AIR QUALITY MODEL GUIDELINE

Alberta Government

Air Quality
Model Guideline

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PREFACE

The Alberta Environment and Sustainable Resource Development (ESRD) Air Quality Model Guideline (Guideline) is intended for operations and proposed operations that require an *Environmental Protection and Enhancement Act* (EPEA) approval, that operate under a Code of Practice for emissions to the atmosphere, or as required by other regulatory agencies within Alberta.

ESRD has developed the Guideline to ensure consistency in the use of dispersion models for regulatory applications in Alberta. The practices recommended within this Guideline are a means to ensure that these objectives are met.

The Guideline outlines ESRD's air quality modelling (also commonly referred to as dispersion modelling or air dispersion modelling) requirements and methods. Although some specific information on models is given, the user should refer to user guides and reference materials for the model of interest for further information on air quality modelling. The Guideline will be reviewed regularly to ensure that the best and most practical available tools are being used to predict air quality.

Additional information relevant to dispersion models can be located at these web pages:

- http://www.environment.alberta.ca/622.html
- http://www.environment.alberta.ca/623.html
- http://www.epa.gov/scram001

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1.0 INTRODUCTION

This Guideline provides detailed guidance on suitable methods and approaches that should be used to assess air quality from emission sources. It sets out:

- the statutory authority;
- an overview of the approach;
- guidance on appropriate technical methods, and
- the information required to demonstrate that a source meets the Alberta Ambient Air Quality Objectives (AAAQO).

It is not intended to provide a technical description of the theory behind air quality modelling - such information is widely available in other published documents, and references are provided within the text.

Detailed advice on the types and uses of air quality models is provided in Sections 2 to 4. Section 5 provides guidance on the application of regulatory models, describing individual models and their intended uses. Section 6 gives Internet addresses for a variety of modelling resources. Section 7 provides some information about regional modelling in the Province. Appendix A lists the contents of screening assessments expected by ESRD. Appendix B lists the expected contents of refined and advanced assessments. There are a key number of technical skills and competencies required to perform air quality modelling. These competencies are outlined in Appendix C.

1.1 Purpose of the Air Quality Model Guideline

ESRD has developed the Air Quality Model Guideline to ensure consistency in the use of air quality models in air quality assessments. The objectives are to:

- provide for uniform benchmarking;
- provide a structured approach to selection and application of models;
- ensure that there is a sound scientific basis for the use of alternatives, when alternatives are appropriate, and
- detail the required content of assessments submitted to the department.

Sections 2 to 5 of the Guideline address only primary substances directly emitted from a source. Some substances are formed in the atmosphere as a result of the interaction of these primary substances with substances from either natural or industrial sources. These are known as secondary substances (e.g., secondary particulate, acid deposition and ozone). Concentrations of secondary substances must be estimated by other means acceptable to ESRD as described in Section 7.

1.2 Statutory Authority

This Guideline is issued by ESRD, under Part 1, 14 (4), the *Environmental Protection and Enhancement Act, 1992* (EPEA). This document replaces all previous versions of the Alberta Air Quality Model Guidelines.

This Guideline should be read in conjunction with the AAAQO and the Air Monitoring Directive, ESRD 1989 or 2006, as amended.

1.3 Air Quality Models

ESRD works with Albertans to protect and enhance the quality of the air through a regulatory management approach that includes:

- air quality models,
- ambient air quality objectives,
- atmospheric emission inventories,
- source emission standards,
- approvals,
- environmental reporting,
- ambient air quality monitoring,
- source emission monitoring,
- inspections/abatement, and enforcement, and
- research.

Information from emission inventories and source controls are utilized in air quality modelling to relate the resulting ambient air quality predictions to the ambient air quality objectives. Ambient monitoring determines the actual air quality resulting from the emissions.

The purpose of a dispersion model is to provide a means of calculating ambient ground-level concentrations of an emitted pollutant given information about the emissions and the nature of the atmosphere. The amount released can be determined from knowledge of the industrial process or actual measurements. However, predictive compliance with an ambient air quality objective is determined by the concentration of the pollutant at ground level. Air quality objectives refer to concentrations of pollutants in the ambient air, not in the emission source. In order to assess whether an emission meets the ambient air quality objective it is necessary to determine the ground-level concentrations that may arise at various distances from the source. This is the function of a dispersion model.

A dispersion model is a set of mathematical relationships or physical models, based on scientific principles that relate emission rates of an air contaminant to the resulting ambient concentrations. Model predictions are useful in a wide variety of air quality decisions, including determining appropriateness of facility location, monitoring-network design, and stack design. Models also provide information on the areas most influenced by emissions from a source, the contribution of weather to observed trends, and the air quality expected under various scenarios. Dispersion modelling requires knowledge of emission rates and the local meteorology and topography.

1.4 Levels of Modelling

The choice of dispersion model depends on a number of factors. There is a wide range of models available, and it is important that the user selects the model that fits the demands of the task. Generally, there are three levels of assessment:

1. A screening assessment is a simple and quick way to estimate a "worst-case" predicted concentration.

2. A refined assessment, because of its higher level of sophistication, more closely estimates actual air quality impacts.

3. An advanced assessment treats specific dispersion processes in greater detail. It potentially gives more accurate results but requires more input data. The user must be careful to ascertain whether the selected dispersion model is being applied to a situation for which the model was designed.

2.0 MODELLING PROTOCOL

A dispersion model is a series of equations describing the relationships between the concentration of a substance in the atmosphere arising at a chosen location, the release rate, and factors affecting the dispersion and dilution in the atmosphere. The model requires information on the emission characteristics (see Section 3.1) and the local meteorology (see Section 3.2). Modelling can also be used to predict future scenarios, short-term episodes, and long-term trends.

Nearby buildings and complex topography can have significant effects upon the dispersion characteristics of a plume. Buildings may cause a plume to settle to ground much closer to the stack than otherwise expected, causing significantly higher ground level concentrations. Plumes can impact directly on hillsides under certain meteorological conditions, or valleys may trap emissions during low-level inversions.

A hierarchy of commonly used dispersion models has been established, categorizing the models according to how they might be used within the assessment process. For example, 'screening' models are used as a benchmark or an initial step of the review, and refined models for more detailed analysis. Advanced models may be needed, depending upon the type of source(s) being studied and the complexity of the situation.

2.1 Modelling Decisions

All proposed emissions to the atmosphere that are subject to an EPEA approval from ESRD, that operate under a Code of Practice, or as required by other regulatory agencies in Alberta are subject to the appropriate modelling which includes baseline assessment (see Section 4.2). For other types of facilities, the dispersion models outlined in this Guideline may be used to demonstrate compliance with the AAAQO. The flow chart for modelling categories is shown in Figure 1.

When a renewal or an amendment is required for existing facilities, an assessment using the current models must be submitted as part of the application.

Further modelling may be required at the discretion of the Director, if

- the screening modelling predicts exceedance of an AAAQO,
- there are many other emission sources in the area,
- the area contains sensitive receptors,
- changes in emissions are expected at the facility, or
- there are other situations deemed necessary to be considered by the Director.

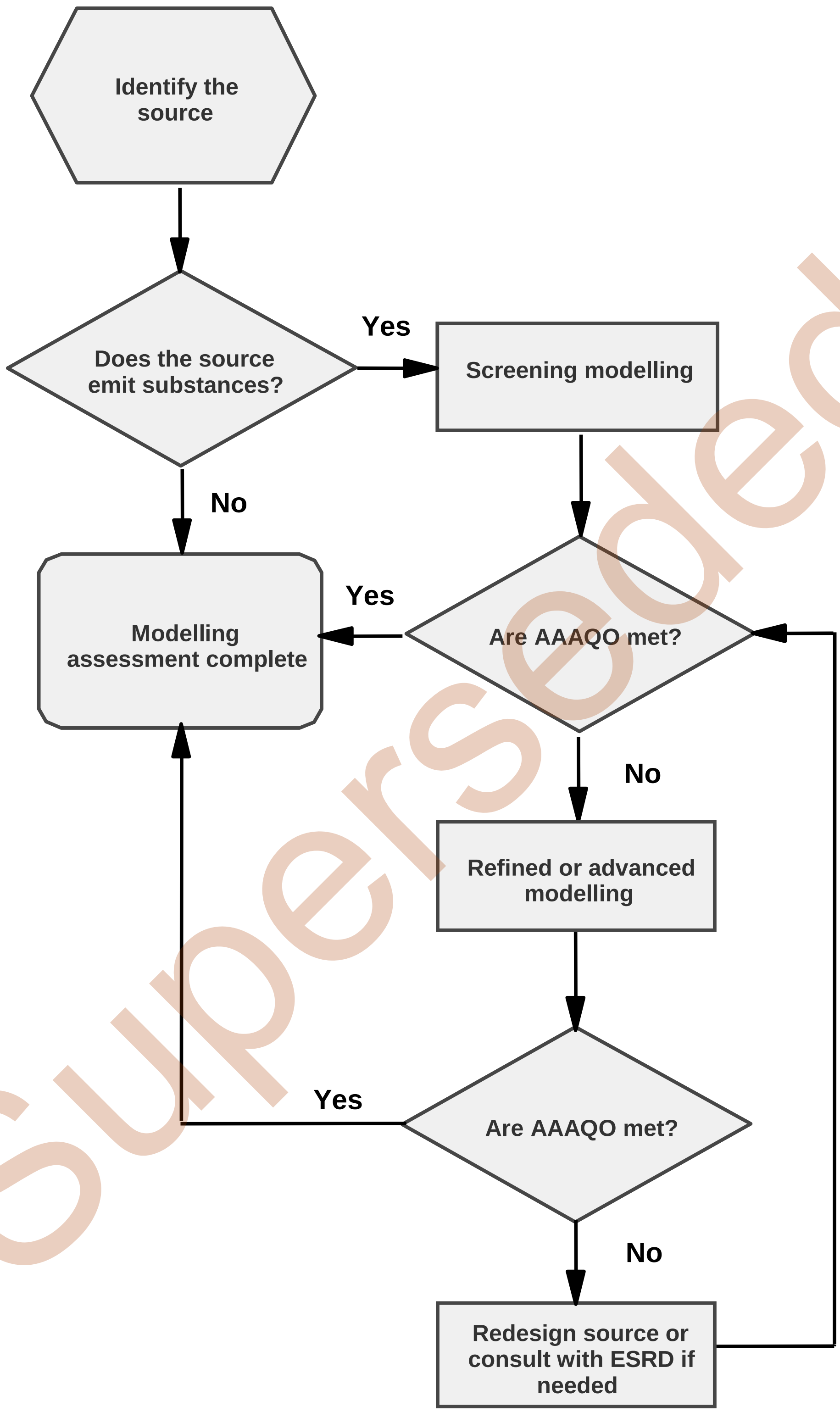

Figure 1. Flow chart indicating situations in which different categories of dispersion models might be used.

2.2 Screening Model

The first tier of evaluation for single- or multiple-source impact employs a screening method such as AERSCREEN. The screening model results serve as a benchmark for each type of source and for comparison against other sources.

AERSCREEN allows for emission inputs, source locations, building downwash, receptors, and meteorological data. AERSCREEN uses the screening mode of the AERMOD model. AERSCREEN is able to generate a site-specific worst-case meteorological data and incorporates complex terrain algorithms. AERSCREEN produces hourly averages and includes time factors for 3-hr, 8-hr, 24-hr and annual averages, which should be used when available. For any other averaging periods, where there is no pre-determined value generated by the model, apply the following formula:

> *Impact parameter* = 1.1233 * (averaging period in hours)$^{-0.2906}$
>
> Multiply the calculated *impact parameter* (appropriate for the averaging period in question) by the maximum predicted 1-hour concentration to obtain the relevant average.

In order to simplify the running of the computer model, AERSCREEN has the option of using the pre-set meteorological conditions included within it. There is then no need to consider local meteorology. The model will calculate worst-case concentrations and may provide the user with information on the meteorological conditions that gave rise to these concentrations. The default MAKEMET options should be used.

AERSCREEN gives an estimate of the highest concentrations that are likely to occur. The model only treats one source at a time, however, if multiple sources are not further than 500 m apart or at different elevations, the sources can be modelled separately, and the maximums (regardless of location) should be totalled. In such an approach, building downwash needs to be assessed carefully.

If concentrations, after adding the baseline concentrations, are below the AAAQO, it is usually unnecessary to undertake further modelling (see Section 4.2). Figure 2 shows the flow chart for the screening level.

2.3 Refined Models

The second tier or refined assessments are required to address the impacts of single or multiple sources, if any of the following conditions apply:

- The screening assessment predicts exceedances of an AAAQO;
- The area is environmentally sensitive (e.g., a national park); and/or
- Public concerns need to be addressed (e.g., sensitive receptors).

Brief descriptions of the regulatory refined models are presented in Section 5.2 (See Section 4 for output interpretation).

2.4 Advanced Models

For an advanced assessment using an alternative or modified model, details should be verified with ESRD prior to commencing the modelling. Brief descriptions of the rationales for using advanced modelling are presented in Section 5.3.

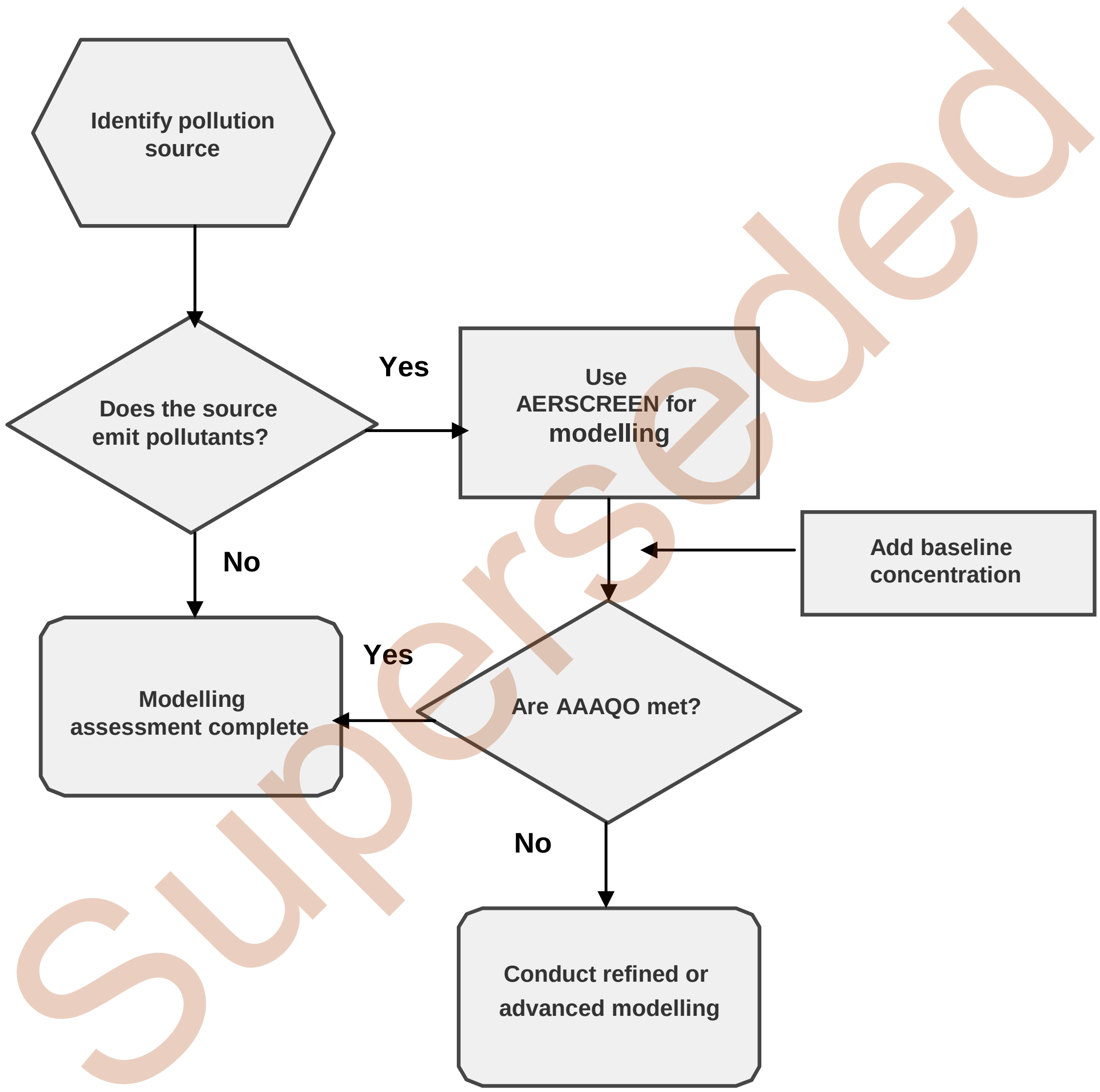

Figure 2. Flow chart for screening modelling tier.

3.0 INPUT DATA

All dispersion models require some form of input data that describe how much of a pollutant is being emitted, details on how the pollutant is being emitted, and the environment into which the emission occurs. It is also necessary to define the locations at which the impact of the emissions is to be predicted; these are termed 'receptor' locations.

The accuracy of the data input to the model has a significant effect on the accuracy of the predicted concentrations. Where the model assumes that the emissions are not chemically transformed in the atmosphere, the predicted concentration is directly proportional to the emission rate, i.e., if the emission rate is doubled, the predicted concentration also doubles. This relationship follows regardless of how simple or sophisticated the dispersion model is. The collation of accurate emissions data is therefore extremely important and proper QA/QC procedures should be undertaken.

3.1 Source Input Data

Different source types are defined as follows:

- ***Point sources*** are localized sources such as stacks or flares. The source parameters normally required for point sources include the UTM or grid coordinates, emission release height (i.e., stack height), exit velocity, stack diameter, exit temperature and mass emission rates of the substance of concern.

- ***Line Sources*** are sources where emissions are in linear form such as roads and rail lines. Parameters normally required for line sources include the dimensions of the line and the mass emission rates.

- ***Area sources*** are clusters of point or line sources (e.g., fugitive emissions from industrial processes having numerous vents). Parameters normally required for area sources include the coordinates of the area perimeter, the emission release height, and the mass emission flux rate of the substance of concern (i.e., mass emission rate per unit of area, $g/s.m^2$).

- ***Volume sources*** are three-dimensional sources such as area sources distributed with a vertical depth, for example, emissions from lagoons. Parameters normally required for volume sources include the coordinates of the volume dimensions and the mass emission rates.

The selection of emission rates for input into the model depends on the type of model and the purpose for which the model is being used. When predicting the hourly, daily and 30 day averaging periods (or any other averaging periods other than the annual) the maximum approved emission rates must be used. However, when the model is used to predict annual average concentrations, average emission rates will be adequate for the purpose.

For areas with multiple facilities, the emissions of all of the other industrial sources within a minimum of 5 km should be included. Stack parameters from existing facilities can be determined from, in order of preference: approval limits, continuous emission monitoring conducted according to the *Continuous Emission Monitoring System* (*CEMS) Code* (ESRD, 1998), or manual stack surveys conducted according to the *Alberta Stack Sampling Code* (ESRD, 1995). In some cases it is not practical to conduct manual stack surveys continuous emission monitoring, so emission factor estimates from published sources can be used (manufacturer specifications or AP-42, (U.S. EPA, 1995a)).

If sources operate only during specified hours, the modelling analysis can be restricted to those hours of operation. If this type of assessment is selected, special approval conditions may apply to restrict the operation to the time periods that were modelled.

Continuous and non-routine flares should always be designed in conformance with the most current guidelines and standards recommended by ESRD or the Alberta Energy Regulator (AER), formerly the Energy Resources Conservation Board. Non-routine flares should be modelled and assessed using guidance from the most current version of the "*Emergency/Process Upset Flaring Management: Modelling Guidance*", ESRD, 2003, or as amended. The AER provides tools for flaring calculations, posted on their website, which are acceptable modelling tools for the intended purposes of routine and non-routine flaring or incinerating.

Fugitive sources are often difficult to characterize since their emissions may vary with wind speed, temperature and time of day (for particle emissions) or process changes. AP-42 emission factors can be used to estimate fugitive emissions.

3.2 Meteorological Data

AERSCREEN is able to generate a site-specific worst-case meteorological data set, the input of meteorological data is not required into the AERSCREEN model.

For refined or advanced assessments more representative meteorological data, both temporally and spatially, for the modelling domain should be used. Meteorological data can come from two sources: ground meteorology or modelled meteorology (or a combination of the two) depending upon the application. Within this context, ESRD allows the following:

a. Applications for which there is on-site meteorology available, that is judged to be representative of the modelling domain, may use the on-site meteorology air quality modelling assessment provided:

    i. There is a minimum of one year of hourly on-site (not modelled) meteorology available. On-site (within facility boundary) meteorology must be related to the longer term (seasonal or annual) by statistical methods. Relating on-site meteorology to data from climate or meteorological stations having longer collection periods ensures that on-site data are temporally representative of meteorology for the entire modelling domain. A data set should not be used if fewer than 90% of the annual data are available. When missing data values arise, they should be handled in one of the ways listed below (U.S. EPA, 2000), in the following order of preference:

ii. If there are other on-site data, such as measurements at another height, they may be used when the primary data are missing and corrections based on established vertical profiles should be made. Site-specific vertical profiles based on historical on-site data may also be appropriate to use after consultation with ESRD.

iii. If there are only one or two missing hours, linear interpolation of missing data may be acceptable; however, caution should be used when the missing hour(s) occur(s) during day/night transition periods.

iv. If representative off-site data exist, they may be used, only for missing data values. In many cases, this approach is acceptable for cloud cover, ceiling height, mixing height, and temperature. An assessment to determine whether this data is adequately representative will involve an examination of the surrounding terrain, surface characteristics, and the height of the source versus the height of the measurements. Meteorological data should be considered representative only when the monitoring site and the facility site are in climatologically similar regimes (U.S. EPA 2000).

The upper air sounding data should be taken from the most representative or closest upper air monitoring station or the current ESRD meteorological data set (provided the ESRD data and on-site data temporally coincide) available on the ESRD website http://environment.alberta.ca/01119.html.

b. For all other applications, five years of modelling must be undertaken with data taken from the ESRD meteorological data set serving as the basic meteorological data set to be used (in CALPUFF applications this would be the initial guess field) to be supplemented by ground based meteorology, where appropriate. In summary:

   i. The ESRD meteorological data set supplemented with meteorology from all readily available (publically accessible) ground meteorology within the modelling domain whose meteorology temporally coincides with the five years provided in the ESRD data set. Missing meteorological data from these stations should be treated as per the instructions for similarly treating missing data for on-site meteorology (outlined above). Complete information on which stations were used and the extent to which any of their data was treated must be provided as part of the reporting process.

   ii. When there are no available ground meteorology in the modelling domain or the data do not temporally coincide with the ESRD meteorological data set or the data is incomplete then the ESRD meteorological data set should be used by itself.

No other meteorological data sets are acceptable.

3.3 Surface Characteristics

Surface characteristics determine the degree of ground turbulence caused by the passage of winds across surface structures.

In CALMET surface characteristics are determined by the terrain data input into the model. Refer to the most recent CALMET user guide for default settings for surface characteristics.

For AERMOD screening assessments the following method is to be used for selecting the rural or urban surface roughness categories.

Classify the land use within a 3-km radius of the source. If more than 50% of the land use falls within the following categories—heavy or light industrial, commercial, and compact residential (two-story dwellings, limited lawn sizes)—it is considered to be urban. Otherwise, use the rural coefficients by selecting rural roughness, except for forests, which are treated as urban locations.

The input for the AERMET meteorological processor of AERMOD requires surface roughness, Bowen ratio and albedo parameters. Although there are default values for surface roughness, the monthly values should be used if available. When monthly data is unavailable, a representative value can be selected based on the land use type as a function of season within a 3 km radius of the input meteorological data (Table 1).

The EPA released AERSURFACE in 2008, a utility to obtain realistic and reproducible surface characteristics using United States land cover datasets. Unfortunately, these datasets do not cover Canada. Tables 1 through 3 are the minimum recommended requirements of the department; however, if modellers see the necessity to implement the recommendations in the *AERMOD Implementation Guide* (USEPA, 2008) for determining surface characteristics, justification should be provided to ESRD.

Table 1. Surface Roughness Length (m) for Land Use and Seasons (Paine, 1987)

Land Use Type	Spring	Summer	Autumn	Winter
Water (fresh water and sea water)	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	1.00	1.30	0.80	0.50
Coniferous Forest	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05
Cultivated Land	0.03	0.20	0.05	0.01
Grassland	0.05	0.10	0.01	0.001
Urban	1.00	1.00	1.00	1.00
Desert Shrubland	0.30	0.30	0.30	0.15

Definition of Seasons:
"Spring" refers to periods when vegetation is emerging or partially green. This is a transitional situation that applies for 1–2 months after the last killing frost in spring.
"Summer" applies to the period when vegetation is lush and healthy, typical of midsummer, but also of other seasons where frost is less common.
"Autumn" refers to a period when freezing conditions are common, deciduous trees are leafless, crops are not yet planted or are already harvested (bare soil exposed), grass surfaces are brown, and no snow is present.
"Winter" conditions apply for snow-covered surfaces and subfreezing temperatures.

Albedo and Bowen Ratio values can also be chosen to appropriately represent particular site conditions. Tables 2 and 3 provide Albedo and Bowen Ratio values as a function of land use and season (Paine, 1987).

Table 2. Albedo of Land Use Types and Seasons (Paine, 1987)

Land Use Type	Spring	Summer	Autumn	Winter*
Water (fresh water and sea water)	0.12	0.10	0.14	0.20
Deciduous Forest	0.12	0.12	0.12	0.50
Coniferous Forest	0.12	0.12	0.12	0.35
Swamp	0.12	0.14	0.16	0.30
Cultivated Land	0.14	0.20	0.18	0.60
Grassland	0.18	0.18	0.20	0.60
Urban	0.14	0.16	0.18	0.35
Desert Shrubland	0.30	0.28	0.28	0.45

Table 3. Daytime Bowen Ratios for Land Use Types and Seasons (Average Moisture Conditions) (Paine, 1987)

Land Use Type	Spring	Summer	Autumn	Winter*
Water (fresh water and sea water)	0.1	0.1	0.1	1.5**
Deciduous Forest	0.7	0.3	1.0	1.5
Coniferous Forest	0.7	0.3	0.8	1.5
Swamp	0.1	0.1	0.1	1.5
Cultivated Land	0.3	0.5	0.7	1.5
Grassland	0.4	0.8	1.0	1.5
Urban	1.0	2.0	2.0	1.5
Desert Shrubland	3.0	4.0	6.0	6.0

* Winter Bowen ratios depend upon whether a snow cover is present. Bowen ratios range from the value listed for autumn for rare snow covers to the value listed for winter for a continuous snow cover.

** This value applies if water body is frozen over.

Definitions of the seasons are the same given in Table 1.

3.4 Local Buildings

To take account of local building effects, models generally require information related to the dimensions and location of the structures with respect to the stack. If the stack is located on the top of a building, or adjacent to a tall building, it may be necessary to consider the size of these buildings. As a general guide, building downwash problems may occur if the height of the top of the stack is less than 2 ½ times the height of the building upon which it sits. It may be necessary to consider adjacent buildings if they are within a distance of 5 times the lesser of the width or peak height from the stack (5L). This distance is commonly referred to as the building's *region of influence*. If the source is located near more than one building, assess each building and stack configuration separately. If a building's projected width is used to determine 5L, determine the *apparent width* of the building. The apparent width is the width as seen from the source looking towards either the wind direction or the direction of interest. The stack height calculation does not dictate a minimum stack height; it determines whether building sizes need to be considered to account for possible building downwash conditions.

For example, the models require the apparent building widths (and also heights) for every 10 degrees of azimuth around each source. Due to the complexity of building downwash guidance, the U.S. EPA has developed a computer program for calculating downwash parameters. The U.S. EPA Building Profile Input Program (BPIP) is designed to calculate building heights (BH’s) and the *apparent width* (U.S. EPA, 1995b), and it is available from the U.S. EPA SCRAM web site. Building downwash should not be analyzed for area or volume sources. The Plume Rise Model Enhancement (PRIME) algorithm that is integrated into AERMOD and CALPUFF is the preferred method used in the models to account for building downwash. AERSCREEN also uses all the advantages of the PRIME algorithm and uses BPIP to calculate building information to run the model.

3.5 Selecting Receptor Grid

The user needs to define the locations at which ground-level concentrations are to be predicted. In selecting receptor locations, it is general practice to identify the nearest sensitive locations to the stack, such as residential housing, hospitals, etc. A careful selection of receptor points should be made so that the maximum ground-level concentration is found.

All modelling assessments should use a Cartesian receptor grid, which can be regularly or irregularly spaced. Since the number of allowed receptors is limited, they should be more densely located where maximum impacts are expected. To ensure the maximum concentrations are obtained, the model should be run with the following set of receptors, at a minimum:

- 20-m receptor spacing in the general area of maximum impact and the property boundary,
- 50-m receptor spacing within 0.5 km from the source,
- 250-m receptor spacing within 2 km from the sources of interest,
- 500-m spacing within 5 km from the sources of interest,
- 1000-m spacing beyond 5 km.

It is best to run the model twice, first with the coarse grid to determine the areas of impact, and then with the finer grid in the vicinity of the impacted area to obtain the maximums.

In areas with many industrial sources, or for large buoyant sources (100-m tall stacks, high exit temperature), a larger 250-m grid, and a coarse grid out to a distance of 20 km may be necessary to find the area of maximum impacts. In some cases, an even larger grid may be necessary.

The model domain for any assessment should not exceed the limitations of the model. If it is necessary to model at points beyond the model limitations, the results should be interpreted with extreme caution.

3.6 Terrain Situation

The terrain in the vicinity of a source can fall into two main categories as defined, based on Rowe's (1982) definition, by ESRD:

- Simple terrain (parallel air flow) - terrain whose elevation does not exceed 2/3 of the plume height (plume rise + stack height) at stability category F with a wind speed of 1 m/s and a flow rate of Qmax/2. The maximum terrain criteria can be calculated using spreadsheet posted on http://www.environment.alberta.ca/2478.html.
- Complex terrain – topography where elevations are greater than those used to define simple terrain.

In any modelling exercise the appropriate terrain option should be applied to the model. Terrain must be considered in the modelling domain if (see Figure 3):

- there is any complex terrain within the modelling domain, or
- terrain elevation increases more than 50 m per 1000 m distance from the source.

Modellers should choose the best available sources of terrain data suitable for AERMOD and/or CALPUFF from the following:

- Geobase Canada provides terrain data in USGS DEM type data (Canadian Digital Elevation Data – CDED) for a 1:50,000 and a 1:250,000 map scale (NAD83). It is available to download from: www.geobase.ca. For this data note the following:
  1) the 250,000 map scale data has a grid resolution range of 3 to 12 arc-seconds, depending on latitude. For data south of 68° N latitude, the grid resolution is roughly 90 m, depending on latitude. The data sheets are directly readable by AERMAP and TERREL and are equivalent to the one-degree USGS DEM data (BC Ministry of Environment, 2006).
  2) the 1:50,000 map scale data has a grid resolution range of 0.75 to 3 arc-seconds. For data south of 68° N latitude, the grid resolution is roughly 20 m, depending on latitude. This data is not directly readable by AERMAP and TERREL, and must be converted to equivalent 7.5-minute USGS DEM data (BC Ministry of Environment, 2006).

- The distribution of Provincial Digital Base Map Data to the public is provided by AltaLIS Ltd. The data can be ordered from the AltaLIS website at www.altalis.com.

- Terrain data for North America at a resolution of three arc-seconds (~90 m) up to 60° N can be freely downloaded from www.src.com/datasets/datasets_terrain.html#SRTM_DATA. Note that this data needs to be checked to make sure that the elevations are ground level and not tree top elevations (BC Ministry of Environment, 2006).

3.7 Facility Boundary

Models are typically used to predict ambient concentrations, which in turn are compared to ambient air quality objectives. The areas of applicability of the AAAQO are not defined, however, often they are applied to areas where there is public access (i.e., beyond the facility boundary). The facility boundary is determined by the facility fence line and/or the perimeter of disturbed area that defines where public access is restricted.

3.8 Study Area

The study area must encompass the project impacts on the surrounding environment. The study area must include all predicted ground-level concentrations (from the project) at or above 10% of the ambient air quality objectives or baseline value, whichever is higher. The project facility should be in the centre of the study area. All existing nearby sources within a minimum of 5 km from the project facility should be considered. A representative baseline value is also required to be added to the maximum predicted concentrations, for details refer to Section 4.2.

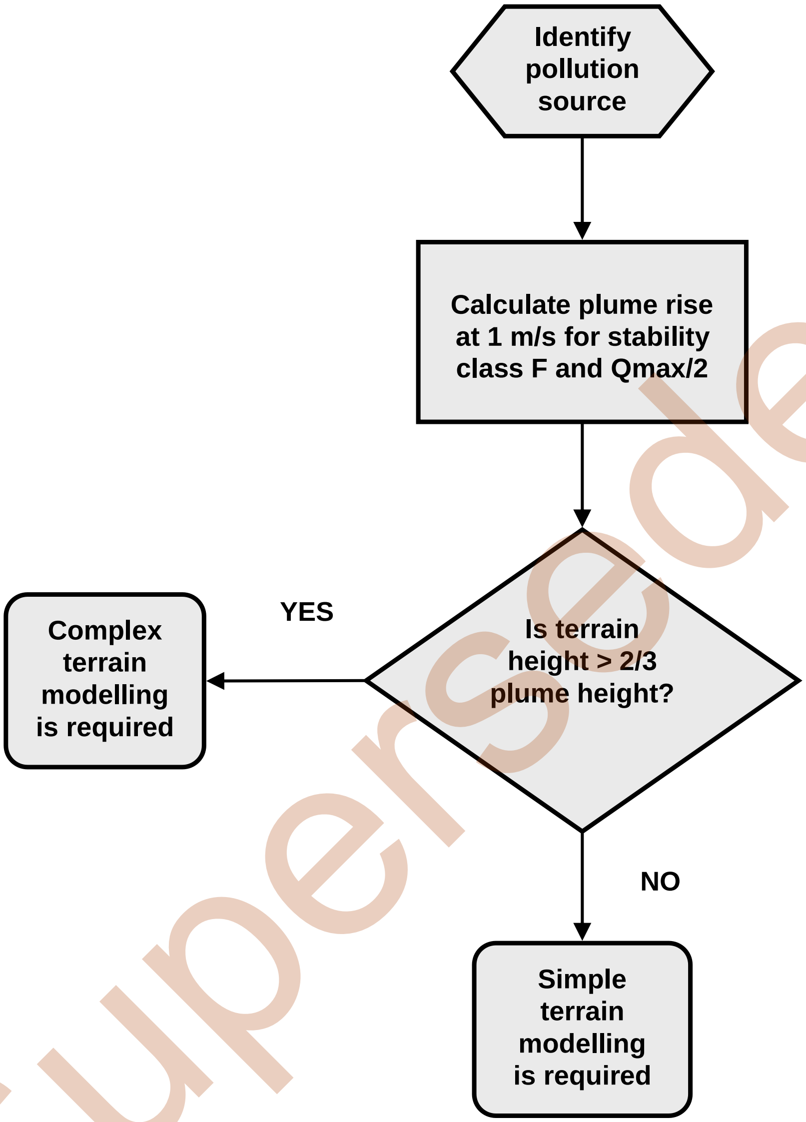

Figure 3. Flow chart for simple and complex terrain determination for modelling.

3.9 Cumulative Effects Assessment of Nearby Emission Sources

All industrial emission sources, within a minimum of 5 km from the facility, must be included in the modelling assessment. When conducting a cumulative assessment, for 1-hour and 24-hour, or 30-day averaging periods, the following emission estimates should be used, in order of preference:

- approval limits,
- manufacturer's emission data,
- emission factors, or
- if none of the aforementioned values are available emissions can be estimated by any method authorized by the department such as manual stack surveys or continuous emission monitoring.

For an annual assessment model the surrounding industrial sources using the average emission rate. Baseline concentrations, as discussed in Section 4.2, must be included in any cumulative effects assessment.

It is the responsibility of the project proponent to obtain the best available and representative emissions data from nearby sources.

3.10 Non-vertical Releases and Stacks with Rain Caps

Model non-vertical releases and stacks with caps using the appropriate options provided in AERSCREEN, AERMOD and CALPUFF.

4.0 POST ANALYSIS

The input to dispersion models consists essentially of emissions and meteorological data. The output from dispersion models consists of concentration values. Predicted concentrations are expressed as micrograms per cubic metre ($\mu g/m^3$) of air. Concentrations of gases may also be expressed as the ratio of the volume of the substance to the volume of air. In this case, concentrations are expressed as parts per million (ppm) or parts per billion (ppb). The following equation is recommended for converting the concentrations in $\mu g/m^3$ to ppm at standard conditions ($T_{std} = 25^oC$, $P_{std} = 101.325$ kPa):

$$[ppm] * 40.8862 * \text{molecular weight} = [\mu g/m^3] \qquad (4.1)$$

4.1 Model Outputs

The concentration of a substance will vary from second to second because of turbulence in the atmosphere. For practical use, concentrations are expressed as averages over specified time periods. AAAQO are usually stated for 1-hour averages, 24-hour averages, 30 day averages and annual arithmetic averages, although other time periods are used for some substances.

Predicted concentrations at ground level can be high due to extreme, rare, and transient meteorological conditions and can be considered outliers. Therefore, any values above the 99.9^{th} percentile for each receptor in each year can be disregarded. For example, the highest eight 1-hour predicted average concentrations for each receptor in each single year should be disregarded. For all other averaging periods the eight highest predicted concentrations (that were disregarded for the 1-hour averaging period), **<u>must be included</u>** when calculating the 99.9^{th} percentile value.

If an AAAQO for a substance does not specify a value, the lesser of Ontario point-of-impingement or Texas Commission of Environmental Quality Effects Screening Levels concentrations should be used. If neither Ontario nor Texas has a value for the substance of interest, a risk assessment should be conducted. Consult with ESRD to determine the appropriate course of action.

If maximum predicted concentrations exceed the AAAQO the applicant must contact the Director to discuss the next steps to address the predicted exceedances. Before contacting the Director, further direction regarding the necessary actions required to meet AAAQO in Alberta is given in the document: *Using Ambient Air Quality Objectives in Industrial Plume Dispersion Modelling and Individual Industrial Site Monitoring* (ESRD, 2011 or as amended).

4.2 Baseline Concentrations

Baseline air quality includes chemical concentrations from natural sources, nearby sources, and unidentified, possibly distant sources. When conducting a screening or refined assessment, the baseline value for the same substance must be added to the predicted value before a comparison to the AAAQO is made. Assessing the effects of the baseline component becomes more complex when short-term objectives (1-hour, 24-hour averages) are being considered.

Air quality data monitored in the vicinity (upwind) of the proposed source or at a representative site may be used as baseline values. A representative site should have similar topography and climate normals. Provide justification to ESRD in the modelling report for the selection of the baseline ambient monitoring station.

The following method should be used to determine a baseline concentration:

- All monitoring data should be subjected to validation and quality control to ensure its accuracy. Hourly, continuous ambient monitoring data is preferred over passive monitoring data where available.

- Generally, at least one year of ambient monitoring data is necessary, as there are usually significant seasonal differences in ambient concentrations. This can be due to atmospheric differences or because of the seasonal nature of some operations.

- The most recent year of hourly ambient data should be used provided it is at least 75% complete. If more than 25% of the hourly ambient data is missing (blanks) then it is acceptable to use the penultimate year of ambient data, provided it meets the 75% completeness criteria. If both of the most recent years fail the 75% completeness criteria then an average of the two years would be acceptable, provided the blended data set meets the 75% completeness criteria. If it is not possible to form such a data set then consult with ESRD for alternatives.

- Screening assessments for all averaging periods should be based on a reduced hourly data set with the top hourly values above the 99.9th percentile non-blank ambient baseline data removed. Do not include blank data as zero values when determining the 99.9th percentile. For all averaging periods greater than one hour, the maximum calculated average for each averaging period, to be used as the baseline value for modelling purposes, must then be based on the reduced hourly ambient data set. No further removal of maximum values for other averaging time periods is allowed.

- Refined and advanced assessments should be calculated in a similar manner as the screening assessment but now on the basis of a 90% percentile. This allows for some variability in the baseline due to anthropogenic or unusual local sources.

4.3 Relationship between NO_X and NO_2

Of the several species of nitrogen oxides, only NO_2 is specified in the AAAQO. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume must be given. The recommended methods, described below, are implemented using a tiered approach as shown in Figure 4. The Total Conversion Method must be presented to ESRD or the AER, for **all** cases.

4.3.1 Total Conversion Method

In this conservative screening approach, the emission rate of all NO_x species is used in the dispersion model to predict ground-level concentrations of total NO_x. These levels of NO_x are assumed to exist as 100% NO_2, and are directly compared to the AAAQO for NO_2. If the AAAQO are met, the methods in 4.3.2, 4.3.3, 4.3.4 and 4.3.5 are not necessary.

4.3.2 Plume Volume Molar Ratio Method (PVMRM) in AERMOD

The PVMRM approach (in AERMOD) limits the conversion of NO to NO_2 based on the amount of ozone available within the volume of the plume. The NO_2/NO_x conversion ratio is therefore coupled with the dispersion of the plume. The PVMRM approach also incorporates a technique for merging plumes from nearby sources for purposes of calculating the NO_2/NO_x ratios (Hanrahan, 1999 a, b) (Alaska Department of Environmental Conservation, 2005). The following defaults are recommended:

- For baseline O_3, it is preferred to use an onsite time-series of hourly O_3 concentrations that match the meteorology being employed if available, but in the absence of such data use one of the hourly O_3 time-series provided in Appendix E
- If the in-stack NO_2/NO_x ratio is not known, use the default in-stack NO_2/NO_x ratio of 0.10 used in the AERMOD-PVMRM model.
- The default equilibrium ratio of NO_2/NO_x used in the AERMOD-PVMRM model is 0.90.

4.3.3 RIVAD / ARM3 Chemical Formulations in CALPUFF

The RIVAD / ARM3 chemical formulations option in the CALPUFF model can be used to calculate NO_2 concentrations directly in rural (non-urban) areas (Morris et al., 1988). The RIVAD / ARM3 option incorporates the effect of chemical and photochemical reactions on the formation of nitrates and other deposition chemicals. For baseline O_3, it is preferred to use an onsite time-series of hourly O_3 concentrations that match the meteorology being employed if available, but in the absence of such data use the hourly time-series for rural O_3 provided in Appendix E.

4.3.4 Ozone Limiting Method (OLM)

Use of onsite O_3 data is always preferred for the OLM method. However, if no onsite ozone data are available, use the ozone time-series, shown in Appendix E. See Section 3.3 for definitions of urban and rural land-use.

Under the OLM an estimate of the NO_2 ground level concentration is determined by the application of the following equation (Cole and Summerhays, 1979):

If $[O_3] > 0.9*[NO_X]$ then $[NO_2] = [NO_X]$ (4.2)
otherwise $[NO_2] = [O_3] + 0.1*[NO_X]$

All concentrations in the previous equations need to be in ppm. The predicted NO_x concentrations are calculated as equivalent NO_2.

According to Equation 4.2, if the ozone concentration is greater than 90% of the predicted NO_X concentrations, all the NO_x is assumed to be converted to NO_2. The OLM is based on the assumption that approximately 10% of the NO_x emissions are generated as NO_2. The majority of the emission is in the form of NO, which reacts with ambient levels of ozone to form additional NO_2.

For all averaging periods other than hourly the ground level concentration of NO_2 should be based upon the hourly NO_2 values determined using the above time-series.

4.3.5 Ambient Ratio Method (ARM)

The ambient ratio method is based upon the premise that the NO_2/NO_x ratio in a plume changes as it is transported but attains an equilibrium value some distance away from the source. However, the location of monitors in the correct location and distance to correctly determine the NO_2/NO_x ratio would be fortuitous in most cases. With this limitation in mind the use of the ARM method must use the following protocol, in order of preference:

1. If there are monitors located between 15 km and 80 km downwind and within the general direction (± 22.5°) of the maximum impact, then the average annual NO_2/NO_x for the most recent year derived from all relevant monitors should be used (OLM/ARM Workgroup – Draft Recommendations, 1998).
2. If there are no suitable monitors available then a NO_2/NO_x value of 0.70 may be used. This represents the average NO_2/NO_x for Alberta for the period 2000 – 2010 for all permanent monitoring stations with at least three years of data.

Under no circumstance may onsite NO_2/NO_x ratios be used for the ARM method.

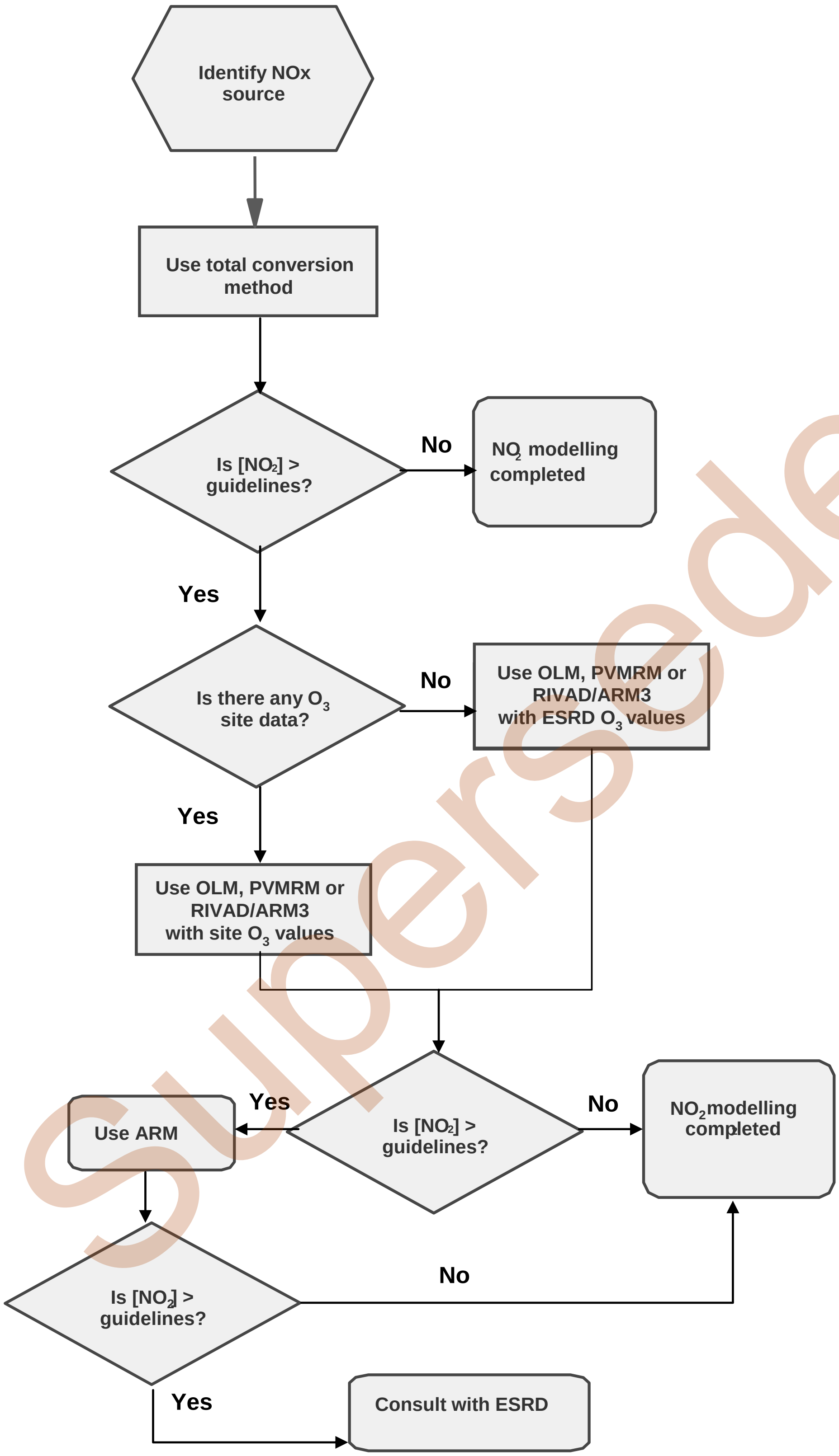

Figure 4. **Flow chart indicating the relationship between NO_X and NO_2.**

5.0 REGULATORY MODELS

A tiered approach will be expedient, as the aim is to progressively reduce uncertainty by moving from simple and cautious models to complex and more representative ones, as circumstances warrant. One screening model and two refined models are recommended by ESRD.

All the regulatory models are short-range. That means that only air quality within 10 - 25 km of the source is predicted reliably, except for CALPUFF, which can be used up to about 200 km.

The user of a model should be able to justify the choice of any particular model. If a simple screening model shows that emissions from a certain process can result in concentrations that are below the air quality objective, including baseline levels, more detailed modelling should not normally be necessary. Refined or advanced models need to be used if the screening predictions of ambient ground concentrations exceed the relevant AAAQO.

In all modelling assessment reports the version of all the models used and the model options (if applicable) must be explicitly provided. The ESRD allowed non-default and/or alternate model option switches are provided in Appendix D.

5.1 Screening Model

- **AERSCREEN** - The U.S. EPA recommended screening model used to produce estimates of worst-case scenarios. AERSCREEN interfaces with the AERMOD model and performs modelling runs in the AERMOD screening mode. AERSCREEN generates a site-specific matrix of worst-case scenario meteorological conditions with MAKEMET. The PRIME downwash algorithms and AERMAP terrain processor are incorporated. AERSCREEN is able to model a single point, capped stack, horizontal stack, rectangular area, circular area, flare, or volume source. (U.S EPA, 2011b).

5.2 Refined Models

- **AERMOD-PRIME** – AERMOD was developed by the U.S. EPA (2004), in collaboration with the American Meteorological Society. This is a multi-source steady-state plume model. In the stable boundary layer (SBL), the concentration distribution is assumed to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). Additionally, in the CBL, AERMOD treats "plume lofting," whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate.

  AERMOD should be run using the most current U.S. EPA regulatory default options with some exceptions allowed (see Appendix D).

- **CALPUFF** - This model is a multi-layer, multi-species, non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on substance transport, transformation, and removal. CALPUFF can use the three-dimensional meteorological fields developed by the CALMET model, or simple, single-station winds in a format consistent with the meteorological files used to derive steady-state Gaussian models. CALPUFF with simple single-station data (AERMOD-type) should be used with dispersion coefficients calculated using turbulence computed from micrometeorology based on similarity theory, **not** Pasquill-Gifford coefficients.

  The default model options from the current TRC Solutions Atmospheric Studies Group (http://www.src.com/) or EPA designated agent's distribution of the CALMET and CALPUFF serve as the basic set of model options to be used for CALPUFF modelling applications. ESRD recommended deviations from these options are provided in Appendix D. Hence, the ESRD default model options are a blend of released model options and ESRD recommended alternate options. **If deviation from the ESRD default model options is required, consult with** ESRD **before use** and provide justification to ESRD in writing; include a table listing ESRD default and user suggested non-default settings. **If deviation from the ESRD default model version is proposed, consult with ESRD before use** and provide justification to ESRD in the assessment report. **When using user suggested non-default model versions and/or options then the results from a run of the ESRD default model with default options must also be presented.** Non-model specific control parameters, e.g., formatting of input/output files and setting the domain projection, etc., may be set to suit the needs of the particular project.

  If the U.S. EPA releases a more current version of CALMET/CALPUFF than posted on the TRC Solutions website, the U.S. EPA release will be preferred.

5.3 Advanced Air Quality Models

In some cases the particular circumstances of topography, climate, source configuration, emissions characteristics, sensitivity of receptors, local concerns, or other unusual features will require the selection of non-recommended air quality model better suited to the situation. Non-recommended air quality models may need to be modified to reflect these unique conditions; these modifications will be accepted if they can demonstrate that they perform better than the recommended model when tested against the available air quality data. Model selection and the level of assessment to be performed can be verified by contacting ESRD.

Any modification to a generally available air quality model must be supported by at least one of the following:

- a detailed observational study (field, wind tunnel, or water channel),
- theory supported by comparisons in literature,
- theory supported by comparison with on-site data.

All non-recommended and modified models must be shown to perform better than the regulatory model when tested against site-specific ambient monitoring data. Performance against the refined model, i.e., a side by side comparison against the ESRD default model and switch settings, as specified in Section 5.2 must also be presented.

In general, a performance evaluation consists of the following (U.S. EPA, 1992a):

- accuracy of peak predicted concentrations (against site-specific air quality data),
- a correlation analysis,
- visual presentation and interpretation of appropriate isopleths showing predicted concentration patterns,
- test of model precision, and
- test of model bias.

6.0 OBTAINING MODELS AND RESOURCES

This section contains instructions for accessing information relevant to dispersion modelling. There are two areas of information, ESRD web page, and the U.S. EPA web page. The ESRD home page contains general information about ESRD, Alberta regulatory information, regional meteorological data sets, and updates of these model guidelines. The U.S. EPA home page has a link to its Support Centre for Regulatory Air Models (SCRAM) page.

Whenever using these dispersion models, it is the responsibility of the user to ensure that they are running the current approved version of the models (see Sections 3 and 5). The use of methods and models other than the previously mentioned regulatory models should always be confirmed with ESRD before proceeding.

6.1 Alberta Environment and Sustainable Resource Development Home Page

ESRD has developed a home page on the internet. Browser software is necessary to view this home page. The address for this page is:

http://environment.alberta.ca/index.html

This home page contains information about air quality monitoring in the province, and a section related to air quality modelling. The web address of the modelling section is:

http://www.environment.alberta.ca/622.html

These guidelines and information relating to the guidelines can be found at this address. ESRD has set up an e-mail list server where information on updates and new versions of the guidelines will be sent periodically. The e-mail list is free, and instructions for signing up can be found at the above site.

http://www.environment.alberta.ca/623.html

Information regarding the current ESRD approved metrological data and how to obtain it is also provided at this web site.

The Protection/Enforcement section contains information related to the regulatory approval process, including the EPEA and AAAQO.

6.2 U.S. EPA SCRAM Home Page

The SCRAM site covers topics related to dispersion models. The internet site can be accessed at the following address:

http://www.epa.gov/scram001/index.htm

6.3 Canadian Climate Normals

The Canadian Climate Normals are available free of charge at the following web site:

http://climate.weatheroffice.ec.gc.ca/Welcome_e.html

This information can be utilized for comparison with dispersion model results for simple cases and to compare the representativeness of site data or other meteorological data for the region. If sufficient data are available, climatological wind directions, wind speeds, and temperatures can be analyzed to determine the frequency of particular meteorological conditions. This could be compared to the worst-case modelled condition, to help determine possible frequencies of occurrence of elevated concentrations.

7.0 REGIONAL MODELLING

7.1 Acid Deposition

Figure 5 outlines the factors that shall be taken into consideration when setting up and implementing a regional management framework or completing an Environmental Impact Assessment (EIA). For regional modelling of acid deposition, CALPUFF, or any other deposition model recommended by ESRD, shall be used. For further details review Alberta Acid Deposition Management Framework (ESRD, March 2008) at http://environment.gov.ab.ca/info/library/7926.pdf

To ensure that planned development in or around a region does not result in acid deposition issues, and also to guide management of acidifying emissions, a project proponent may be required to complete regional acid deposition modelling if:

- the proponent's combined emissions of SO_2, NO_x, and NH_3 are greater than 0.175 t/d of H^+ equivalent,
    - Total H^+ equivalent (t/d) = 2*(SO_2 t/d)/(64)+1*(NO_x t/d)/(46)+1*(NH_3 t/d)/(17) or
- there is evidence that regional soil and surface water is more sensitive to acidification than is estimated in the provincial framework, or
- there is existing deposition and/or acidification impact monitoring that indicates a potential concern if acid deposition increases.

7.2 Ozone and Secondary Particulate Matter (PM)

An advanced assessment or regional airshed management planning study may require ozone and secondary PM modelling. Normally, ESRD would accept models developed or recommended by the U.S. EPA. Examples of these models are: CALPUFF, California Photochemical Grid (CALGRID) model, the Models-3/Community Multiscale Air Quality (CMAQ) modelling system, the Comprehensive Air quality Model with extensions (CAMx), the Regional Modelling System for Aerosols and Deposition (REMSAD), and the Variable Grid Urban Airshed Model (UAM-V) System. These models can be obtained through the U.S. EPA's Support Centre for Regulatory Atmospheric Modelling (SCRAM). However, preparation of input data for these models would require significant efforts.

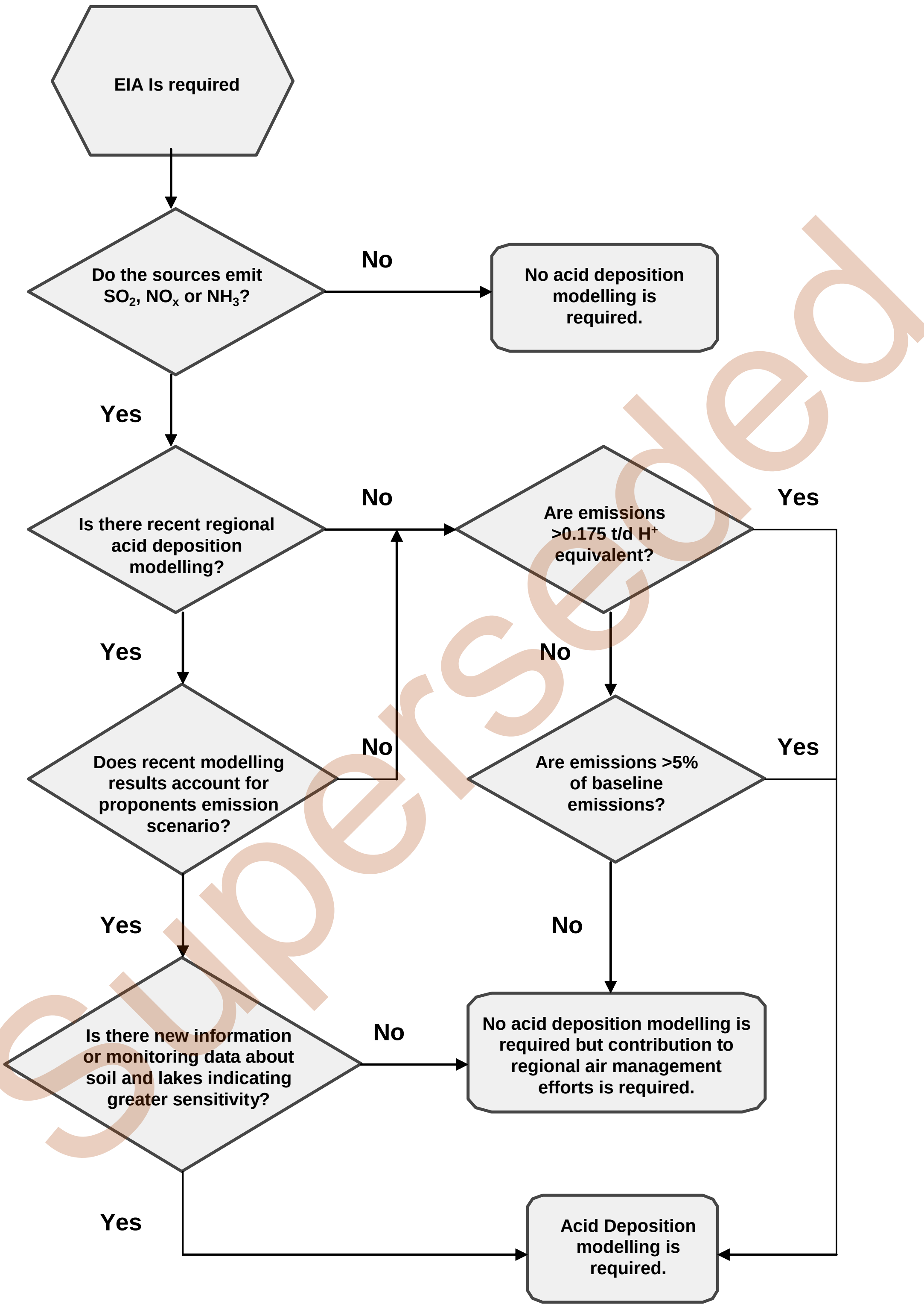

Figure 5. Procedural steps to determine if acid deposition modelling is required for a proposed project.

8.0 CONCLUSION

This Guideline provides detailed guidance on suitable methods and approaches that should be used to assess air quality from emission sources in Alberta. The Guideline objectives are to supply a structured approach to the selection and application of models and to detail the required content of air quality assessments submitted to the department. The dispersion modelling aspects discussed in the Guideline include model input data, model output interpretation, application of regulatory models, obtaining models and resources and regional modelling in the province. The following appendices detail the expected content of screening and refined assessments, the competencies required to perform dispersion modelling, and ESRD recommended ozone levels. The practices recommended within this Guideline are a means to ensure consistency in the use of dispersion models for regulatory applications in Alberta.

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APPENDICES

APPENDIX A: EXPECTED CONTENT OF SCREENING ASSESSMENTS

Facility Information

- Facility address and company name
- EPEA approval or registration # (if applicable)
- AER facility number (if applicable)
- Industrial sector

1.0 Sources and Emissions

1.1 Source Data

- Number and type of sources (i.e., stack, flare, area, etc.)
- Plot plan
- Locations and dimensions of buildings (length, width, height)
- Design capacity (normal or average capacity may also be needed)

1.2 Characteristics of Emissions

- Chemical composition (substance type) and emission rates (g/s)
- Exit (stack) height above ground (m)
- Temperature (K) or heat content (MJ/m^3 and cal/s)
- Exit velocity (m/s)
- Stack top inside diameter (m)
- Pseudo flaring parameters
- Other parameters if not a point source
- Calculations or explanations on how emissions were calculated

1.3 Potential Emissions during Abnormal Operations, Start-Up or Shutdown

2.0 Topography

- Description and map if necessary
- Vegetation cover/land use
- Sensitive receptors nearby (public buildings, homes, etc.)

3.0 Results - Air Quality Modelling Predictions

- Summary of baseline air quality if available or applicable (from air quality stations - same or other facility, or appropriate ESRD station)
- Building downwash (include whether effects seen on or off facility property)
- Predicted 1-hour average, 24-hour average, 30 day average (if applicable), and annual average maximums
- Comparison with existing monitoring data (if applicable)
- Soft copy of dispersion model input and output files. These may be provided in digital format (i.e., on CD).

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APPENDIX B: EXPECTED CONTENT OF REFINED AND ADVANCED ASSESSMENTS

Facility Information

- Facility address and company name
- EPEA approval or registration # (if applicable)
- AER facility number (if applicable)
- Industrial sector

1.0 Sources and Emissions

1.1 Source Data

- Number and type of sources (on-site and off-site)
- Plot plan
- Dimensions of nearby buildings
- Design, average and nominal capacity

1.2 Characteristics of Emissions

- Temperature or heat content at exit
- Exit velocity
- Stack top inside diameter (m)
- Exit height above ground
- Chemical composition and emission rates
- Water content
- Other parameters for non-point sources
- Explanations or calculations on how emissions were estimated

1.3 Time Variations (Short and Long-Term)

1.4 Potential Emissions during Abnormal Operations

- Start-up or shutdown
- Pollution control equipment failure

- Process equipment malfunction
- Damage to storage vessels
- Other accidental/unplanned emissions

1.5 Other Major Existing or Proposed Sources

- Identification of existing industrial sources within study area
- Identification of major proposed or approved (but not constructed) facilities within study area
- Facility type of industrial sources within study area
- Number, unique identifier and type of sources (stack, flare, etc.) for each facility
- Geographic locations of each source (UTM or Lat/Long NAD 83)
- Chemical composition (substance type) and emission rates (g/s)
- Exit (stack) height above ground (m)
- Temperature (K) or heat content (MJ/m^3 and cal/s)
- Exit velocity (m/s)
- Stack top inside diameter (m)

2.0 Topography

- Description and map
- Elevation maxima and minima
- Vegetation cover/land use
- Receptor grid resolution and domain size
- Sensitive receptors
- Parks, campgrounds, and wilderness areas
- Population centres and public facilities
- Location of meteorological and air quality stations

3.0 General Climatology

- Temperature
- Precipitation
- Pressure
- Solar radiation
- Wind
- Cloud cover

4.0 Meteorology

- Sources of data
- Representativeness of measurements (time and space)
- Topographic influences

4.1 Wind

- Speed and direction distributions (roses)
- Relation of short-term on-site to long-term off-site
- Persistence
- Diurnal and seasonal variations
- Extreme values
- Mean speed
- Prevailing and resultant winds
- Relation to visibility restrictions
- Relation to topographic effects

4.2 Temperature

- Inversion heights, strengths, frequencies, and persistence
- Mixing layer heights, diurnal and seasonal variation
- Magnitude and behaviour, diurnally and seasonally

4.3 Turbulence

- Direct measurements - frequency distributions, diurnal and seasonal variations
- Indirect determinations, definition of stability parameter (thermal/mechanical turbulence index) and description of inference scheme
- Frequency distribution, diurnal and seasonal variations

5.0 Results – Air Quality Modelling Predictions

- Summary of baseline air quality
- Contribution of sources to maximums, nearby and distant
- Building downwash
- Stack aerodynamic downwash
- Buoyancy momentum rise
- Topographic effects
- Model description and references
- **Identification of the specific model version and switches used**.
- Predicted hourly averages - magnitude, frequencies, duration, and timing
- Discussion of meteorology leading to highest concentrations
- Predicted daily averages
- Predicted 30 day averages (if applicable)
- Predicted annual averages
- Predicted depositions
- Comparisons to standards
- Expected frequency of visibility impairment due to smoke, particulate, or condensed water vapour

6.0 Special Topics

- Risks due to uncontrolled releases
- Unusual natural phenomena
- Atmospheric chemical transformations
- Chemical reactions between plumes containing different substances
- Synergistic effects of multiple-component emissions
- Icing caused by water vapour emissions

7.0 Conclusion

- Summary of impact on concentrations, depositions, visibility, and odour.
- Summary of model options used and justifications for use.
- Soft copy of the input and output files. These may be provided in digital format (i.e., on CD).
- Predicted concentration isopleths (1-hour average, 24-hour average (30-day if applicable) and annual).
- Predicted concentration isopleths showing frequency of exceedance (if applicable).

APPENDIX C: COMPETENCIES FOR PERFORMING AIR QUALITY MODELLING

INTRODUCTION

Competencies are any attitude, skill, behavior, motive or other personal characteristic that are essential to perform a job, or more importantly, differentiate superior performers from solid performers.

The following lists the tasks and knowledge required for competent air quality modelling. The introductory sections- Context, Core Knowledge and Abilities, and Quality Assurance- are integral to further understanding the Task and Knowledge and Experience requirements.

CONTEXT

The competencies must be interpreted within the following context:

- Communication with field workers, technicians, laboratories, engineers and scientists during the process is important to the success of the model.
- Record keeping is important to support the accountability of the model.

CORE KNOWLEDGE AND ABILITIES

The modellers must have the following core knowledge and abilities, in addition to specific technical knowledge:

- Knowledge of chemical and physical meteorology.
- Understanding of the chemical and physical interactions of atmospheric pollutants.
- Knowledge of primary pollutants, and their interaction with other substances (natural or industrial) to form secondary pollutants.
- Knowledge of risks due to uncontrolled releases.
- Knowledge of legislation, regulations and guidelines in regards to Air Quality.
  - Knowledge of Air Quality Objectives (AQO) and limits
  - Familiarity with AAAQO
- Knowledge of information sources relevant to the model.
- Ability to read and understand map information.
- Ability to prepare reports and documents as necessary. Ability to review reports to ensure accuracy, clarity and completeness.
- Communication skills.
- Team skills.

QUALITY ASSURANCE

- Use of standard assessment and modelling protocol.
- Selection of appropriate practitioners for the task. Referral to specialists when the situation requires specialized training.

Tasks

- Obtain, review and interpret data from monitoring sites
- Obtain, review and interpret meteorological data
- Identify potential pollution (emission) sources and rates
  - Gather information on sources such as mass flow rates (e.g. kg of SO_2/hr), stack top temperature, velocity (i.e. m/s) or volumetric flow rate (e.g. cubic meters/second), and stack height and diameter. Calculate emission rates based on collected information
- Identify land use (urban/rural)
- Identify land cover/terrain characteristics
- Identify the receptor grid/site
- Prepare and execute dispersion model
- Interpret results of model
- Prepare reports and recommend changes based on modelling results
- Determine if further assessment is necessary

Knowledge and Experience

- Knowledge of chemical and physical meteorology
  - Familiar with terminology, principles and interactions
  - Understanding of data collection methods and technologies
  - Ability to identify good and bad data points/sets
  - Understanding of how to deal with incomplete/missing meteorological data

- Knowledge of chemical and physical interactions of atmospheric pollutants
  - Familiarity with fate and transport of pollutants in air
  - Understanding of meteorological impacts on pollutants
  - Knowledge of primary pollutants and the synergistic effects with other substances (natural or industrial) to form secondary pollutants

- Knowledge of surface characteristics
  - Ability to identify and describe soil, water, drainage and terrain conditions
  - Understanding of their interaction
  - Familiarity with surface roughness

- Knowledge of pollution sources (point, line, area, volume)
  - Familiarity with emission control technologies
  - Knowledge of AAAQO
  - Understanding of baseline concentrations

- Understanding/ experience with computer modelling programs/ applications and limitations
  - Selection of model which best meets needs of the task
  - Understanding of model input parameters
  - Understanding of modelling results

- Ability to read and understand map information
  - Ability to create predicted concentration isopleths with model results

APPENDIX D: ALLOWED NON-DEFAULT AND/OR ALTERNATE MODEL OPTIONS FOR AIR QUALITY DISPERSION MODELLING

These switches represent allowed alternate model options, which may be used as part of any regulatory application. Requirements as specified in the body of the Guideline, e.g., the requirement to model for total conversion of NO_x to NO_2, must still be met. Administrative switches, .e.g., switches related to the type and style input/output data, grid domain, etc., may be changed as required for a particular regulatory application without additional modelling. **When not specified in the following table the default value for a model option must be used.

Model	Allowed Non-Default/Alternate Model Options**	Comment
AERSCREEN		As required.
AERMET	Adjusted_U*	As required.
AERMOD	Flat & Elevated Terrain	As required.
	Conversion of NOx to NO2 (OLM or PVMRM)	To be used for Tier 2 modelling. Total conversion of NO_x to NO_2 always required.
	Capped and Horizontal Stack Releases	Allowed.
	Adjusted Friction Velocity (u*)	Allowed. This must be used with Adjusted_U* created by AERMET. An explanation of the use of Adjusted_U* should be provided. At this time, until the US EPA approves settings (not defaults) for LOW1 and LOW2 wind speed options these are not allowed to be used.
CALMET	IPROG	Set IPROG = 14 .
	IRHPROG	Set IRHPRG = 1.
	ITPROG	Set ITPROG = 0 or 1 for NOOBS = 0 or 1; ITPROG = 2 when NOOBS = 2.
	IWFCOD	Set IWFCOD = 1.
	IXTERP	Set IXTERP = +/-1 when NOOBS = 2.

	MCLOUD	Use cloud cover derived from the ESRD provided meteorological data (MCLOUD = 4 is preferred) unless complete set of surface observations are available (MCLOUD = 1). Provide explanation of choice.
	NOOBS	Use NOOBS = 0 for on site meteorlogy. Use NOOBS = 1 when blending ground data into ESRD provided meteorological data. NOOBS = 2 when using ESRD meteorological data only.
	R1, R2	Set to one half the resolution of the ESRD meteorological data set. These are only suggested values, variation from these values do not require additional modelling. Provide explanation of choice.
	RMAX1, RMAX2, RMAX3	Set to twice the resolution of ESRD provided meteorological data set. These are only suggested values, variation from these values do not require additional modelling. Provide explanation of choice.
	TERRAD	Set TERRAD according to terrain features in modelling domain. Provide explanation.
	TRADKM	Set TRADKM to twice the resolution of ESRD provided meteorological data set.
	ZFACE	ZFACE = 0., 20., 40., 80., 120., 280., 520., 880., 1320., 1820., 2380., 3000., 4000.
CALPUFF	MBDW	Use the Prime algorithm for downwash (MBDW = 2).
	MCHEM	MCHEM = 1 (MESOPUFFII) or MCHEM = 3 (RIVAD/ARM3) chemistry are acceptable. All other chemical paths are

		considered alternate models and may only be modelled in addition to one of the accepted chemical models listed above (See Section 5.3).
	MDISP	Set MDISP = 2.
	MPDF	Set MPDF to match the selected MDISP setting (MPDF = 1).
	MPARTLBA	Allow for partial penetration of plume (MPARTLBA = 1).
	MREG	Waive MREG check (MREG = 0).
	ZFACE	As for CALMET.

APPENDIX E: ESRD RECOMENDED OZONE LEVELS

Based on ambient air quality monitoring data in Alberta from 2000 to 2010 (Urban: Calgary North, Calgary Central, Calgary East, Edmonton South, Edmonton Central, Edmonton East, Fort Saskatchewan – 92nd Street and 96th Avenue, Lethbridge, Red Deer – Riverside; Rural: Anzac, Beaverlodge, Caroline, Elk Island, Fort Chipewyan, Genesee, Tomahawk, Violet Grove).

Urban (ppm)

Hour	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.013	0.015	0.021	0.026	0.026	0.022	0.018	0.016	0.013	0.014	0.013	0.012
2	0.013	0.016	0.021	0.025	0.025	0.021	0.018	0.016	0.013	0.014	0.014	0.013
3	0.013	0.016	0.021	0.025	0.023	0.020	0.017	0.015	0.013	0.014	0.014	0.013
4	0.013	0.016	0.021	0.024	0.022	0.019	0.016	0.014	0.012	0.013	0.014	0.013
5	0.013	0.015	0.020	0.021	0.020	0.016	0.014	0.012	0.011	0.012	0.014	0.013
6	0.012	0.014	0.018	0.018	0.018	0.015	0.012	0.010	0.009	0.010	0.013	0.012
7	0.011	0.012	0.016	0.017	0.018	0.016	0.013	0.009	0.007	0.008	0.011	0.011
8	0.010	0.011	0.016	0.020	0.022	0.019	0.016	0.011	0.008	0.008	0.009	0.009
9	0.009	0.011	0.019	0.026	0.027	0.024	0.021	0.016	0.011	0.010	0.009	0.009
10	0.011	0.015	0.024	0.031	0.033	0.029	0.026	0.021	0.015	0.013	0.012	0.011
11	0.013	0.019	0.029	0.035	0.037	0.033	0.031	0.026	0.020	0.017	0.015	0.013
12	0.016	0.022	0.032	0.038	0.039	0.036	0.034	0.030	0.024	0.020	0.017	0.015
13	0.018	0.025	0.034	0.040	0.041	0.038	0.036	0.033	0.027	0.023	0.020	0.017
14	0.019	0.026	0.036	0.041	0.042	0.039	0.037	0.035	0.028	0.025	0.021	0.018
15	0.019	0.027	0.036	0.042	0.042	0.039	0.038	0.036	0.029	0.025	0.020	0.017
16	0.017	0.026	0.036	0.042	0.042	0.038	0.037	0.035	0.029	0.024	0.018	0.014
17	0.013	0.022	0.034	0.042	0.042	0.038	0.037	0.035	0.028	0.022	0.013	0.010
18	0.010	0.017	0.032	0.041	0.042	0.038	0.037	0.034	0.026	0.017	0.010	0.009
19	0.010	0.014	0.027	0.039	0.041	0.037	0.035	0.031	0.021	0.014	0.010	0.009
20	0.011	0.014	0.024	0.035	0.038	0.035	0.032	0.026	0.016	0.013	0.011	0.010
21	0.011	0.014	0.022	0.030	0.032	0.030	0.026	0.020	0.014	0.013	0.011	0.011
22	0.011	0.014	0.021	0.028	0.029	0.025	0.021	0.018	0.013	0.013	0.011	0.011
23	0.012	0.014	0.021	0.027	0.027	0.023	0.019	0.017	0.013	0.013	0.012	0.011
24	0.012	0.015	0.021	0.026	0.022	0.022	0.018	0.017	0.013	0.014	0.013	0.011

Rural (ppm)

Hour	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.024	0.029	0.035	0.037	0.033	0.027	0.022	0.020	0.019	0.022	0.022	0.022
2	0.026	0.030	0.035	0.038	0.034	0.028	0.022	0.020	0.019	0.022	0.024	0.023
3	0.024	0.029	0.034	0.036	0.031	0.025	0.020	0.018	0.018	0.022	0.022	0.021
4	0.023	0.028	0.033	0.034	0.029	0.023	0.018	0.016	0.016	0.021	0.022	0.022
5	0.023	0.028	0.033	0.033	0.028	0.022	0.017	0.016	0.016	0.020	0.022	0.022
6	0.023	0.027	0.032	0.033	0.027	0.021	0.016	0.015	0.015	0.020	0.022	0.022
7	0.023	0.027	0.031	0.032	0.028	0.022	0.017	0.015	0.015	0.019	0.021	0.022
8	0.023	0.026	0.032	0.033	0.031	0.025	0.020	0.016	0.015	0.019	0.021	0.022
9	0.023	0.027	0.033	0.036	0.034	0.029	0.023	0.019	0.017	0.019	0.021	0.021
10	0.023	0.028	0.035	0.039	0.037	0.032	0.027	0.023	0.020	0.021	0.022	0.021
11	0.024	0.030	0.037	0.041	0.039	0.035	0.030	0.027	0.023	0.023	0.023	0.023
12	0.026	0.031	0.038	0.043	0.041	0.037	0.032	0.030	0.026	0.026	0.025	0.024
13	0.027	0.033	0.040	0.045	0.042	0.039	0.034	0.031	0.028	0.028	0.026	0.025
14	0.027	0.034	0.041	0.046	0.043	0.040	0.035	0.033	0.029	0.029	0.027	0.026
15	0.028	0.035	0.042	0.047	0.044	0.040	0.036	0.034	0.030	0.029	0.027	0.026
16	0.027	0.035	0.042	0.047	0.044	0.041	0.036	0.034	0.031	0.029	0.026	0.025
17	0.026	0.034	0.042	0.047	0.045	0.040	0.036	0.034	0.030	0.028	0.025	0.024
18	0.025	0.033	0.041	0.047	0.044	0.040	0.035	0.033	0.029	0.027	0.024	0.023
19	0.025	0.032	0.040	0.046	0.043	0.039	0.034	0.031	0.027	0.026	0.024	0.023
20	0.024	0.031	0.039	0.044	0.042	0.037	0.032	0.028	0.025	0.025	0.023	0.022
21	0.024	0.031	0.038	0.042	0.039	0.034	0.028	0.025	0.023	0.024	0.023	0.022
22	0.024	0.030	0.037	0.041	0.037	0.032	0.026	0.024	0.022	0.023	0.023	0.022
23	0.024	0.030	0.036	0.039	0.036	0.030	0.025	0.022	0.021	0.023	0.022	0.022
24	0.024	0.029	0.036	0.038	0.034	0.028	0.023	0.021	0.020	0.022	0.022	0.022