power plants, steel mills, chemical plants, unpaved roads and parking lots, wood-burning stoves and fireplaces, automobiles and others.	Increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing; asthma; chronic bronchitis; irregular heartbeat; nonfatal heart attacks; and premature death in people with heart or lung disease. Impairs visibility.
Ozone (O ₃)	Formed by a chemical reaction between reactive organic gases/volatile organic compounds (ROG or VOC) ¹ and nitrogen oxides (NO _x) in the presence of sunlight. Sources include motor vehicle exhaust industrial emissions, gasoline storage and transport, solvents, paints and landfills.	Irritates and causes inflammation of the mucous membranes and lung airways; causes wheezing, coughing, and pain when inhaling deeply; decreases lung capacity; aggravates lung and heart problems. Damages plants; reduces crop yield.
Sulfur Dioxide (SO ₂)	A colorless gas formed when fuel containing sulfur is burned and when gasoline is extracted from oil. Examples are petroleum refineries, cement manufacturing, metal processing facilities, locomotives, and ships.	Respiratory irritant. Aggravates lung and heart problems. In the presence of moisture and oxygen, sulfur dioxide converts to sulfuric acid which can damage marble, iron and steel. Damages crops and natural vegetation. Impairs visibility. Precursor to acid rain.
Carbon Monoxide (CO)	An odorless, colorless gas formed when carbon in fuel is not burned completely; a component of motor vehicle exhaust.	Reduces the ability of blood to deliver oxygen to vital tissues, affecting the cardiovascular and nervous system. Impairs vision, causes dizziness, and can lead to unconsciousness or death.
Nitrogen Dioxide (NO ₂)	A reddish-brown gas formed during fuel combustion for motor vehicles and industrial sources. Sources include motor vehicles, electric utilities, and other sources that burn fuel.	Respiratory irritant; aggravates lung and heart problems. Precursor to O ₃ . Contributes to global warming and nutrient overloading which deteriorates water quality. Causes brown discoloration of the atmosphere.
Lead (Pb)	Lead is a metal found naturally in the environment as well as in manufactured products. The major sources of lead emissions have historically been motor vehicles (such as cars and trucks) and industrial sources. Due to the phase out of leaded gasoline, metals processing is the major source of lead emissions to the air today. The highest levels of lead in air are generally found near lead smelters. Other stationary sources are waste incinerators, utilities, and lead-acid battery manufacturers.	Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues and can adversely affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ.
1. Volatile Organic Compounds (VOCs or Reactive Organic Gases [ROG]) are hydrocarbons/organic gases that are formed solely of hydrogen and carbon. There are several subsets of organic gases including ROG and VOCs. Both ROG and VOCs are emitted from the incomplete combustion of hydrocarbons or other carbon-based fuels. The major sources of hydrocarbons are combustion engine exhaust, oil refineries, and oil-fueled power plants; other common sources are petroleum fuels, solvents, dry cleaning solutions, and paint (via evaporation).		
Source: U.S. EPA. <i>Criteria Air Pollutants</i> . https://www.epa.gov/criteria-air-pollutants . Accessed March 2026.		

ANALYSIS

Data Center Operations

Data center projects result in emissions of numerous regulated air pollutants, primarily NO_x, PM, and CO from emergency generators. For the purposes of this analysis, the hypothetical data center would consist of 5 data center buildings each encompassing a total built area of approximately 220,000 square feet. Each building would be designed with a maximum power demand of 130 megawatts (MW) of power capacity, for a total facility capacity of 650 MW.

To accommodate this demand, the data center would be supported by 217 diesel-fueled emergency back-up generators, each rated at 3 MW. Additional generators are typically installed to provide redundancy and operational flexibility in the event of equipment failure, maintenance outages, or unexpected load fluctuations. This analysis therefore includes 53 diesel-fueled redundant generators, each rated at 3 MW. This analysis also includes 10 smaller “house” generators (2 per building) assumed to be rated at 1.75 MW, that would support back of house (BOH) operations for the data center.

This analysis assumes an annual operation of 15 hours per year per generator. Generators may be utilized for longer in emergency situations, but for regular testing and maintenance, 15 hours per year is an industry standard. This practice is consistent with National Fire Protection Association (NFPA) guidance pertaining to minimum load tests, recommending at least monthly 30-minute tests at not less than 30 percent load, which would account for at least six (6) hours per year.¹

This analysis also assumes the use of Tier 4 Final-certified generators. Tiers are different levels of emissions standards set by the U.S. Environmental Protection Agency (U.S. EPA), with Tier 4 Final being the most stringent. Tier 4 Final-certified generators include features such as selected catalytic reduction and oxidation catalysts that reduce exhaust emissions, primarily NO_x, PM, and CO. Emissions associated with the data center generators are summarized in **Table 2**.

Table 2: Data Center Operational Emissions				
Source	Criteria Pollutant Emissions (tpy)			
	NO_x	CO¹	PM_{2.5}	PM₁₀
<i>Data Center</i>				
Primary Engines	7.22	14.43	0.32	0.32
Redundant Engines	1.76	3.53	0.08	0.08
House Engines	0.19	1.01	0.01	0.01
Total Facility	9.17	18.35	0.40	0.40
Refer to Appendix A for detailed calculations.				

¹ NFPA, *NFPA 110 Standard for Emergency and Standby Power Systems*, 2025, pp. 24.

High Distribution Warehouse Operations

Heavy-duty diesel truck operations associated with warehouses and distribution centers result in emissions of numerous regulated air pollutants, primarily NO_x, CO, and PM from exhaust and brake and tire wear. For the purposes of this exercise, the facility consists of 3,300,000 square feet of warehousing, based on information provided by the Client. Operational emissions associated with truck travel to and from the site, internal circulation within the facility, and truck idling during loading and unloading activities are considered in this analysis. These mobile source emissions represent the primary operational air quality impact associated with warehouse and distribution center uses due to the high volume of heavy-duty diesel truck activity typically required to support freight movement and logistics operations. While warehouse uses may also generate additional emissions from other operational sources, such as on-site landscaping equipment, employee vehicle trips, architectural coatings, maintenance activities, and other minor area or stationary sources, those emissions are not quantified as part of this comparative analysis.

Truck travel emissions are based on Institute of Transportation Engineers (ITE) truck trip generation rates for the Warehousing land use. An average trip length of 100 miles was assumed, consistent with the typical freight truck trip lengths as reported in a U.S. Department of Transportation (DOT) 2021 study.² Idling emissions are also based on ITE trip generation, with an assumed idling time of 15 minutes for each truck trip. There are no state or county-wide idling time limits in the project area, but this assumption is consistent with the nearby City of Atlanta Ordinance limiting truck idling to no more than 15 minutes (in most weather conditions) at a single location.³ Emissions associated with warehouse truck travel and idling are summarized in **Table 3**.

Table 3: High Distribution Warehouse Operational Emissions				
Source	Criteria Pollutant Emissions (tpy)			
	NO_x	CO	PM_{2.5}	PM₁₀
<i>High Distribution Warehouse</i>				
Travel	155.37	91.59	4.48	4.48
Idling	4.79	3.64	0.16	0.17
Total Mobile	160.16	95.23	4.64	4.65
Refer to Appendix A for detailed calculations.				

² U.S. DOE. *U.S. Truck Freight Tonnage Was Shipped Less than 250 Miles*. 2023. <https://www.energy.gov/eere/vehicles/articles/fotw-1302-august-7-2023-2021-87-us-truck-freight-tonnage-was-shipped-less>. Accessed March 2026.

³ City of Atlanta. Code of Ordinances. Section 150-97. 2026.

Air Quality Emissions Comparison

Emissions associated with the high distribution warehouse and data center are summarized in **Table 4** for comparison.

Table 4: High Distribution Warehouse vs. Data Center Operational Emissions				
Source	Criteria Pollutant Emissions (tpy)			
	NO_x	CO	PM_{2.5}	PM₁₀
<i>High Distribution Warehouse</i>				
Total Mobile	160.16	95.23	4.64	4.65
<i>Data Center</i>				
Total Facility	9.17	18.35	0.40	0.40
Refer to Appendix A for detailed calculations.				

As shown above, the data center results in substantially lower emissions across all evaluated pollutants (NO_x, CO, PM_{2.5}, and PM₁₀). NO_x and CO are primarily associated with acute respiratory and cardiovascular effects, including airway irritation, inflammation, and reduced oxygen delivery in the bloodstream. Short-term exposure to these pollutants can exacerbate asthma and other respiratory conditions, while longer-term exposure has been linked to increased risks of cardiovascular disease and mortality.⁴

PM_{2.5} and PM₁₀ is of greater concern from a chronic health risk perspective. PM_{2.5} can penetrate deep into the lungs and enter the bloodstream, contributing to systemic inflammation, cardiovascular disease, and premature mortality, while both PM_{2.5} and PM₁₀ have been associated with increased respiratory morbidity and mortality.^{5 6} Furthermore, studies have also linked long-term PM exposure to increased cancer risk, particularly lung cancer, due to the ability of fine particles to carry toxic compounds into sensitive regions of the respiratory system.⁷

Importantly, potential health effects are a function of both pollutant concentrations and the level and duration of exposure at nearby sensitive receptor locations. While NO_x, CO, and PM are associated with adverse health outcomes, the magnitude of risk depends on resulting ambient concentrations rather than emissions alone. Emissions from the analyzed uses would be subject to atmospheric dispersion, resulting in decreasing pollutant concentrations with increasing distance from the source due to dilution, atmospheric

⁴ Syrek-Gerstenkorn, Z.; Syrek-Gerstenkorn, B.; Paul, S. A Comparative Study of SO_x, NO_x, PM_{2.5} and PM₁₀ in the UK and Poland from 1970 to 2020. <https://doi.org/10.3390/app14083292>

⁵ Pryor JT, Cowley LO and Simonds SE (2022) The Physiological Effects of Air Pollution: Particulate Matter, Physiology and Disease. <https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.882569/full>

⁶ USEPA, Health and Environmental Effects of Particulate Matter (PM), May 2025. <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>

⁷ Meo, S. A. (2021). Effect of Environmental Pollutants PM_{2.5}, CO, NO₂, and O₃ on the Incidence and Mortality of SARS-CoV-2 Infection in Five Regions of the USA. International journal of environmental research and public health. <https://doi.org/10.3390/ijerph18157810>

mixing, and deposition processes. Air dispersion modeling and empirical studies indicate that ground-level concentrations from localized sources typically decline rapidly within the first several hundred meters and continue to decrease toward background levels within approximately 1 kilometer under typical meteorological conditions.⁸ Additionally, emissions associated with mobile sources, such as heavy-duty diesel truck traffic for warehouse operations, are inherently distributed along roadway networks rather than concentrated at a single location, which promotes further dispersion. As such, the proposed data center use represents a lower-emitting operational scenario and would be expected to result in reduced potential air quality and associated health impacts relative to other feasible development options.

DISCLAIMER

This report is based on publicly accessed data sources obtained through desktop research of hypothetical scenarios. No site visits or agency consultations were conducted, and no project-specific information was utilized. Kimley-Horn and Associates, Inc. appreciates the opportunity to provide you with these services.

⁸ Roostaei, V., Gharibzadeh, F., Shamsipour, M., Faridi, S., & Hassanvand, M. S. (2024). Vertical distribution of ambient air pollutants (PM_{2.5}, PM₁₀, NO_x, and NO₂); A systematic review. *Heliyon*, 10(21), e39726. <https://doi.org/10.1016/j.heliyon.2024.e39726>

APPENDIX A

Emission Calculations

Land Use			
Land Use	Number of Buildings	Capacity/Building (MW)	Facility Capacity (MW)
Data Center	5	130	650

Backup Generation						
Generator Type	Number of Generators	Rating/Generator (kW)	EPA Certification	Total Capacity (MW)	Hours/Year/Generator ²	Total Production (kWh)
Primary	217	3,000	Tier 4 Final	651	15	9,765,000
Redundant	53	3,000	Tier 4 Final	159	15	2,385,000
House	10	1,750	Tier 4 Final	18	15	262,500
					Total	12,412,500

Emission Rates ¹						
Unit	VOC	NO _x	CO	SO ₂	PM ₁₀	PM _{2.5}
g/hp-hr	0.140	0.500	1.000	0.006	0.022	0.022
g/kw-hr	0.188	0.671	1.341	0.007	0.030	0.030
lb/kw-hr	0.00041	0.00148	0.00296	0.00002	0.00007	0.00007

Criteria Pollutant Emisions (tons/year)						
Source	VOC	NO _x	CO	SO ₂	PM ₁₀	PM _{2.5}
Primary Generators	2.02	7.22	14.43	0.08	0.32	0.32
Redundant Generators	0.49	1.76	3.53	0.02	0.08	0.08
House Generators	0.05	0.19	0.39	0.00	0.01	0.01
Total Facility	2.57	9.17	18.35	0.10	0.40	0.40

Conversions		
1 kW =	1.341	hp
1 lb =	453.592	g
1 ton =	2000	lb

Notes

¹ Emission factors set at Tier 4 Final emissions standards (<https://dieselnet.com/standards/us/nonroad.php>).

² Assuming annual operation of 15 hours per generators as an industry standard, consistent with National Fire Protection Association (NFPA) guidance pertaining to minimum load tests, recommending at least monthly 30-minute tests, which would account for at least 6 hours per year.

Land Use	
Facility Type	Total Square Feet
High Distribution Warehouse	3,300,000

Truck Trip Generation						
Facility Type	ITE Code	ITE Category	Truck Trips/1000 SF/Weekday ¹	Truck Trips/Weekday	Weekdays/Year	Trips/Year
High Distribution Warehouse	155	Warehousing	0.6	1980	260	514,800

Fleet Mix						
Vehicle Classification	Percentage of Truck Trips ²	Trips/Year	Miles/Trip ³	VMT/Year	Idling Hours/Trip ⁴	Idling Hours/Year
Heavy-Duty Trucks	100%	514,800	100	51,480,000	0.25	128,700

Travel Emission Rates (grams/mile) ⁵					
Unit	HC	NO _x	CO	PM ₁₀	PM _{2.5}
Heavy-Duty Trucks	0.178	2.738	1.614	0.079	0.079

Idle Emission Rates (grams/hour) ⁶					
Unit	HC	NO _x	CO	PM ₁₀	PM _{2.5}
Heavy-Duty Trucks	3.503	33.763	25.628	1.196	1.100

Criteria Pollutant Emissions (tons/year)					
Source	HC	NO _x	CO	PM ₁₀	PM _{2.5}
Heavy-Duty Travel	10.10	155.37	91.59	4.48	4.48
Heavy-Duty Idling	0.50	4.79	3.64	0.17	0.16
Total	10.60	160.16	95.23	4.65	4.64

Conversions		
1 lb =	453.592	g
1 ton =	2000	lb

Notes
¹ Truck trip generation per 1000 square feet (weekday average rate) from ITE <i>Trip Generation Appendices: 100s - Industrial - Truck Data Plots</i> (https://www.ite.org/tripgenappendices/)
² Assuming 100% heavy-duty trucks, consistent with available EPA emission rates.
³ Truck trip distance based on typical freight truck trip distance in 2021 U.S. DOT study (https://www.energy.gov/eere/vehicles/articles/fotw-1302-august-7-2023-2021-87-us-truck-freight-tonnage-was-shipped-less).
⁴ Although no state or county-wide limit, assuming 15 minutes of idling per trip, consistent with nearby Atlanta idling ordinance (City of Atlanta Code of Ordinances, Section 150-97).
⁵ Heavy-duty diesel vehicle emission factors for 2026 from EPA's MOVES4 (https://www.bts.gov/content/estimated-national-average-vehicle-emissions-rates-vehicle-vehicle-type-using-gasoline-and). Assuming PM ₁₀ equal to PM _{2.5} .
⁶ Heavy-duty diesel vehicle idling emission factors from EPA <i>Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks</i> (2008) (https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EVXV.PDF?Dockey=P100EVXV.PDF)