AIR DISPERSION MODELING GUIDANCE DOCUMENT – Technical Modeling Considerations

EGLE

MICHIGAN DEPARTMENT OF
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Introduction

This guidance document supports the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Air Quality Division (AQD) Air Dispersion Modeling Guidance Document – How to Model[1] by providing technical information on how modeling is performed. The contents of this document were developed by dispersion modelers in the AQD, and it outlines current air quality modeling policies and guidance. It does not supersede any state or federal rules. EGLE's AQD modeling reviews follow the United States Environmental Protection Agency (USEPA) Guideline on Air Quality Models, 40 CFR Part 51, Appendix W[2].

The information below reiterates much of the information found in Appendix W and other USEPA guidance documents. However, these are only guidelines on how modeling can be performed. The AQD realizes there may be other methods/methodologies regarding how modeling can be done. Other methods may be approved after justification is provided and discussed with the AQD. If questions arise on whether a dispersion modeling analysis **is required** for a facility, please reference AQD's Policy and Procedure AQD-022: Dispersion Modeling Guidance for Federally Regulated Pollutants(AQD-022)[3].

Please reach out to AQD modeling staff if questions arise during the modeling process.

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[1] https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/AQD/modeling-and-meteorology/air-dispersion-modeling-guidance-document-how-to-model.pdf

[2] https://www.epa.gov/scram/clean-air-act-permit-modeling-guidance

[3] https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Policies-Procedures/AQD/aqd-022.pdf

Technical Modeling Considerations

Ambient Air and Secure Property

The AQD follows the most recent USEPA guidance found in the Revised Policy on Exclusions from "Ambient Air" – December 2019[4]. While the determination is generally made on a case-by-case basis, the definition of ambient air used by the AQD is "the atmosphere over land owned or controlled by the stationary source may be excluded from ambient air where the source employs measures, which may include physical barriers, that are effective in precluding access to the land by the general public".

Modeled impacts do not need to be calculated in areas not considered ambient air. A detailed explanation of the means a source is proposing to use as a secure property boundary, which outlines the ambient air boundary, must be included in an application.

Receptor Grids

In any modeling demonstration, it is important that the receptor grid (i.e., specific coordinates where the model predicts concentrations) is sufficiently dense enough to ensure that the point of maximum ambient impact is identified. While each modeling demonstration is unique, grid intervals of 50 meters outside the secure property are generally sufficient to identify the point of maximum impact, but short distance impacts may require an even smaller interval (25 m). The AQD prefers Cartesian grids over Polar grids since Polar grids become less dense farther away from the origin. Discrete receptors should be placed along secured property lines at intervals not to exceed 25 meters and at any school, hospital, or residence where there is a need to determine pollutant impacts. For facilities without a distinct fence line or other secured boundary, it is reasonable to include a 25-meter buffer distance between receptors and structures with stacks as a practical matter to determine modeled impacts. However, closer spacing may be required for projects that involve sources located in very close proximity to sensitive areas including, but not limited to, private residences, schools, or parks.

NAAQS and PSD increment analyses require receptors to be at ground level. Flagpole (above the ground) receptors can be added when elevated areas such as balconies, rooftops, etc. are of concern with respect to the NAAQS. However, PSD increment impacts should be based on receptors located at ground level. Also, it may be necessary to employ "flagpole" receptors to ascertain the toxic pollutant concentrations at locations such as elevated air intake vents on buildings or hospitals, balconies, bridges, and rooftop restaurants.

Land Use Classification

The selection of either rural or urban dispersion coefficients in a specific application should follow one of the procedures described below.

Land Use Procedure:

1. Classify the land use within the total area (A_o) circumscribed by a 3-km radius around the source using the land use typing scheme proposed by Auer (1978).

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[4] https://www.epa.gov/nsr/ambient-air-guidance

2. If land use types I1, I2, C1, R2 and R3 account for 50 percent or more of A_o, use urban dispersion coefficients; otherwise, use appropriate rural dispersion coefficients.

Population Density Procedure:

1. Compute the average population density (p) per square kilometer with A_o as defined above.
2. If p is greater than 750 people/km^2, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

Of the two methods, the land use procedure is considered more definitive. Population density should be used with caution. It should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied. It should also be noted that most of Michigan is considered Rural, except for a portion of southeast Michigan close to and in the Detroit area. Justification must be provided defending the dispersion coefficient used, especially if Urban is chosen.

Meteorology

AERMOD requires the use of meteorological data that is representative of the location of the facility being evaluated. The AQD used the most recent version of AERMET to process meteorological data collected by the National Weather Service (NWS) to create AERMOD-ready files for 72 airports across Michigan. When running AERSURFACE to determine inputs into AERMET the program uses data from the National Land Cover Database (NLCD) from the United States Geological Survey (USGS) to determine surface characteristic values that vary by land cover type and season. Twelve sectors are used to determine surface characteristics, and average moisture conditions are considered. The Meteorological Data Support Document[5] contains the most recent five years of surface and upper-level meteorological data for all 72 stations. Applicants are asked to justify the reasoning for selecting the meteorology data used in modeling. This should include the selection of hourly vs. 1-minute data, along with whether adjusted u-star has been used.

The AQD can be consulted to help identify which meteorological station is most representative for a specific modeling demonstration.

Terrain

While a large part of Michigan is relatively flat, AQD modelers include terrain in all model analysis. AERMAP is the terrain preprocessor for AERMOD. AERMAP processes digital elevation terrain to create an input file for AERMOD. Within a modeling writeup for an application, please note which terrain datum files were used in the modeling analysis. Any questions about what terrain to use can be

[5] https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/AQD/modeling-and-meteorology/meteorological-support.pdf

directed to one of the AQD modelers. For elevation data access, reference the USEPA's document Data Source and Conversion of Elevation Data for AERMAP[6].

NOx Tiers

Tier 1 Full Conversion:

Tier 1 modeling analysis assumes full conversion of NO to NO_2.

Tier 2 Ambient Ratio Method (ARM2):

Tier 2 assumes ambient equilibrium between NO and NO_2 by multiplying the Tier 1 results by the Ambient Ratio Method 2 (ARM2) to provide an estimate of representative equilibrium ratios of NO_2/NO_x based on ambient levels of NO_2 and NO_x derived from national data from the USEPA's Air Quality Systems (AQS).

Default values of ARM2: minimum ambient NO_2/NO_x ratio of 0.5 and a maximum ambient ratio of 0.9.

Alternative minimum ambient NO_2/NO_x values may be established based on the source's in-stack emissions ratios. Preferably, alternative minimum ambient NO_2/NO_x ratios should be based on source-specific data that satisfies all quality assurance procedures that ensure data accuracy for both NO_2 and NO_x within the typical range of measured values. However, alternate information may be used to justify a source's anticipated NO_2/NO_x in-stack ratios, such as manufacturer test data, state or local agency guidance, peer-reviewed literature, and/or the USEPA's NO_2/NO_x ratio database[7].

Tier 3 OLM, PVMRM, and GRSM:

Tier 3 modeling is performed on a case-by-case basis in consultation with the USEPA Regional Office along with the appropriate reviewing authority (AQD).

Tier 3 options include: 1) Ozone Limiting Method (OLM) analysis, 2) Plume Volume Molar Ratio Method (PVMRM), and 3) Generic Reaction Set Method (GRSM). These three techniques estimate NO_X concentrations and then estimate the conversion of primary NO emissions to NO_2 based on the ambient levels of ozone and the plume characteristics. OLM only accounts for NO_2 formation based on the ambient levels of ozone, while PVMRM and GRSM also accommodate distance-dependent conversion ratios based on ambient ozone. GRSM, PVMRM and OLM require explicit specification of the NO_2/NO_X in-stack ratios and that ambient ozone concentrations be provided on an hourly basis. GRSM requires hourly ambient NO_X concentrations in addition to hourly ozone.

[6] https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aermap/Access_and_Conversion_of_Elevation_Data_for_AERMAP.pdf

[7] https://www.epa.gov/scram/nitrogen-dioxidenitrogen-oxide-stack-ratio-isr-database

OLM works best for large groups of sources, area sources, and near-surface releases, including roadway sources, while PVMRM works best for relatively isolated and elevated point source modeling. The GRSM option addresses photolytic conversion of NO_2 to NO and addresses the time-of-travel necessary for NO_X plumes to disperse and convert the NO portion of the plume to NO_2 via titration and entrainment of ambient ozone. OLM and PVMRM do not address this.

Non-Point Source modeling

Non-Vertical/Obstructed Point Source Releases

Most point sources have a vertical release, therefore, Release Type in AERMOD is set as default to Vertical. If the point source for an application has either a non-vertical or obstructed release, then the Release Type should be changed to what is most representative of the stack; Capped or Horizontal. The non-default release type selected should be justified in the application.

Volume and Line Sources

Volume sources are used in AERMOD to model releases from a variety of sources. Examples include elevated sources such as building roof monitors, multiple vents, and conveyor belts. Below are suggestions for estimating Initial Lateral and Initial Vertical Dimensions for Volume and Line Sources.

Initial Lateral Dimension (σ_{yo})

Type of Source[8]	Procedure for determining Initial Lateral Dimension
Single Volume Source	Length of side divided by 4.3
Line Source Represented by Adjacent Volume Sources (ex. see Fig. 1-8 (a) in EPA, 1995a)	Length of side divided by 2.15
Line Sources Represented by Separated Volume Sources (ex. see Fig. 1-8 (b) in USEPA, 1995a)	Center to center distance divided by 2.15

Initial Vertical Dimension (σ_{zo})

Type of Source	Procedure for determining Initial Lateral Dimension
Surface-Based Source ($h_c \sim 0$)	Vertical dimension of source divided by 2.15
Elevated Source ($h_c > 0$) on or Adjacent to a Building	Building height divided by 2.15
Elevated Source ($h_c > 0$) not on or Adjacent to a Building	Vertical dimension of source divided by 4.3

h_c - Release Height; center of volume above ground, in meters

[8] EPA, 1995a: User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume I - User Instructions. EPA-454/B-95-003a. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711

Haul Road Recommendations:

The AQD uses the recommendations determined by the Haul Road workgroup when modeling emissions from roads. Below are the recommended source configurations:

- Adjacent Volume Source
- Top of Plume Height – 1.7 x VH
- Volume Source Release Height – 0.5 x Top of Plume Height
- Width of Plume – VW + 6 m for a single lane roadway / Road Width +6 m for 2-lane roadways
- Initial Sigma Z – Top of Plume / 2.15
- Initial Sigma Y – Width of Plume / 2.15

"VH" refers to vehicle height (~3 m for typical haul trucks; ~10 m for large mining trucks)
"VW" refers to vehicle width (~3 m for typical haul trucks; ~10 m for large mining trucks)

For detailed information on the recommendations, please see the Haul Road Workgroup Guidance Document[9].

Area Sources

Area sources are used in AERMOD to model low level or ground level releases with no plume rise (e.g., storage piles, slag dumps, and lagoons). There are various options for specifying the shape of an area source: AREA, LINE, AREAPOLY, AREACIRC, OPENPIT, etc. The emission rate for an area source is an emission rate per unit area, which is different from the point and volume source emission rates. The emission rate of an AREA source is calculated by dividing the total emissions in grams per second by the total area in square meters.

Storage Pile example:

Storage piles should be simulated as an area source with the following input parameters:

Release Height = [Height of Pile] / 2
Initial Vertical Dimension **(**σ_z) = 0 (optional parameter)

The release height is based on the premise that the wind speed increases with height and the surface area decreases, which tend to counteract each other in terms of emissions. The initial vertical dimension should be 0 because wind erosion emissions from a pile does not have a plume depth, unlike emissions generated by mechanical agitation such as material transfer from a conveyor.

Flares

There is an option in AERMOD to model a source as a flare by setting the Source Type to FLARE within the Source Input area. If the FLARE option is used, input actual FLARE parameters into AERMOD.

[9] https://www.epa.gov/sites/default/files/2020-10/documents/haul_road_workgroup-final_report_package-20120302.pdf

Based on information found in the USEPA's AERSCREEN User's Guide[10], flares can also be modeled as pseudo point sources. If this option is used, the AERMOD Source Type should be set to POINT and the effective stack input parameters are calculated using the techniques below.

1. Calculate the Total Heat Release (Q_T) by multiplying the heating value of the flare gas by the gas flow rate to obtain the total potential gross heat release in calories per second (cal/s).

2. Calculate the sensible or Net Heat Available (Q_H) for plume rise enhancement in cal/s by multiplying the total heat release by 0.45, which assumes that 55 percent of the total heat is lost due to radiation.

$$Q_H = 0.45(Q_T)$$

3. Determine the effective flare stack diameter in meters (m) based on the net heat release:

$$D_{eff} = 9.88x10\text{-}4(Q_H)^{0.5}$$

4. Calculate the Effective Release Height (H_{eff}) using the following:

$$H_{eff} = H_S + [0.00456 \text{ x } (Q_T)^{0.478}]$$

   where: H_S = physical height of the stack in meters (m)
   Q_T = Total Heat Release (cal/s)

5. For model inputs, use the effective release height and diameter as calculated above, and an assumed stack gas exit velocity (V_e) of 20 m/sec and gas exit temperatures (T_e) of 1273 K.

Variable/Intermittent Emissions

USEPA guidance states modeling demonstrations for 1-hour NO_2 (and SO_2) should be based on emissions that are continuous and frequent enough to significantly contribute to the annual distribution of daily maximum 1-hour concentrations. With this, they deemed running potential emissions from emergency equipment that often are limited to 500 hours of operation or less a year, may be an overly conservative assumption. The AQD agrees with this methodology and therefore allows applicants to: 1) annualize the 1-hour maximum emission rate for intermittent emergency equipment over the number of hours the emergency equipment is allowed to run per year, or 2) exclude emissions of emergency equipment in the modeling analysis. The option of annualizing emissions is preferred over excluding emissions.

Depending on the frequency of startup/shutdown scenarios, they may fall into the intermittent category as well. This is on a case-by-case basis dependent on the type of facility. Some facilities may have infrequent startup/shutdown scenarios where emissions could be annualized, while a peaking unit may go through more frequent startup/shutdown cycles. Therefore, annualizing or excluding the emissions is not appropriate. If questions arise, please reach out to the AQD modeling staff.

Secondary Ozone and $PM_{2.5}$ Analysis

The AQD requires PSD applications to submit a secondary analysis for both ozone and $PM_{2.5}$ based on potential project emissions following the USEPA's final Guidance for Ozone and Fine Particulate Matter

[10] https://gaftp.epa.gov/Air/aqmg/SCRAM/models/screening/aerscreen/aerscreen_userguide.pdf

Permit Modeling[11]. The USEPA recommends two Cases to determine if a Tier 1 or Tier 2 secondary analysis is required.

Ozone:

Case 1: if NO_2 emissions **and** VOC emissions are less than their Significant Emission Rates (SERs), no secondary ozone analysis is required.

Case 2: if **either** NO_2 **or** VOC are greater than their SERs, a secondary analysis needs to be performed for both NO_2 and VOC.

$PM_{2.5}$:

Case 1: if direct $PM_{2.5}$ emissions, **and** NO_2 emissions, **and** SO_2 emissions are less than their SERs, no primary or secondary $PM_{2.5}$ analysis is required.

Case 2: if **either** direct $PM_{2.5}$ emissions, **or** NO_2 emissions, **or** SO_2 emissions are greater than their SERs, a primary analysis is required for $PM_{2.5}$ and a secondary analysis is required for both NO_2 and SO_2.

The secondary analysis should follow the USEPA's two-tiered approach for addressing single-source impacts. To assist in the development of a Tier 1 approach, the USEPA developed the Modeled Emission Rates for Precursors (MERPs) guidance[12] to illustrate how MERPs can be used as a compliance tool under the PSD permitting program. In a Tier 1 assessment, it is generally expected that applicants use existing empirical relationships between precursors and secondary impacts (e.g., ozone and $PM_{2.5}$). The USEPA has generated empirical relationships between single sources and ozone and $PM_{2.5}$ impacts for hundreds of hypothetical sources that vary in stack height, emission rate, and geographic location. The MERPs View Qlik[13]application was developed by the USEPA and provides easy access to the USEPA's hypothetical single source modeled impacts. Justification on the selection of hypothetical site and stack parameters must be included within the modeling protocol submitted prior to the application. Below is the equation to be used when calculating Tier 1 secondary impacts using the USEPA's hypothetical modeling and proposed project emissions.

$$\text{Project Impact} = \text{Project emission rate} \times \frac{\text{Modeled impact from hypothetical source}}{\text{Modeled emission rate from hypothetical source}}$$

For ozone, project impacts must be calculated for both precursors (VOC and NOx), and the combined project impact from both precursors must meet the ozone SIL of 1 ppb.

For $PM_{2.5}$, the combined project impacts from both precursors (SO_2 and NOx), along with the primary modeled impact, must meet the PSD Increment. In the NAAQS analysis, the combined project impacts from both precursors, along with the primary modeled impact, and the monitored design value (background) must meet the NAAQS. If only a Significant Impact Level analysis is needed for a project,

[11] https://www.epa.gov/scram/guidance-ozone-and-fine-particulate-matter-permit-modeling
[12] https://www.epa.gov/sites/default/files/2020-09/documents/epa-454_r-19-003.pdf
[13] https://www.epa.gov/scram/merps-view-qlik

the combined precursor impacts must be added to the primary impact and the combined result must meet the $PM_{2.5}$ Significant Impact Level.

In most cases, a Tier 1 demonstration will be sufficient for the secondary analysis. However, a Tier 2 approach may be used. A Tier 2 analysis involves a more sophisticated case-specific chemical transport model (e.g., photochemical grid models). The use of a Tier 2 demonstration should be determined in consultation with the AQD and the USEPA Regional Office and conducted consistently with new USEPA single-source modeling guidance. The appropriate tier for a given application should be selected in consultation with the AQD and be consistent with USEPA guidance.