Air Emissions Risk Analysis (AERA) Guidance

Facility characterization

This section provides general information on facility emissions sources, identifying potentially emitted air toxics, and emission estimation methods.

Project proposers are expected to provide all of the information identified in the AERA-05 Emissions form. The information submitted in an AERA-05 Emissions form (found under the Forms section on MPCA's website) includes the following:

- A definition of the process and methodology in identifying chemicals of potential interest
- Limits or assumptions
- Identification of any changes made between submittals
- Assumptions made for air toxic speciation and references

The AERA emissions form also requests an emissions calculation spreadsheet including all pertinent information needed to review the specific air toxics emission rates, including but not limited to:

- Hourly emission rate calculations
- Annual emission rate calculations
- Emission factors with references
- Control efficiencies with references
- Process throughputs
- Any proposed permit limits that may impact emission rate calculations
- Stack and fugitive source parameters (found in the air dispersion modeling forms)

Identifying air emission sources

An emissions unit is any piece of equipment or any process that emits pollutants into the air, including stacks, vents, and fugitive processes. The AERA-05 Emissions form, together with the emissions calculation spreadsheet, are used to document which sources are present at the facility and which ones will be included in the AERA.

Below is a list of common emission sources:

- Combustion stack/vent point sources
- Non-combustion stack/vent point sources
- Onsite mobile source tail pipe emissions
- Idling vehicle tail pipe emissions
- Tanks
- Onsite fugitive emission sources
  - paved & unpaved roads
  - storage/surge piles
  - material handling operations
  - valve, tanks, equipment leaks

During the EAW process, some stacks may be excluded for criteria modeling. However, for an AERA submittal, all stacks will need to be included in the modeling.

Fugitive emissions sources

Operations without a specific stack or vent that exhaust into outdoor air through building ventilation or their emissions escape through doors or windows (e.g., parts washers), are called fugitive sources. These sources are included in the AERA and can be modeled using the RASS at a screening level. Examples of emissions from fugitive sources include volatile organic compounds from outdoor leaking valves, hydrogen sulfide from uncovered wastewater treatment plants, and particulates blowing from outdoor stockpiles.

Natural gas combustion sources

Emissions due to combustion of natural gas as a fuel for boilers or other equipment need to be included in the RASS and Q/CHI Spreadsheet. If backup fuels are permitted, such as in the case of a natural gas curtailment, the worst-case emissions, by pollutant from each fuel source, needs to be assessed in the AERA. Although some natural gas combustion activities were once exempted from the AERA, these emissions now need to be quantified because of the general increase in natural gas combustion and the availability of natural gas emissions information.

Exempt emission sources

Certain types of emission sources do not need to be included in quantitative risk estimates.

These sources include:

- Some insignificant activity emissions sources
- Emergency generators (follow link for quantitative exclusion criteria)
- Non-continuous sources: some start-up, shutdown, upset, and emergency situations
- Sources emitting only air toxics without inhalation health benchmarks in the RASS
- Other (e.g., case-by-case determination on vehicle emissions)

Some insignificant activity emission sources

Some “insignificant activities” as defined in Minn. R. 7007.1300 may emit substantial amounts of air toxics that need to be included in the AERA process. However, the emissions associated with an insignificant activity may be excluded from quantitative risk estimates if:

a) the activity emits only air toxics that do not have an IHB listed in the RASS, or

b) the contribution of the individual activity is less than 1% of the total emission inventory for each air toxic (hourly for acute and annual for chronic)

If an emission source does not meet one of these two tests, then it must be included in the RASS. Documentation and calculations needs to be provided indicating why an activity is excluded.

Emergency generators

The emissions from an internal combustion engine associated with an “emergency generator” or fire pump are generally not quantified in the AERA. All other engines are included if not exempted as an insignificant activity emissions source. An “emergency generator” is only operated when unforeseen conditions result in disruption of electrical power to the stationary source. An emergency generator may not be omitted from quantification in the AERA if it is a part of a peak shaving contract, reduced use contract, or if it is used as a standby source during periods when power is available from the utility. The definition of emergency generators used for the purposes of an AERA comes from the EPA memo titled “Calculating Potential to Emit (PTE) for Emergency Generators”, Calculating Potential to Emit (PTE) for Emergency Generators (epa.gov).

Maintaining emergency generators as a backup power source is recognized by the MPCA as being essential; however, they are sources of air toxics. Emergency generators require testing with a specific frequency and load. Testing regimens can be frequent (e.g., weekly) and if there are multiple generators, testing can be performed

simultaneously or can be conducted within a period of several hours. This may result in very high localized concentrations of pollution which can represent significant risk. The MPCA therefore requests a project proposer to inventory, characterize, and certify emergency generators and fire pumps at the facility using the AERA-04 form. Suggestions for minimizing emissions and impacts from emergency generators as well as detailed information on emergency generator use are provided in this form, and on the MPCA website (https://www.pca.state.mn.us/business-with-us/stationary-engines-or-generators).

Screening out sources

Emissions from all units or sources at a facility need to be evaluated within either the quantitative or the qualitative sections of an AERA, with the exception of those screened out using the methods described below in Screening out pollutants and sources using the RASS section.

Identifying chemicals of potential interest (COPI)

Once all relevant emission sources are identified, an inventory of air toxics emitted or potentially emitted needs to be provided. These air toxics are called Chemicals of Potential Interest (COPI) and include air toxics with inhalation health benchmarks (IHBs), some criteria pollutants with health benchmarks, and pollutants for which an IHB is not available.

COPI quantitatively assessed for risk

Chemicals with IHBs

Air toxics with readily available inhalation health benchmarks (IHBs) (i.e., those listed in the Tox Values tab of the RASS), which are emitted, or potentially emitted are quantified in the AERA for risk estimates. If emission factors are not available for an air toxic with an IHB, and if the project proposer and MPCA staff agree that it is unreasonable to make a comparison to a similar type of air emissions source, a project proposer may not have to provide emissions data for the air toxic. However, a project proposer must describe attempts made to identify emission factors (e.g., list databases consulted, literature reviewed, internet searches, industry databases, personal interviews with experts).

COPI qualitatively assessed

Chemicals without IHBs

If there is no toxicity value in the hierarchy, nor is there sufficient toxicity information for the MDH to develop an IHB, a pollutant-specific quantitative analysis is not necessary. However, project proposers may provide qualitative information comparing modeled results to occupational health IHBs.

Air toxics emitted or potentially emitted without IHBs will be screened by MPCA staff for EPA-designated hazardous air pollutants (HAPs), respiratory sensitizers, persistent, bioaccumulative toxicants, and emerging pollutants of concern.

Criteria pollutants

Criteria pollutants are those pollutants with federal or state ambient air quality standards that include $PM_{2.5}$, PM_{10}, TSP, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, carbon monoxide, lead, and ozone, for various time averaging scenarios. Air toxics are air pollutants that are known or suspected to cause cancer or other adverse health effects and may include criteria pollutants that have an inhalation health benchmark in addition to the air quality standard. The MPCA defines air toxics as any pollutant that has a health benchmark from the AERA hierarchy of toxicity information, and therefore many criteria pollutants are assessed as air toxics within the air emissions risk analysis process.

Natural gas boiler and furnace air toxics

All air toxics emitted from natural gas boilers and furnaces (as defined by AP-42, Fifth Edition, Section 1.4), with AP-42 emissions values, need to be evaluated quantitatively with the following exceptions, which have E rated emission factors based on detection limits. These air toxics do not need to be included in quantitative emission estimates from the defined natural gas boilers and furnaces because of the associated uncertainty. Instead, these air toxics need to be discussed qualitatively.

- 56-49-5 3-Methylchloranthrene
- 57-97-6 7,12-Dimethylbenz(a)anthracene
- 83-32-9 Acenaphthene
- 203-96-8 Acenaphthylene
- 120-12-7 Anthracene
- 56-55-3 Benz(a)anthracene
- 50-32-8 Benzo(a)pyrene
- 205-99-2 Benzo(b)fluoranthene
- 191-24-2 Benzo(g,h,i)perylene
- 205-82-3 Benzo(k)fluoranthene
- 218-01-9 Chrysene
- 53-70-3 Dibenzo(a,h)anthracene
- 193-39-5 Indeno(1,2,3-cd)pyrene
- 7440-41-7 Beryllium
- 7782-49-2 Selenium

Screening out pollutants

All emitted pollutants need to go through the quantitative AERA process with the exception of those screened out using the methods described in the Screening out pollutants and sources using the RASS section or those specifically addressed in this guidance.

Emissions

The foundation of all qualitative and quantitative information in an AERA is a comprehensive list of air toxics and their hourly and annual emission rates. As such, it is crucial that a project proposer provide high quality information about the air toxics emission rates for a complete list of COPI. Proposed emission rates that are below an emission source's unrestricted emission rate or below a permit limit may become the basis of new enforceable permit limits. Project proposers need to submit current facility emissions based upon current permitted limits and total facility emissions after the proposed modification.

Emission factors

Process-related emission factors must be found or developed for each air toxic before emission rates can be estimated. An emission factor is a representative value that relates the quantity of an air toxic released to the atmosphere with an associated activity.

There are accurate and representative data to derive emission factors for the sources contained in Minn. R. 7005.0100, subp. 10a.

There are fewer emissions measurements available for air toxics than criteria pollutants. This means that there is usually a higher uncertainty and a greater variability associated with air toxics emissions estimates. As in other steps of an AERA, and risk assessment in general, conservative assumptions are made when there is uncertainty in data. Many emission factors are arithmetic averages of a data set and need not automatically be assumed to represent maximum emissions for a source type on either a short- or long-term basis.

Emission factors that are arithmetic averages

Emission factors, such as those found in AP-42, are often arithmetic averages of the available data set. If used without modifying to account for being an arithmetic average, the MPCA will describe the resulting risk estimate as potentially underestimated (see discussion of the development of emission factors from stack test data below). Describe any mitigating factors if AP-42 factors are believed to be upper-bound estimates in the AERA-05 Emissions form.

Sources of emission factors

Emission factors can be either source-specific or generic. Source-specific emission factors are derived from source-specific emission testing, mass balance, or chemical analysis and are preferred in comparison to generic emission factors. The MPCA has worked with certain industrial sectors such as metal mining, iron ore processing, electric services, and coal burning facilities to develop source-specific emission factors. Generic emission factors are usually derived from actual measurements of the emissions from representative sources/processes and are assumed to be the long-term averages for all facilities in the source category.

Occasionally, similar facilities may be identified that have developed emission factors. References and supporting data may allow project proposers to estimate source specific emission factors. Such identified similar facilities may originate from other states.

EPA's AP-42 is the most common source for non-facility specific emission factors. However, before using these factors directly, consider their derivation and applicability. AP-42 factors can be assumed to represent long-term emissions for a source. However, estimating hourly emissions may require additional rigor. AP-42 guidance directs users to review the literature and technology and to be aware of circumstances that might cause specific sources to have emissions characteristics that are different from generic sources.

Few data sources will contain emissions from emerging or novel air emission processes. Furthermore, emerging, or novel processes are generally not included in emission factor databases. Reasonable effort is expected to identify emissions associated with these types of sources by examining professional literature or interviewing expert authorities. Characterizing emissions from similar sources (e.g., by fuel type, process) might be appropriate in these instances, while recognizing the attendant limitations. Table 1 on the next page describes common sources of emissions information.

Table 1: Types of sources of data for air toxics assessment

Source	Comments on data quality	URL Link
Air emission test data from a project proposer's own facility or similar facilities elsewhere	Test data are very useful for developing the list of chemicals emitted from a facility, along with an emissions rate. Cannot be used to exclude chemicals not tested.	Facility or source specific
U.S. Environmental Protection Agency's (EPA) AP-42	Emissions data published by EPA which is categorized according to data quality. Provides criteria pollutant emission factors and for most emission sources, toxics emissions factors. Also, will often include emissions summaries for source types for which a MACT standard has been developed. AP-42 factors can be assumed to represent long-term emissions for a source, but care needs to be exercised when using them. AP-42 guidance directs users to review the literature and technology to be aware of circumstances that might cause sources to have emissions characteristics that are different from other typical existing sources.	https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors
EPA's Factor Information Retrieval (FIRE) Data System	EPA's "staging area" for air toxics emissions factors. Somewhat complete information for combustion sources, but incomplete for emissions from manufacturing units.	http://cfpub.epa.gov/webfire/
Material Safety Data Sheets	Very reliable source of air toxics content information for painting and other coating or evaporative uses. MSDS sheets may not be reliable data sources for estimating emissions where chemical reactions are involved.	http://www.ilpi.com/msds/#Internet
Chemical analyses of feedstocks and products	They are very useful for developing the list of chemicals emitted from a facility, along with an emissions rate. Cannot be used to exclude chemicals not tested.	Facility or source specific
Reasonable attempts to find information not available elsewhere • Peer-Reviewed technical literature • Conference proceedings • Trade organizations that maintain emissions databases or information • Industry publications • Trade group reports	Best engineering judgment and consideration of the following factors needs to be used when developing emission factors: (a) the precision and accuracy of the data (b) the design and operational similarity between the emission units (c) the size of the data set (d) the availability of data of equal or greater quality (e) operating conditions of the emissions unit when data was collected (f) the data analysis procedures	Reasonable attempts to find information not available elsewhere • Peer-Reviewed technical literature • Conference proceedings • Trade organizations that maintain emissions databases or information • Industry publications • Trade group reports

Source	Comments on data quality	URL Link
Document for the Electric Generating Unit (EGU) National Emissions Inventory (NEI)	Data are obtained using the Energy Information Administration (EIA) – 767 electric power survey. These are EPA derived emission factors.	https://www.epa.gov/air-emissions-inventories
California Air Toxics Emission Factors Search California's Best Available Control Technology	California database of emission factors. May provide emission factors for chemicals not available through other sources.	https://ww2.arb.ca.gov/california-air-toxics-emission-factor
North Carolina DENR Division of Air Quality		https://deq.nc.gov/about/divisions/air-quality
EPA tool: PM Calculator		https://www.epa.gov/air-emissions-inventories/emission-inventory-tools
NCASI Technical Bulletins	Forest products industry group developed emission factors. (Forest products—mainly paper but some wood products also).	http://www.ncasi.org/Programs/Reports-and-Articles/Technical-Bulletins-and-Special-Reports/Technical-Bulletins/Index.aspx
Novel Air Emission Sources	Few data sources will contain emissions from emerging or novel air emission processes (i.e., processes that are not common or have not had stack testing)	Reasonable effort is expected to identify toxic air emissions associated with these types of sources: professional literature, or interviewing expert authorities, Characterizing emissions from similar sources (e.g., by fuel type, process)
EPA, Health Assessment Document for Diesel Engine Exhaust. 2002. EPA/600/8-90/057F.	Dioxin/furan combustion of diesel emissions, large variability, contact MPCA if you propose to use this source.	https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=29060&simpleSearch=1&searchAll=diesel

Note: Compilation of Air Pollutant Emission Factors (AP-42), Factor Information Retrieval (FIRE) as well as the California Air Toxics Emission Factors (CATEF) database are preferred information sources. In considering multiple sources of emissions information, EPA's emissions information presented in AP-42 needs to be used where available. When an emission factor for a pollutant is not available from AP-42; FIRE or CATEF may be used. If you determine that either FIRE, CATEF, or another published emission factor has been developed using more robust data than that used for AP-42, that alternate factor may be used. When using alternative emission factors, describe the number of tests used to generate the factor, and the similarity of the emission unit, operating conditions, and control equipment to the proposed facility.

AERA emissions

Emission estimates calculated for an AERA need to be the most accurate estimate of permitted emissions over the appropriate timeframe, with a reasonable certainty that air toxics emission rates are not underestimated. The availability of an acute or a chronic health benchmark will determine the "appropriate time frame" for each chemical. The MPCA permitting webpage includes source-specific and some pollutant-specific emissions estimation guidance.

This webpage should be the primary source for estimating emissions. The information required for AERA emission rates is the same as the information required for permit applications, with a few exceptions:

- In addition to listed HAPs, the AERA needs to include air toxics that have toxicity values listed in the RASS.
- The AERA reviewer will need to follow emission rate calculations from the process capacity and emission factor to the emission rate used in refined AERMOD modeling (grams/second) or entered into the RASS (pounds/hour and tons/year).

Emission rates used in AERAs

Project proposers need to assess the proposed "potential to emit" (PTE) calculations as defined by permit conditions. These permit-allowable emission rates take into account existing and proposed permit limits, rule-based limits, and any other enforceable limits.

Types of limits within a permit include numeric emission limits, operating limits (such as hours per year or use of control equipment), throughput limits, allowable fuels, and allowable materials. A permit may describe multiple or alternative operating scenarios. If emission rates reflecting a lower-emitting operating scenario are used in an AERA, they may become the basis for state-only enforceable limits within the facility's permit.

Generating emission estimates

The methodology for calculating air toxics emissions needs to be the same at existing facilities for pre- and post-modification scenarios. If not, documentation and justification need to be provided.

Emission rates need to be estimated for the subset of chemicals on the COPI list with readily available IHBs (see those listed in the *Tox Values* tab of the RASS). The RASS is designed to assess inhalation risks from long-term exposure to the average ambient air concentration during a year (chronic), short-term exposure to the maximum potential hourly ambient air concentration (acute), and mid-term exposure over a one-month period (sub-chronic). Maximum annual and the maximum hourly emission rate for each chemical must therefore be determined to conduct the AERA (monthly air concentrations for air toxics are estimated in the RASS based on annual emission rates).

Since AERA risk estimates generally rely on RASS, AERMOD, or HHRAP-based software, the emission rates are required to be in the appropriate units for the software used.

AERA submittals need to include emission calculations spreadsheets including all the information described on the MPCA Emissions Estimates for Permitting webpage.

Special considerations for hourly emissions

If a permit has a ton per year limit on an air toxic, it is not appropriate to divide by 8,760 hours per year to obtain an hourly emission rate. The maximum hourly emission rate needs to be based on the hourly capacity of the unit and the appropriate emission factor. For short-term emissions, it is very likely that the estimated actual emissions are the same as the potential hourly emissions since many emission units can and do operate at full capacity for short-term periods.

Certain parameters should be adjusted for short-term emissions estimates. For example, when using a material balance method, if a range of particular compound content is provided on the MSDS, the highest number of the range should be used to estimate the potential hourly emissions. In the case of batch processes that last more than an hour, where the air toxic emission rate may fluctuate throughout the batch, the hourly air toxic emission rate needs to be based on the hour with the highest emission factor.

Using an emission factor developed from stack emission tests

For use in an AERA, the stack tests need to be conducted at maximum permitted operation. The values are generally collected in sets of three measurements. Many times, there may be two sets of three measurements. The preferred summary of these measurements for use in developing an emissions rate is a 95 percent upper confidence limit (95 UCL-AM) of an arithmetic mean. If the 95 UCL-AM exceeds the maximum measurement, the project proposer needs to use the maximum measurement to develop the emission rate. Air permitting engineers may advise on the correct summary for stack test data, or other summaries used to develop an emissions factor. At times it may be advisable to use a mean plus 1 or more standard deviations, dependent on the distribution of the data and the number of values.

The 95-UCL is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals, or exceeds the true mean 95 percent of the time. The 95 UCL-AM should not be confused with the 95th percentile of the measured data. Five or more total values with 4 of those values being detected measurements, are required to obtain 95 UCL-AM values from ProUCL (https://www.epa.gov/land-research/proucl-software).

All small data sets below 8-10 values will result in warnings from the ProUCL software. If there are less than five detected values in the data set, the highest measured stack test value needs to be used to develop annual and hourly emission rates. In some cases, no values are detected. In this case, the emission rate should be developed using the detection limit for that specific stack test. If any other value is proposed, MPCA review will be required.

It should be emphasized that the stack test data need to reflect the emissions unit under consideration or a similar emission unit(s). If the emission unit has been modified, previously generated test data may not be appropriate.

Emission rate calculation

An emission rate is calculated as follows:

$$[Emission\ Rate = Process\ Rate * Emission\ Factor * (1 - control\ efficiency)]$$

Note: This is a general expression, and therefore other parameters may be used.

Refining emissions estimates

If the total estimated risks generated by the AERA are greater than facility risk guidelines, a project proposer may choose to refine the emission rates for emission sources that contribute to the largest fraction of estimated risk. For example, the composition estimate of a coating might be specified more narrowly, or a stack test might be performed to reflect control efficiency or variability. In this way, an iterative method of estimating emissions based on the AERA results is used.

When emissions data are not available

Reasonable effort needs to be expended to identify sources of emissions data. If no data are available for an air toxic, and it is unreasonable to make a comparison to a similar type of air emissions source, the project proposer may not be asked to provide emissions data. However, all attempts made to identify emission factors (e.g., list database consulted, literature reviewed, internet searches, industry databases, personal interviews with experts) must be described.

Special air toxics considerations

The MPCA has found that several air toxics require careful treatment in estimating emissions. Guidance for many of these air toxics is provided here.

Diesel exhaust particulates

If available, particulate emission rates of $PM_{2.5}$ need to be included in the RASS as “diesel exhaust particulate” for diesel-fired combustion sources; if not available, PM_{10} data needs to be used. This is an analysis of particulate exposure that is separate from analyses to predict impacts for comparison to the NAAQS and is used to estimate the potential non-cancer health effects from long term diesel exposure.

Individual chemical constituents of diesel exhaust emissions are estimated from the emissions information sources cited in Table 1. These are calculated to estimate the potential carcinogenic health effects from long-term diesel exposure.

Mercury

Form HG-01 is an editable spreadsheet and used to report mercury emissions (when emissions are greater than 3 lbs/yr) and their calculations to the MPCA. Total mercury emissions need to be speciated into particulate bound, reactive gaseous and elemental mercury. The speciation of mercury is process specific and needs to follow this hierarchy of data sources:

1. Facility or industry stack testing using the most current EPA method
2. Methodology described in technical support document of the National Air Toxics Assessment or the U.S. EPA National Emissions Inventory
3. Default speciation of 20%-elemental, 60% particulate, and 20% oxidized (U.S. EPA HHRAP, 2005).

Exposure assessment

An exposure assessment identifies how humans can come into contact with environmental pollutants. Exposure depends on several elements: the activity patterns of people living and frequenting the vicinity surrounding the facility; how the pollutant gets from the source to the individual (exposure pathway), how much of the pollutant is available to get into the body (exposure concentration), how the pollutant gets into the body (exposure route), and how much of the pollutant is absorbed and available for interaction with biological receptors, organs or cells within the body (dose).

The first step of the exposure assessment is characterizing the neighborhood and potential receptors surrounding the facility.

General neighborhood

A description of the general locale of the proposed project needs to be included in the AERA_02 Qualitative Information Checklist. The description needs to identify neighborhood characteristics and areas of industry and other air emission sources of significance in the area. Of specific interest may be:

- Population demographics within appropriate census tracts surrounding a facility
- Air Emission Point Sources identified by MPCA's air toxics emissions inventory
- Other air emission sources, industrial facilities, or environmentally sensitive areas
- Locations of sensitive receptors

Maps can be useful in clarifying available information. Possible resources for locating much of the information recommended in this section are provided in the qualitative risk characterization section.

Buffer distances

Buffer distances based on stack height are used to determine appropriate distances for evaluating qualitative information about the setting of an emissions source. Incremental ambient air concentrations and risk estimate from an emissions source occur within a distance that depends upon stack height (among other factors). As a rule of thumb, the greater the stack height, the greater the distance to the maximum modeled air toxic concentration, deposition, and risk estimate. The buffer distances are judgments of areas around an emission source that will encompass most emissions of concern and are based on MPCA staff's experience in estimating air toxic concentrations and deposition fluxes. For the purposes of AERA guidance, the MPCA recommends the following buffer distances for maps showing sensitive receptors, general neighborhood information, and nearby permitted air emission facilities:

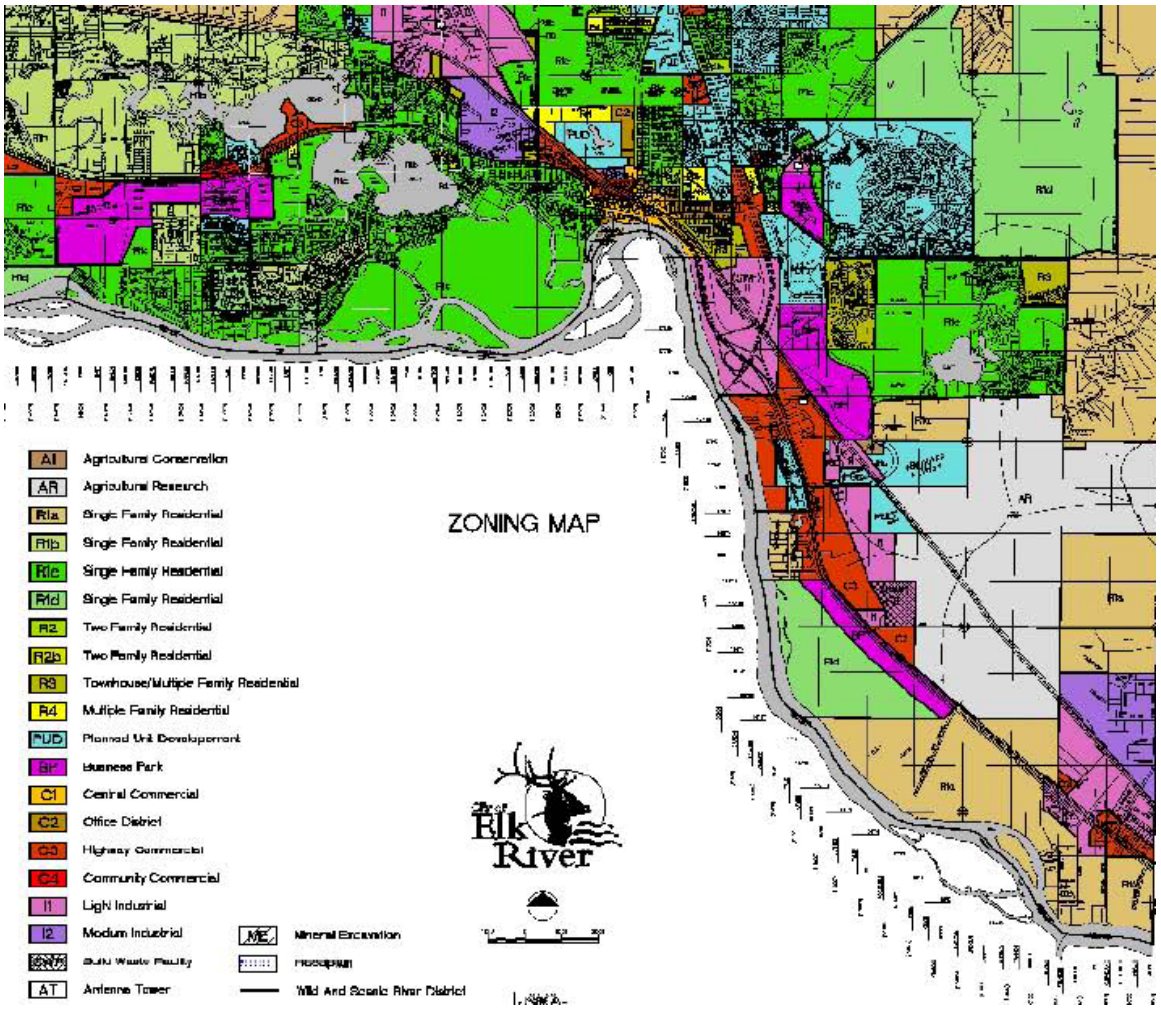
Table 2. Buffer distances for placement of receptors, based on stack height

Stack height (meters)	Radius (kilometers)
< 50	1.5 (approximately one mile)
50 to 100	3 (approximately two miles)
> 100	10 (approximately six miles)

Zoning and land use

Zoning and land use maps need to be based on a 10-kilometer radius regardless of stack height. If zoning or land use information exists for a city, township, or county that does not specifically include the 10-kilometer radius surrounding the facility, this information may be considered inadequate. Maps can be supplemented with relevant ordinances that would inform potential exposures, (e.g., raising chickens in town or prohibitions of livestock). The MPCA recognizes that some areas of the state do not have specific zoning information available.

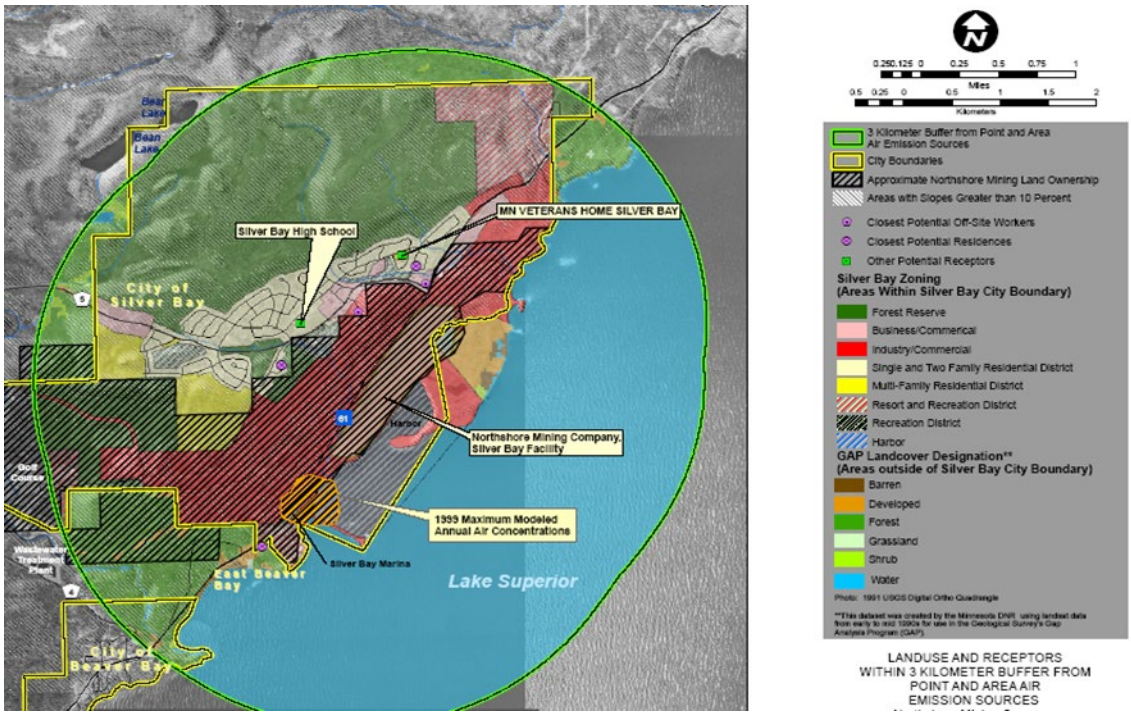
Figure 1: Zoning map example



A land use map shows current land use within 10 kilometers of the facility. Land use maps include information such as areas of residential, commercial, and industrial use, farms, forests, and waterways. If no map is provided, the most restrictive land use will be assumed. The project proposer needs to also state whether the land is used for purposes other than those designated on the land use maps.

The MPCA considers “reasonable potential future land use” when evaluating potential impacts to nearby property. Definitions for “reasonable potential future land use” come from U.S. Environmental Protection Agency’s (EPA) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP).

Figure 2: Zoning and land use map example

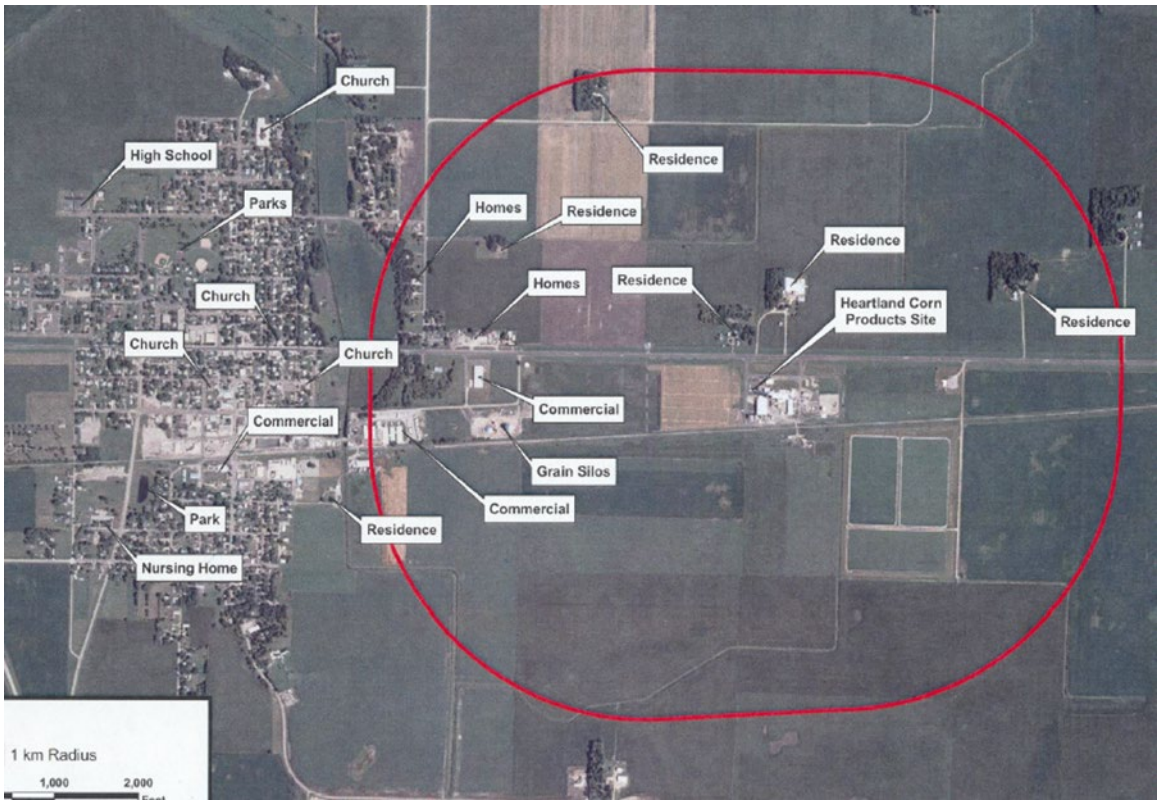


Sensitive receptors

For purposes of an AERA, sensitive receptors are groups of people who, due to their age or health status, are sensitive to air pollutants. Sensitive receptors may include infants, children, pregnant women, elderly, asthmatics, athletes, or immuno-compromised people.

The project proposer's submittals need to include maps identifying schools, daycare facilities, hospitals, nursing homes, recreational areas (including parks, tennis courts and swimming pools), senior centers, and other public or private facilities at which sensitive people may be congregated. If a map is not readily available or feasible, these types of potential receptors need to be described in writing and identified in the area around the facility. The maps or descriptions of sensitive receptor locations need to include the area within a radius of at least 1.5 kilometers from the facility.

Figure 3: Sensitive receptor map example



Provided by Natural Resources Group, Inc. for the purposes of an AERA submittal.

Farming

Various types of farming (e.g., beef farming, dairy cows, chickens, urban gardening) in the vicinity may generate foods that can be consumed by people living on the farms or by nearby residents. In addition to existing farming locations, the MPCA considers "reasonable potential future land use" in assessing potential risks from farms. According to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP), three examples of reasonable potential future land use are:

- Rural area characterized as undeveloped open fields that could reasonably be expected to become farmland if it can support agricultural activities.
- Rural area currently characterized by open fields and intermittent housing that could reasonably be expected to become a residential subdivision.
- An area currently characterized as an industrial area would not reasonably be expected to become farmland.

If no information is available regarding land use, the default assumption will be that a farmer could be impacted by facility emissions, and the farmer scenario risks will be used as a basis for decisions. If land use indicates that farms do not exist within the appropriate radius, only resident risks will be assessed. Resident exposures could include ingesting chickens, eggs, or other livestock that are raised on the property if allowed by ordinances.

Fishing

Water bodies in the vicinity of the facility may be impacted by the deposition of facility emissions. The distance from the source to where air pollutants deposit depends in part on the stack or release height.

The MPCA recommends the following buffer distances for maps that show lakes, rivers, and streams. Water bodies outside the specified area that may be fed by rivers and streams lying within the radius of interest also need to be shown.

Table 3. Buffer distances for maps with water bodies

Stack height (meters)	Radius (kilometers)
< 100 m	3 km (approximately two miles)
> 100 m	10 (approximately six miles)

Fishable water bodies

A "fishable water body" typically contains water year-round in a year that receives at least 75 percent of the normal annual precipitation for that area. Whether a water body has public access is also an important consideration.

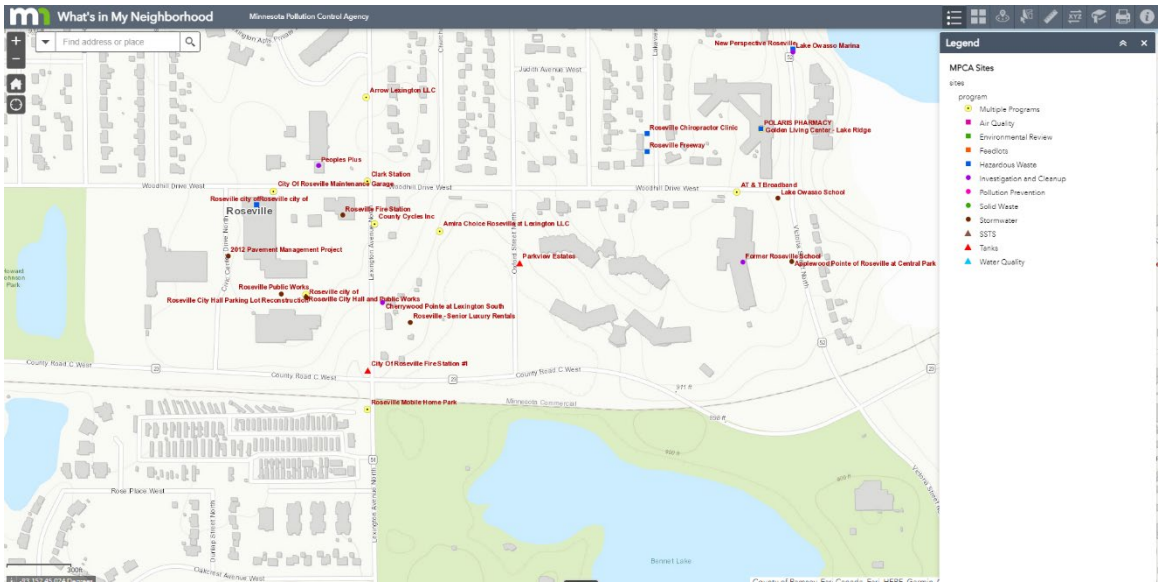
Any fishable water body occurring at the area of maximum deposition needs to be evaluated in a MMREM based analyses. If the area of maximum deposition does not fall on a fishable water body, the project proposer needs to determine which water body is nearest to the area of maximum deposition. The nearest water body may represent the worst-case impacts at the screening level; however, it also may not be clear which water body would be most impacted. There may be a water body with more impact because it has less dilution from its watershed and more fishing. If it is not clear which water bodies need to be evaluated, MPCA staff should be contacted.

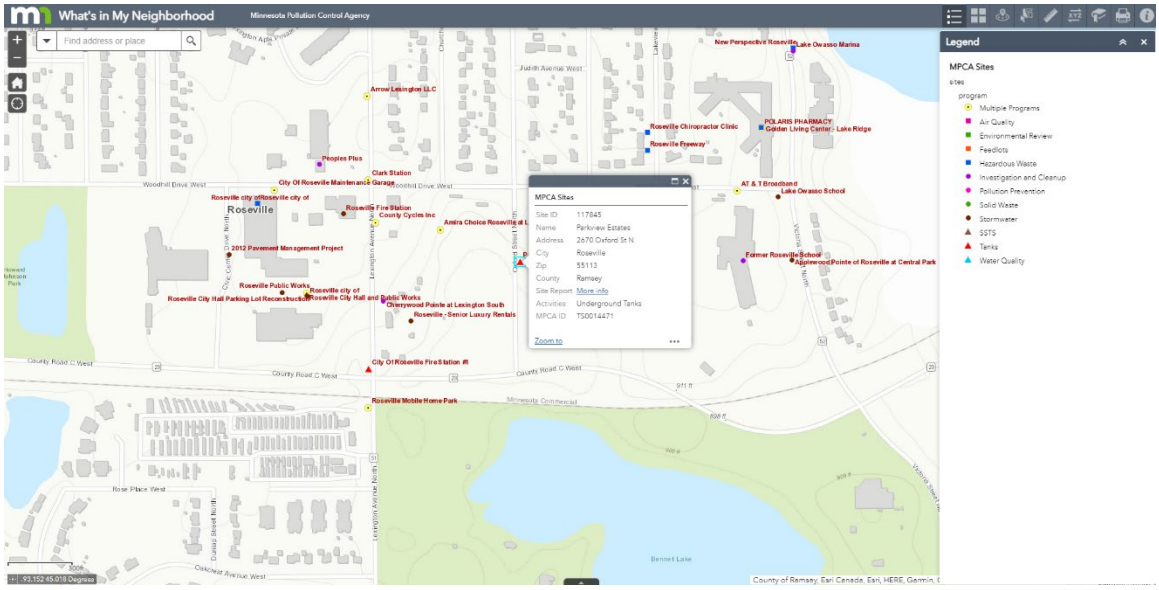
Nearby permitted air emission facilities

The project proposer will be asked to provide a map and/or list of permitted air emission facilities and sources within the proper radius of the facility.

List of nearby air emissions sources: MPCA's "What's in My Neighborhood" website provides either a map or text search for facilities. By clicking on the Map Search option an interactive map will appear. There is a search bar located on the top left of the page where specific facilities can be searched (first image below). Once your facility has been located, by clicking on the symbol next to the facility name more information on the facility pops up (second image below). By clicking on more info in this pop up another website will open with more detailed information on the facility.

Figure 4: Maps of nearby air emission sources





Exposure assessments

The MPCA assesses emissions exposure follow three distinct categories: direct inhalation, indirect, and multipathway. Refinements may be applied to each of these distinct categories, but may not necessarily apply to all, such as applying the “resident” scenario to direct inhalation assessments.

National data on human consumption and behavior have been used by the EPA and other regulatory agencies to develop methods for assessing exposure of humans to environmental contaminants for use in regulatory risk assessments.

The following exposure scenarios are based on the default exposure scenarios recommended in the EPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP, 2005). Receptor types evaluated in AERAs, and recommended exposure pathways are summarized below.

Table 4: Recommended exposure scenarios

	Recommended exposure scenarios[a]		
Exposure pathways	Farmer	Resident	Fisher
Inhalation of vapors and particles	*	*	*
Incidental ingestion of soil	*	*	*
Ingestion of drinking water from surface water sources	*	*	*
Ingestion of homegrown produce	*	*	*
Ingestion of homegrown beef	*	--	--
Ingestion of milk from homegrown cows	*	--	--
Ingestion of homegrown chicken	*	b	b
Ingestion of eggs from homegrown chickens	*	b	b
Ingestion of homegrown pork	*	--	--
Ingestion of fish	b	b	*

* Pathway is included in exposure scenario.
-- Pathway is not included in exposure scenario.
a Exposure scenarios are defined as a combination of exposure pathways evaluated for a receptor at a specific location.
b Site-specific exposure setting characteristics (e.g., presence of ponds on farms, or presence of ponds or small livestock within semi-rural residential areas) warrants the permitting authority to consider adding this exposure pathway to the scenario.

Table 5: The exposure routes and durations evaluated in AERA

Exposure duration	**Inhalation**	**Ingestion**
Acute (hourly)	Hourly	Not applicable
Subchronic	2 weeks to 3 months	Not applicable
Chronic (approximate lifetime assessments)	Lifetime	30 years, resident 40 years, farmer

Acute inhalation

The acute inhalation exposure scenario is used to describe potential adverse effects from breathing hourly maximal air concentrations of facility air toxics at locations where this exposure could possibly occur. This type of exposure includes those living or working nearby; someone running or biking near a facility; snowmobiling along the facility boundary; or a delivery person waiting for their truck to be emptied. An assessment of acute inhalation is rarely scoped out of an AERA.

Resident

A "resident" is an EPA-developed exposure scenario assessed over an approximate adult human lifetime for inhalation and 30 years for ingestion. This hypothetical "resident" inhales air indirectly, ingests soil, and ingests home-grown produce that could be affected by facility air emissions. Maximum annual average air concentrations, derived from 5 years of meteorological data, are considered inhalation exposure concentrations (IEC) in this exposure scenario. This means that five years of meteorological data are incorporated into AERMOD and the highest annual average is chosen. This is similar to the practice used for the annual NO_2 NAAQS. The exposure durations may be limited to the life of a project (e.g., a 20-year mine plan, if that is acceptable upon MPCA review); however, the "resident" scenario generally assumes a lifetime exposure for the inhalation pathway. Less than lifetime exposures consistent with EPA guidance are assumed for the ingestion pathways. An assessment of a potential resident is rarely scoped out of an AERA.

Farmer

A "farmer" is an EPA-developed exposure scenario assessed over an approximate adult human lifetime for inhalation and 40 years for ingestion. This hypothetical "farmer" inhales air, indirectly ingests soil, ingests home-grown produce, drinks home-produced milk, and eats home-grown meat products (pork, beef, chicken eggs, and chicken) that could be impacted by facility air emissions. Maximum annual average air concentrations, derived

from 5 years of meteorological data, are considered in this exposure scenario. This means that five years of meteorological data are incorporated into AERMOD and the highest annual average is chosen. This is similar to the practice used for the annual NO_2 NAAQS. The exposure duration may be limited to the life of a project (e.g., a 20-year mine plan, if that is acceptable upon MPCA review); however, the "farmer" scenario generally assumes a lifetime exposure for the inhalation pathway. Less than lifetime exposures consistent with EPA guidance are assumed for the ingestion pathways. An assessment of a potential "farmer" is not relevant to an AERA conducted for an area without production of food products or animal husbandry. Zoning and/or land use information may be required if the "farmer" scenario is scoped out of an AERA.

Urban gardener

In some cases where adequate land use documentation is provided, consideration of the "farmer" is not appropriate. This is the case in densely populated urban areas where animal husbandry is not allowable. For this reason, an "urban gardener" exposure scenario was developed by MPCA staff so that some reasonable assessment of ingestion-based exposures in urban areas was possible. The ingestion rates used in this exposure scenario were drawn from those in the EPA guidance for the "farmer". An "urban gardener" exposure scenario assumes a hypothetical person inhales air, indirectly ingests soil, ingests home-grown produce, and eats home-raised chicken eggs. Maximum annual average air concentrations, derived from 5 years of meteorological data, are considered in this scenario. This means that five years of meteorological data are incorporated into AERMOD and the highest annual average is chosen. This is similar to the practice used for the annual NO_2 NAAQS. The exposure durations may be limited to the life of a project (e.g., 20-year mine plan, if that is acceptable upon MPCA review); however, the "urban gardener" scenario generally assumes a lifetime exposure for the inhalation pathway. Less than lifetime exposures consistent with EPA guidance are assumed for the ingestion pathways.

Fisher

A fisher is considered in cases where one or more fishable water bodies may be impacted by emissions from a facility that emits persistent and bio-accumulative toxics (PBTs). Ingestion risks from consuming fish from an impacted water body are estimated independently from the other exposure scenario risks and may be added to risks estimated for the resident, farmer, or urban gardener if it is reasonable.

Sub-chronic exposure

A sub-chronic inhalation exposure scenario is employed to assess a mid-term exposure duration. This exposure scenario may be considered as being approximately a month-long vacation or work-related assignment. Maximum monthly air concentrations, derived from 5 years of meteorological data, are considered in this exposure scenario.

Exposure scenario refinement: eliminating pathways, scenarios, and additional information

Exposure scenarios may be scoped out of quantitative assessment based on land use designations. If there is not currently the potential for, nor the future potential for a certain land use connected to a specific exposure scenario, that exposure scenario may be scoped out of the quantitative risk results. Examples of this type of scoping include:

- A residential exposure scenario will not be conducted in a land use area zoned as industrial.
- A farmer exposure scenario, including all the related exposure pathways, will not be included in an urban area that is not zoned for extensive animal husbandry.
- The likelihood of a farmstead existing at the location of maximum air concentration is small because of the large distance between farms. Therefore, the farmer risk may be greatly over-predicted if this type of receptor is placed at the maximum air concentration. In that case, the project proposer may choose to evaluate risks at the location of the closest actual farm in addition to a hypothetical farmer at the location of maximum air concentration.
- Acute inhalation exposures are rarely, if ever, scoped out of an analysis.

Reasonable maximum and central tendency exposure assumptions in a Level 3 AERA

An important element of a human health risk assessment is the transparent communication of uncertainty and variability. A portion of the uncertainty in a final risk estimate stems directly from the assumptions used to characterize potential human exposures.

The EPA and MPCA recommend estimating risks based on a set of default exposure assumptions called the "Reasonable Maximum Exposure" (RME)[1] (see Table 6 below). The goal of RME is to combine upper-bound and mid-range exposure factors so that the result represents an exposure scenario that is both protective and reasonable; not the worst possible case (U.S. EPA OSWER directive). Some of these factors are central tendency (ingestion rates), and other factors used in final risk estimates are maximal values (air concentrations).

The recommended exposure concentration is a "conservative estimate of the media average contacted over the exposure period". MPCA recommends using the maximum annual average air concentration and the maximum hourly average air concentration as exposure point concentrations. A maximum annual average in practice, means that five years of meteorological data are incorporated into AERMOD and the highest annual average is chosen. This is similar to the practice used for the annual NO_2 NAAQS. These concentrations fall within EPA's definition of a maximally exposed individual. The final AERA results reflect a RME exposure scenario by combining these conservative concentration estimates with refined air dispersion modeling and central tendency ingestion rates.

One approach to communicate the uncertainty associated with the default exposure assumptions is to provide risk estimates using multiple human exposure assumptions. MPCA staff reviewed the human exposure data in the EPA Exposure Factor Handbooks (1997, updated Children's EFH, 2008, 2011) and provide the following guidance for estimating risk using central tendency human exposure factors. However, risk results using central tendency human exposure factors need not replace risk estimates based on the RME. Furthermore, they need not be considered a refinement to screening level risk assessments that follow MPCA's AERA guidance, unless under very rare circumstances, there is appropriate and adequate site-specific human exposure data. Presenting central tendency exposure estimates may be most appropriate in larger, more complicated, multi-pathway risk assessments, where more discussion of uncertainty is warranted.

The exposure duration and consumption rates used in the default settings of multi-pathway risk software (HHRAP, 2005) are chosen from US national studies examining where people spend their time, how much they eat of certain foods, or with what frequency they inhale. These studies result in a range of data (including high, low, and mid-range). Risk calculations based on central tendency exposure estimates are the same as RME risk calculations except that they use central tendency estimates (such as means or medians) for exposure durations and frequency. Included in Table 6 are guidance values for calculating risk estimates using both reasonable maximum and central tendency exposure assumptions.

[1] Reasonable Maximum Exposure – maximum exposure reasonably expected to occur in a population.

Table 6: Default exposure assumptions for RME human exposure estimates and suggested exposure factor values for risk estimates based on Central Tendency Estimates

	Reasonable maximum exposure	Central tendency exposure
Consumption rates (Table 7)	HHRAP default[1]	HHRAP default[1]
Percent contaminated food	100%[2]	100%[2]
Body weight (Table 7)	HHRAP default	HHRAP default
Exposure duration (adult)	30 years resident 40 years farmer	12 years[3]
Exposure frequency	350 days	226 days[4]
Inhalation exposure time	24 hours/day adult and child	18 hours/day child 19 hours/day adult
Emissions estimates	Same	Same
Toxicity values	Same	Same

[1]These data are based on US national means that have been time-weighted for age and in the case of the farmer, adjusted with a factor for households who farm. Since the data are based on means for the RME, there is no justification to change this for the central tendency estimate.

[2]This factor describes the portion of the items produced on site that are considered contaminated. In general, the scale resolution for modeled deposition is not adequate to describe the portion of onsite food or soil contamination. The RME suggested value is 100%, and there is no justification at this time to change this value for the central tendency estimate. The amount of food that is grown onsite (i.e., contaminated) and consumed is accounted for in the consumption rate value development.

[3]Mean residency period reported in the U.S. EPA Exposure Factors Handbook.

[4]Mean time spent at home (California) from U.S. EPA Exposure Factors Handbook used in place of a US national average.

Intake assumptions and estimation

Generally, the above suggested exposure factors are multiplied by modeled or measured media concentrations to estimate human pollutant exposure (intake). An example equation is included below:

$$\begin{bmatrix} Media \\ Concentration \end{bmatrix} x \begin{bmatrix} Exposure \\ Duration \end{bmatrix} x \begin{bmatrix} Consumption \\ Rate \end{bmatrix} = Intake$$

Consumption rate studies are used to estimate doses from ingesting pollutants in foods and from incidental ingestion of soil. Consumption rates may vary depending on the hypothetical exposure scenario or population under consideration (resident, farmer, adult, or child, etc.). The default consumption rates recommended in the HHRAP, 2005 are included in the Table 7 below.

Default ingestion exposure assumptions

Table 7: Default exposure factors for consumption rates and bodyweight from HHRAP, 2005

	HHRAP Default (approximate lbs. per week)	
	Adult	Child
Exposed vegetables (e.g., tomatoes, peppers) *	0.5	0.3
Root vegetables consumption (e.g., potatoes, turnips, carrots) *	0.2	0.1
Protected Vegetables Consumption (e.g., winter squash) *	0.7	0.4
Beef consumption	1.3	0.2
Pork consumption	0.6	0.1
Poultry consumption	0.7	0.1
Egg consumption	4 eggs/week	1 egg/week
Dairy consumption	15 pints/week	5 pints/week
Indirect soil ingestion*	0.7 grams/week	1.4 grams/week
Body weight	70 kg	15 kg

Farmers consume all products. Residents consume products identified by "*"

Fish consumption rates

Fish consumption rates that are more representative of Minnesota fishers are used rather than the HHRAP default values for both HHRAP-based analyses and the Minnesota Mercury Risk Estimation Method (MMREM).

The subsistence fisher ingestion rate was taken from EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (EPA, 2000). The recreational fisher ingestion rate is consistent with Minnesota Department of Health fish consumption advice. Adult daily doses assume body weights of 70 kg. Child fish consumption rates are calculated using the HHRAP ratio of adult to child fish consumption rates.

MPCA may request a higher-level fish consumption rate that is based on Native American Treaty rights. This higher-level exposure assessment will be requested if facility emissions may impact tribal land, or waters of interest.

Table 8: Ingestion rates recommended for the subsistence, recreational, and Native American fishers

	Raw fish tissue consumption rate(g/day)	**Daily dose (kg/kg-day)**	**Weekly consumption**
Subsistence fisher			
Adult	142	0.00203	Approx. ½ lb. fish 4-5 times a week (adult)
Child	21.4	0.00143	
Recreational fisher			
Adult	30	0.00043	Approx. ½ lb. fish per week (adult)
Child	4.5	0.00030	
Native American treaty rights based	224	0.0032	Approx. ½ lb. fish 7 times a week (adult)

Estimating air toxics concentrations: Modeling and monitoring

Monitoring

Ambient air monitoring is a measurement of air pollutant concentrations at a specific time and location: Air monitoring stations are sited according to criteria established by the EPA (C.F.R. 40 Part 58 Appendix E). These include requirements to be within ambient air (e.g., areas where the public has access, outside facility fenceline, etc.) as well as requirements related to the effective operation of the monitoring equipment (spacing from obstructions, horizontal and vertical placement, etc.). Monitoring is limited by expense, equipment capabilities, availability of a power source, security, and time.

Ambient air monitoring data are used in cumulative AERAs to represent air toxics concentrations and risks from surrounding sources or to confirm modeled air concentrations. However, identifying specific sources of air pollution from monitoring data is complex and requires many air measurements over time with site specific meteorological data.

Ambient air monitoring data are generally not preferred to represent exposure concentrations in AERAs because of the difficulty in ensuring a combination of the worst case operating and meteorological conditions that are specific to the facility under review.

Air dispersion modeling

Air dispersion modeling is the preferred method for estimating air concentrations used in AERAs. Air dispersion modeling is the process of simulating the movement of air pollutants after they are emitted from a source to estimate the concentrations of pollutants at locations around the source.

In AERAs, air dispersion modeling is used to estimate air pollutant concentrations at the fenceline and in the area surrounding a facility. Air dispersion modeling is done using an air quality modeling system that has been developed and refined over many years by the EPA and partners. The models have been tested against measurements to verify accuracy.

Air dispersion modeling information is preferred by the MPCA for use in AERAs because air dispersion modeling: can combine worst case meteorological conditions and worst-case operational conditions, is not limited by equipment detection limits, and can include information about specific air toxics that are traceable to emission units. This allows the results to inform final permit limits on specific sources and emission units within a facility.

A modeling analysis requires inputs of pollutant emission rates along with the parameters that characterize the release from each source (e.g., height, temperature, exit velocity), plus data on surrounding terrain, buildings, meteorology, and receptor locations (i.e., where exposure concentration calculations will be made). The air dispersion model provides estimations of air concentrations (and deposition if needed) at each selected location.

General air dispersion modeling guidance for AERAs

In general, recommendations for air dispersion modeling follow the MPCA Air Dispersion Modeling (ADM) guidance. When dispersion modeling is performed for use in AERAs, the maximum annual modeled air concentrations and the first high modeled hourly air concentrations are used. A maximum annual average in practice, means that five years of meteorological data are incorporated into AERMOD and the highest annual average is chosen. This is similar to the practice used for the annual NO_2 NAAQS.

Air dispersion and deposition modeling refinement Levels

Air Dispersion modeling can be done at a screening level or with increasing levels of refinement. Since all the AERA tools listed at the beginning of this guidance document typically use the same toxicity values and exposure scenarios and any level of emissions/operating assumptions, the main differences between them are how air concentrations and other media concentrations (soil, water, food) are calculated.

The more refined analyses require more data and are more resource intensive. In general, there are three levels of air dispersion and deposition modeling completed for MPCA AERAs:

- **Level 1/Initial screening:** Screening dispersion modeling and food chain analysis using MPCA Risk Assessment Screening Spreadsheet (RASS) and the embedded dispersion factor and multi-pathway screening factor look-up tables
- **Level 2:** Refined dispersion modeling using AERMOD, and screening food chain analysis using spreadsheet tools (RASS and/or Q/CHI)
- **Level 3:** Refined dispersion modeling using AERMOD, and refined food chain analysis using commercially available software that follows EPA's Human Health Risk Assessment Protocol (HHRAP, 2005)

Level 1: Using the RASS default screen

Level one AERA analyses are most successful when there is one, or only a few emission stacks, when there are relatively low levels of emissions, or the facility fenceline ensures receptors are well removed from the facility. When evaluation of the fish pathway is necessary, Level 2 or 3 refined dispersion and deposition modeling is required.

RASS dispersion factors

The RASS contains a look-up table of default hourly and annual dispersion factors (in terms of µg/m3 per g/s). These were generated from many AERMOD modeling runs generally reflecting worst-case conditions including but not limited to: stack diameter, stack exit velocity, stack exit temperature, meteorological conditions, and stack-to-building geometry. [Note: In some very specific circumstances, the use of a RASS may provide results that are nearly as refined as Level 2 and 3 assessments (e.g., for a single short stack that extends just above building height)].

The default dispersion factors in the RASS look-up table are based on the stack height and receptor/fenceline distance input by the user on the "Dispersion" tab of the RASS. The factors are combined within the spreadsheet with hourly or annual emissions to estimate worst-case air concentrations at or beyond the receptor distance input by the RASS user. Concentrations are estimated at ground level receptors only; receptors at elevated levels are not considered in the RASS at this time.

Receptor/fenceline distance

Generally, the nearest receptor distance input to the RASS (on the "Dispersion" tab) is assumed to be at the facility's fenceline, or at the owned and controlled boundary of the facility. For AERA guidance purposes, fenceline will mean either a physical barrier or a boundary controlled by other means (e.g., fence, security guards). In AERAs, a receptor represents a hypothetical person who is potentially exposed to air pollution. In air dispersion modeling, however, a receptor is a location where the model calculates concentrations and provides results.

If the facility is accessible to the public, the distance to the fenceline or receptor for the acute exposure scenario may be different from the distance considered for sub-chronic and chronic exposures. If physical access to a facility's property is not restricted, acute impacts need to be assessed at the location of maximum hourly air concentration predicted anywhere (unless it falls over a building, in which case it need only be considered if there is public rooftop access). Chronic risks need to be computed for potential receptors located at the maximum annual air concentration at or beyond the property fenceline. If the facility is not accessible to the public, only one receptor/fenceline distance is entered, and the RASS is only run one time.

Merging stacks with similar dispersion characteristics

To accommodate multiple stacks more efficiently, it may be helpful to merge stacks with similar dispersion characteristics such as stack height, stack diameter, exit velocity, exit temperature, and proximity to similarly sized buildings. Stacks must be located within approximately 100 meters of each other, near similar sized buildings, and have stack parameters that vary less than 20 percent (EPA 1992). The equation for merging stacks can be found in the MPCA Air Dispersion Modeling (ADM) guidance in the Nearby Source Characterization section. The calculation of "M" is what assists in determining if stack parameters vary less than 20%.

Defining 'Stacks' for fugitive sources

The RASS evaluates air emissions impacts based on releases through 'stacks'. Thus, the characteristics of emission sources or points that are not stacks (windows and doors or fugitive emission sources) must be modified in some way to allow the RASS to estimate dispersion and risk. Options for modification include entering fugitive emissions in the RASS as though they are emitted through a one-meter stack or using facility-specific refined dispersion modeling to estimate ambient air concentrations. More detailed options for the modification of fugitive sources are included in the MPCA Air dispersion guidance.

Level 2: using the RASS or Q/CHI with site-specific dispersion factors and air concentrations

There are several combinations of methods and tools that can be used to provide more accurate dispersion and deposition modeling than can be provided by the RASS alone. Possible tools for use in Level 2 Refinement include: RASS, AERMOD, and Q/CHI spreadsheet.

Using the RASS with AERMOD Site-Specific Dispersion Factors

AERMOD may be used to generate unitized dispersion factors for each stack, which are then entered directly into the RASS in the "Dispersion" tab. The MPCA Air Dispersion Modeling Guidance needs to be used to determine receptor placement, meteorological data, and source characterization. Emission rates of 1 g/s are entered into AERMOD for each air emission source.

Using the RASS with site-and-pollutant-specific concentration modeling using AERMOD-Multi-Chem

The Multi-Chem function of AERMOD may be used to calculate specific air toxics concentrations. These air concentrations are entered directly into an unprotected MPCA RASS in a worksheet tab set up by the analyst. The project proposer needs to request an unprotected RASS if this type of modeling is proposed. Multi-Chem is a desirable function for complex facilities with many pollutants and stacks (>50), as it avoids a model run for each air toxic.

Using the Q/CHI Spreadsheet

To obtain a copy of the Q/CHI spreadsheet please contact airtoxics.pca@state.mn.us. Hourly and annual air toxics emissions must be input into the Q/CHI spreadsheet on the "Emissions" tab. The Q/CHI sums are then calculated in this spreadsheet, and reported on the "Q_CHIs for ADM" tab. These Q/CHI sums are modeled in AERMOD in place of air toxic-specific or unitized emission rates. The AERMOD results are risk estimates, not air concentrations. AERMOD must be run once for each exposure scenario being assessed: acute, chronic non-cancer inhalation, chronic non-cancer indirect, and chronic non-cancer total. It may be more efficient to run AERMOD for the indirect and inhalation pathways, and then sum the results for the total risks.

Level 3: dispersion and deposition modeling for HHRAP-based tools

More refined multi-pathway modeling involves different air modeling options and assumptions than are typically used for screening-level and criteria pollutant modeling. This type of modeling involves the calculation of dispersion factors as well as wet and dry deposition-related factors in AERMOD. These dispersion and deposition factors are then input into a multi-pathway risk model to calculate media concentrations and multi-pathway risk estimates. In general, multi-pathway risk models follow the EPA's Human Health Risk Assessment Protocol (HHRAP, 2005), and include model software such as BreezeR and IRAP-h ViewTM.

Possible tools that can be used in conjunction with the HHRAP-based analysis include the RASS (for acute analysis), AERMOD, and the MMREM spreadsheet for mercury in fish pathway.

Guidance documents for HHRAP-based tools

Consult MPCA to develop a refined multi-pathway dispersion and deposition modeling protocol. The following information will be helpful in its development.

1. MPCA default pollutant characteristics for gas and particle size distribution are provided in the AERA-26 Refined HHRAP-Based Analysis form.
2. Guidance for the setup of AERMOD to calculate dispersion (vapor phase) and deposition (wet and dry particulate) are included in Chapter 3 of the HHRAP, 2005 Protocol. This guidance is directed toward the older ISCST3 model; however, the basic steps are the same.
3. Basic deposition modeling guidance in the MPCA ADM guidance document and website
4. General air toxics modeling guidance for deposition is included in the EPA SCRAM website.

Fish pathway air dispersion modeling

If non-mercury bioaccumulative pollutants such as dioxins and PAHs are emitted from the facility near a fishable water body, a Level 3 analysis using HHRAP-based tools needs to be performed. The fish consumption pathway is not evaluated in either the RASS or the Q/CHI spreadsheet since air concentrations over water bodies and watersheds must be modeled and deposition from the air into the receiving media must be estimated. If mercury emissions are greater than 3 pounds/year, AERMOD results for mercury can be used in combination with the MMREM spreadsheet to evaluate this pathway.

Acute analysis

The RASS or Q/CHI spreadsheet is typically used for the acute inhalation analysis even when completing a refined multi-pathway risk analysis. However, for facilities where it can be demonstrated that there is very little variability in hourly emission rates, HHRAP-based software may be used. In this case the acute inhalation health benchmarks must be entered into the HHRAP based software because MPCA's acute IHB values are not typically used in HHRAP-based software. In these cases, the software must be run separately for the acute and chronic analyses.

Plume depletion

Plume depletion is a default assumption embedded in the AERMOD model. Adjustments may be made to the algorithm if there are facility-specific data for particle size distributions. Any changes to this algorithm will require additional MPCA review.

Dispersion modeling information needed for MPCA review:

- AERA modeling protocol: Submitted as the AERA-03 form. For more complex modeling analyses, MPCA requests that the AERA modeling protocol be submitted prior to completion of the analysis. This may eliminate multiple modeling runs. More refined modeling needs to follow standard EPA and MPCA guidance and practices. The MPCA air dispersion modeling guidance can be found on the air dispersion modeling web page, and includes discussion of the air dispersion models generally accepted by MPCA.
- Information requested in the Air Dispersion Modeling Analysis Form to Support AERA (AERA-03), including but not limited to:
  a. Input and output files.
  b. Descriptions of non-default assumptions, and the level of refinement.
  c. Maps showing property boundaries and fencelines.
  d. A screening RASS, if used.

Nitrogen dioxide modeling: Special considerations for modeling hourly concentrations

The MPCA assesses an acute inhalation hazard quotient from short term exposures to nitrogen dioxide (NO_2). This is conducted in addition to the criteria pollutant modeling completed for comparison to the NAAQS. In general, nitrogen dioxide emissions are available as total NO_x, which is a combination of NO_2, N_2O, NO_y, and NO. Nitrogen dioxide may be directly emitted from sources, but to a greater extent is formed through atmospheric chemical reactions. Therefore, assumptions are made about the percentage of NO_2 from NO_x that is directly emitted from the stack, as well as the percentage of NO_2 that is formed once emitted. Default assumptions for the nitrogen dioxide modeling tiers are described in the MPCA Air Dispersion Modeling guidance under the Pollutant Considerations/NO_2 section.

Estimating pollutant concentrations in water bodies, soil, and food

Basic air dispersion modeling is expanded to include deposition to assess ingestion-based risks from air emissions that deposit into other environmental media. This additional modeling facilitates a multi-pathway risk assessment, in that air particles are allowed (within the model) to deposit from the air onto other environmental media (e.g., soil, water, crops) over time according to their density and particle size. Food chain analyses then use these modeled deposition rates along with other scientific data to estimate uptake of the pollutants into soil, water, produce, fish, livestock, and related food products (eggs and milk).

As discussed in the Air Dispersion Modeling section, there are the following 3 levels of refinement recommended in AERAs. Levels 1 and 2 entail using results from default dispersion/deposition modeling and exposure scenarios, hence are considered more screening.

- **Level 1/Initial screening:** Screening dispersion modeling and food chain analysis using MPCA Risk Assessment Screening Spreadsheet (RASS), the embedded look-up table and Multi-Pathway Screening Factors.
- **Level 2:** Refined dispersion modeling using AERMOD, and screening Food Chain analysis using spreadsheet tools (RASS and/or Q/CHI) with the Multi-Pathway Screening Factors.
- **Level 3:** Refined dispersion using AERMOD and refined Food Chain analysis using commercially available software that follows EPA's Human Health Risk Assessment Protocol (HHRAP, 2005)

Level 3 Environmental media and food-stuff concentration estimation

Additional facility and MPCA recommended data and information will be required if a Level 3 AERA is being conducted. This information is listed and described in the AERA 26-Refined HHRAP-based Analysis form. To inform the exposure scenarios discussed in the next section, and depending on the scope of the AERA, the following environmental media and food concentrations will need to be estimated:

- Soil
- Produce
- Pork
- Chicken
- Beef
- Dairy
- Eggs
- Fish

In only very specific cases are drinking water concentrations estimated in an AERA. Most Minnesotans drink groundwater or treated water from municipal water systems, and most facilities under review do not include direct discharge to drinking water supplies.

Watershed and water body parameters

Many Minnesota-specific parameters are available for use in HHRAP-based tools for estimating pollutant water concentrations. These parameters and their sources are summarized below and need to be used unless more relevant site-specific information is available. Other types of information that may be more relevant to the facility location should be proposed in the Refined HHRAP-Based Analysis Form (AERA-26) along with rationale for its use.

Table 9: Minnesota-specific sources and parameters for use in HHRAP-based tools for estimating pollutant water concentrations.

Variable name	MN specific value	Units	Variable code	HHRAP input location	Source
USLE erodibility factor	0.39	ton/acre	K_erode	Watershed site parameters	Value of 0.39 is typical/conservative of average soil types. Used in Universal Soil Loss Equation. Consistent with HHRAP-based software (NC DEHNR 1997, EPA 1994). This default value is based on a soil organic content of 1%.
USLE length slope factor	0.50	unitless	LS	Watershed site parameters	Value of 1.5 appropriate for moderately steep slopes; lower values likely for mildly steep slopes. Dependent on the nature of the watershed. HHRAP-based software suggests a default value consistent with NC DEHNR 1997 and EPA 1994. However, they recommend "using current guidance (U.S. Department of Agriculture 1997; EPA 1985) in determining watershed specific values for this variable based on site specific information."

Variable name	MN specific value	Units	Variable code	HHRAP input location	Source
Air viscosity (temp corrected)	1.72E 04	g/cm s		Risk receptor site parameters	Used in gas phase transfer coefficient. The air viscosity was calculated for a temperature of 6oC, the estimated average air temperature of Minnesota.
Water viscosity (temp corrected)	1.31E 02	g/cm s		Watershed site parameters	Used in liquid phase transfer coefficient. The value provided is 10 ^{o}C and 1 atm, as approximately 10 ^{o}C is average temperature of water bodies in Minnesota.
Sediment delivery empirical slope coefficient	0.125	unitless	SD_X_e	Risk receptor site parameters	Vanoni 1975 Used in calculating the sediment delivery to the water body.
Dry particle deposition velocity	0.15	cm/s		Risk receptor site parameters	Upper range of values reported by Pratt, et al (1986) for semivolatile substances. Only use in previous versions of HHRAP-based software. Current HHRAP-based software version uses AERMOD, which calculates deposition.
Dry vapor depositional velocity	1.50	cm/s			Upper range of measured values for nitric acid vapor as reported by Pratt, et al (1986). Only use in previous versions of HHRAP-based software. Current HHRAP-based software version uses AERMOD, which calculates deposition.
Average annual precipitation	83.82	cm/yr	P	Risk receptor site parameters	County specific values from the MN Climatology Working Group 2003.
Average annual temperature	280.93	K	T_A	Risk receptor site parameters	County specific values from the MN Climatology Working Group 2003.
Average annual irrigation	0.01	cm/yr	I	Risk receptor site parameters	USGS 2000. County specific. Part of the water balance. Data was retrieved for irrigated land per county (acres) and the total amount of irrigation water used from the USGS, at http://water.usgs.gov/watuse/data/2000/index.html. Based on the number of gallons used each year, acres of farmland, and acres of each county (from 2000 US Census Data).
Average surface runoff from pervious areas	16.61	cm/yr	RO	Not directly input into HHRAP-based software – calculated from % pervious	Calculated average surface runoff from pervious areas. Values for surface runoff vary throughout the state. Default values for different regions were provided in Geraghty et al. (1973) – Water Atlas of the United States.
Water body temperature	14.5	^{o}C	T_wk	Watershed site parameters	Estimated from Hondzo and Stefan (1993) study, "Regional Water Temperature Characteristics of Lakes Subjected to Climate Change. *Climatic Change*. 24:187 211." Based on the type of water body assessed and the species of fish that might be found in a similar water body.

Variable name	MN specific value	Units	Variable code	HHRAP input location	Source
Total suspended solids	13	mg/L	TSS	Watershed site parameters	MPCA 2005, calculated Ecoregion values for TSS were taken from the Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria (2005). TSS values for rivers are four times the particulate organic carbon content for lakes in the same ecoregion.
Cover Management Factor (for USLE)	0.3	unit less	C_var	Watershed site parameters	MN Agricultural Statistics (2002). County specific.
USLE rainfall (erosivity) factor	175	yr^ 1	RF	Watershed site parameters	Determined by rainfall characteristics of ecoregion. From Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses – A Guide to Conservation Planning. USDA Handbook 537. Washington, D.C.: U.S. GPO.
Average evapotranspiration	67.22	cm/yr	E_v	Risk receptor site parameters	USGS National Water Summary 1987. Calculated by multiplying the total precipitation for a given county by the fraction of precipitation that is evapotranspirated.

If non-recommended values are proposed other than those recommended in this AERA guidance or forms, these values need to be discussed with MPCA staff. The potential effects of other parameter values and calculations used in the assessment need to be explored and explained in the AERA-26 form. This will ensure clarity and transparency of the final risk assessment results.

The equations used to estimate media concentrations are provided in HHRAP Appendix B.

Fish tissue concentrations (Mercury)

Some facilities may be requested to assess potential human health risks from mercury exposure for the fish consumption pathway. Monitored fish tissue data are used to estimate non-cancer health effects from exposure to mercury from ingesting fish using specific guidance and tools (MMREM). MPCA risk assessment staff will provide representative Minnesota-specific fish tissue data and/or fish tissue data from EPA's National Fish Survey once water bodies are selected.

Due to the uncertainty associated with estimating an accurate average mercury fish tissue concentration, the 95 percent UCL of the arithmetic mean needs to be used. The EPA has formulated guidance for calculating the UCL-AM: EPA, OSWER, 2002, Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. The guidance has been implemented in the EPA ProUCL software (https://www.epa.gov/land-research/proucl-software). This software may be downloaded and run to obtain UCL-AM values from fish tissue data.

Toxicity assessment

Pollutant concentrations estimated using the procedures described in the exposure section are compared to health benchmarks. Health benchmarks are values developed from scientific studies to estimate potential cancer and non-cancer human health risks. The ingestion intake values are combined with ingestion-based toxicity benchmark values to estimate cancer and non-cancer risks (see How risk estimates are calculated). Estimated air concentrations are compared inhalation health benchmark (IHB) values. For chronic resident or farmer exposure scenarios, the air exposure concentration is the annual average air concentration. For acute exposures, the air exposure concentration is an average hourly air concentration.

What are inhalation health benchmarks?

Inhalation health benchmarks (IHBs) are developed through scientific review of toxicity and exposure data. IHBs are generally derived as air concentrations likely to be without appreciable risk of harmful effects on sensitive humans. The IHBs for carcinogenic air toxics used by MPCA are developed so the additional lifetime cancer risk of a lifetime exposure to the IHB concentration is equal to or less than 1 chance in 100,000 (or $1x10^{-5}$).

Non-cancer effects are predicted using IHBs that are estimates of continuous inhalation exposure likely to be without appreciable risks of deleterious effects during a lifetime.

Exposures to air concentrations somewhat higher than the IHBs may also be without appreciable risk of harmful effects, but there is not enough information to know how much higher, if any, would be considered safe.

MPCA/MDH inhalation health benchmark hierarchy

The MPCA consults with the Minnesota Department of Health as to which inhalation health benchmark (IHB) values to apply in AERAs. The MDH is charged in Minnesota rule to develop IHBs called health-based values (HBVs) or health risk values (HRVs). These IHBs are "*intended for use by public agencies or private entities in Minnesota as one set of criteria in evaluating risks to human health by chemical emissions to the ambient air*". The Statement of Need and Reasonableness (SONAR) for the HRV Rules provides a thorough description of the scientific methods and principles used to develop HRVs.

If there is not a value developed by the MDH, the MPCA and MDH have agreed upon a hierarchy of IHB information sources. The list below identifies the hierarchy of information sources for the IHB values used in AERAs.

1. MDH Health-Based Values and Risk Assessment Advice for Air
2. U.S. EPA Integrated Risk Information System (IRIS)
3. California Environmental Protection Agency Reference Exposure Levels and Cancer Potency Values
4. Provisional Peer Reviewed Toxicity Values (PPRTVs) derived by U.S. EPA's Superfund Health Risk Technical Support Center (STSC) for the U.S. EPA Superfund program

A list of the Inhalation Health Benchmarks used in AERAs is available in the RASS.

Sources of IHBs that are not included in this hierarchy may be discussed qualitatively in an AERA. The qualitative information may be considered for risk management decisions when additional context is needed.

Updated values according to this hierarchy are input into the Risk Analysis Screening Spreadsheet (RASS) by MPCA staff approximately every year and posted to the AERA website. In some cases, it may be recommended to contact an MPCA risk assessor directly to receive an updated RASS. If a HHRAP-based multi-pathway analysis is being conducted, the toxicity values in the software need to be updated to correspond to the most current RASS inhalation toxicity values. A MPCA risk assessor should be contacted to get the most up-to-date ingestion toxicity values.

Early life exposure adjustment factors

Some estimated cancer risks from exposure to air toxics may be elevated if the exposure occurs during the early years of life before the age of 16. The MPCA follows MDH guidance to ensure that AERAs are protective of early life sensitivity to carcinogens. This guidance suggests that some unit risks or cancer-based air concentrations may require an adjustment to become protective of potential exposures to air toxics in early life. Other unit risks or cancer-based air concentrations may already have this adjustment incorporated. As a screening level estimate, the MPCA suggests multiplying the summed facility-specific cancer risks (except for those estimates based on an already-adjusted IHB) by 1.6. This default factor is described in more detail in the MDH Risk Assessment Advice for Incorporating Early-Life Sensitivity into Cancer Risk Assessment for Linear Carcinogens.

Additivity by toxicity endpoint

At a screening level, the MPCA RASS automatically sums all individual pollutant hazard quotients to determine one total hazard index across all non-cancer endpoints (e.g., neurological, respiratory, reproductive). This "summation" practice follows both MDH and EPA guidance.

If a project proposer undergoes a reasonable amount of refinement in other areas (e.g., more refined emissions estimates or air dispersion modeling) and is still unable to calculate a non-cancer hazard index below facility risk guidelines, hazard indices may be separated and summed by non-cancer health endpoints. The estimated risks for cancer endpoints are summed regardless of the specific disease association.

In a real human system, the individual air toxics may interact in a manner that implies additivity (summation of toxic responses), a manner that implies a greater than summed interactive toxic response (synergy), or in a manner that implies less than a summed toxic response (antagonism). There are few data, however, that address the variety of potential interactions. In some cases, there may be two or more emitted air toxics with data available suggesting a synergetic response. In this case, if these air toxics are emitted at risk driver levels, MPCA may request a qualitative discussion of the potential underestimation due to the potential for a synergistic toxic response. Discussions of potential antagonism may also be included in the qualitative section of the AERA.

Developmental toxicants/Air toxics with ceiling values

Acute IHBs with developmental endpoints are considered ceiling values not to be exceeded and are identified as such in the RASS. Although many chemical exposures can have adverse effects to a pregnant woman and her fetus, chemicals that are developmental toxicants may directly harm a fetus. Unfortunately, most chemicals have not been tested for developmental effects; for many chemicals there is uncertainty regarding time of exposure and mass of a chemical necessary to generate developmental effects. Those chemicals for which sufficient scientific evidence was available to develop an IHB for developmental effects are noted in the Risk Calcs tab of the RASS.

The MPCA will review RASS workbooks to note whether air toxics are emitted that have acute IHBs for the developmental health endpoint (i.e., ceiling value), and note if the maximum modeled air concentration exceeds the ceiling value.

Chemicals of potential interest without IHBs

Diesel exhaust particulate

Cancer risks and non-cancer hazard quotients are currently estimated differently for diesel exhaust particulates. Non-cancer health effects are assessed for the complex mixture known as "diesel exhaust particulates" using an IHB value from the AERA toxicity value hierarchy. However, potential cancer-related diesel exhaust health effects are not assessed as a diesel exhaust particulate mixture, but are assessed from individual chemical constituents (e.g., dioxins/furans, PAHs) adsorbed on or absorbed within the particles. The different methods are used because of the uncertainty in cancer unit risk factors for the diesel exhaust particulate mixture. A portion of this uncertainty stems from the continued modifications to both engines and fuel formulations invoked to reduce diesel related emissions. Once a unit risk factor for diesel exhaust particulate mixtures is found acceptable by MDH, the chemical constituent-based assessment approach will be replaced with using a cancer unit risk factor based on the complex mixture.

MDH review of air toxics without IHBs

In reviewing an AERA, MPCA staff, a member of the public, or the project proposer may find that there is an air toxic emitted without an IHB within the MPCA/MDH toxicity value information source hierarchy. If this is the case, MPCA may request the MDH to review available information to assess the potential to develop a value for that air toxic. The air toxics currently under review are listed and described on the MDH Chemicals Under Review webpage. The process to review scientific literature and develop an IHB is lengthy; in some circumstances an IHB may be recommended by MDH for use only on a given project so that an AERA may be completed and the additional risk estimate using a newly developed inhalation toxicity value would be included later.

Risk characterization

In risk characterization, information from each of the risk analysis elements described above (source characterization, pollutant identification, emission estimation, exposure, and toxicity assessment) are summarized and integrated into quantitative and qualitative expressions of risk.

The EPA's Science Policy Council Handbook, *Risk Characterization*, states that "*The goal of risk characterization is to clearly communicate the key findings and their strengths and limitations so its use in decision making can be put into context with the other information critical to evaluating options….*". It also suggests that important traits of a high-quality risk characterization are transparency, clarity, consistency, and reasonableness.

EPA's definition of transparency is "*The characterization needs to fully and explicitly disclose the risk assessment methods, default assumptions, logic, rationale, extrapolations, uncertainties, and overall strength of each step in the assessment.*"

Such transparency and other traits of a high-quality risk characterization will be achieved by following the AERA guidance. The forms and guidance were designed so that AERA submittals are clear; they are consistent with federal and state requirements and guidelines; and AERA risk results are reasonable. These qualities are obtained through use of the forms, as they provide information on the accuracy of the assumptions and data, the level of refinement and the relevance to current and future land use.

Quantitative risk characterization

By following the steps described in previous sections of this guidance document, the magnitude of a hypothetical individual's exposure and pollutant intake by inhaling air toxics, incidentally ingesting pollutants in the soil and ingesting pollutants in foods will have been estimated. The next step in estimating risks (both cancer and non-cancer) is to compare that individual's exposure and intake levels with benchmark toxicity values for those pollutants.

This comparison results in probabilities that an individual will develop cancer over a lifetime of exposure Major assumptions, scientific judgments, and to the extent possible, estimates of the uncertainties are also presented in the risk characterization.

AERA quantitative risk estimation

In the quantitative risk estimation portion of an AERA cancer risk and hazard descriptors ("risks") are intended to convey information about the potential risks to hypothetical individuals impacted by emissions from a facility or project. Quantitative risk estimates from an AERA may include:

- multi-pathway and inhalation cancer risks from facility emissions
- multi-pathway and inhalation non-cancer hazard quotients and indices from facility emissions for both chronic and acute exposure durations
- estimates of blood levels in children associated with exposure to lead from a facility
- non-cancer hazard quotient from ingestion of mercury in fish tissue
- potential cumulative risks from nearby sources

The precise methods for calculating risks may differ depending on the tool used, whether an air toxic is a carcinogen, the nature and number of exposure pathways being assessed, and whether cumulative risks are being assessed.

Regardless of which tool is used, the basic equations for calculating risks from individual pollutants are shown in Table 10.

Table 10: Equations for calculating risks from individual pollutants

Risk equation description	Risk equation	Definition of terms
Carcinogens (inhalation)	$\boldsymbol{Inhalation\ cancer\ risk = IEC\ x}$ UR	IEC = inhalation exposure concentration in air (µg/m^3) UR = Inhalation unit risk (µg/m^3)$^{-1}$
Carcinogens (ingestion)	$\boldsymbol{Ingestion\ cancer\ risk = Intake\ x\ SF}$	Intake = daily intake of pollutant SF = Cancer slope factor (mg/kg-day)$^{-1}$
Total cancer risk	$\boldsymbol{Total\ Cancer\ Risk = \sum Ingestion\ Cancer\ Risks + \sum Inhalation\ Cancer\ Risks}$	
Non-carcinogens (inhalation)	$\boldsymbol{Inhalation\ Hazard\ Quotient =}$ IEC$/\boldsymbol{RfC}$	IEC = exposure concentration in air (µg/m^3) RfC = reference concentration (µg/m^3)
Non-carcinogens (ingestion)	$\boldsymbol{Ingestion\ Hazard\ Quotient =}$ Intake$/\boldsymbol{RfD}$	Intake = daily intake of pollutant RfD = Reference dose (mg/kg-day)
Total non-cancer	$\boldsymbol{Hazard\ Index = \sum Ingestion\ Hazard\ Quotients + \sum Inhalation\ Hazard\ Quotients}$	

Total risks estimated in an AERA are calculated by adding the individual risks for each air toxic in each pathway of concern (i.e., inhalation, ingestion), then summing the risk for each receptor-type evaluated (e.g., resident, farmer) for all pathways.

Tool-specific equations and methods are described below.

RASS and Q/CHI

The RASS and the Q/CHI both provide a screening level assessment of inhalation and indirect exposure pathways by using Multi-pathway screening factors. These risk screening methods correspond with AERA screening levels 1 and 2 (MPSFs). The basic calculations performed in the RASS and Q/CHI spreadsheets are shown below.

RASS calculations

Inhalation risks are estimated in the RASS by first comparing each modeled air toxic concentration with its respective inhalation health benchmark (IHB) concentration. Acute inhalation risks are a comparison of maximum modeled hourly air concentrations with acute IHBs. Chronic inhalation risks (both cancer and non-cancer) are comparisons of maximum modeled annual air concentrations with chronic IHB concentrations. For non-carcinogens, this is the reference concentration (RfC). For carcinogens, the IHB concentration is the concentration in air that could result in an excess lifetime cancer risk of 1 in 100,000 (1 x 10^{-5}). Pollutant-specific risks are then summed to obtain total inhalation risks.

$$Total\ facility\ inhalation\ risks = \sum \left(\frac{pollutant\ modeled\ air\ concentration\ from\ all\ sources}{Inhalation\ Health\ Benchmark\ Concentration} \right)$$

Ingestion risks are estimated in the RASS by multiplying pollutant-specific inhalation risks by MPSF values. Cancer risks and hazard quotients are summed across all pollutants for the inhalation and ingestion exposure routes. This is done for the farmer, resident, and urban gardener. The fish consumption pathway is not evaluated in the RASS.

$$Total\ facility\ ingestion\ risk\ = \sum (pollutant\ inhalation\ risk\ from\ all\ sources * MPSF)$$

Total risks from each exposure route (inhalation and ingestion) are summed and displayed in the Risk Calcs tab of the RASS. A summary of the total risks for each exposure route and exposure scenarios is displayed in the Summary tab of the RASS.

$$Total\ faciltiy\ risk = total\ inhalation\ risk\ from\ all\ sources\ + total\ ingestion\ risk\ from\ all\ sources$$

Q/CHI calculations

The Q/CHI method is useful when there are multiple sources and more refined spatial and temporal modeling is desired. The Q/CHI spreadsheet is a "RASS-like" spreadsheet that calculates emission rate/chemical health index ratios (Q/CHI). These pollutant-specific ratios are then summed through pollutants, but they remain specific to emission units and exposure scenarios. For ingestion-based exposure scenarios the Q/CHI value is multiplied by a Multi-Pathway Screening Factor prior to Q/CHI value summation. The Q/CHI sum is then entered into AERMOD in the place of pollutant-specific or unitized emission rates. AERMOD modeling using this method results in risk estimates at each modeling receptor. The risk estimates are paired in time and space and may be mapped using a geographic information system. More detailed instructions for the use of the Q/CHI spreadsheet are included in the ReadMe tab within the spreadsheet itself.

If the only exposure pathway of interest is inhalation, total facility risks are obtained by summing pollutant-specific Q/CHI values to obtain total inhalation Q/CHI values, which then may serve as input to AERMOD to obtain total facility inhalation risks as follows:

$$\sum\left(\frac{emission\ rate}{inhalation\ health\ benchmark}\right) \rightarrow dispersion\ modeling \rightarrow total\ modeled\ inhalation\ risks$$

For most projects the ingestion pathway is also of interest, so pollutant-specific ingestion-based Q/CHI values are obtained by multiplying inhalation Q/CHI values by respective MPSFs. Inhalation and ingestion Q/CHI values are summed in the spreadsheet to provide total inhalation and ingestion input to AERMOD. The outcome is total modeled inhalation plus ingestion risks.

$$\sum\left(\left(\frac{emission\ rate}{inhalation\ health\ benchmark}\right)+\left(\frac{emission\ rate}{inhalation\ health\ benchmark}*MPSF\right)\right)$$
$$\rightarrow dispersion\ modeling \rightarrow total\ modeled\ inhalation\ and\ ingestion\ risks$$

Once each risk estimate is calculated by AERMOD these risk estimates are input into the Q/CHI spreadsheet under the tab for the appropriate exposure scenario (e.g., Acute Q_CHI, for the maximum acute inhalation hazard index). This allows the spreadsheet to calculate pollutant-specific hazard quotients and cancer risks.

Note: The pollutant-specific hazard quotients and cancer risks will not sum to the same values as the AERMOD produced risk estimates. This is due to the fact that the pollutant-specific risks calculated in the "RiskDrv" tab are maxima from each location, rather than being paired in time and space. To achieve a more accurate estimation of pollutant-specific risk estimates, one may multiply the percent contribution of that pollutant by the total risk estimate (acute inhalation HI * 97% contribution from nitrogen dioxide as calculated from the RiskDrvr tab). The percent contribution is calculated from the hazard quotients or cancer risks calculated on the "RiskDrv" tab.

$$Percent\ Contribution = pollutant\ specific\ risk\ estimate \div \sum pollutant\ specific\ risk\ estimates$$

Multi-pathway screening factors (MPSFs)

Multi-Pathway Screening Factors (MPSFs) are embedded in the RASS and Q/CHI spreadsheet analysis to estimate ingestion risks from eating vegetables and non-fish foods.

Multi-pathway Screening Factors are defined as ratios of the maximum risk from the indirect (ingestion) exposure routes to the maximum risk from the direct (inhalation) exposure route as shown below.

$$MPSF = \frac{ingestion\ risk}{inhalation\ risk}$$

The MPSFs were updated in 2015 modeled ingestion to inhalation ratios using the Minnesota MNRISKS cumulative air pollution tool. Point source modeled results were used to calculate the ratios, and the 98th percentile summary of all statewide ratios was reported in the RASS. Some near-site ratios were eliminated if point estimations were close enough such that deposition was being estimated but dispersion was still aloft. MPSFs were developed for three scenarios, the adult farmer, the adult resident, and the urban gardener.

Only those pollutants with a ratio of one (rounded values) or higher were assigned MPSFs in the RASS. For many volatile compounds, the inhalation risks are higher than ingestion risks, so the calculated MPSFs are less than one. Pollutants that accumulate in the food chain (PBTs) have higher ingestion risks, and therefore have MPSFs greater than one. MPSFs were rounded to whole numbers to better reflect the appropriate level of certainty.

The general development of the MPSFs prior to the MNRISKS update is described in detail in Pratt and Dymond, 2009.

HHRAP-based analyses (refined Multi-pathway AERA, Tier 3)

The EPA developed an approach for conducting multi-pathway, site-specific human health risk assessments on hazardous waste combustors, Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP). The guidance was developed to describe the evaluation of inhalation risks and to provide procedures for estimating risks from indirect exposure pathways. Equations for estimating potential cancer risks and non-cancer hazards are provided in HHRAP Appendix C.

The HHRAP procedures provide default assumptions that typically reflect national averages. MPCA staff reviewed the default values provided in the HHRAP guidance and have performed some sensitivity analyses. MPCA-recommended values are discussed below and provided in the Refined HHRAP-based analysis form (AERA-26 Form). Many of the alternative values in the AERA-26 form are Minnesota-specific (e.g., average annual precipitation) and are intended to reflect Minnesota conditions more accurately while producing a health-protective analysis. The AERA-26 form provides additional recommendations reflecting the most recent, scientifically defensible data and approaches (e.g., using the most current regulatory air dispersion model and the most current toxicity values).

In addition to the exposure scenarios evaluated using the RASS and Q/CHI tools, HHRAP-based tools are equipped to evaluate the fish consumption exposure pathway.

Toxicity values in HHRAP Analyses

Inhalation toxicity values from the RASS need to be used in HHRAP-based tools (e.g., IRAP). A hierarchy like that used to compile inhalation values has been followed by MPCA staff to tabulate ingestion toxicity values for use in HHRAP-based analyses. These values are available upon request.

Acute analyses are performed using the RASS. If a rare circumstance arises where it may be deemed appropriate, after discussion with MPCA risk assessment staff, to perform the acute analysis using a HHRAP-based tool, the acute toxicity values from the RASS needs to be entered in the tool. Most HHRAP-based software acute values are emergency levels issued by DOE as part of their Temporary Emergency Exposure Limits or are from the EPA Acute Inhalation Exposure Guideline Levels - Level 1 (AEGL 1s) Database. These sources are not part of the AERA hierarchy of toxicity information sources.

Mercury analysis using MMREM

In general, facilities that emit more than 3 pounds of mercury a year (actual facility emissions, potential controlled emissions may differ) and/or are located near water body(s) may be asked to estimate potential human health risks from mercury. Fish consumption is the primary pathway of concern for mercury and needs to be assessed using the MPCA Mercury Risk Estimating Method (MMREM). This approach relies on measured mercury concentrations in Minnesota fish and measured ambient background mercury deposition. The MMREM spreadsheet is used to estimate an incremental hazard index from eating the methyl mercury in fish from the water body(s) assessed. Inputs to the spreadsheet include measured mercury concentrations in Minnesota fish tissue from the water body(s) being assessed (or from representative water bodies), the area of the water body, the area of the terrestrial portion of the watershed, averaged modeled concentrations of speciated mercury over the water body, and the modeled average concentration over the terrestrial watershed area. A detailed description of this process is provided in a MMREM guidance document. Additional details and the scoping process for performing mercury-based analyses are described in the MMREM protocol form.

The RASS may be used to estimate inhalation risks from mercury exposure.

Lead analysis using the IEUBK model

A non-cancer health benchmark is not currently available in the MPCA/MDH toxicity value hierarchy because there is no known threshold for potential non-cancer health effects associated with lead exposure. There is, therefore, no direct methodology for calculating non-cancer risk estimates for air lead emissions. The Center for Disease Control (CDC) and MDH, however, provide consistent recommendations for a blood-lead reference level for triggering medical and prevention actions. This creates concern for lead and a desire to screen lead for potential non-cancer health effects but requires consideration beyond a calculation of an inhalation hazard quotient from lead emissions.

In effort to screen for potential non-cancer impacts from lead, the NAAQS ambient air quality standard was included in the RASS as a surrogate for an RfC. If a screening RASS results in a risk estimate for lead above 10% of the ambient air quality standard, or if there is a modeled lead NAAQS exceedance, then the MPCA recommends that blood lead concentrations are estimated and compared to recommended reference levels for triggering medical and prevention actions.

The EPA has developed the Integrated Exposure Uptake Biokinetic (IEUBK) model to estimate blood-lead levels in children associated with multiple lead exposure pathways (air, soil, dust, diet, drinking water, and maternal lead). The IEUBK model integrates several assumptions about the complex exposure patterns and physiological handling of lead by the body and predicts blood lead levels and distributions for children 0 to 7 years of age. The IEUBK exposure module includes default media concentrations and media intake rates, including ingestion rates for air, drinking water, soil/dust, diet, and other sources. The default intake parameters selected for use in the IEUBK model are from the central observations of the ranges of values.

The model defaults may be used for all parameters except air and soil lead concentrations. The highest modeled project-related annual average lead air concentration and the highest lead soil concentration from the HHRAP-based modeling exercise needs to be used. Indoor dust concentrations can be assumed to be the same as outdoor. Modeled blood-lead levels can then be compared with the MDH and CDC recommended reference level.

In special circumstances the Adult Lead Methodology model may be requested.

Persistent, bioaccumulative, and toxic pollutants (PBTs)

Organic pollutants that might be considered PBTs were identified using the EPA PBT profiler model. Potential inorganic PBTs were identified using a more comprehensive list adopted by the European Union. The PBT pollutants identified by the MPCA using these resources with IHB values are indicated on the Risk Calcs tab of the RASS.

PBT pollutants without multi-pathway screening factors

Some pollutants may be considered PBTs and have toxicity information available with which to assess the ingestion pathways. Some of these PBT pollutants do not have inhalation toxicity information and a MPSF cannot therefore be calculated. In this case, although they are considered toxic through the ingestion pathway, they are not assessed quantitatively in the RASS. A list of air toxics considered to be PBTs is provided in the RASS in the Risk Calcs tab. These pollutants need to be discussed in the qualitative section of the AERA in AERA form-02.

Quantitative risk estimation of special mixtures

Petroleum hydrocarbons—Aliphatic (C7 – C11)

Air toxics emissions of mixtures that include primarily aliphatic hydrocarbons, in the C7 – C11 range, and with less than 1.5 % aromatics, need to be entered in the RASS as “petroleum hydrocarbons, aliphatic (C7 – C11)”. Consistent with the general approach described above for the treatment of mixtures, the mass of all aromatics with available IHBs (e.g., benzene) needs to be subtracted from the mixture to be assessed separately. If a petroleum hydrocarbon mixture contains a higher fraction of aromatics than 1.5% and subtracting the mass of aromatics with IHBs reduces the fraction to less than 1.5%, the remaining mixture needs to be assessed using the recommended inhalation health benchmark derived from aromatized petroleum stream inhalation studies.

Information documenting the composition of the mixtures assessed with this IHB needs to be provided by the project proposer.

Dioxins/Furans

Specific dioxin and furan congener emissions need to be entered into the RASS if the information is available. If specific congener emissions are not available, but total emissions of the congener group are available, the total congener group emissions are entered into that row in the RASS Emissions tab. For example, if emissions are not available for each specific penta-chlorinated dioxins (PeCDD), but the total of this congener group is available, the group emissions are entered into the RASS Emissions tab on the row for "pentachlorodibenzodioxins, all isomers". If a project proposer converts individual dioxin/furan congener emission rates to 2,3,7,8-TCDD equivalents, these emissions can be summed and entered the RASS Emissions page on the line for 2,3,7,8-TCDD equivalents (Air Pollutant Identification Number 00-09-1). If refined multi-pathway modeling (e.g., HHRAP-based software) is being conducted, the preferred method is to enter specific dioxin and furan congener emissions rather than 2,3,7,8 TCDD equivalent emissions.

Pollutant identification numbers

If specific air toxics emissions information is available (and the Chemical Abstract Service [CAS] number of the emitted air toxic matches a CAS number on the spreadsheet), enter it directly. In some cases, there is no available CAS number. MPCA air pollutant identification numbers were developed to facilitate the tracking and analysis of air toxics in the RASS.

How to report quantitative risk estimates

Risk results are estimated differently depending on the tool used. Risk results are displayed in various ways in the RASS and Q/CHI spreadsheets, both for the total facility and by pollutant. Mercury fish consumption hazard quotients are presented in the MMREM spreadsheet.

The following HHRAP results need to be submitted in a spreadsheet:

- Indirect, and inhalation cancer and non-cancer risk results by exposure scenario for all receptors
- Indirect, inhalation cancer and non-cancer risk results by exposure scenario for the risk driver pollutants (only for the maximum receptors).

Rounding and significant figures

Due to the uncertainties and variability of data included in a final AERA risk estimate, it is important to discuss rounding and significant figures. The MPCA intends for AERA risk estimates to:

- Reflect uncertainty and variability
- Contain transparent calculations
- Be protective of human health

The MPCA realizes that no general guidance about significant figures will completely fulfill all three of the objectives mentioned above because of uncertainty in emission estimates, toxicity information, and modeling.

Standard rules for rounding apply which will commonly lead to an answer of one significant figure in both risk and hazard estimates. Hazard quotients, hazard indices, and cancer risk estimates are usually reported as one significant figure for presentation and summary purposes. The MPCA recommends rounding only the final reported results, not the intermediate calculations.

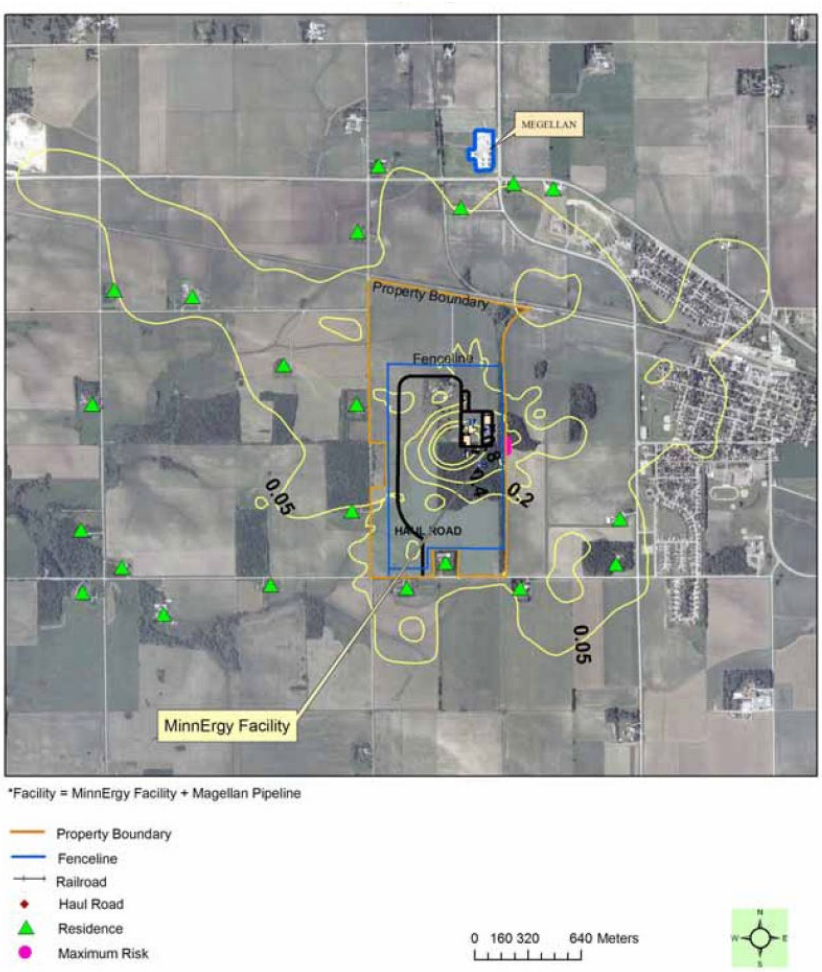
In some circumstances there may be enough information to report single pollutant risk estimates to more than 1 significant figure. This may be the case when there is a toxicity value with low uncertainty, facility specific toxicity value, and nearby meteorological data. However, this is case specific and the MPCA will need to review the work.

Tables showing risk calculations may also require more than one significant figure to represent the calculations transparently. More than 1 significant figure needs to be used in these circumstances.

Displaying risk contours using maps

If conducting a refined risk assessment using the Emission Rate/Chemical Health Index (Q/CHI) process or a receptor grid-based HHRAP type multi-pathway analysis, a project proposer can use AERMOD to generate risk isopleth maps. Locations of all receptors need to be noted on the map. Submit only isopleth maps for risk results above 0.1 (0.1 in 100,000 for cancer estimates).

Figure 5: Example isopleth map to display risk contours



Total facility risks

The use of the RASS in any form results in the summation of maximum modeled risks from all facility sources regardless of where they are located or the time in which they were modeled. This typically results in overly conservative risk estimates. For example, a maximum concentration for pollutant 1 may be modeled in year 2 of the meteorological data, and a maximum concentration for pollutant 2 may be modeled in year 3 of the meteorological data. Furthermore, the maximum modeled concentrations for pollutant 1 and pollutant 2 may not occur in the same location. Since the RASS sums the maximum modeled concentrations from all pollutants from all sources, it is therefore usually the case that the RASS results in facility-specific screening risk estimates that exceed facility risk guidelines. Further investigation is then required using more facility specific information, more refined dispersion modeling, or closer investigation of possible exposure pathways, as discussed in previous sections of this guidance.

Infrequently, screening results for the entire facility may be below human health benchmarks or facility risk guidelines. In these cases, there is no further need for refining the AERA with more facility-specific information. The RASS used for this screening exercise must be submitted to the MPCA for review and approval.

Ethanol facilities

Some proposed Ethanol facilities meeting certain criteria will not be asked to complete an AERA. A project proposer is asked to fill out Form AERA-13 Determination checklist for proposed ethanol facilities to determine if the facility meets the criteria. This form will be reviewed by MPCA staff.

Screening out pollutants and sources using the RASS

Screening analyses may be used as part of the scoping process to eliminate sources, pollutants or exposure pathways that are unlikely to result in human health risks. The default dispersion factors in the RASS can be used to provide screening results. Sources or pollutants should not be eliminated after refined facility modeling is completed (e.g., post AERMOD). The elimination of pollutants from further evaluation does not imply the complete elimination of risk, rather, the contribution from these air toxics to the total facility risk is insignificant relative to the potential risks posed by the pollutants retained for analysis.

Risk-driver levels

The following AERA risk management criteria are used for eliminating pollutants or sources with relatively low total facility risks:

- Pollutant-specific hazard quotient less than 0.1 and cancer risk less than $1x10^{-6}$ (without rounding and including the sum of all exposure routes)
- Total hazard index less than 0.1 and total cancer risk less than $1x10^{-6}$ and for a single emission unit (without rounding and including the sum for all exposure routes and all pollutants)

Once the scope of the AERA has been narrowed using the default dispersion factors the user may choose to run AERMOD to generate more site-specific dispersion factors. Documentation must be provided to demonstrate the rationale for excluding pollutants or sources from further analysis.

Qualitative risk characterization

Qualitative information is important to decision makers and interested community members because it provides context for the quantitative risk estimates. The contextual information is used in all the AERA steps but is particularly important in developing a protocol; and in understanding and communicating the key AERA findings. The qualitative information used in an AERA is documented by the project proposer in the AERA-02 form.

Qualitative information resources

The following resources in Table 11 can be useful in finding contextual information to support decision-makers in making fully informed decisions.

Table 11: Reference Table for qualitative information

AERA 02 form information	What to include	Resources
Receptors and sensitive populations	Schools, daycares, recreation centers/playgrounds, nursing homes, hospitals, and residence locations	Aerial photos from sites referenced above or local records, databases.
General neighborhood information	Nearest residents if not addressed under Receptors and Sensitive Populations.	U.S. Census Bureau: http://www.census.gov/ Minnesota Demographer's Office: http://mn.gov/admin/demography/
Nearby facilities	Map and/or list of permitted facilities with air emissions; not limited to facilities with air permits	What's In My Neighborhood?: https://www.pca.state.mn.us/data/whats-my-neighborhood
Zoning	Description of zoning within a 10 km radius where available	Zoning maps are searchable on the internet for most counties in Minnesota – use your preferred search engine to find "MN zoning maps"

AERA 02 form information	What to include	Resources
Land use	Provide map showing land use within a 10 km radius including farming, forests, residential and industrial areas. It is recommended to verify information with a site visit.	Minnesota County Land Use Maps: https://www.mngeo.state.mn.us/maps/LandUse/index.html Minnesota Land Use and Cover: https://www.mngeo.state.mn.us/chouse/land_use.html
Risk receptor information and isopleths	Maps can be generated using AERMOD when using the Q/CHI methodology. Maps can be produced for each exposure time and scenario, e.g., acute inhalation, by overlaying the risk isopleths with an aerial photograph of the area.	AERMOD software Aerial photographs obtained from either the Agency or other GIS-based source.
Fishable water bodies	Provide map with labels of fishable water bodies. Information on accessibility to water body should be provided when available.	Lake Finder:http://www.dnr.state.mn.us/lakefind/index.html
Farming locations	Provide map showing farming locations surrounding facility. Additional information regarding crop types, animals raised, number of animals, farm size, and other qualitative information about the farm may be provided.	Minnesota County Land Use Maps: https://www.mngeo.state.mn.us/maps/LandUse/index.html

Environmental Justice policy: Implementation in the AERA

Definition

It is the policy of the MPCA to incorporate the concepts of environmental justice into agency work, including AERAs. The MPCA environmental justice policy:

"The Minnesota Pollution Control Agency (MPCA) will, within its authority, strive for the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

The AERA provides a tool by which quantitative risk results may be considered within the context of potential disproportionate impacts on low income and otherwise historically disadvantaged communities. The AERA summary form that is filled out by MPCA staff includes a question about whether or not the facility lies within a potential environmental justice area of concern. This is part of the information presented to MPCA leadership in reviewing the AERA results. The MPCA defines an area of concern for Environmental Justice as an area that meets at least one of the following criteria (this demographic information is available at the census tract level):

- The number of people of color is greater than 40%; or
- More than 35% of the households have a household income of less than 200% of the federal poverty level; or
- At least 40% of people have limited English proficiency; or
- Federally recognized Indian Tribes

Uncertainty and variability in AERAs

The risk assessment process is subject to uncertainty and variability from a variety of sources. These are inherent in human health risk assessment and are not unique to the MPCA AERA. The EPA definition of these terms are included in the paragraphs below.

Uncertainty

The term uncertainty refers to unknown actuals since it is often due to incomplete data. For example, when assessing the potential for risks to people, toxicology studies generally involve dosing of sexually mature test animals such as rats as a surrogate for humans. Since it is not known how differently humans and rats respond, EPA often employs the use of an uncertainty factor to account for possible differences. Additional consideration may also be made if there is reason to believe that the very young are more susceptible than adults, or if key toxicology studies are not available.

Variability

The term variability refers to the range of toxic response or exposure. For example, the dose that might cause a toxic response can vary from one person to the next depending on factors such as genetic differences and preexisting medical conditions. Exposure may vary from one person to the next depending on factors such as; where one works, time spent indoors or out, where one lives, and how much people eat or drink.

Conservatism

The main difference between uncertainty and variability is that variability can only be better characterized, but not necessarily reduced. In addressing uncertainty and variability, the AERA and EPA risk assessments, include assumptions that may increase risk estimates. This is called, "conservatism", and is incorporated into human health risk assessments to ensure that they are as health protective as is reasonable.

Reporting uncertainty and variability in an AERA

Table 12 provides an example of several AERA parameters and possible uncertainties that may be associated with each. An informed qualitative judgment needs to be provided as to the effect of each parameter on the risk estimate.

Table 12: Example AERA uncertainty and variability table

AERA component	Description	Effect on risk estimate	Approximate magnitude
Provide the risk analysis parameter being discussed (examples are provided below)	*Describe the information source and the specific way the information was used, or what assumption was made.*	*Report whether this likely results in an overestimate, underestimate, or if it may over- or under-estimate overall risk estimates.*	*High (would change overall risk estimate by more than 10X),* *Moderate (would change overall risk estimate by approximately 2X),* *Low (would change risk estimate by less than 2X), or Unknown.*
Facility characterization	Assumed 24 hour operation, actual operation limited to 6am to 9pm	Overestimate	Moderate
Chemical identification	Literature review of similar facilities but facility studies may not have considered all possible pollutants	May underestimate	High to unknown
Emissions estimates	Emission factor source was AP-42: controls on facility emission units differ from AP-42 scenario	May over-or under-estimate	Unknown
	Emission factor source AP-42: AP-42 factor is based on average of stack test results	Underestimate	Moderate
	Stack tests with non-detects: non-detects assumed to be at detection limit to estimate emissions	Overestimate	Moderate
	The worst-case fuel is used to estimate each air toxic emission rate from a boiler allowed to operate with multiple fuels	Overestimate	Unknown
	Stack tests with non-detects: non-detects assumed to be zero in emissions estimates	Underestimate	Unknown
Air dispersion modeling	RASS lookup tables: modeled maximum concentrations from several stacks were summed, stacks are distant, which results in maximum concentrations at very different receptor locations	Overestimate	High
	RASS lookup tables: Only one short stack and nearby receptors	May over or underestimate	Unknown

AERA component	Description	Effect on risk estimate	Approximate magnitude
	AERMOD used to calculate dispersion coefficients entered into RASS: pollutants are not paired in time and space	Overestimate	Low
Exposure scenario	Estimated farmer scenario on fenceline, but closest potential farmer is 1km from fenceline.	Overestimate	High
Multi-pathway assessment	MPSFs: unknown how well default assumptions in model represent site conditions	Over or underestimate	Unknown
	Level 3 multi-pathway analysis: unknown how well default assumptions in model represent site conditions	Over or underestimate	Unknown
Toxicity assessment	MPCA/MDH hierarchy: a California REL value an order of magnitude lower was published last month. Pollutant was only one of 3 risk-drivers and overall risks will not change much	Underestimate	Low
	Quantitative cancer risk estimates were not adjusted using early life-stage exposure adjustment factors for linear carcinogens.	May underestimate	Low
	Summed hazard index regardless of health endpoints	Overestimate	Moderate

Cumulative air emission risk analysis

This section of the AERA guidance contains a summary of MPCA's methods for conducting a cumulative AERA and discusses the regulatory framework for this requirement. The cumulative information recommended for a Cumulative Air Emissions Risk Analysis is documented by the project proposer in the AERA-19 form.

The three main objectives of this section are:

- To describe how to complete a cumulative AERA, and the roles of MPCA technical staff and project proposers
- To describe the EQB regulatory requirement to consider the cumulative potential effects
- To describe who is required to, or may be requested to, complete a cumulative AERA

What is a cumulative AERA?

The following concepts of cumulative risk assessment methodologies are shared by AERAs and cumulative AERAs:

- Non-cancer health endpoints are summed at the screening level

The probability of disease of all cancer types are summed as one total cancer risk estimate

- Qualitative contextual information is included
- Risk estimates are reported as a summation of all pollutants
- Risk Estimates are summed from multiple media (air toxic deposition and subsequent uptake into soil, plants, and animals)
- Risk Estimates are summed from multiple pathways (food ingestion, incidental soil ingestion and inhalation)
- Risk estimates are for a total facility and include multiple emission units

A cumulative AERA builds on the facility-specific AERA methodology to include air emissions from all appropriate offsite sources. A cumulative AERA incorporates offsite air emissions sources utilizing modeling, monitoring or qualitative data and information. The choice of the type of information depends on the specifics of the project and the available data.

Approach development and resources

The MPCA developed an approach to meet the intent of the environmental review rules and to be consistent with the Minnesota Supreme Court's CARD decision.

In developing an approach, the MPCA examined EPA guidance on cumulative risk assessment, relevant literature, and past MPCA practices. EPA has published documents describing the framework for and tools for use in cumulative risk assessments: U.S. EPA Cumulative Risk Assessment Framework Document and U.S. EPA's Cumulative Risk Resource Document.

The MPCA also considered data quality and availability, tools, method, time, and resource availability among other technical factors.

How to conduct a cumulative air emissions risk analysis

The MPCA always needs to be consulted before conducting a cumulative AERA. In special circumstances, project-proposers may suggest deviations from this guidance. The cumulative AERA form is available on the AERA Forms and Deliverables website.

Potential air emissions sources to be considered

On-Site Sources

For projects requiring a cumulative AERA, risks based on emissions from stationary sources at the existing, modified and/or proposed facility will already have been estimated in the facility-based AERA. These AERA results need to be included in a cumulative AERA. Tailpipe emissions and dust suspension from mobile sources are included in AERAs if they remain on-site; idling mobile sources are included in an AERA on a case by case basis. If facility-based mobile source emissions are not evaluated in the AERA, their inclusion in the cumulative AERA will be considered.

Off-site Sources

Off-site emissions sources considered for inclusion in a cumulative AERA include:

- **Vehicle tailpipe emissions** and dust suspension for vehicles that leave the facility
- **Offsite point sources** (within 10km)[2] : Examples are facilities with Title V and registration air permits. MPCA staff will provide project proposers with a list of existing and future off-site point-sources from submitted permit applications upon request
- **Offsite area sources**. Examples include smaller stationary emission sources such as dry cleaners, gasoline service stations, or residential wood combustion appliances
- **Ambient background** air concentrations related to sources not associated with sources listed above

The inclusion or exclusion of a quantitative analysis of a specific off-site source depends on the following factors: population density, proximity of existing facility and receptors to nearby point and area sources, local traffic counts and the potential increase in traffic counts associated with proposed project, and availability and quality of data. The inclusion or exclusion of off-site point sources in a cumulative AERA is described in general in the EAW language in terms of "geography" and "timing". The MPCA's interpretation of these terms is discussed below and is the basis for the inclusion or exclusion of off-site point sources.

Timing

Based on the EAW language, the project proposers are asked to include any point sources that are existing at the time of the submission of permit or environmental review materials. A historical facility that has closed operation and is no longer emitting air toxics need not be included as a point source in the cumulative AERA. Potential future projects need to be included as point sources for consideration in the cumulative AERA if the facility/project has submitted plans, a permit application or environmental review materials to the State of Minnesota or a local governmental unit.

Geography

Geography is the other area of consideration for the inclusion of projects/facilities in a cumulative AERA. The major factors contributing to the inclusion or exclusion of an off-site source on the basis of geography are: distance to receptors of interest, emission rates, dispersion characteristics, and the pollutants emitted.

Cumulative AERA sources of information are modeling, monitoring, and qualitative representation.

Quantitative representation of off-site air toxics sources can be derived from either modeled air concentrations and/or ambient monitoring data; and then supplemented with qualitative information. Off-site point sources of air toxics need to be considered in the cumulative AERA within 10 km of the proposed project's receptors of maximum impact.

[2] The distance of 10 km is a generally applicable empirically derived value. This distance was derived by assessing Minnesota point sources with the highest emissions of the most toxic pollutants assessed in the MPCA RASS. Modeling data, or the RASS lookup tables, were used to calculate air concentrations of pollutants, which were then compared to health benchmarks. A distance was reported when that individual pollutant was no longer a risk driver (0.1 for hazard quotients and 1E-6 for cancer risks). The distance of 10km was found to be protective for the point sources that were assessed in this process. In special circumstances a site-specific radius may be determined.

Including modeled air concentrations in a cumulative AERA

The Agency prefers that project proposers use modeled air concentrations for facilities when possible. In general, there is less uncertainty as to source apportionment when source-specific modeled air concentrations are used rather than ambient monitoring data. Source-specific modeled air concentrations also provide information on a broader range of pollutants than does ambient monitoring data. Since source-specific modeled air concentrations are generally not available, relevant air monitoring data sets may be used.

Off-site point sources within 10 km

The origin, or centroid, of a cumulative AERA is the maximum modeled location that is zoned as residential or where people are or could in the future legally reside. Generally, off-site point sources that are farther than 10 km from the maximum modeled location do not need to be modeled individually. Instead, they need to be considered as ambient background sources. Point sources within 10 km from the maximum modeled location need to be identified on a map and considered quantitatively or qualitatively in a cumulative AERA.

Whether to assess off-site point sources quantitatively or qualitatively depends on the availability and quality of air toxics data or existing air dispersion modeling results. Modeling information is sometimes available for off-site point sources that have undergone AERA review or air permitting. If an AERA was completed for the off-site source in question, a RASS is generally available. This RASS needs to be used to calculate dispersion factors for the distance between the off-site point source and the maximum modeled location where people could live. Off-site point sources with a dispersion factor of greater than or equal to 1 µg/m3/g/s (the lowest numerical value for a dispersion factor in the RASS look-up table) needs to be assessed quantitatively when possible. A dispersion factor (greater than or equal to 1 µg/m3/g/s) at the location of the receptor of interest is an indication that the off-site point source has the potential to impact air concentrations at that receptor location. If refined modeling has been completed for the off-site point source, this modeling data may be used to estimate a refined dispersion factor.

If there are no modeled air toxics data from offsite point sources within 10 km of the maximum modeled location where people could live, further analysis is conducted by gathering the following information: the off-site facility's likely emissions profile, processes and fuel type, historical regulatory compliance, public complaints, and dispersion characteristics of the source (stack height, prevailing wind direction). This analysis is completed by the project proposer with support and assistance from MPCA staff. Should any of this information lead MPCA to consider this off-site source to have the potential to increase cumulative air emissions risks by more than pollutant risk driver levels (greater than 0.1 for non-cancer, greater than $1x10^{-6}$ for cancer), the project proposer may be asked to submit emission rates for risk drivers and to develop modeling files.

If further analysis is not possible, yet the MPCA cannot eliminate potential concern for that facility, then ambient monitoring data that best reflects the off-site point sources needs to be selected and the off-site source can be discussed qualitatively.

Off-site mobile, area, and ambient background sources

Air concentrations from off-site mobile, area, and other ambient background sources need to be considered quantitatively to the greatest extent possible and supported by qualitative information. Air concentrations associated with these sources may be included in a cumulative AERA with modeled concentrations from MPCA's Minnesota Risk Screening (MNRISKS) tool. MNRISKS includes air concentrations and risk estimates from all MN air pollutant sources including mobile and area sources. These mobile and area source emissions are from the MN emissions inventory and include general flowing traffic.

Including monitored air concentrations

The most recent and relevant ambient monitoring data may be used to assess offsite sources when modeled air concentrations are not available. Ambient monitoring data may also be used in combination with modeled air concentrations from an off-site point source. In some cases, this may result in over-counting measured pollutants from the ambient monitoring data set that is also modeled. A solution to this issue is to add in only

the modeled pollutants that are not also measured within the ambient monitoring dataset. The limitations of using monitoring data include:

- Some potential risk-drivers may not be measured (e.g. acrolein, dioxins/furans, PAHs, PCBs, and acidic aerosols)
- Detection limit constraints
- Relatively few monitors
- No direct source apportionment
- Potential for over-counting existing components of a proposed project
- Date of monitoring data

Included in Table 13 below are averaged risk results from the Minnesota ambient monitoring network. If there are no off-site sources to be specifically modeled, the project proposer needs to choose risk results from ambient data according to ZIP Code-based population density. In this case, the ambient monitoring data are used to represent off-site area, mobile, point, and ambient background sources. These data are presented as risks that can be summed with the on-site modeled risks.

Table 13: Risk results from ambient monitoring data for Cumulative Air Emission Risk Analyses

Averaged risk values from Statewide MN air monitoring network	
Mostly Rural Sites (ZIP Code population density of less than 500 people per square mile):	Intermediate Sites (ZIP Code population density between 500 and 2999 people per square mile):
Acute Hazard Index Values: **1.5**	Acute Hazard Index Values: **1.7**
Chronic Non-Cancer Hazard Index Values: **0.7**	Chronic Non-Cancer Hazard Index Values: **0.6**
Cancer risk values in 100,000: **1.4**	Cancer risk values in 100,000: **3.3**

Note: ZIP Code population density can be found at www.city-data.com. The population density needs to be found using the maximum modeled location where people could live.

A more refined analysis of population density using Census data is available upon request from MPCA staff.

Below are some of the conditions under which MPCA will consider site-specific ambient monitoring data for use in Cumulative Air Emission Risk Analyses. Project proposers with conditions described in the list below, need to request specific ambient monitoring data.

- Unique site location (e.g., Iron Range)
- Unique population consideration (e.g., potential environmental justice area)
- Unique modeled off-site sources (e.g., coal or biomass energy producer with recently modeled emissions)
- Urban sites (ZIP Code population density of over 3,000 people per square mile)
- Recently monitored ambient data within 10km of the facility
- Sites described in specific legislation

Explanation of risk calculations from ambient monitoring data

Risk estimates from all MPCA ambient monitoring data are available upon request. These risk estimates are updated annually. Measured air toxics concentrations are included in the risk estimates if over 20% of the pollutant measurements are above the detection limit within a year, there are at least 3 unique values, and the sample collection was 75% complete by season.

The following steps are carried out to produce risk estimates from ambient monitoring data:

1. The detected data and flagged non-detects are used to calculate a 95% upper confidence limits of the arithmetic mean (95UCL-AM). This calculation is completed for each pollutant and year using Maximum Likelihood statistics.

2. Chronic risk estimates (cancer and non-cancer): The 95% UCL-AM is then divided by the appropriate inhalation health benchmark (IHB) to calculate a risk estimate (cancer risk, chronic non-cancer) for each pollutant with an IHB in the RASS.
3. Acute risk estimates (non-cancer): Air toxics are measured for 24 hours at a frequency of one in twelve days. Hourly maximum concentrations are estimated from these 24 hour measurements by multiplying the second highest annual 24 hour measurement by ten. Trichloroethylene has a 24 hour inhalation health benchmark, not an hourly health benchmark, and therefore isn't multiplied by 10. For pollutants that are measured hourly (nitrogen dioxide, ozone, sulfur dioxide), the highest measured value is used directly. Each of these short term air concentrations are divided by the appropriate inhalation health benchmark to calculate an acute non-cancer hazard quotient.
4. The pollutant specific risks are summed within the following categories: chronic cancer risk, chronic non-cancer hazard indices, and acute non-cancer hazard indices.
5. All air toxics are not measured at every site, and in these cases, risks are summed by pollutant category and then averaged by population density, region, or other monitoring location category.

Population density-based risk estimates

Many proposed facilities do not have nearby monitoring locations. In these cases, monitoring data are averaged by population density (rural, intermediate, and urban) or region (Iron Range). Some of the ambient monitoring sites that are within a ZIP Code identified as rural or intermediate are proximate to a facility. Therefore, some of these risk estimates may be higher than expected for a truly rural or intermediate population density location.

Including qualitative information

Quantitative estimates of risks from monitored or modeled data need to be supplemented by qualitative information. Sources of qualitative information include but are not limited to: distance to the proposed project, processes and fuel type, historical regulatory compliance, public complaints, source dispersion characteristics, land use or zoning, population density, distance to receptors of interest, likely emissions profiles, prevailing wind direction, current mobile source activity, and a projection of how mobile source activity may change.

The risk results reported in Table 13 include inhalation-only risks. Past AERAs have shown that potential on-site risk drivers are often from ingestion pathways. In some instances, MPCA has included a qualitative discussion of background risk from food basket surveys (e.g., population averaged baseline risks from dioxins in food products) in the cumulative AERA. Until methods for the quantitative estimation of non-inhalation risks from off-site emissions are developed, project proposers may discuss non-inhalation risks from off-site emissions qualitatively.

Who must conduct a cumulative AERA?

All mandatory AERAs require a cumulative AERA, because the AERA threshold is tied to the trigger requiring environmental review. The MPCA, however, retains the discretion to request a cumulative AERA for facilities completing a non-mandatory AERA. These decisions are influenced by the following factors:

- Proposed project emissions (typically greater than 100 tons per year)
- Data availability and quality
- Proximity of receptors
- Presence and location of nearby sources
- Emissions of nearby sources
- Potential areas of concern for environmental justice
- Ambient air concentrations based on monitoring data.

This list is not exhaustive and additional information may be considered.

Regulatory framework

Minn. R. 4410.1700, subp. 7, item B, states that the Responsible Governmental Unit (RGU) must consider specific factors identified in the rule to decide whether a project has the potential for significant environmental effects when determining the need for an EIS. One of these factors is the "cumulative potential effects of related or anticipated future projects." The RGU is to identify any past, present, or reasonably foreseeable future projects that may interact with the project described in the EAW in such a way as to cause cumulative potential effects. Furthermore, the RGU is asked to describe the nature of the cumulative potential effects and summarize any other available information relevant to determining whether there is potential for significant cumulative potential effects.

In the Minnesota Supreme Court CARD Decision, the Court described how an RGU should apply the rule criterion on cumulative potential effects for determining when to order an EIS.

Cumulative AERA risk management framework

The type of final risk management decisions made at the MPCA include determination of adequacy of an environmental review document, a negative or positive declaration for the continuation to an EIS, or the issuance of a permit. These final risk management decisions are made by the MPCA commissioner or a delegate of the commissioner. An AERA and a cumulative AERA are only a portion of the information used in these larger agency-wide decisions. Decisions that include consideration of an AERA and/or a cumulative AERA incorporate both the qualitative and the quantitative information.

Cumulative risk goals and facility risk guidelines

The EPA guidance for conducting air toxics analyses and making risk management decisions at the facility and community-scale level considers a range of "acceptable" cancer risks from one in a million to one in ten thousand. For non-carcinogenic pollutants, EPA considers a reference level, or hazard index, of 1. Exposures above the reference level may have some potential for causing adverse effects.

Cumulative risk guidelines are currently unavailable but are under discussion at the state and national level. Several conceptual starting points include: the acceptance of EPA's cancer risk range of one in one million to one in 10,000; using a hazard index of one for similar non-cancerous human health systemic effects; or developing "acceptable" risk increments for each source contributing to risk at a selected receptor (similar to the PSD process).

Cumulative air emissions risk analysis limitations

Ingestion-based risks from off-site sources are not quantitatively assessed in the cumulative AERA. There are methodological challenges associated with cumulative ingestion-based risk analyses. The uncertainty associated with these challenges could be propagated with the summation of multiple pathways, routes, and endpoints. Other issues not addressed by the cumulative AERA are like those not included in facility AERAs and include: indoor air quality, pollutants without health benchmarks, chemical transformation, pollutant interaction effects that are greater than or less than additive (e.g., synergistic toxicity, antagonistic absorption), occupational exposures, and personal micro-environmental exposure.

Acronyms

AERA:	Air Emission Risk Analysis
AERMOD:	American Meteorological Society/Environmental Protection Agency Regulatory Model
COPI:	Chemicals of Potential Interest
EAW:	Environmental Assessment Worksheet
EIS:	Environmental Impact Statement
FIRE:	U.S. EPA's Factor Information Retrieval Data System
HAPs:	Hazardous Air Pollutants (https://www.epa.gov/haps)
HBV:	Health Based Value
HI:	Hazard Index
HRV:	Health Risk Value
HQ:	Hazard Quotient
IHB:	Inhalation Health Benchmark
IRAP:	Industrial Risk Assessment Program
IRIS:	Integrated Risk Information System
MACT:	Maximum Achievable Control Technology
MDH:	Minnesota Department of Health
MSDS:	Material Safety Data Sheets
MPCA:	Minnesota Pollution Control Agency
NAAQS:	National Ambient Air Quality Standards
NESHAP:	National Emissions Standard for Hazardous Air Pollutants
OSWER:	Office of Solid Waste and Emergency Response (EPA)
PAHs:	Polycyclic Aromatic Hydrocarbons
PBTs:	Persistent Bio-accumulative Toxic chemical
PCB:	Polychlorinated Biphenyls
PTE:	Potential to Emit
RASS:	Risk Assessment Screening Spreadsheet
REL:	Reference Exposure Level (California EPA)
EPA:	United States Environmental Protection Agency
EPA AP-42:	U.S. EPA's air pollutant emissions factor database

Definitions

As used in this Guidance, the following terms have the meaning provided.

Accidental release: non-routine release to air due to various process upsets such as: start-ups, shutdowns, malfunctions of emission units or air pollution control systems

Acute exposure: Exposure to one or more doses of a contaminant within a short period of time. Acute exposure is evaluated using the maximum ambient air concentration of a contaminant that occurs during one hour.

Agency: Minnesota Pollution Control Agency

Air toxics: pollutants that are known or suspected to cause cancer or other adverse health effects and may include criteria pollutants that have an inhalation health benchmark in addition to the air quality standard. The MPCA defines air toxics as any pollutant that has a health benchmark from the AERA hierarchy of toxicity information.

AP-42: Air pollutant emission factors from "Compilation of Air Pollutant Emission Factors." Online at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors.

Background: Background air quality is the general concentration of pollutants in the air, not including the pollutants contributed by the source or sources under review.

Cancer risk: Cancer risk from exposure to air emissions from a given facility is the probability that a hypothetical human receptor will develop cancer based on an assumed set of exposure, model, and toxicity assumptions. For example, a risk of 1x10-5 is interpreted to mean that a hypothetical individual has up to a one in 100,000 chance of developing cancer during their lifetime from exposure to pollutants emitted from the facility under evaluation.

Carcinogen: An agent capable of inducing a cancer response. Carcinogenic air toxics may act by initiation, promotion, and conversion.

CAS number: Chemical Abstracts Service registry number. Each chemical has a CAS registry number to ensure unique identification.

Ceiling value: Acute HRVs and California Reference Exposure Levels with developmental endpoints need to be considered ceiling values not to be exceeded. Adverse developmental effects could occur upon short term exposure to these chemicals at concentrations above inhalation health benchmarks.

Chemicals of potential interest (COPI): The chemicals known or reasonably expected to be emitted by a facility.

Chronic exposure: Multiple exposures occurring over an extended period of time or a significant fraction of an individual's lifetime. For the purpose of AERA, chronic exposure is evaluated using an annual averaged ambient air concentration of a contaminant.

Conservatism: In addressing uncertainty and variability, the AERA methodology includes assumptions that may increase risk estimates. This is called "conservatism" and is incorporated into human health risk assessments to ensure that they are as health protective as is reasonable.

Conservative: There are never perfect data sets upon which to base a risk assessment and many assumptions must be made. In risk assessment, decisions are made that increase risk estimates if there is uncertainty in a value. Risk assessments are completed in this way so that risk management decisions made incorporating this information are protective of public health. This maximizing of risk estimates when there are uncertainties is called "conservatism". These assumptions are referred to as "conservative".

Criteria pollutants: The pollutants for which EPA has established national ambient air quality standards. The criteria pollutants are particulate matter less than 10 microns in diameter (PM10), particulate matter less than 2.5 microns in diameters (PM2.5), sulfur dioxide (SO2), oxides of nitrogen (NOx), carbon monoxide (CO), ozone, and lead (Pb).

Cumulative risk assessments: An analysis, characterization, and possible quantification of the combined risks to health or the environment from multiple agents or stressors.

Developmental toxicants: Chemicals with acute Health Risk Values (HRVs) and acute Reference Exposure Levels (RELs) with "reproductive/developmental" listed as endpoint of concern (or toxicologic endpoint). Exposure of a developing fetus or newborn to these chemicals for short periods of time during a critical period of development can result in severe adverse effects.

Dispersion factor: a numerical value that represents the proportional relationship between an emissions rate from a stack or vent and the resulting ambient air concentration.

Estimated future actual emissions: The mass of pollutants emitted under an operating scenario that is reflected by some future business case that is not the "potential to emit" for the emissions source or facility.

Facility: a business or source of air emissions.

Facility project team: an MPCA review team generally including an air permit engineer, an air dispersion modeler, and a risk assessor.

Hazard: numeric value representing the potential for adverse health effects from non-cancerous pollutants; value can be described as a hazard index or hazard quotient, depending on whether a single pollutant or multiple pollutants are represented.

Hazard index: The sum of more than one hazard quotient for multiple substances with the same or similar toxic endpoints. For AERA purposes, at the screening level it is assumed all noncarcinogens have the same or similar toxic endpoint. A hazard index less than one poses no appreciable likelihood of adverse health effects to potential receptors, including sensitive populations.

Hazard quotient: The ratio of a single substance exposure level to an inhalation health benchmark (IHB) for that substance derived from a similar exposure period (e.g., Conc/IHB, where Conc is the air concentration for a particular contaminant, and the IHB is the inhalation health benchmark. A hazard quotient less than one poses no appreciable likelihood of adverse health effects to potential individuals, including sensitive populations, if there are no other pollutants present.

Hazardous Air pollutants (HAPs): The 188 chemicals identified in the Clean Air Act. The specific list can be found at: https://www.epa.gov/haps.

Hierarchy of toxicity data sources: MPCA and MDH guidance for the preferred order for the selection of toxicity data sources. Specific MDH guidance > MDH HRVs > USEPA IRIS > CalEPA (OEHHA) > ATSDR > PPRTV > MPCA.

Incremental cancer risk: Excess risk to an individual, over background risk of cancer, attributed to lifetime exposure to a cancer-causing chemical.

Inhalation health benchmark (IHB): A chronic IHB is a concentration in ambient air at or below which an air toxic is unlikely to cause an adverse health effect to the public when exposure occurs daily throughout a person's lifetime. An acute IHB is a concentration in ambient air at or below which an air toxic is unlikely to cause an adverse health effect to the public when exposure occurs over a prescribed period. For implementation purposes, acute IHBs are compared to one-hour averaged concentrations. A subchronic IHB is the concentration in ambient air at or below which the air toxics is unlikely to cause an adverse health effect to the public when exposure occurs on a continuous basis over a less than lifetime exposure. For implementation purposes, subchronic IHBs are compared to a monthly averaged concentration.

Modification: The definition for "modification" is provided in Minn. R. 7007.0100, subp. 14.

MPCA air pollutant identification numbers: MPCA has developed a system of applying identifying numbers to groups of air toxics that do not have CAS numbers.

Potential to emit: The maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant, including air pollution control equipment and restriction on hours of operation or on the type and amount of fuel combusted, stored, or processed, shall be treated as part of its design if the limit or the effect it would have on emissions is federally enforceable. (Minn. R. 7055.0100, subp. 35a)

Project: a way of referring to a facility that is undergoing an AERA, this generally refers to the potential change in the facility that may result in a change in air emissions.

Qualitative analysis: Refers to any pertinent information not represented by the estimated "risk" values generated by the RASS. The AERA qualitative analysis may include qualitative, semi-qualitative, and quantitative components.

Quantitative analysis: The estimation of cancer risks and hazard indices using the RASS.

Reference concentration (RfC): Pollutant concentration in air that is expected to cause no harm when exposure occurs daily for a 70 year lifetime.

Risk: Characterizes estimated cancer risks and non-cancer health endpoints.

Speciation: Chemicals are often a part of a larger group or class, such as polyaromatic hydrocarbons (PAHs). Speciation is a process in which individual chemicals emitted at a facility are identified and removed from the larger group or class for individual assessment.

Surrogate: In the AERA process, IHBs for specific chemicals have been applied to compounds, groups, or mixtures containing a fraction of that specific chemical. When a value that was developed for one specific chemical is applied to other chemicals, that value is known as a surrogate value.

Toxic endpoint: The endpoint of cancer for carcinogens or the organ or physiological system(s) affected by exposure to non-carcinogens. For carcinogenic air toxics, the organ or physiological systems are not differentiated, but all treated as a single endpoint.

Uncertainty: Uncertainty refers to our inability to know for sure - it is often due to incomplete data. For example, when assessing the potential for risks to people, toxicology studies generally involve dosing of sexually mature test animals such as rats as a surrogate for humans. Since we don't really know how differently humans and rats respond, EPA often employs the use of an uncertainty factor to account for possible differences. Additional consideration may also be made if there is some reason to believe that the very young are more susceptible than adults, or if key toxicology studies are not available. (From EPA risk assessment glossary)

Unit risk: The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/m3 in air.

Variability: This refers to the range of toxic response or exposure - for example, the dose that might cause a toxic response can vary from one person to the next depending on factors such as genetic differences and preexisting medical conditions. Exposure may vary from one person to the next depending on factors such as where one works, time spent indoors or out, where one lives, and how much people eat or drink. (From EPA risk assessment glossary)

Volatile organic compounds (VOCs): Compounds identified as participating in photochemical reactions that contribute to the concentration of ozone in the ambient air. VOC is defined by EPA definition 40 C.F.R. 51.100(s).