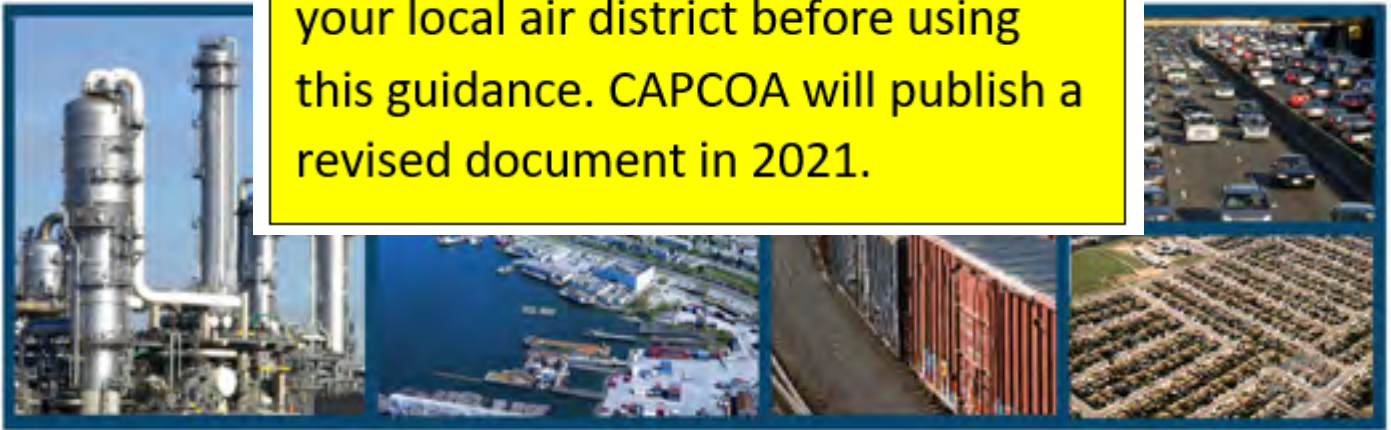


# Health Risk Assessments for Proposed Land Use Projects

**Attention:** Portions of this document may be out of date. Please consult your local air district before using this guidance. CAPCOA will publish a revised document in 2021.



## CAPCOA Guidance Document



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July 2009

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## Glossary

Acute Hazard Index	Acute Hazard Index is the ratio of the average short term (generally one hour) ambient concentration of an acutely toxic substance(s) divided by the acute reference exposure level set by the Office of Environmental Health Hazard Assessment. If this ratio is above one, then adverse health effects may occur.
Background Risk	Background risk is the risk level found throughout an area. This risk is not caused by a particular facility; it is the cumulative risk and may be partly due to air pollution from vehicle traffic.
Cancer Risk	Cancer risk is defined as the probability that an individual will contract cancer usually expressed as so many chances per million persons exposed to a specified concentration of carcinogenic substance(s).
Chronic Hazard Index	Chronic Hazard Index is the ratio of the average annual ambient concentration of a chronically toxic substance(s) divided by the chronic reference exposure level set by the Office of Environmental Health Hazard Assessment. If this ratio is above one, then adverse health effects may occur.
Commenting Agency	A commenting agency is any public agency that comments on a CEQA document, but is neither a lead agency nor a responsible agency. For example, a local air district, as the agency with the responsibility for air pollution control, could review and comment on an air quality analysis in a CEQA document, even though the project was not subject to an air permit or other air pollution control requirements.
Cumulative impact	Cumulative impacts represent the risks from all onsite sources and from sources near enough to the project to significantly contribute to the total risk levels.
Hot Spots Program	Health and Safety Code §44300-44394, Program which requires existing sources to inventory toxic emissions, prepare risk assessments, notify significantly exposed receptors, and prepare and implement risk reduction plans.
Lead Agency	A lead agency is the public agency that has the principal responsibility for carrying out or approving a project that is subject to CEQA. In general, the land use agency is the preferred public agency serving as lead agency, because it has jurisdiction over general land uses. The lead agency is responsible for determining the appropriate environmental document, as well as its preparation.

Receptors	Receptors include sensitive receptors and worker receptors. Sensitive receptors refer to those segments of the population most susceptible to poor air quality (i.e., children, the elderly, and those with pre-existing serious health problems affected by air quality). Land uses where sensitive individuals are most likely to spend time include schools and schoolyards, parks and playgrounds, daycare centers, nursing homes, hospitals, and residential communities (these sensitive land uses may also be referred to as sensitive receptors). Worker receptors refer to employees and locations where people work.
Responsible Agency	A responsible agency is a public agency, other than the lead agency, with discretionary approval authority over a project that is subject to CEQA (i.e., project requires a subsequent permit).
Risk Assessment	An evaluation that assesses the impact of toxic substances affecting receptors. A risk assessment can include minimal input parameters resulting in conservative results (screening risk assessment) or include increasingly detailed input parameters (refined risk assessment).
Source	A source is referred to as the locality where toxic emissions originate and are released into the atmosphere. Sources of emissions are categorized into groups such as point source (e.g., refinery) or line source (e.g., roadway).
Type A Project	Land use project that impacts receptors near the project.
Type B Project	Land use project with receptors that are impacted by nearby, existing toxics sources.

## **Acronyms**

ARB:	California Air Resources Board
ATCM:	Air Toxic Control Measure
CAPCOA:	California Air Pollution Control Officers Association
CEQA:	California Environmental Quality Act
DPM:	Diesel Particulate Matter
EIR:	Environmental Impact Report
EPA:	U.S. Environmental Protection Agency
HRA:	Health Risk Assessment
OEHHA:	California Office of Environmental Health Hazard Assessment
PM:	Particulate Matter
REL:	Reference Exposure Level
TAC:	Toxic Air Contaminant
TBACT:	Toxic Best Available Control Technology



## Executive Summary

This guidance was prepared to assist Lead Agencies in complying with the requirements of the California Environmental Quality Act (CEQA)<sup>1</sup>. CEQA requires environmental impacts of a proposed project be identified, assessed, and avoided or mitigated (as possible) if these impacts are significant. To determine the impact of airborne toxic emissions [i.e., toxic air contaminants (TACs)] for CEQA purposes, health risk assessments must be prepared. This document describes when and how a health risk assessment should be prepared and what to do with the results.

In 2005, the California Air Resources Board (ARB) prepared the *Air Quality and Land Use Handbook: a Community Health Perspective* (ARB Handbook)<sup>2</sup>, to help readers understand the potential cancer risks from some common sources of toxic emissions such as:

- Freeways and High Traffic Volume Roads,
- Goods Distribution Centers,
- Rail Yards,
- Ports,
- Refineries,
- Chrome Platers,
- Dry Cleaners using Perchloroethylene, and
- Gasoline Dispensing Facilities.

The ARB Handbook identified the potential cancer risks at various distances from these sources and recommended buffer distances between those sources and receptors.

Recent air pollution studies have shown an association between respiratory and other non-cancer health effects and proximity to high traffic roadways. Other studies have shown that diesel exhaust and other cancer-causing chemicals emitted from cars and trucks are responsible for much of the overall cancer risk from airborne toxics in California.

While local air districts have ample experience evaluating and mitigating toxic emissions from permitted stationary sources, most have limited experience preparing or reviewing risk assessments associated with multiple toxic sources or assessments for exhaust from mobile sources that are typically found when evaluating health risks to proposed land use projects.

In order to provide consistency to lead agencies, project proponents and the general public throughout the state, the California Air Pollution Control Officers Association (CAPCOA) formed a subcommittee composed of representatives from the Planning Managers Committee and the Toxic Risk Managers Committee to develop guidance on assessing the health risk impacts from and to proposed land use projects. This CAPCOA guidance document focuses on the acute, chronic, and cancer impacts of sources affected by CEQA. It also outlines the

<sup>1</sup> Title 14 California Code of Regulations, Chapter 3. Guidelines for Implementation of the California Environmental Quality Act.

<sup>2</sup> Air Quality and Land Use Handbook: a Community Health Perspective, CARB, April 2005, <http://www.arb.ca.gov/ch/handbook.pdf>



recommended procedures to identify when a project should undergo further risk evaluation, how to conduct the health risk assessment (HRA), how to engage the public, what to do with the results from the HRA, and what mitigation measures may be appropriate for various land use projects. With respect to health risks associated with locating sensitive land uses in proximity to freeways and other high traffic roadways, HRA modeling may not thoroughly characterize all the health risk associated with nearby exposure to traffic generated pollutants.

This guidance does not include how risk assessments for construction projects should be addressed in CEQA. As this is intended to be a “living document”, the risks near construction projects are expected to be included at a later time as the toxic emissions from construction activities are better quantified. State risk assessment policy is likely to change to reflect current science, and therefore this document will need modification as this occurs.

## 1.0 Requirements to Evaluate Health Risks in CEQA

This guidance was prepared to assist Lead Agencies in complying with the requirements of the California Environmental Quality Act (CEQA)<sup>3</sup>. CEQA requires that environmental impacts of proposed projects be identified, assessed, avoided and/or mitigated (as possible) if the environmental impacts are significant.

Section 15126.2(a) requires the following: *“An Environmental Impact Report (EIR) shall identify and focus on the significant environmental effects of the proposed project. In assessing the impact of a proposed project on the environment, the lead agency should normally limit its examination to changes in the existing physical conditions in the affected area as they exist at the time the notice of preparation is published, or where no notice of preparation is published, at the time environmental analysis is commenced. Direct and indirect significant effects of the project on the environment shall be clearly identified and described, giving due consideration to both the short-term and long-term effects. The discussion should include relevant specifics of the area, the resources involved, physical changes, alterations to ecological systems, and changes induced in population distribution, population concentration, the human use of the land (including commercial and residential development), health and safety problems caused by the physical changes, and other aspects of the resource base such as water, historical resources, scenic quality, and public services. The EIR shall also analyze any significant environmental effects the project might cause by bringing development and people into the area affected. For example, an EIR on a subdivision astride an active fault line should identify as a significant effect the seismic hazard to future occupants of the subdivision. The subdivision would have the effect of attracting people to the location and exposing them to the hazards found there.”*

This language is included here to clearly show that risk assessments can be required for both projects that will impact nearby receptors (Type A), and projects that will be impacted by nearby sources (Type B).

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<sup>3</sup> Pub. Resources Code § 21067; 14 Cal. Code Regs., §§ 15150, 15367.

## 2.0 Overview of the Process

Figure 1 shows an overview of the proposed Health risk Assessment (HRA) process. There are basically two types of land use projects that have the potential to cause long-term public health risk impacts:

**Type A** - Land use projects with toxic emissions that impact receptors, and

**Type B** - Land use project that will place receptors in the vicinity of existing toxics sources.

**Type A** project examples (project impacts receptors):

- combustion related power plants,
- gasoline dispensing facilities,
- asphalt batch plants,
- warehouse distribution centers,
- quarry operations, and
- other stationary sources that emit toxic substances.

**Type B** project examples (project impacted by existing nearby toxic sources):

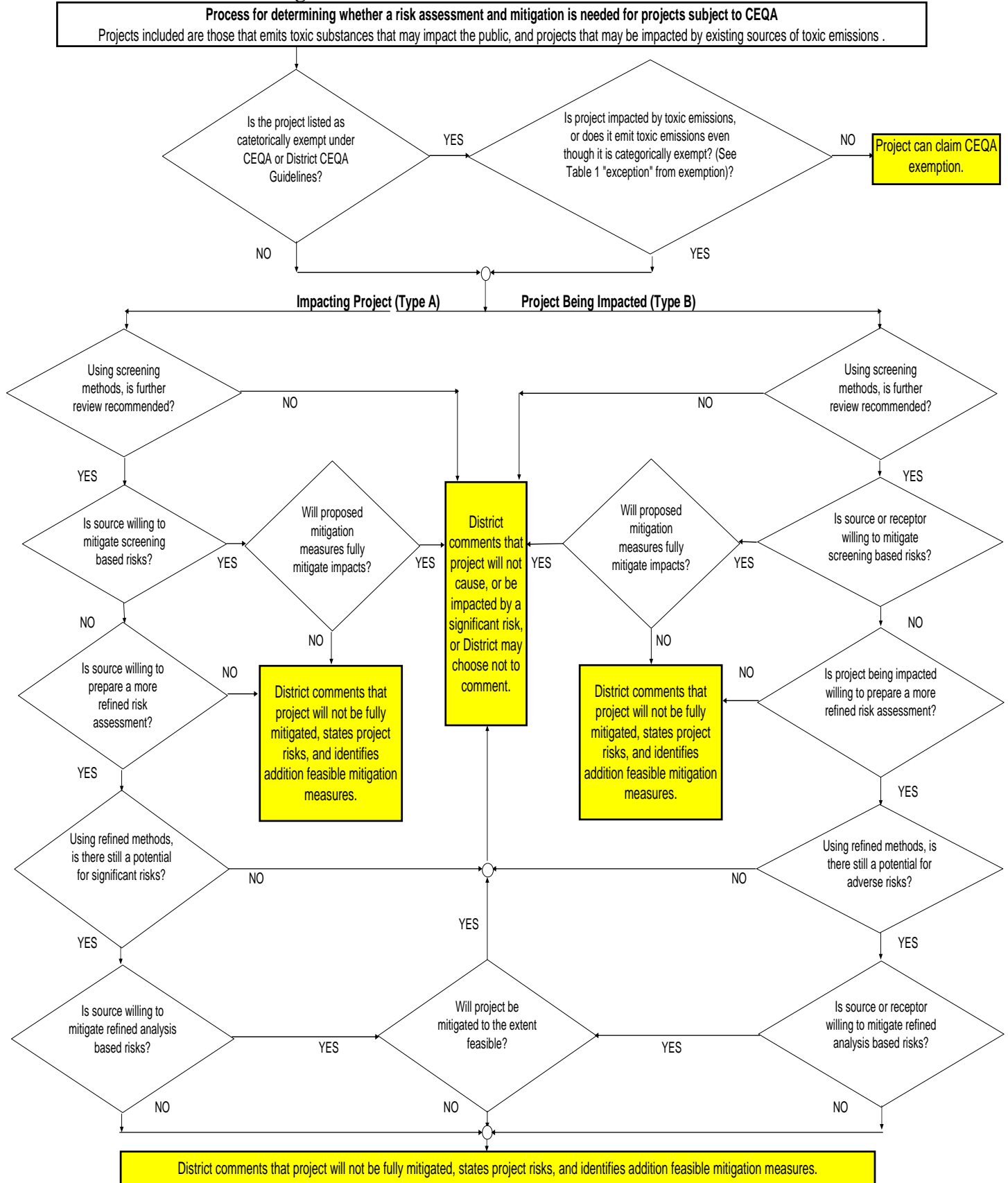
- residential, commercial, and institutional developments proposed to be located in the vicinity of existing toxic emission sources such as:
  - stationary sources,
  - high traffic roads
  - freeways,
  - rail yards, and
  - ports.

The flowchart (Figure 1) shows how to proceed with the CEQA process when either a Type A or Type B related project is proposed. The following summarizes the process for proceeding through the flowchart:

- First determine if the project is categorically exempt from CEQA;
- Next, determine if the project is impacting, or being impacted (Type A or B);
- Using screening methods, calculate acute, chronic, and cancer risk;
- If the screening analysis indicates significant health risk as defined by the lead agency, demonstrate that risks will be mitigated with all feasible measures even though a refined risk assessment may show that less mitigation is needed;
- Or, conduct a refined screening risk assessment; and,
- If the risk continues to be deemed significant by the lead agency even with the refined screening, demonstrate that the risks will be adequately mitigated with feasible measures.

Air districts, in their role as either a responsible agency or a commenting agency, should review the HRA and communicate to the lead agency their evaluation of the risk assessment and whether it is fully described (e.g., methodology, assumptions and resulting risk values) and mitigated with all feasible measures.

**Figure 1. Overview of Health Risk Assessment**



### **3.0 Overview of Risk Assessment Methodology and Guidance Documents**

This document bases the risk assessment methodology on the procedures developed by the California Office of Environmental Health Hazard Assessment (OEHHA) to meet the mandates of the Air Toxics "Hot Spots" Information and Assessment Act (AB 2588). The Hot Spots program applies to stationary sources and requires affected facilities to prepare a toxic emissions inventory, and if the emissions are significant, that a risk assessment be prepared. The OEHHA procedures can be found at [http://www.oehha.ca.gov/air/hot\\_spots/index.html](http://www.oehha.ca.gov/air/hot_spots/index.html) and describe:

- The toxicity factors associated with various substances,
- How these toxicity factor are to be used to determine the acute, chronic, and cancer risks associated with downwind concentrations of chemicals in the air at various receptors, and
- Dispersion modeling procedures.

## 4.0 CEQA Exemptions

The first step in a risk analysis is to determine if the project is statutorily or categorically exempt from CEQA. There are no exceptions to statutorily exempt projects, however, certain projects that are categorically exempt under the state or air district guidelines, may emit toxic emissions or may be impacted by existing toxic sources. Table 1 shows the exceptions from categorical exemptions where an HRA evaluation is needed. These are situations where a project proponent or lead agency may not rely on a categorical exemption because the health risk may trigger an exception (CEQA §15300.2), preventing their use. In such cases, a negative declaration or environmental impact report should be prepared.

**Table 1**  
**Categorical Exemptions Requiring HRA Evaluation<sup>4</sup>**

<b>Categorical Exemption</b>	<b>Exempt Activity with <i>Possible Impact</i></b>
15301. Existing Facilities	This exemption also allows use of a single-family residence as a day care facility without CEQA review. <i>However, such uses near existing TAC emissions may warrant further review.</i>
15302. Replacement or Reconstruction	This exemption allows the replacement or construction of existing schools and hospitals in certain cases without CEQA review. <i>However, locating new facilities near existing TAC emissions may warrant further review.</i>
15303. New Construction or Conversion of Small Structures	This exemption class allows small new construction projects to proceed without CEQA review. <i>However, projects claiming this exemption should be reviewed for possible TAC impacts from ongoing nearby sources.</i>
15314. Minor Additions to Schools	This exemption class allows small school addition projects to proceed without CEQA review. <i>However, projects claiming this exemption should be reviewed for possible TAC impacts from ongoing nearby sources.</i>
15316. Transfer of Ownership of Land in Order to Create Parks	Exemptions in this class should be reviewed for <i>possible impacts from locating near ongoing sources of TAC.</i>
15332. In-Fill Development Projects.	This exemption class allows certain in-fill development projects to proceed without CEQA review. <i>However, projects claiming this exemption should be reviewed for possible TAC impacts from ongoing nearby sources such as high volume roadways and freeways.</i>

<sup>4</sup> Although methodology for assessing health risk for construction projects is not included in this document, lead agencies under CEQA are required to identify health risk from construction activities or projects and mitigate if they are deemed significant.

## 5.0 Screening Risk Assessments

Various tools already exist to perform a screening analysis from stationary sources impacting receptors (Type A projects) as developed for the AB2588 Hot Spots and air district permitting programs. Local air districts should be contacted for appropriate screening tools for proposed projects. Screening tools may include: prioritization charts, SCREEN3 and various spreadsheets.

For projects being impacted by existing sources (Type B projects), one screening tool is contained in the ARB Handbook<sup>4</sup>. The handbook includes a table (reproduced in these guidance documents as Table 2) with recommended buffer distances associated with various types of common sources. ARB's Handbook focuses on community health and provides important public health information to land use decision makers. In this document, ARB's primary goal is to provide information that will help keep California's children and other vulnerable populations out of harm's way with respect to nearby sources of air pollution.

For example, as shown in Table 2, ARB recommends avoiding siting new sensitive land uses such as residences, schools, daycare centers, playgrounds, or medical facilities within 500 feet of a freeway, urban roads with traffic volumes exceeding 100,000 vehicles/day, or rural roads with volumes greater than 50,000 vehicles/ day. Therefore, siting a residential project within 500 feet of a freeway, and the associated public health risks, should be disclosed as such in a CEQA document. Re-designing the project so that sensitive receptors are moved greater than 500 feet away from such roadways may mitigate the risk. Other non-sensitive land uses such as commercial uses may be sited in this area. ARB recommends that their guidelines be considered by the decision makers along with housing needs, economic development priorities, and other quality of life issues. It should also be noted that health risk assessments conducted on sensitive land uses in close proximity to freeways and other high traffic roadways may not thoroughly characterize all the health risk associated with nearby exposure to traffic generated pollutants.

**Table 2**  
**Recommendations on Siting New Sensitive Land Uses Such As Residences, Schools, Daycare Centers, Playgrounds, or Medical Facilities**<sup>5</sup>

Source Category	Advisory Recommendations
Freeways and high-traffic roads	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses within 500 feet of a freeway, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles per day.</li> </ul>
Distribution centers	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses within 1,000 feet of a distribution center (that accommodates more than 100 trucks per day, more than 40 trucks with operating transport refrigeration units (TRUs) per day, or where TRU unit operations exceed 300 hours per week).</li> <li>Take into account the configuration of existing distribution centers and avoid locating residences and other new sensitive land uses near entry and exit points.</li> </ul>
Rail yards	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses within 1,000 feet of a major service and maintenance rail yard.</li> <li>Within one mile of a rail yard, consider possible siting limitations and mitigation approaches.</li> </ul>
Ports	<ul style="list-style-type: none"> <li>Avoid siting of new sensitive land uses immediately downwind of ports in the most heavily impacted zones. Consult local air districts or the ARB on the status of pending analyses of health risks.</li> </ul>
Refineries	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses immediately downwind of petroleum refineries. Consult with local air districts and other local agencies to determine an appropriate separation.</li> </ul>
Chrome platers	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses within 1,000 feet of a chrome plater.</li> </ul>
Dry cleaners using perchloroethylene	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses within 300 feet of any dry cleaning operation. For operations with two or more machines, provide 500 feet. For operations with 3 or more machines, consult with the local air district.</li> <li>Do not site new sensitive land uses in the same building with perc dry cleaning operations.</li> </ul>
Gasoline dispensing facilities	<ul style="list-style-type: none"> <li>Avoid siting new sensitive land uses within 300 feet of a large gas station (defined as a facility with a throughput of 3.6 million gallons per year or greater). A 50 foot separation is recommended for typical gas dispensing facilities.</li> </ul>

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- These recommendations are advisory. Land use agencies have to balance other considerations, including housing and transportation needs, economic development priorities, and other quality of life issues.
- Recommendations are based primarily on data showing that the air pollution exposures addressed here (i.e., localized) can be reduced as much as 80% with the recommended separation.
- The relative risk for these categories varies greatly. To determine the actual risk near a particular facility, a site-specific analysis would be required. Risk from diesel PM will decrease over time as cleaner technology phases in.
- These recommendations are designed to fill a gap where information about existing facilities may not be readily available and are not designed to substitute for more specific information if it exists. The recommended distances take into account other factors in addition to available health risk data (see individual category descriptions).
- Site-specific project design improvements may help reduce air pollution exposures and should also be considered when siting new sensitive land uses.
- This table does not imply that mixed residential and commercial development in general is incompatible. Rather it focuses on known problems like dry cleaners using Perchloroethylene that can be addressed with reasonable preventative actions.
- A summary of the basis for the distance recommendations can be found in the ARB Handbook.



## 6.0 Refined Risk Assessments

If a screening risk assessment shows that a risk is a concern, then a more refined analysis may be prepared. The refined analysis for the project may show lower risks, and provide more accurate information for decision makers. The screening assessment uses more conservative assumptions and thus gives higher risk than refined assessment. Risk assessments are normally prepared in a tiered manner, where progressively more input data is collected to refine the results. These guidelines include the evaluation of both mobile and stationary sources.

Attachment 1 to this document consists of the **Technical Modeling and Risk Assessment Guidance** which address various air quality dispersion modeling issues pertinent to California and is based primarily on information found in ARB, EPA and OEHHA guidance.

Appendix A, **Meteorological Data**, provides information on preparing meteorological data, mixing height and upper air data and land use characterization.

Appendix B, **Modeling and Exposure Assessment Input and Output Data**, is a checklist of parameters designed to provide an overview of all information that should be submitted for a refined air dispersion modeling assessment.

## 7.0 Risk Thresholds

An air district can set CEQA significant risk thresholds (e.g. the excess cancer risk shall be less than ten per million, the acute or chronic hazard index shall be less than one, or other significance levels as arrived at through a public process) that are used on a per-project basis. If the air district's governing board has adopted specific risk thresholds, the lead agency may choose to use them to determine acceptable risk levels. Additionally, clear risk thresholds are helpful when mitigation measures are necessary. The degree of mitigation can be clearly defined when a risk threshold has been determined before a project is proposed.

The absence of a risk threshold does not relieve an agency of its obligation to address toxic emissions from projects under CEQA. The implications of not having a threshold are different depending on the role the agency has under CEQA – whether it is acting as a commenting agency, as a responsible agency, or as a lead agency.

### 7.1 *Significant Risk Thresholds - Type A (Impacting Sources)*

For Type A projects, those that generate toxic air contaminants (such as gasoline stations, distribution facilities or asphalt batch plants), air districts are uniform in their recommendation to use the significance thresholds that have been established under each district's "Hot Spots" and permitting programs. For the majority of the air districts the **excess cancer risk** significance threshold is set at **10 in a million**. For toxic air contaminants with acute and chronic, non-carcinogenic health effect, a **hazard index of one** must not be exceeded. Depending on the substances being emitted, a project with a hazard index greater than one could result in adverse health effects of various sorts. It should be noted that a hazard index exceeding one may need additional analysis to determine whether the acceptable level of acute or chronic risk could be higher depending upon the safety factors that were incorporated into the reference exposure levels (RELs) associated with the hazard index results. This additional analysis could be considered an additional refinement tier.

It should be noted that these thresholds may be applied differently for air district permitting, the Hot Spots program, and CEQA. For air district permitting, the thresholds apply only to individual permit units. For the Hot Spots program, the thresholds apply to the entire facility excluding vehicle emissions. Neither the permitting programs nor the Hot Spots program apply to vehicle emissions. For CEQA, the thresholds apply to all facilities including vehicle emissions, and road related emissions.

### 7.2 *Significant Risk Thresholds - Type B (Projects Impacted by Existing Sources)*

For Type B projects, those that are impacted by existing sources, air districts are not uniform in their recommendation on what significance threshold should be adopted or what processes should be undertaken when disclosing potential risks.

The CEQA statutes encourage an air district or any lead agency to establish significance thresholds under CEQA for any pollutant. While there are considerations that support the establishment of thresholds, there is no obligation to do so. The absence of a threshold does not relieve agencies of their obligations to address toxic emissions from projects under CEQA. The implications of not having a threshold are different depending on the role the agency has under CEQA – whether it is acting in commenting agency, as a responsible agency, or as a lead agency.

An air district or other lead agency may elect not to establish significance thresholds for a number of reasons.

A lead agency or air district may also determine there is insufficient information to support selecting one specific threshold over another. Air districts have historically recommended CEQA thresholds for air pollutants in the context of the air district's clean air attainment plan, or (in the case of toxic air pollutants) within the framework of a rule or policy that manages risks and exposures due to toxic pollutants.

Significance levels have been approached differently by air districts as enumerated below:

- Thresholds can be based on a specific risk level such that a 10 per million excess cancer risk and an acute and chronic hazard index of one should not be exceeded. These thresholds tend to be consistent with the Hot Spot Program thresholds.
- Thresholds can also be based on the region's existing background cancer risk value if one exists.
  - One option is to establish a risk level equal to a region's background risk level.
  - Another option is to establish a risk level equal to twice a region's background risk level.
  - Still another option is to look at the ambient risk in the immediate vicinity of the project area rather than the regional risk level.
- Case by case thresholds may also be defined.

## 8.0 Mitigation Measures

CEQA requires that adverse environmental impacts of a proposed project be identified, assessed, avoided, and, if deemed significant, mitigated (as feasible) to a level that is considered less than significant. “‘Feasible’ means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors” (CEQA Guidelines §15364).

In cases where significant adverse impacts are not avoided or substantially lessened, the public agency may approve the project if it first adopts a “statement of overriding considerations.” The statement of overriding considerations sets forth the specific reasons why the public agency found the project’s benefits outweigh its unavoidable adverse environmental effects (CEQA Guidelines §15043).

In addition to being a CEQA requirement, mitigating public exposure to toxic air pollution is needed to achieve air district goals. All potentially significant emission sources must be mitigated to the greatest extent feasible, including placing people out of harm’s way.

Table 3 presents mitigation measures that are currently considered to be feasible to reduce health risk from both Type A and Type B projects. The mitigation measures included in the table are not considered to be exhaustive. The lead agency and project proponents are encouraged to think creatively in devising measures to mitigate air quality impacts. However, the air districts recognize that the final determination of feasibility for a project will be determined by the lead agency. Aside from the mitigation measures shown below, knowing about the regulatory programs to reduce air pollutant emissions through statewide strategies provide information to local air districts and lead agencies to help assess and mitigate cumulative air pollution impacts as well.

### ***8.1 Mitigations due to Air Toxic Control Measures***

ARB has been developing Air Toxic Control Measures (ATCMs) for many years. Many of these measures have a phase-in schedule. Implementation of others has already been completed. While cancer and non-cancer risks from the air toxic sources implementing ATCMs are expected to decrease with time, the Office of Environmental Health Hazard Assessment (OEHHA) recommends that it is inappropriate to assume these yet-to-be realized emissions reductions in a health-risk assessment. However, the project proponent is encouraged to become familiar with existing and proposed ATCMs in order to determine if any of the ATCMs affect project-specific emissions.

### ***8.2 Mitigating Through Land Use and Design***

To a certain extent, the long-term air quality impact of a project is a function of its design. The layout of streets, the mix of land uses, and the placement of homes and businesses can all affect overall project emissions. Yet in many instances, the air quality impacts of a project are not considered until well after a project has been designed. At such a late stage, it can be very difficult to make any substantial changes to the project to reduce the project’s air quality impact.

As indicated throughout the ARB Handbook, land use agencies are strongly encouraged to consult early and often with local air districts. Including air quality considerations during the initial design phase can help an applicant to implement design features that will reduce its air quality impact.

In addition to considering the suitability of the project location, opportunities for mitigation of air pollution impacts through design should be considered. In some cases, control devices and changes in processes may be implemented at the source in order to reduce the risk from toxic air contaminant emissions. Examples of land-use based air quality specific performance standards include the following:

- Placing a process vent away from the direction of nearby receptors, or increasing the stack height so that emissions are dispersed to reduce the emissions impact on the immediate surroundings.
- Limiting the hours of operation of a facility to avoid excess emissions exposure to nearby individuals.
- An ordinance that requires fleet operators to use cleaner vehicles before project approval (if a new business), or when expanding the fleet (if an existing business).
- Providing alternate routes for truck operations that discourage detours into sensitive receptor neighborhoods.

While such measures may reduce the dimensions of a buffer zone, they do not obviate the need to maintain buffer zones to protect public health and safety. This is particularly true in situations where a sensitive receptor is encroaching on an existing source of toxic air contaminant. Also note disclosure statements, community alert procedures, etc., that are targeted at potential receptors are not appropriate mitigations to be used in lieu of buffer zones or technical controls.

Table 3 below contains examples of both project and program-level mitigation measures.

- Project-level mitigation measures are applicable to development which results in the implementation or modification of a land use which creates unacceptable levels of risk. Examples include redesigning the project to locate receptors away from TAC sources, the installation of barriers and/or vegetation and indoor air filtration.
- Program-level mitigation measures, on the other hand, are applicable to long-range community planning such as General Plans, and address land use incompatibility at a much earlier stage. Examples of program-level mitigation measures include rezoning vacant land adjacent to high-volume roadways, ports, railroads or heavy industry to avoid future proposed siting of residential and/or sensitive receptors.

## 8.3 *Mitigation Effectiveness*

The mitigation measures identified in Table 3 include both quantifiable and unquantifiable measures.

### 8.3.1 **Quantifiable Mitigation Measures**

The effect of quantifiable mitigation measures can be modeled or calculated beyond a reasonable doubt. As pertaining to health risk impacts, quantifiable mitigation measures generally result in a measurable reduction of toxic air contaminant emissions (such as DPM), or a measurable decrease in exposure to such emissions through increased buffer distances, reduced exposure durations or control devices having a certified control effectiveness.

Examples of quantifiable mitigation measures include:

- Diesel particulate filters: as of 2008, DPFs reduce the emissions of diesel particulate matter up to 85% as verified by the CARB.
- Increasing the distance between a TAC source and receptor may reduce the receptor's level of exposure to TACs; the effect of this mitigation measure can be estimated through dispersion modeling;
- Idling restrictions can greatly reduce or completely eliminate DPM emissions from stationary trucks; if such restrictions are quantitative and include a concrete limit on the number of minutes a truck (or similar) is allowed to idle, the benefits of this mitigation measure can be modeled.

Several cautionary notes regarding estimating the effectiveness of mitigation measures are warranted:

- Clearly explain the assumptions underlying the environmental document's analysis of mitigation measure effectiveness. The analysis should specifically describe the mitigation measure, identify the source(s) of air pollutants that are expected to be affected by the measure, clearly explain how and to what extent the measure will affect the source(s), and identify the basis for the estimate (empirical observations, computer modeling, case studies, etc.). Critical assumptions should be linked to the mitigation monitoring and reporting program.
- Be specific regarding implementation of mitigation measures. The environmental document should describe each mitigation measure in detail, identify who is responsible for implementing the measure, and clearly explain how and when the measure will be implemented. Methods for assessing the measure's effectiveness once it is in place, and possible triggers for additional mitigation if necessary, may be needed. This level of detail regarding mitigation measure implementation frequently is not addressed until the preparation of the mitigation monitoring and reporting program, which often takes place very late in the environmental review process. In order to reliably assess the effectiveness and feasibility of mitigation

measures, however, air agencies believe it is necessary to consider the specifics of mitigation measure implementation as early in the environmental review process as possible.

- Be sure not to double count the effect of proposed mitigation measures. The project description and assumptions underlying the analysis of project impacts should be carefully considered when estimating the effect of mitigation measures. If certain conditions or behavior are assumed in the impact analysis, then credit may not be claimed when proposing mitigation measures.
- Health risk assessments discussed in this document estimate outdoor risk. While some mitigation measures may reduce risks by filtering outdoor air to be used indoors, they do nothing to reduce the risk assessment values for outdoor air.

### **8.3.2 Unquantifiable Mitigation Measures**

In some cases, it simply may not be possible to quantify the effect of proposed mitigation measures. It may be that the specific conditions surrounding a particular project are so unique as to render extrapolation from other examples unreliable. A proposed measure may be innovative, with little precedent. The combined effects of a package of measures may be too difficult to quantify. While a certain degree of professional judgment is usually involved in estimating the effectiveness of mitigation measures, speculative estimates should be avoided. If the project proponent cannot quantify mitigation effectiveness with a reasonable degree of certainty, the environmental document should at least address effectiveness qualitatively. If the lead-agency makes a finding that non-quantified mitigation measures reduce an impact to a level of insignificance, the document should provide a detailed justification of that conclusion.

#### **8.3.2.1 *Effects of Vegetation Next to Roadways***

The Sacramento Air District funded a study to measure the removal rates of particulate matter passing through leaves and needles of vegetation. Particles were generated in a wind tunnel and a static chamber and passed through vegetative layers at low wind velocities. Redwood, deodar cedar, live oak, and oleander were tested. The results from this study indicate that all forms of vegetation able to remove 65-85 percent of very fine particles at wind velocities below 1.5 meters per second (roughly 3 miles per hour) with redwood and deodar cedar being the most effective.

This study supports the effectiveness of planting finely needled trees along sources of toxic particulate matter as an air toxics mitigation measure. Though further studies that reflect actual roadway conditions are needed to better quantify the real-world effectiveness of this mitigation measure, projects that propose sensitive receptors adjacent to sources of particulate matter such as freeways, major roadways, rail lines, and rail

yards should consider tiered plantings of redwood and/or deodar cedar in order to reduce toxic exposures.

### 8.3.2.2 *No Idle Zone*

California law currently places restrictions on idling of heavy-duty diesel motor vehicles to reduce health risk impacts from diesel emissions. The 2003 school bus idling airborne toxic control measure (ATCM) requires a driver of a school bus or vehicle, transit bus, or other commercial motor vehicle to manually turn off the bus or vehicle engine upon arriving at a school and to restart no more than 30 seconds before departing. A driver of a school bus or vehicle is subject to the same requirement when operating within 100 feet of a school and is prohibited from idling more than five minutes at each stop beyond schools, such as parking or maintenance facilities, school bus stops, or school activity destinations.

California's more recent anti-idling regulations (with some exemptions) require that drivers of diesel-fueled commercial vehicles weighing more than 10,000 pounds:

- Shall not idle the vehicle's primary diesel engine for greater than 5 minutes at any location,
- Shall not use diesel-fueled auxiliary power units for more than 5 minutes to power a heater, air conditioner, or any ancillary equipment on the vehicle equipped with a sleeper berth, at any location.

Lead agencies may place additional requirements on heavy duty diesel delivery and haul trucks less than 10,000 pounds, and create "no idle" zones at locations where there is a potential for significant health risk. It may not be possible to quantify the emission reductions associated with the creation of a no idling zone. However, this feasible mitigation measure may eliminate idling emissions and may avoid potentially significant health risk impacts.

**Table 3**  
**Mitigation Measures**

<b>Source Category</b>	<b>Mitigation Measure (listed in order of effectiveness by category)</b>
Stationary Sources Type A (Sources Impacting receptors) (e.g., Auto body shops, Gas Stations, Manufacturers, Metal Platers, Chemical Producers, Rock Quarries, Incinerators, Power Plants, Diesel Engines)	<ol style="list-style-type: none"> <li>1. Move source location to provide effective buffer zone.</li> <li>2. Reduce throughput.</li> <li>3. Install Toxic Best Available Control Technology (TBACT) to reduce the risks to below significance.</li> <li>4. Install other than TBACT air pollution control devices or process operation modifications.</li> <li>5. Address Diesel vehicle engines as listed below.</li> </ol>



Source Category	Mitigation Measure (listed in order of effectiveness by category)
Onsite Diesel Truck Activities (including transport refrigeration units)	<p><u>Idling Mitigation Measures:</u></p> <ol style="list-style-type: none"> <li>1. Move source location to provide effective buffer zone.</li> <li>2. Establish truck parking restrictions.</li> <li>3. Provide utility hook-ups for trucks that need to cool their load.</li> <li>4. Limit truck idling to &lt;5 minutes (State law limits to 5 minutes of idling, and includes various exemptions).</li> <li>5. Require Trucks to operate an Auxiliary Power Unit.</li> <li>6. Require the installation of electrical hookups at loading docks and the connection of trucks equipped with electrical hookups to eliminate the need to operate diesel-powered TRUs at the loading docks.</li> </ol> <p><u>Onsite Truck Traveling Emissions:</u></p> <ol style="list-style-type: none"> <li>1. Move source location to provide effective buffer zone.</li> <li>2. Restrict operation to 2007 model year or newer trucks.</li> <li>3. Require or provide incentives to use Diesel Particulate Filters for truck engines.</li> <li>4. Re-route truck traffic by adding alternate access for truck traffic or by restricting truck traffic on certain sensitive routes.</li> <li>5. Improve traffic flow by signal synchronization.</li> <li>6. Implement incentive for improved communications of fluctuating demand forecasts for labor and equipment among carriers and operators.</li> </ol>
High-traffic road vehicle emissions impacting adjacent receptors	<ol style="list-style-type: none"> <li>1. Move receptors or source to provide effective buffer zone between the source and the receptor.</li> <li>2. Improve traffic flow by signal synchronization.</li> <li>3. Plant vegetation between receptor and roadway.</li> <li>4. Construct wall barriers between receptor and roadway.</li> <li>5. Install newer electrostatic filters in adjacent receptor buildings.</li> <li>6. Fund “clean” street sweepers.</li> <li>7. Improve road infrastructure to facilitate improved traffic flow without inducing capacity.</li> <li>8. Improve alternative transportation options</li> </ol>
Freeway vehicle emissions impacting adjacent receptors	<ol style="list-style-type: none"> <li>1. Move receptors or source to provide effective buffer zone between the source and the receptor.</li> <li>2. Plant vegetation between receptor and roadway.</li> <li>3. Construct wall barriers between receptor and roadway.</li> <li>4. Install newer electrostatic filters in adjacent receptor buildings.</li> <li>5. Improve road infrastructure to facilitate improved traffic flow.</li> </ol>
Marine Vehicles (e.g., recreational boating, commercial marine operations, hoteling operations, loading and unloading services)	<ol style="list-style-type: none"> <li>1. Move receptors or source to provide effective buffer zone between the source and the receptor.</li> <li>2. Require or provide incentives to install add-on Diesel Particulate Matter control devices or cleaner engines or boilers.</li> <li>3. Require use of electric power when berthed.</li> <li>4. Require cleaner fuels.</li> <li>5. Limit vessel speed.</li> </ol>

Source Category	Mitigation Measure (listed in order of effectiveness by category)
Railroad (i.e., switch yards, maintenance yards, intermodal centers)	<ol style="list-style-type: none"> <li>1. Move receptors or source to provide effective buffer zone between the source and the receptor.</li> <li>2. When ambient temperatures are above 50 deg F, minimize locomotive engine idling by shutting down and re-starting engines.</li> <li>3. Require Idle Reduction Technologies - The rail industry has developed and designed a new Auxiliary Power Unit (APU) system that provides power during idling conditions and shuts down the main locomotive engine. Installing APU system reduces locomotive PM emissions by 84 percent-</li> <li>4. Require new engine technologies be applied to the engines - Modifying fuel injectors, which includes fuel injection pressure, fuel spray pattern, injection rate and timing, has been found to reduce emissions from locomotive diesel engines.</li> <li>5. Require hybrid switcher locomotives.</li> <li>6. Require use of locomotive technology that meets or exceeds the latest EPA emission regulations for locomotives.</li> <li>7. Apply the 1998 Railroad MOU for South Coast Air Basin.</li> <li>8. Apply the 2005 Statewide MOU for Rail Yard Risk Reduction.</li> </ol>

## 8.4 Mitigation Monitoring and Reporting

### 8.4.1 Primary Mitigation Measures

As part of CEQA environmental review procedures, Public Resources Code Section 21081.6 requires a public agency to adopt a monitoring and reporting program for assessing and ensuring efficacy of mitigation measures applied to the proposed project. Specifically, the lead or responsible agency must adopt a reporting or monitoring program for mitigation measures incorporated into a project or imposed as conditions of approval. The program must be designed to ensure compliance during project implementation. As stated in Public Resources Code, Section 21081.6 (a) (1):

*“The public agency shall adopt a reporting or monitoring program for the changes made to the project or conditions of project approval, adopted in order to mitigate or avoid significant effects on the environment. The reporting or monitoring program shall be designed to ensure compliance during project implementation. For those changes which have been required or incorporated into the project at the request of a responsible agency or a public agency having jurisdiction by law over natural resources affected by the project, that agency shall, if so requested by the lead agency or a responsible agency, prepare and submit a proposed reporting or monitoring program.”*

This requirement is intended to assure that mitigation measures included as conditions of project approval are indeed implemented. A mitigation monitoring and reporting program should include the following components:

- A description of each mitigation measure adopted by the Lead Agency.
- The party responsible for implementing each mitigation measure.
- A schedule for the implementation of each mitigation measure.
- The agency or entity responsible for monitoring mitigation measure implementation.
- Criteria for assessing whether each measure has been implemented.
- Enforcement mechanism(s).

The mitigation monitoring and reporting program is not required to be included in the environmental document, but its inclusion will encourage the Lead Agency and other entities to specifically consider the feasibility and effectiveness of each mitigation measure while the environmental analysis is still underway. If a responsible agency or any agency having jurisdiction over natural resources affected by the project proposes mitigation measures, the Lead Agency may require that agency to prepare a monitoring and reporting program for those mitigation measures.

#### **8.4.2 Contingency Mitigation Measure**

A mitigation implemented to reduce health risk for a particular project may degrade or fail over time. Continuous monitoring and enforcement programs are recommended to ensure the ongoing effectiveness of all mitigation measures over the project life. In the instance that one or more mitigation measures fail or become ineffective, they should be replaced with mitigation measures of equal or greater effectiveness.

Examples of health risk mitigation measures subject to degradation and/or failure include:

- Vegetation barriers, which may die due to natural causes or lack of upkeep;
- Particulate filters, which may become clogged, mechanically damaged or simply reach the end of their design life; and,
- Indoor air filtration systems, which may become clogged or fail completely due to lack of regular maintenance.

## 9.0 Public Participation

As emphasized in the ARB Handbook, community involvement is an important part of the overall land use approval process. Public participation is critical when proposed projects could create increased health risk to the individuals or the community. To that extent, engaging community members during the initial phase of the project evaluation process provides a communication conduit between impacted individuals, project proponents and the decision makers. This dialog aims to expand the community's overall understanding of the risk assessment process and the resulting health impact values. While the air district is not typically the lead agency for a project undergoing health risk evaluation, it plays a critical role in working with the impacted community to explain the technical modeling tools and assumptions used to calculate the overall risk values that are ultimately provided to local decision makers for approval action.

Active public participation requires engaging individuals in ways that do not require prior knowledge of air pollution issues impacting their communities. Information should be provided to illustrate how a land use decision can affect the health of the community due to emission impacts from Type A or to Type B projects. Due to the overly technical nature of health risk assessments, air districts need to take specific efforts to develop messages and outreach tools that will assist to convey complex issues to a non-technical community. The outreach process needed to build effective community participation requires data, methodologies and formats customized to the needs of the specific community. Depending on the community characteristics cultural barriers, such as translation to another language, need to be assessed prior to conducting community outreach. More importantly, it requires the strong collaboration of community members and agencies that review and approve projects and land uses of the local community.

The ARB Handbook's Table 7-1, Public Participation Approaches includes some general outreach strategies that air districts might consider in designing an outreach program to increase understanding of the air pollution impacts to specific land use projects. Such a program could consider the preparation and presentation of information in a way that supports sensible decision-making and public involvement. In order to build community trust in the health risk assessments being conducted for proposed development, public participation should occur at the initial phases of project evaluation and continue throughout the approval process.

## 10.0 HRA Issues in the CEQA Process

There are number of issues that have been encountered at the local decision making level that present challenges during the evaluation of health risk impacts from proposed land use projects. To provide more assistance to air districts, lead agencies and community members on how to overcome these challenges, this chapter outlines a few issues that have been encountered during the project evaluation phase, as well as potential solutions to reduce health risk, minimize errors and assist decision makers in their final action.

### 10.1 *Smart Growth*

Land use planners, developers, public health agencies and environmentalists alike all struggle with the apparent dichotomy between the public health benefits of limiting development adjacent to freeways and major roadways, and the public health benefits of smart growth strategies which call for development closer in to the urban core, often adjacent to major travel corridors, as a way to reduce overall emissions. Guidance that helps local planners disclose potential risk, and/or seeks to limit development adjacent to freeways and major roadways appears to conflict with smart growth policies, especially when the guidance affects small projects.

A potential solution to this dilemma is the identification and implementation of effective mitigation measures that will help reduce impacts to sensitive receptors, thereby supporting smart growth policies. Table 3 contains program-level TAC mitigation measures. Such measures are applicable to long-range community planning programs such as General Plans and address land use incompatibility at an early stage. These measures are particularly effective in that they can prevent many high-risk projects from being considered or proposed in the first place, thereby eliminating the necessity for project-level mitigation which may not always be feasible or sufficiently effective. Examples of program-level mitigation measures include rezoning vacant land adjacent to freeways, high-volume roadways, ports, railroads or heavy industry to avoid future proposed siting of residential and/or sensitive receptors.

### 10.2 *Less than Lifetime Cancer Risk Exposures*

The standard OEHHA 70 year exposure timeframe for HRAs is often vigorously challenged as to whether it is reasonable to base residential cancer risk on a 70 year, 24 hour per day, seven day per week exposure. A 70-year lifetime exposure is a worst-case assumption. Shorter exposure periods can be appropriate depending on the situation. The cancer risks caused by projects impacting offsite workers can be factored in accordance with guidance provide in the State Office of Environmental Health Hazard Assessment provided a document called the *Air Toxic Hot Spots Program Guidance Manual for the Preparation of Health Risk Assessments*, August 2003. This guidance document also describes how the exposure period can be reduced from 70 year to shorter periods for Type A projects that will operate for periods less than 70 years. This information is also included in the **Technical Modeling and Risk Assessment Guidance** component of this document in Attachment 1.

### ***10.3 Mitigating Roadway Toxics***

As discussed above, lead agencies often struggle with requiring mitigation when, due to a lack of a threshold, the roadway toxics impacts are not considered “significant.” At other times, lead agencies are eager to require mitigation, but feel most comfortable being able to point to studies that quantify the actual mitigation levels before asking project proponents to bear the additional costs of the mitigation. In addition, lead agencies often do not feel comfortable asking a project to make changes via implementing mitigation when the project complies with existing zoning requirements and does not request exemptions. While this is a contentious issue, districts may choose to suggest mitigation measures regardless of whether a health risk determination was made by the lead agency.

### ***10.4 Existing Background Risk***

Often, environmental documents with site specific HRAs contain lengthy discussions comparing a project’s health risk to the existing background health risk levels, and often, potential project-specific cancer risk levels are expressed as a percentage of the existing background risk without disclosure of the actual additional risk due to the project. It is the actual additional risk due to the project (Type A), or the risk to the project (Type B) that must be disclosed and compared to CEQA significance thresholds.

### ***10.5 Inappropriate Discounting of Risks***

Standardized health risk assessment methodologies have been developed to reduce inconsistencies between HRAs and aid in comparing impacts on receptors. However, in practice inappropriate HRA calculations are still carried out and presented as the basis for public disclosure and notification. Such inappropriate HRA calculations are most often made in an attempt to present reduced risk values compared to the higher results produced by standard methodologies. This is a significant concern, especially with respect to health risks associated with locating sensitive land uses in proximity to freeways and other high traffic roadways, where even the standardized HRA modeling methods may not thoroughly characterize all the health risk associated with nearby exposure to traffic generated pollutants.

Inappropriate HRA methodologies often result in protracted controversy, which is sometimes played out in the public arena - for example, at project approval hearings. To minimize these situations, the HRA preparer should adhere to the standard risk calculation methodologies set forth by OEHHA, the Air Resources Board, and the local air district, and as described in this document.

Examples of some mistakes to avoid are described in the following paragraphs.

- One inappropriate calculation is to calculate the cancer risk using the 70-year exposure timeframe, but then reduce the risk values by dividing the risk values by the number of receptors in the subdivision. Doing so is misleading and not scientifically supported. Potential cancer risk should be expressed as probability per million, based upon OEHHA recommendations.

- For Type A projects, it is also inappropriate to present risk values as a percentage of some existing risk value, such as the existing background risk. Often this is done in an attempt to persuade readers that the project specific risk is of little consequence because the increased risk is small compared to the background risk. In cases where project specific risk is compared to other risks or expressed as a percentage of the existing background, it should be made clear that the project specific risk is in addition to the existing background risk.
- Another inappropriate calculation sometimes included in risk assessments is to base emissions on emission factors that may result from future actions, such as emission reduction rules that have not yet gone into effect, or expected emission reductions due to expected market forces.

### ***10.6 Misleading Comparison of Cancer Risks***

Comparing cancer risks can be misleading in a CEQA document. Some CEQA documents discuss a variety of cancers and the prevalence of it in our population. It's sometimes stated, for example, that currently throughout the United States, one in three or four persons will experience cancer sometime during their lifetime. This can be a misleading statistic if it is used to imply that the incremental probability of increased cancer cases due to toxic airborne emissions are very small compared to the overall probability of cancer. For example, a Health Risk Assessment may find that the increased probability of cancer cases is 200 in one million for certain sensitive receptors located near a busy freeway. To compare that HRA result with the overall population's cancer incidence would discount the risk unfairly. The CEQA document should disclose the risk without any such comparisons.

### ***10.7 "Experts Disagree"***

When project proponents submit HRAs and related materials that are developed via methodologies not supported by the air district or OEHHA, protracted controversy can result. One air district noted that, despite comment from OEHHA and ongoing district comments on the inappropriate discounting of a project's HRA results, those results remained unchanged in the Final EIR. The Final EIR discussed the nature of the disagreement, citing Section 15151 of the CEQA Guidelines which states that disagreement among experts "does not make an EIR inadequate, but the EIR should summarize the main points of disagreement among experts." Ultimately, the lead agency will make a land use decision based on their understanding. But for sources that need an air district permit, the applicable air district's risk assessment procedures will apply.

## 11.0 Conclusion

The study of the impact of toxic air emissions on sensitive receptors is an evolving one. Air districts in the state of California generally have had a consistent way of performing health risk assessments of stationary sources on nearby sensitive receptors (Type A projects). However, with the publication in 2005 of ARB's Handbook, the issue of the effect of mobile sources on sensitive receptors (Type B projects) required air districts to augment their guidance. This CAPCOA guidance reflects the fact that currently, the various air districts in the state have different approaches to the topic. For example, some districts have developed a threshold of significance for these projects and some have not. Despite these differences, this document offers some common guidance about the need to analyze the impacts, to disclose the risk to decision makers and to mitigate it. As health risk analysis tools, methodology, and protocol as developed, the document will be revised.



## **Attachment 1**

# **Technical Modeling and Risk Assessment Guidance**

Prepared by  
CAPCOA Planning Managers  
HRA Subcommittee

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## Preface

The document shows how to model emissions of toxic substances from various source types to determine the cancer risk, acute risk, and noncancer chronic risk impacting nearby receptors. It can also be used to determine the impacts to new receptors (such as housing projects) proposed to be built next to existing sources that emit toxic substances. These guidelines were prepared to assist in complying with the requirements of the California Environmental Quality Act (CEQA). CEQA requires that environmental impacts of a proposed project be identified, assessed, and mitigated (as possible) if the environmental impacts are significant.

This document consists of three components:

- Modeling Guidelines,
- Exposure Assessment Guidelines, and
- Appendices describing how to determine the emissions and risks from common source categories. Examples of these sources categories include:
  - Roadways,
  - Facilities with onsite truck travel and idling,
  - Stationary diesel engines, and
  - Fast food and other restaurants.

The modeling guidelines are based on a document entitled “Provision of Services to Develop Guidance for Air Dispersion Modeling,” developed by Dr. Jesse Thé of Lakes Environmental Software. They have been modified to include various air quality dispersion modeling issues pertinent to California, and are based primarily on information found in EPA’s Guideline on Air Quality Models (Appendix W of Part 51 of Title 40 of the Code of Federal Regulations). The modeling components are intended to provide insight into recommended modeling approaches and provide consistency in the modeling methods used.

The Exposure Assessment components are based on the procedures developed by the California Office of Environmental Health Hazard Assessment (OEHHA). These calculation methodologies may change over time as the OEHHA refines the methodologies. **It is important that the air district be contacted before any risk assessment calculations are prepared, so that the most current methodologies are applied.**

This document is not designed to provide theoretical background on the models it discusses. Technical documents covering these topics can be easily obtained from several U.S. EPA sources and are listed as references in this document. This document does provide details on performing a successful modeling study including:

- Model Backgrounds and Applicability,
- Model Selection and Study Approach,
- Tiered Approach to Assessing Compliance,
- Model Input Data Requirements,
- Geographical Information,
- Meteorological Data Requirements and Acquisition, and
- Information/Parameters for Inclusion in an Assessment.

# Glossary of Terms

<b>AERMAP:</b>	The terrain preprocessor for AERMOD, AERMAP allows the use of digital terrain data in AERMOD.
<b>AERMET:</b>	The meteorological preprocessor for AERMOD.
<b>AERMIC:</b>	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee.
<b>AERMOD:</b>	A new air dispersion model developed by AERMIC. It is intended to replace the ISCST model.
<b>Air Emissions:</b>	Release of pollutants into the air from a source.
<b>Albedo:</b>	Portion of the incoming solar radiation reflected and scattered back to space.
<b>Ambient Air:</b>	Air that is accessible to the public.
<b>AMS:</b>	American Meteorological Society.
<b>CAL3QHCR:</b>	CAL3QHCR is derived from CAL3QHC which is also derived from CALINE3. CALINE3 is a Carbon Monoxide (CO) model with queuing, hot spot calculations, and a traffic model to calculate delays and queues that occur at signalized intersections. CAL3QHCR is a more refined version requiring local meteorological data.
<b>Calm:</b>	Cessation of horizontal wind.
<b>Complex Terrain:</b>	Terrain exceeding the height of the stack being modeled.
<b>DEM:</b>	Digital Elevation Model. Digital files that contain terrain elevations typically at a consistent interval across a standard region of the Earth's surface.
<b>Dispersion Model:</b>	A group of related mathematical algorithms used to estimate (model) the dispersion of pollutants in the atmosphere due to transport by the mean (average) wind and small scale turbulence.
<b>Emission Factor:</b>	An estimate of the rate at which a pollutant is released to the atmosphere
<b>Flagpole Receptor:</b>	Any receptor located above ground level.

<b>Inversion:</b>	An increase in ambient air temperature with height. This is the opposite of the usual case.
<b>ISCST:</b>	Industrial Source Complex – Short Term Dispersion Model.
<b>Lee side:</b>	The lee side of a building is the side that is sheltered from the wind.
<b>Mixing Height:</b>	Top of the neutral or unstable layer and also the depth through which atmospheric pollutants are typically mixed by dispersive processes.
<b>Monin-Obukhov Length:</b>	A constant, characteristic length scale for any particular example of flow. It is negative in unstable conditions (upward heat flux), positive for stable conditions, and approach infinity as the actual lapse rate for ambient air reaches the dry adiabatic lapse rate.
<b>NWS:</b>	National Weather Service. A U.S. government organization associated with the National Oceanic and Atmosphere Administration.
<b>PCRAMMET:</b>	Meteorological program used for regulatory applications capable of processing twice-daily mixing heights (TD-9689 FORMAT) and hourly surface weather observations (CD-144 format) for use in dispersion models such as ISCST, CRSTER, MPTER and RAM.
<b>Preferred Model:</b>	A refined model that is recommended for a specific type of regulatory application.
<b>Primary Pollutant:</b>	Substance emitted from the source.
<b>Regulatory Model:</b>	A dispersion model that has been approved for use by the regulatory offices of the U.S. EPA, specifically one that is included in Appendix A of the Guideline on Air Quality Models (Revised), such as the ISC model.
<b>Screening Technique:</b>	A relatively simple analysis technique to determine if a given source is likely to pose a threat to air quality. Concentration estimates from screening techniques are conservative.
<b>Simple Terrain:</b>	An area where terrain features are all lower in elevation than the top of the stack of the source.
<b>Upper Air Data (soundings):</b>	Meteorological data obtained from balloon-borne instrumentation that provides information on pressure, temperature, humidity and wind away from the surface of the earth.



**U.S. EPA:**

United States Environmental Protection Agency.

**Worst Case:**

The maximum exposure, dose, or risk that can conceivably happen to specific receptors.

# Chapter 1. A Tiered Approach to Risk

## 1.0 Modeling and Exposure Assessment Tiers Overview

Risk assessments are normally prepared in a tiered manner, where progressively more input data is collected to refine the results. Both the modeling component and the exposure assessment component are based on a tiered method. This document shows how to:

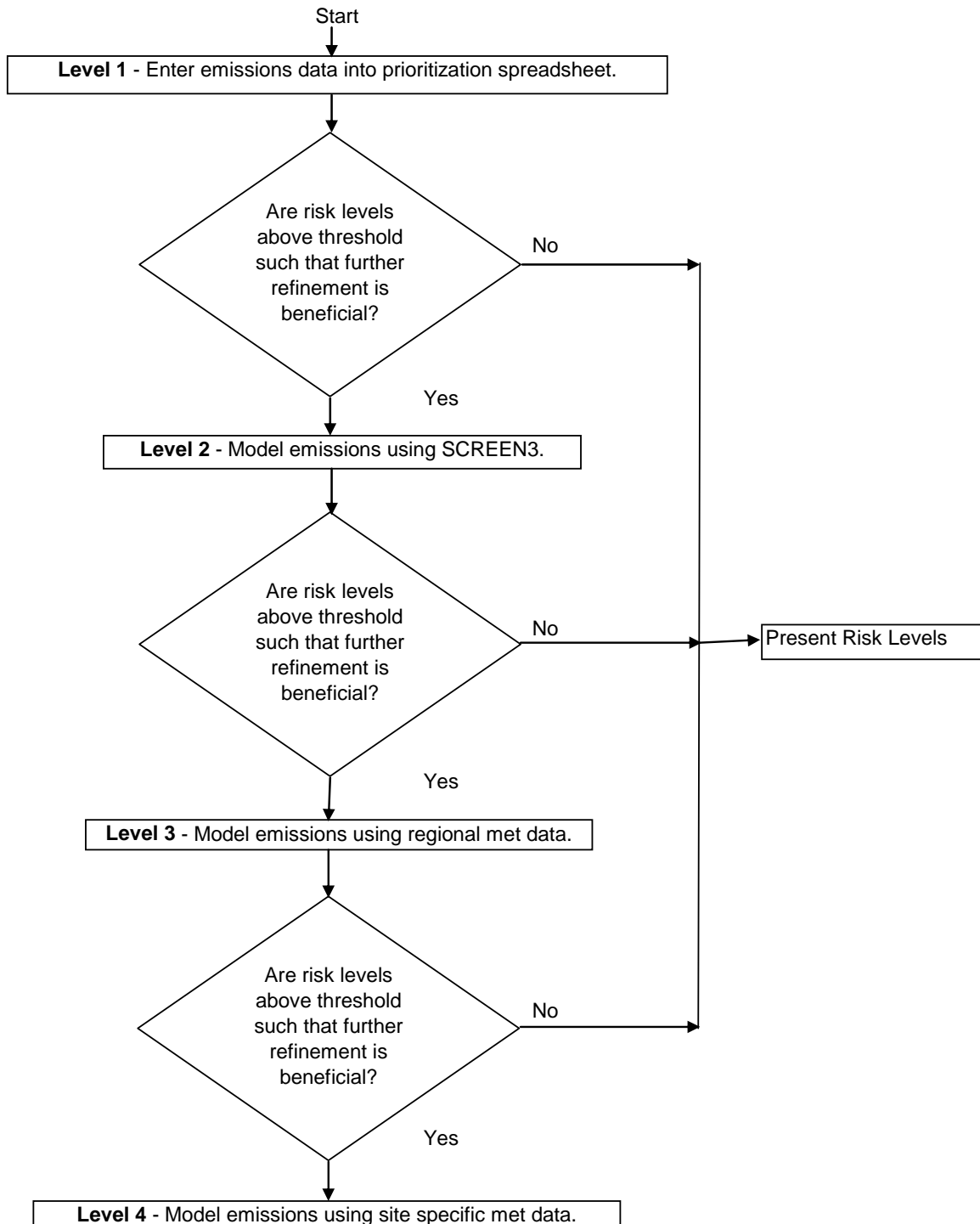
- Model the downwind concentrations of pollutants using each of the four modeling tiers (levels), then
- Use tiers to prepare the exposure assessment part of the risk assessment.

The models described in the document include:

- Screening models:
  - SCREEN3, and
  - AERSCREEN
- Refined models:
  - ISCST3,
  - ISC-PRIME, and
  - AERMOD
  - CAL3QHCR

A tiered approach to air dispersion modeling is presented in Figure 1. The level of effort generally increases with level number. It should be noted that any of the tiers or levels can provide risk assessment results, although the higher the tier or level the more accurate the results. Linear progression through each tier or level is not necessary. For example, a refined modeling analysis can be prepared without first preparing a screening analysis.

**Figure 1 - Tiered approach to modeling for risk assessments:**



## **1.1 Dispersion Models used for each TIER:**

### **1.1.1 Level 1 – Prioritization Screening**

A Level 1 analysis utilizes the CAPCOA prioritization methodology (<http://www.arb.ca.gov/ab2588/RRAP-IWRA/priguide.pdf>), or an air district's prioritization procedure to determine the potential impact from a facility's operation based on the quantity of emissions emitted and proximity to a receptor(s) and release height. But before preparing a Level 1 analysis, the air district should be consulted. A prioritization calculation is a screening tool that identifies whether a source has the possibility to exceed a prioritization score that represents the need for further analysis, usually this level is a score of ten

The following input data must be included in a prioritization calculation:

- The nearest receptor (residential or offsite worksite) must be used to represent all other receptors; regardless of the location of the receptor to the proposed project.
- Emissions should represent the "worst case" emissions estimate. Worst case for cancer risk is based on 70 years of exposure. Worst case for acute adverse health effects is based on the hour with the highest emissions. Worst case for chronic adverse health effects is based on the annual average emissions. These emissions should be based on actual expected worst case emissions, rather than a theoretical potential to emit estimate. The emissions should be routine and predictable.
- The prioritization calculations must follow those in the CAPCOA Prioritization Guidelines or the district's prioritization guidelines.

### **1.1.2 Level 2 - SCREEN3 Modeling**

A Level 2 analysis is a screening level analysis using the U.S. EPA's SCREEN3 model, which includes all potential worst-case meteorological conditions. If a risk assessment based on SCREEN3 modeling shows risks below significance thresholds, then there is no need for additional modeling.

**Note:** At the time of writing this document, AERSCREEN remains unavailable and is currently in development. When AERSCREEN becomes available, it may be substituted for SCREEN3 in the multi-tier approach.

### **1.1.3 Level 3 – CAL3QHCR, ISCST3, or AERMOD modeling using Regional Met Data**

A Level 3 analysis is a more refined analysis using CAL3QHCR, ISCST3, or AERMOD and regional hourly meteorological data. Contact the District regarding the availability of preprocessed meteorological data sets.

### **1.1.4 Level 4 - CAL3QHCR, ISCST3 or AERMOD Modeling using Site Specific Met Data**

A Level 4 analysis is a more refined analysis using CAL3QHCR, ISCST3, or AERMOD and site specific hourly meteorological data. Contact the District regarding the availability of preprocessed meteorological data sets. This data typically must be pre-processed by the modeler or a meteorological data provider such as the National Weather Service (NWS). Local meteorological data sets include site-specific parameters and meteorological characteristics that directly represent the site of consideration with a greater level of detail than most regional data sets. A Level 4 analysis also encompasses modeling analyses that make use of any alternative models.

## 1.2 Exposure Assessment Tiers

When substances are emitted that can affect intake pathways other than inhalation, the use of the latest version of the Hot Spots Analysis and Reporting Program (HARP) modeling and risk assessment software is recommended. The latest version of HARP can be downloaded at <http://www.arb.ca.gov/toxics/harp/harp.htm>. If the emissions consist of only substances that enter the body through the inhalation pathway, other risk assessment methodologies consistent with the methodologies approved for the Air Toxics “Hot Spots” Emissions Inventory and Risk Assessment Program can be used. Most substances enter the body only through the inhalation pathway. Ingestion, dermal absorption, and other pathways are not usually significant pathways for emitted gases. Therefore, if all the substances impacting receptors only enter the body through inhalation, then the risk assessment preparation effort can be minimized. If just one substance can enter the body through another pathway, then a multipathway analysis must be prepared. An exception to this is diesel particulate, which is modeled only through the inhalation pathway.

The toxicity values that are used must be those that the California Office of Environmental Health Hazard Assessment (OEHHA) has identified. These toxicity values can be found at (<http://www.arb.ca.gov/toxics/healthval/healthval.htm>). If a substance is emitted and toxicity values have not been identified by OEHHA, other sources of data can be applied.

Although more detailed information can be found by directly reviewing the latest OEHHA risk assessment procedures, what follows is a description of the tiers associated with a multipathway exposure assessment. Additional information can be found at ARB’s HARP websites and OEHHA’s websites.

There are four basic tiers or levels that can be applied in the exposure assessment portion of the risk assessment:

### **Tier 1 -Point Estimate, Default Intake Values**

The easiest tier to complete assumes various intake default values, and calculates the risk as a single value rather than a distribution curve.

### **Tier 2 -Point Estimate, Site Specific Intake Values**

The next tier requires site specific information to determine intake values, but continues to apply single intake values to the risk values.

### **Tier 3 -Distribution Curve Risk Estimate, Default Distribution Curve Intake Values**

The third tier applies default distribution curve values to determine a distribution curve risk result.

### **Tier 4 -Distribution Curve Risk Estimate, Site Specific Distribution Curve Intake Values**

The fourth tier applies site specific distribution curve values to determine a distribution curve risk result.

## **1.3 Exposure Duration Adjustment (Cancer Only)**

Cancer risk calculations are based on a 70 year lifetime exposure. In some limited cases, it may be appropriate to also use either 9 or 40 years exposure in the calculation. The 9 year exposure scenario is based on exposure to children during the first 9 years of life. Some districts use the 9 year exposure scenario to model short term projects. The 40 year exposure scenario can be used to represent the risk to nearby workers. The local district should be contacted before using any exposure duration less than 70 years. In no case should an exposure period of less than 9 years be used.

## **Chapter 2. Application of Models**

### **2.0 Modeling Overview**

Air dispersion modeling is the mathematical estimation of pollutant impacts from emissions sources within a study area. Several factors impact the fate and transport of pollutants in the atmosphere including, but not limited to meteorological conditions, site configuration, emission release characteristics, and surrounding terrain.

### **2.1 Preferred Models**

Preferred Models are defined as standard models that are expected to be used for air quality studies. Alternative models may be used if conditions warrant their use. These are outlined in Section 2.3. The U.S. EPA's preferred models include SCREEN3 for screening analyses and AERMOD for refined modeling analyses. For CEQA, CAL3QHCR, ISCST, and ISC-PRIME may also be used.

For efficient risk assessment processing, the district should be consulted to determine the appropriateness of the model proposed for use. A brief overview of each of these models can be found below. For appropriate model selection, please review the section that outlines:

#### **2.1.1 AERMOD**

The American Meteorological Society/EPA Regulatory Model Improvement Committee (AERMIC) Regulatory Model, AERMOD<sup>1,2,3</sup> was specially designed to support the U.S. EPA's

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<sup>1</sup> U.S. Environmental Protection Agency, 1998. Revised Draft - User's Guide for the AMS/EPA Regulatory Model – AERMOD. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>2</sup> Paine, R.J., R.W. Brode, R.B. Wilson, A.J. Cimorelli, S.G. Perry, J.C. Weil, A. Venkatram, W.D. Peters and R.F. Lee, 2003. AERMOD: The Latest Features and Evaluation Results. Paper # 69878 presented at the Air and Waste Management Association 96th Annual Conference and Exhibition, June 22-26, 2003. Air and Waste Management Association, Pittsburgh, PA 15222.

<sup>3</sup> Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from <http://www.epa.gov/scram001>.

regulatory modeling programs. AERMOD is the next-generation air dispersion model that incorporates concepts such as planetary boundary layer theory and advanced methods for handling complex terrain. AERMOD was developed to replace the Industrial Source Complex Model-Short Term (ISCST3) as U.S. EPA's preferred model for most small-scale regulatory applications.<sup>4,5</sup> The latest versions of AERMOD also incorporate the Plume Rise Model Enhancements (PRIME) building downwash algorithms, which provide a more realistic handling of downwash effects than previous approaches.

The PRIME model was designed to incorporate two fundamental features associated with building downwash:

- Enhanced plume dispersion coefficients due to the turbulent wake.
- Reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.

AERMOD contains basically the same options as the ISCST3 model with a few exceptions, which are described below:

- Currently, the model only calculates concentration values. Dry and wet deposition algorithms were not implemented at the time this document was written.
- AERMOD requires two types of meteorological data files, a file containing surface scalar parameters and a file containing vertical profiles. These two files are produced by the U.S. EPA AERMET meteorological preprocessor program<sup>4</sup>.
- For applications involving elevated terrain, the user must also input a hill height scale along with the receptor elevation. The U.S. EPA AERMAP terrain-preprocessing program<sup>6</sup> can be used to generate hill height scales as well as terrain elevations for all receptor locations.

The options AERMOD has in common with ISCST3 and ISC-PRIME are described in the next section.

## **2.1.2 ISCST3 & ISC-PRIME Overview**

The ISCST3 dispersion model is a steady-state Gaussian plume model, which can be used to assess pollutant concentrations and/or deposition fluxes from a wide variety of sources associated with an industrial source complex. The ISCST3 dispersion model from the U.S. EPA was designed to support the EPA's regulatory modeling options, as specified in the Guidelines on Air Quality Models (Revised)<sup>7</sup>.

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<sup>4</sup> U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>5</sup> U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II – Description of Algorithms. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. Available from website <http://www.epa.gov/scram001> as of January 2003.

<sup>6</sup> U.S. Environmental Protection Agency, 1998. Revised Draft - User's Guide for the AERMOD Terrain Preprocessor (AERMAP). Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>7</sup> U.S. Environmental Protection Agency, 1986. Guidelines on Air Quality Models (Revised) and Supplement A. EPA-450/2-78-027R. U.S. Environmental Protection Agency, Research Triangle Park, NC.

The PRIME algorithms have been integrated into the ISCST3 (Version 96113) model. This integrated model is called ISC-PRIME<sup>8</sup>. The ISC-PRIME model uses the standard ISCST3 input file with a few modifications in the Source Pathway section. These modifications include three new inputs that which are used to describe the building/stack configuration.

To be able to run the ISC-PRIME model, you must first perform building downwash analysis using the Building Profile Input Program (BPIP). For more information on building downwash please refer to Section 3.8 - Building Impacts.

Some of the ISCST3/ISC-PRIME modeling capabilities are:

- ISC-PRIME model may be used to model primary pollutants and continuous releases of toxic and hazardous pollutants.
- ISC-PRIME model can handle multiple sources, including point, volume, area, and open pit source types. Line sources may also be modeled as a string of volume sources or as elongated area sources.
- Source emission rates can be treated as constant or may be varied by month, season, hour-of-day, or other periods of variation. These variable emission rate factors may be specified for a single source or for a group of sources.
- The model can account for the effects of aerodynamic downwash due to nearby buildings on point source emissions.
- The model contains algorithms for modeling the effects of settling and removal (through dry deposition) of large particulates and for modeling the effects of precipitation scavenging for gases or particulates.
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system.
- ISC-PRIME incorporates the COMPLEX1 screening model dispersion algorithms for receptors in complex terrain.
- ISC-PRIME model uses real hourly meteorological data to account for the atmospheric conditions that affect the distribution of air pollution impacts on the modeling area.
- Results can be output for concentration, total deposition flux, dry deposition flux, and/or wet deposition flux. Until AERMOD has incorporated deposition, ISC-PRIME would be the preferred model for applications such as risk assessment where deposition estimates are required.

Unlike AERMOD, the ISC models do not contain a terrain pre-processor. As a result, receptor elevation data must be obtained through alternative means. The use of an inverse distance algorithm for interpolating representative receptor elevations is an effective method.

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<sup>8</sup> U.S. Environmental Protection Agency, 1997. Addendum to ISC3 User's Guide – The Prime Plume Rise and Building Downwash Model. Submitted by Electric Power Research Institute. Prepared by Earth Tech, Inc., Concord, MA.



### 2.1.3 SCREEN3 Overview

The SCREEN3 model was developed to provide an easy-to-use method of obtaining pollutant concentration estimates. These estimates are based on the document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources"<sup>9</sup>.

SCREEN3, version 3.0 of the SCREEN3 model, can perform all the single source short-term calculations in the EPA screening procedures document, including:

- Estimating maximum ground-level concentrations and the distance to the maximum.
- Incorporating the effects of building downwash on the maximum concentrations for both the near wake and far wake regions.
- Estimating concentrations in the cavity recirculation zone.
- Estimating concentrations due to inversion break-up and shoreline fumigation.
- Determining plume rise for flare releases.

EPA's SCREEN3<sup>10</sup> model can also:

- Incorporate the effects of simple elevated terrain (i.e., terrain not above stack top) on maximum concentrations.
- Estimate 24-hour average concentrations due to plume impaction in complex terrain (i.e., terrain above stack top) using the VALLEY model 24-hour screening procedure.
- Model simple area sources using a numerical integration approach.
- Calculate the maximum concentration at any number of user-specified distances in flat or elevated simple terrain, including distances out to 100 km for long-range transport.
- Examine a full range of meteorological conditions, including all stability classes and wind speeds to find maximum impacts.
- Include the effects of buoyancy-induced dispersion (BID).
- Explicitly calculate the effects of multiple reflections of the plume off the elevated inversion and off the ground when calculating concentrations under limited mixing conditions.

### 2.1.4 CAL3QHCR Overview

"CAL3QHCR is a refined version of the original CALINE (California Line Source Dispersion Model) that was developed as a modeling tool to predict roadside CO concentrations. CAL3QHCR can be used to estimate ambient PM concentrations and to process hourly meteorological data over a year, hourly emissions, traffic volume, and signal data. The model can be obtained from EPA at [http://www.epa.gov/scram001/dispersion\\_prefrec.htm](http://www.epa.gov/scram001/dispersion_prefrec.htm).

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<sup>9</sup> U.S. Environmental Protection Agency, 1992: Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised, October 1992 (EPA-450/R-92-019), User's Guide for the Industrial Source Complex (ISC2) Dispersion Models: Volume II—Description of Model Algorithms. U.S. Environmental Protection Agency, OAQPS, Research Triangle Park, NC 27711. Publication No. EPA-450/4-92-008b.

<sup>10</sup> U.S. Environmental Protection Agency, 1995. SCREEN3 Model User's Guide. EPA-454/B-95-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

## 2.2 ISC and AERMOD Model Comparison

The ISC and AERMOD models share several similarities:

- Both are steady state plume models
- AERMOD input and output are intentionally similar to ISC for ease of use

AERMOD is a next-generation model, and while input and output may share similarities in format, there are several differences as detailed in the table below.

**Table 2 – Differences between ISCST3 and AERMOD**

ISCST3	AERMOD
Plume is always Gaussian	Plume is non-Gaussian when appropriate
Dispersion is function of six stability classes only	Dispersion is function of continuous stability parameters and height
Measured turbulence cannot be used	Measured turbulence can be used
Wind speed is scaled to stack height	Calculates effective speed through the plume
Mixing height is interpolated	Mixing height is calculated from met data
Plume either totally penetrates the inversion, or not at all	Plume may partially penetrate the inversion at the mixing height
Terrain is treated very simplistically	More realistic terrain treatment, using dividing streamline concept
Uses single dispersion for all urban areas	Adjusts dispersion to size of urban area
Cannot mix urban and rural sources	Can mix urban and rural sources

## 2.3 Alternative Models

Alternative models may also be accepted to determine health risks for CEQA projects. Please see the Guideline on Air Quality Models (published as Appendix W of 40 CFR Part 51) for terms of appropriate use and required supporting explanations. **Please note**, pre-approval is normally sought from the district before using alternative models.

## 2.4 Model Validations

The U.S. EPA ISCST3 / ISC-PRIME and AERMOD models are some of the most studied and validated models in the world. Studies have typically demonstrated good correlation with real-world values. AERMOD particularly handles complex terrain very well, closely matching the trends of field observations from validation studies.

ISC-PRIME differs from ISCST3 primarily in its use of the PRIME downwash algorithm. A model evaluation study was carried out under the auspices of the Electric Power Research Institute

(EPRI). The report<sup>11</sup> is available from EPRI and from the U.S. EPA SCRAM website <http://www.epa.gov/scram001>. The report analyzed comparisons between model predictions and measured data from four databases involving significant building downwash. This is in addition to 10 additional databases that were used during the development of ISC-PRIME. The study found that ISC-PRIME performed much better than ISCST3 under stable conditions, where ISCST3 predictions were very conservative (high). In general, ISC-PRIME was unbiased or somewhat over predicting. Also, ISC-PRIME showed a statistically better performance result than ISCST3 for each database in the study.

The U.S. EPA performed the evaluation of AERMOD. A summary of the evaluation studies was prepared by Paine, et al<sup>12</sup>. This and more detailed reports can be found at the U.S. EPA SCRAM website. Five databases were used during the development of the model. Five additional non-downwash databases were used in the final evaluation. For cases involving building downwash, four developmental databases were used to check the implementation of PRIME into AERMOD as it was accomplished. Three additional databases were reserved for the final evaluation. AERMOD remained unbiased for complex terrain databases as well as flat terrain, while ISCST3 severely over-predicted for complex terrain databases.

## **Chapter 3. MODEL INPUT DATA**

### **3.0 Comparison of Screening and Refined Model Requirements**

The use of the screen model requires the least amount of effort to calculate risks but produces the most conservative results. The SCREEN3 model input requirements are described in the next section.

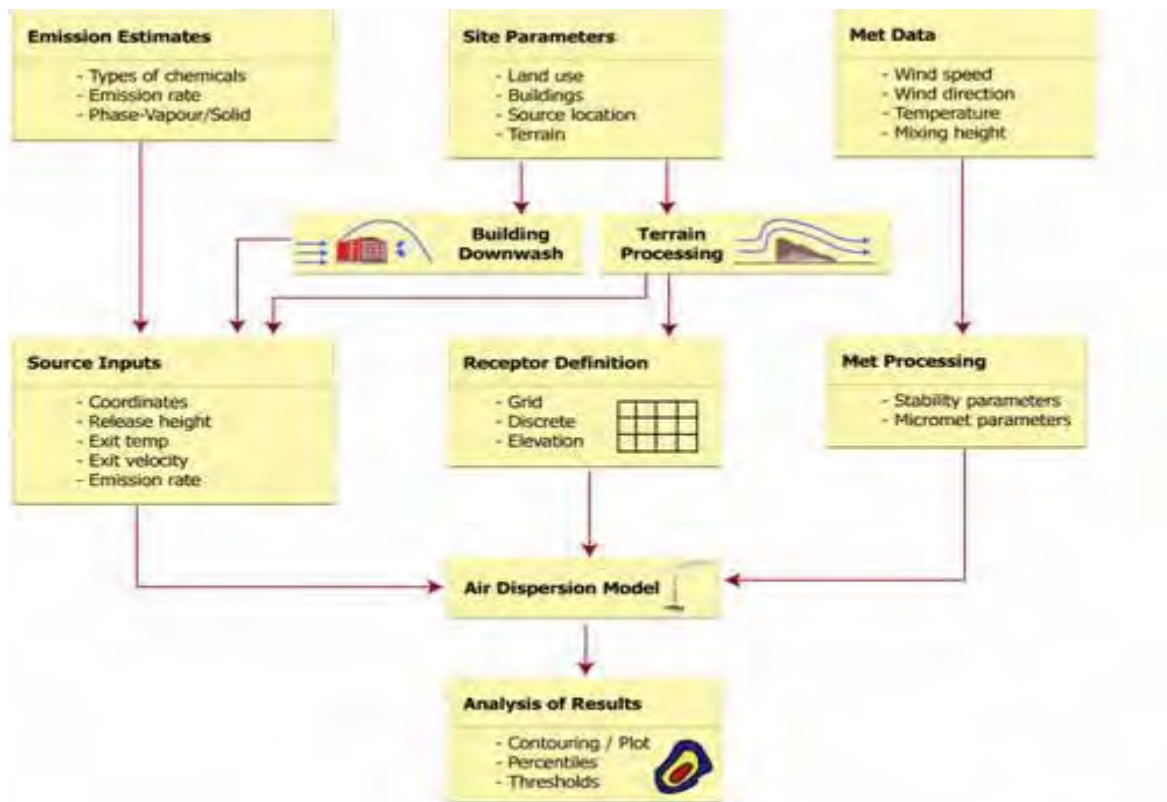
Refined air dispersion modeling using the U.S. EPA AERMOD or ISCST3 / ISC-PRIME models can be broken down into a series of steps. These are outlined in Sections 3.2 and 3.3.

A general overview of the process typically followed for performing an air dispersion modeling assessment is present in Figure 3.1 below. The figure is not meant to be exhaustive in all data elements, but rather provides a picture of the major steps involved in an assessment.

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<sup>11</sup> Paine, R.J. and F. Lew, 1997. Results of the Independent Evaluation of ISCST3 and ISC-PRIME. EPRI Paper No. TR2460026, WO3527-02, Final Report. Electric Power Research Institute, Palo Alto, CA 94304.

<sup>12</sup> Paine, R.J., R.W. Brode, R.B. Wilson, A.J. Cimorelli, S.G. Perry, J.C. Weil, A. Venkatram, W.D. Peters and R.F. Lee, 2003. AERMOD: The Latest Features and Evaluation Results. Paper # 69878 presented at the Air and Waste Management Association 96th Annual Conference and Exhibition, June 22-26, 2003. Air and Waste Management Association, Pittsburgh, PA 15222.



**Figure 3.1 - Generalized process for performing a refined air dispersion modeling assessment.**

### 3.1 SCREEN3

The SCREEN model<sup>13</sup> was developed to provide an easy-to-use method of obtaining pollutant concentration estimates. This model is normally used as an initial screening tool to assess **single sources** of emissions. SCREEN3 can be applied to multi-source facilities by conservatively summing the maximum concentrations for the individual emissions sources.

To perform a modeling study using SCREEN3, data for the following input requirements must be supplied:

- Source Type (Point, Flare, Area or Volume)
- Physical Source and Emissions Characteristics.  
(For example, a point source requires:
  - Emission Rate
  - Stack Height
  - Stack Inside Diameter
  - Stack Gas Exit Velocity
  - Stack Gas Exit Temperature
  - Ambient Air Temperature

<sup>13</sup> U.S. Environmental Protection Agency, 1995. SCREEN3 Model User's Guide. EPA-454/B-95-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

- Receptor Height Above Ground
- Meteorology: SCREEN3 can consider all conditions, or a specific stability class and wind speed can be provided.
  - If a single wind speed/stability combination is used, the predicted concentration should only be used to determine hourly concentration, as the factors used to convert hourly concentration to annual concentrations are only valid when SCREEN3 is ran with full meteorological data selected.
- Building Downwash: If this option is used then building dimensions (height, length and width) must be specified.
- Terrain: SCREEN3 supports flat, elevated and complex terrain. If elevated or complex terrain is used, distance and terrain heights must be provided.
- Fumigation: SCREEN3 supports shoreline fumigation. If used, distance to shoreline must be provided.

As can be seen above, the input requirements are minimal to perform a screening analysis using SCREEN3. The refined models discussed in the next sections, have much more detailed options allowing for greater characterization and more representative results.

## 3.2 AERMOD

The supported refined models have many input options, and are described further throughout this document as well as in their own respective technical documents<sup>14,15,16,17</sup>. An overview of the modeling approach and general steps for using each refined model are provided below. The general process for performing an air dispersion study using AERMOD includes:

- Meteorological Data Processing (AERMET is used for this)
- Obtain Digital Terrain Elevation Data (If terrain is being considered)
- Building Downwash Analysis (BPIP-PRIME is used for this) – Project requires source and building information
- Final site characterization – complete source and receptor information
- AERMAP – Perform terrain data pre-processing for AERMOD air dispersion model if required.
- AERMOD – Run the model.
- Visualize and analyze results.

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<sup>14</sup> Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from <http://www.epa.gov/scram001>.

<sup>15</sup> U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

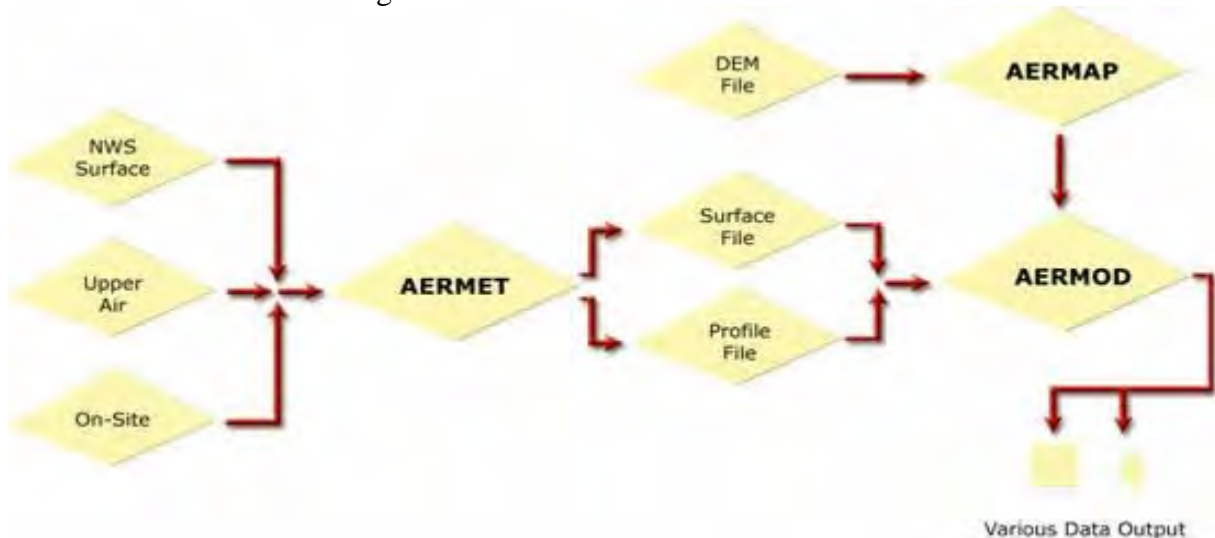
<sup>16</sup> U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II – Description of Algorithms. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. Available from website <http://www.epa.gov/scram001> as of January 2003.

<sup>17</sup> U.S. Environmental Protection Agency, 1997. Addendum to ISC3 User's Guide – The Prime Plume Rise and Building Downwash Model. Submitted by Electric Power Research Institute. Prepared by Earth Tech, Inc., Concord, MA.

As can be seen above, the AERMOD modeling system is comprised of 3 primary components as outlined below and illustrated in Figure 3.2:

- AERMET – Meteorological Data Preprocessor
- AERMAP – Digital Terrain Preprocessor
- AERMOD – Air dispersion model

To successfully perform a complex terrain air dispersion modeling analysis-using AERMOD, you must complete the processing steps required by AERMET and AERMAP. See Appendix A for more information on meteorological data.



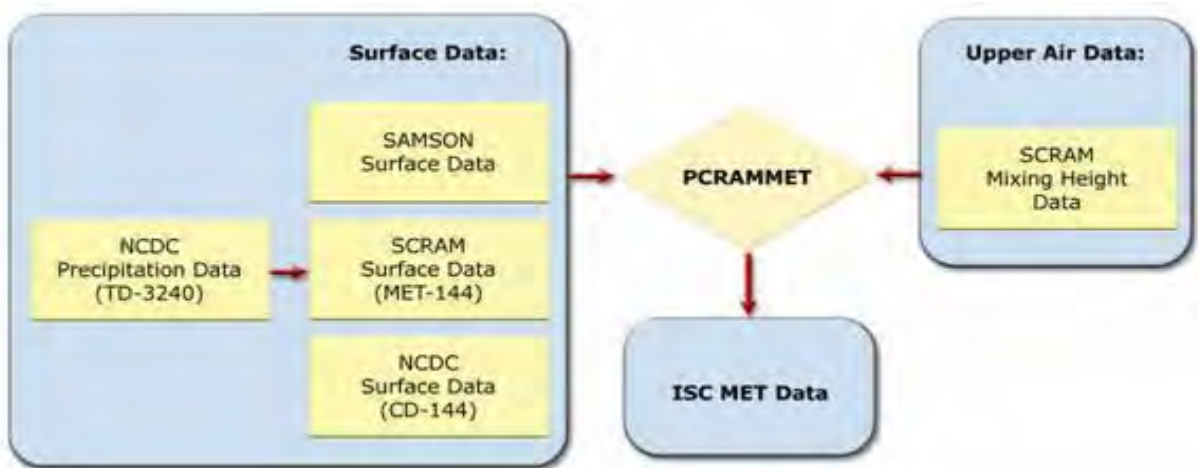
**Figure 3.2 - The AERMOD air dispersion modeling system.**

### 3.3 ISC-PRIME

The ISC-PRIME model has very similar input requirements when compared with AERMOD. These include:

- Meteorological Data Processing - PCRAMMET
- Obtain Digital Terrain Elevation Data (If terrain is being considered)
- Building Downwash Analysis (BPIP-PRIME) – Project requires source and building information
- Final site characterization – complete source and receptor information
- ISC-PRIME – Run the ISC-PRIME model.
- Visualize and analyze results.

As can be seen above, the ISC and AERMOD models follow a very similar approach to perform an air dispersion modeling project. The primary difference between running the ISC and AERMOD models is that ISC does not require a terrain preprocessor, such as AERMAP. Furthermore, ISC relies on a different meteorological preprocessor known as PCRAMMET. The components of meteorological data pre-processing using PCRAMMET are illustrated in Figure 3.3 below. For a complete outline on how to obtain meteorological data, please see Appendix A.



**Figure 3.3 - Meteorological data pre-processing flow diagram for the U.S. EPA ISC models**

### 3.4 Regulatory and Non-Regulatory Option Use

The ISC-PRIME and AERMOD models contain several regulatory options, which are set by default, as well as non-regulatory options. Depending on the model, the non-regulatory options can include:

- No stack-tip downwash (NOSTD)
- Missing data processing routine (MSGPRO)
- Bypass the calms processing routine (NOCALM)
- Gradual plume rise (GRDRISM)
- No buoyancy-induced dispersion (NOBID)
- Air Toxics Options (TOXICS)
- By-pass date checking for non-sequential met data file (**AERMOD**)
- Flat terrain (FLAT) (**AERMOD**)

The use of any non-regulatory default option(s) must be justified through a discussion in the modeling report and approved by the district before performing any modeling runs. Regulatory models that account for elevated terrain should be used when appropriate.

### 3.5 Coordinate System

Any modeling assessment will require a coordinate system to be defined in order to assess the relative distances from sources and receptors and, where necessary, to consider other geographical features. Employing a standard coordinate system for all projects increases the efficiency of the review process while providing real-world information about the site location. The AERMOD model's terrain pre-processor, AERMAP, requires digital terrain in Universal Transverse Mercator (UTM) coordinates. The UTM system uses meters as its basic unit of measurement and allows for more precise definition of specific locations than latitude/longitude.

For more information on coordinate systems and geographical information inputs, see Section 6.

## 3.6 Averaging Times

A key advantage to the more refined air dispersion models is the ability to compare effects-based standards with appropriate averaging times. OEHHA assigns different exposure periods to different health effects. For example, cancer risks are assessed for “lifetime” exposure. Chronic noncancer health effects are calculated for long-term, but not necessarily lifetime exposures. Acute noncancer health effects are usually based on a maximum 1-hour exposure, but there are some exceptions, such as benzene which is based on a maximum 6 hour exposure. Use of effects-based averaging times enables a contaminant to be assessed using modeled exposure concentrations for the appropriate averaging period for that contaminant and endpoint.

In addition to enabling the use of appropriate model averaging times, refined models allow the input of variable emission rates, where appropriate, for assessing concentrations over different averaging times. That is, a source that operates only during certain hours of the day can be modeled using only those hours of meteorology data.

The ability to assess air quality using the most appropriate effects-based averaging time means the refined air dispersion models provide a more representative assessment of health and environmental impacts of air emissions from a facility.

## 3.7 Defining Sources

### 3.7.1 Point, Area, Volume, and Flare Emissions Release Parameters Required for each Model

The U.S. EPA SCREEN3, ISCST3, ISC-PRIME and AERMOD models support a variety of source types that can be used to characterize most emissions within a study area. The following sections outline the primary source types and their input requirements for both screening and refined models. Detailed descriptions on the input fields for these models can be found for SCREEN3 in U.S. EPA<sup>18</sup>, for ISC-PRIME in U.S. EPA<sup>19,20</sup>, and for AERMOD in U.S. EPA<sup>21</sup>.

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<sup>18</sup> U.S. Environmental Protection Agency, 1995. SCREEN3 Model User's Guide. EPA-454/B-95-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>19</sup> U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>20</sup> U.S. Environmental Protection Agency, 1997. Addendum to ISC3 User's Guide – The Prime Plume Rise and Building Downwash Model. Submitted by Electric Power Research Institute. Prepared by Earth Tech, Inc., Concord, MA.

<sup>21</sup> Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from <http://www.epa.gov/scram001>.



### 3.7.1.1 Point Sources

Point sources are typically used when modeling releases from sources like stacks and isolated vents. Input requirements for point sources include:

#### SCREEN3

- **Emission Rate** [g/sec]: The emission rate of the pollutant.
- **Stack Height** [m]: The stack height above ground.
- **Stack Inside Diameter** [m]: The inner diameter of the stack.
- **Stack Gas Exit Velocity** [m/s] or **Stack Gas Exit Flow Rate** [m<sup>3</sup>/s]: Either the stack gas exit velocity or the stack gas exit flow rate should be given. The exit velocity can be determined from the following formula:

$$V_s = 4 * V / (\pi * (d_s^2))$$

Where,

$V_s$  = Exit Velocity

$V$  = Flow Rate

$d_s$  = Stack Inside Diameter

- **Stack Gas Temperature** [K]: The temperature of the released gas in degrees Kelvin.
- **Ambient Air Temperature** [K]: The average atmospheric temperature (K) in the vicinity of the source. If no ambient temperature data are available, assume a default value of 293 degrees Kelvin (K). For non-buoyant releases, the user should input the same value for the stack temperature and ambient temperature.

#### AERMOD/ISCST/ISC-PRIME

- **Source ID**: An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate**: The x (east-west) coordinate for the source location in meters (center of the point source).
- **Y Coordinate**: Enter here the y (north-south) coordinate for the source location in meters (center of the point source).
- **Base Elevation** [m]: The source base elevation. The model only uses the source base elevation if Elevated terrain is being used.
- **Release Height above Ground** [m]: The source release height above the ground in meters.
- **Emission Rate** [g/sec]: The emission rate of the pollutant in grams per second. **Stack Gas Exit Temperature** [K]: The temperature of the released gas in degrees Kelvin.
- **Stack Gas Exit Velocity** [g/sec]: The stack gas exit velocity in meters per second or the stack gas flow rate (see above section on SCREEN3).
- **Stack Inside Diameter** [m]: The inner diameter of the stack.

### 3.7.1.2 Area Sources

Area sources are used to model releases that occur over an area (e.g., landfills, storage piles, slag dumps, and lagoons). SCREEN3 allows definition of a rectangular area, aligned with the north-

south axes, while the ISC-PRIME and AERMOD models accept rectangular areas that may also have a rotational angle specified relative to a north-south orientation, as well as a variety of other shapes.

## SCREEN3

- **Emission Rate** [ $\text{g}/(\text{s}\cdot\text{m}^2)$ ]: The emission rate of the pollutant. The emission rate for area sources is input as an emission rate per unit area ( $\text{g}/(\text{s}\cdot\text{m}^2)$ ).
- **Source Release Height** [m]: The source release height above ground.
- **Longer Side Length of Rectangular Area** [m]: The longer side of the rectangular source in meters.
- **Shorter Side Length of Rectangular Area** [m]: The shorter side of the rectangular source in meters.
- **Wind Direction Search Option**: Since the concentration at a particular distance downwind from a rectangular area is dependent on the orientation of the area relative to the wind direction, the SCREEN model provides the user with two options for treating wind direction. The regulatory default option is “yes” which results in a search of a range of wind directions. See U.S. EPA<sup>22</sup> for more detailed information.

## AERMOD/ISC-PRIME

- **Source ID**: An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate**: The x (east-west) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in meters.
- **Y Coordinate**: The y (north-south) coordinate for the vertex (corner) of the area source that occurs in the southwest quadrant of the source. Units are in meters.
- **Base Elevation** [m]: The source base elevation. The model only uses the source base elevation if elevated terrain is being used. The default unit is meters.
- **Release Height above Ground** [m]: The release height above ground in meters.
- **Emission Rate** [ $\text{g}/(\text{s}\cdot\text{m}^2)$ ]: Enter the emission rate of the pollutant. The emission rate for Area sources is input as an emission rate per unit area. The same emission rate is used for both concentration and deposition calculations.
- **Options for Defining Area**: In ISC-PRIME the only option for defining the area is a rectangle or square. The maximum length/width aspect ratio for area sources is 10 to 1. If this is exceeded, then the area should be divided to achieve a 10 to 1 aspect ratio (or less) for all sub-areas. See U.S. EPA<sup>23</sup> for more details on inputting area data. In addition to the rectangular area, AERMOD can have circular or polygon areas defined (see U.S. EPA<sup>24</sup> for details).

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<sup>22</sup> U.S. Environmental Protection Agency, 1995. Quality Assurance Handbook for Air Pollution Measurement Systems. Vol. IV, Meteorological Measurements. EPA/600/R-94/038d, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. Also available from the following website as of February 2003: <http://www.epa.gov/scram001>.

<sup>23</sup> U.S. Environmental Protection Agency, 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised), Volume 1. EPA-454/B-95-003a. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>24</sup> Cimorelli, A.J., S.G. Perry, A. Venkatram, J.C. Weil, R.J. Paine, R.B. Wilson, R.F. Lee, W.D. Peters, R.W. Brode, J.O. Paumier, 2002: AERMOD: Description of Model Formulation. U.S. Environmental Protection Agency, EPA-454/R-02-002d (draft dated October 31, 2002). Available from <http://www.epa.gov/scram001>.

**Note:** There are no restrictions on the location of receptors relative to area sources. Receptors may be placed within the area and at the edge of an area. The U.S. EPA models (ISCST3, ISC-PRIME, and AERMOD) will integrate over the portion of the area that is upwind of the receptor. The numerical integration is not performed for portions of the area that are closer than 1.0 meter upwind of the receptor. Therefore, caution should be used when placing receptors within or adjacent to areas that are less than a few meters wide.

### 3.7.1.3 Volume Sources

Volume sources are used to model releases from a variety of industrial sources, such as building roof monitors, fugitive leaks from an industrial facility, multiple vents, and conveyor belts.

#### SCREEN3

- **Emission Rate** [g/sec]: The emission rate of the pollutant in grams per second (g/s).
- **Source Release Height** [m]: The source release height above ground surface at the center of the volume.
- **Initial Lateral Dimension** [m]: See Table 3.1 below for guidance on determining initial dimensions. Units are meters.
- **Initial Vertical Dimension** [m]: See Table 3.1 below for guidance on determining initial dimensions. Units are meters.

**Table 3.1 Summary of Suggested Procedures for Estimating Initial Lateral Dimension ( $y_o$ ) and Initial Vertical Dimension ( $z_o$ ) for Volume and Line Sources.**

Type of Source	Procedure for Obtaining Initial Dimension
<b>Initial Lateral Dimension</b>	
Single Volume Source	$S_{y_o} = (\text{side length})/4.3$
Line Source (Represented by Adjacent Volume Sources)	$S_{y_o} = (\text{side length})/2.15$
Line Source (Represented by Separated Volume Sources)	$S_{y_o} = (\text{center to center distance})/2.15$
<b>Initial Vertical Dimension</b>	
Surface-Based Source ( $h_e \sim 0$ )	$S_{z_o} = (\text{vertical dimension of source})/2.15$
Elevated Source ( $h_e > 0$ ) on or Adjacent to a Building	$S_{z_o} = (\text{building height})/2.15$
Elevated Source ( $h_e > 0$ ) not on or Adjacent to a Building	$S_{z_o} = (\text{vertical dimension of source})/4.3$

## AERMOD/ISCST3/ISC-PRIME

- **Source ID:** An identification name for the source being defined, up to 8 characters in length.
- **X Coordinate:** The x (east-west) coordinate for the source location in meters. This location is the center of the volume source.
- **Y Coordinate:** The y (north-south) coordinate for the source location in meters. This location is the center of the volume source.
- **Base Elevation [m]:** The source base elevation. The model only uses the source base elevation if elevated terrain is being used. The default unit is meters.
- **Release Height above Ground [m]:** The release height above ground surface in meters (center of volume).
- **Emission Rate [g/s]:** The emission rate of the pollutant in grams per second. The same emission rate is used for both concentration and deposition calculations.
- **Length of Side [m]:** The length of the side of the volume source in meters. The volume source cannot be rotated and has the X side equal to the Y side (square).
- **Building Height (If On or Adjacent to a Building) [m]:** If your volume source is elevated and is on or adjacent to a building, then you need to specify the building height. The building height can be used to calculate the Initial Vertical Dimension of the source. Note that if the source is surface-based, then this is not applicable.
- **Initial Lateral Dimension [m]:** This parameter is calculated by choosing the appropriate condition in Table 3.1 above. This table provides guidance on determining initial dimensions. Units are in meters.
- **Initial Vertical Dimension [m]:** This parameter is calculated by choosing the appropriate condition in Table 3.1 above. This table provides guidance on determining initial dimensions. Units are in meters.

### 3.7.2 Source Grouping

Source groups enable modeling results for specific groups of one or more sources. The default in AERMOD and ISCST3/ISC-PRIME is the creation of a source group “ALL” that considers all the sources at the same time.

Analysis of individual groups of sources can be performed by using the SRCGROUP option. One example may be assigning each source to a separate source group to determine the maximum concentration generated by each individual source.

### 3.7.3 Special Considerations

During some air quality studies, modelers may encounter certain source configurations that require special attention. Some examples include horizontal sources or emissions from storage tanks. The following sections outline modeling techniques to account for the special characteristics of such scenarios.

### 3.7.3.1 Multiple Stacks

When the plumes from multiple closely spaced stacks or flues merge, the plume rise can be enhanced. Briggs<sup>25</sup> has proposed equations to account for this. The reader is referred to that document for further details. Most models do not explicitly account for enhanced plume rise from this cause, and most regulatory agencies do not permit it to be accounted for in regulatory applications of modeling, with one exception. That exception is the case of a single stack with multiple flues/multiple stacks very close together (less than one stack diameter apart). In these cases, the multiple plumes may be treated as a single plume. To do this, a pseudo stack diameter is used in the calculations, such that the total volume flow rate of the stack gases is correctly represented.

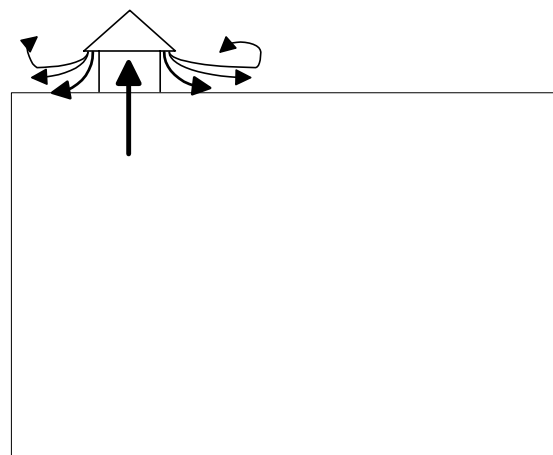
### 3.7.3.2 Horizontal Sources and Rain Caps

This section is intended to provide guidance for modeling a stack with a rain cap that is located on top of a building.

When emissions are released through a stack with a rain cap, the rain cap redirects the vertical release into a horizontal release, as shown in Figure 3.4.

The presence of a rain cap or any obstacle at the top of the stack hinders the momentum of the exiting gas. Therefore, assuming that the gas exit velocity would be the same as the velocity in a stack without an obstacle is an improper assumption. The extent of the effect is a function of the distance from the stack exit to the obstruction and of the dimensions and shape of the obstruction.

On the conservative side, the stack could be modeled as having a non-zero, but negligible exiting velocity, effectively eliminating any momentum rise. Such an approach would result in final plume heights closer to the ground and therefore higher concentrations nearby.



**Figure 3.4**

Plume buoyancy is not strongly reduced by the occurrence of a rain cap. Therefore if the plume rise is dominated by buoyancy, it is not necessary to adjust the stack conditions. (The air dispersion models determine plume rise by either buoyancy or momentum, whichever is greater.)

The stack conditions should be modified when the plume rise is dominated by momentum and in the presence of a rain cap or a horizontal stack. Sensitivity studies with the SCREEN3 model, on a case-by-case basis, can be used to determine whether plume rise is dominated by buoyancy or momentum. The District should be consulted before applying these procedures.

<sup>25</sup> Briggs, G.A., 1974. Diffusion Estimation for Small Emissions. In ERL, ARL USAEC Report ATDL-106. U.S. Atomic Energy Commission, Oak Ridge, TN.

- Set exit velocity to 0.001 m/sec
- Turn stack tip downwash off
- Reduce stack height by 3 times the stack diameter

Stack tip downwash is a function of stack diameter, exit velocity, and wind speed. The maximum stack tip downwash is limited to three times the stack diameter in the ISC3 air dispersion model. In the event of a horizontal stack, stack tip downwash should be turned off and no stack height adjustments should be made.

Note: This approach may not be valid for large (several meter) diameter stacks.

An alternative, more refined, approach could be considered for stack gas temperatures which are slightly above ambient (e.g., ten to twenty degrees Fahrenheit above ambient). In this approach, the buoyancy and the volume of the plume remains constant and the momentum is minimized.

- Turn stack tip downwash off
- Reduce stack height by 3 times the stack diameter ( $3D_o$ )
- Set the stack diameter ( $D_b$ ) to a large value (e.g., 10 meters)
- Set the stack velocity to  $V_b = V_o (D_o/D_b)^2$

Where:

$V_o$  and  $D_o$  are the original stack velocity and diameter, and

$V_b$  and  $D_b$  are the alternative stack velocity and diameter for constant buoyancy.

This approach is advantageous when  $D_b \gg D_o$  and  $V_b \ll V_o$  and should only be used with District approval.

Reference: Technical Support Document for Exposure and Stochastic Analysis, Office of Environmental Health Hazard Assessment, September 2000, p. 2-39 and p. 2-40.

### **3.7.3.3 Modeling Bay Door or Window Openings (Volume Source)**

This section is intended to provide guidance for modeling openings such as doors and windows as a volume source. When determining how to model an opening, first determine how the emissions are being released from the opening. If a profile of the emissions (% of substance and heat at different levels) is not provided, then assume that emissions are being released at all levels of the opening, and that the emissions are going out some distance from the opening before they are mixed with the outside air. Thus the release from the opening resembles a volume source where the height is the height of the opening, and the width is the width of the opening, and length is also the width of the opening. Volume source modeling requires the width and length to be equal.

Based on these assumptions, the height of the volume is equal to the height of the opening, the width of the volume is equal to the width of the opening, and the length of the volume is equal to the distance from the opening to the nearest edge of the building, see Figure 3.5.

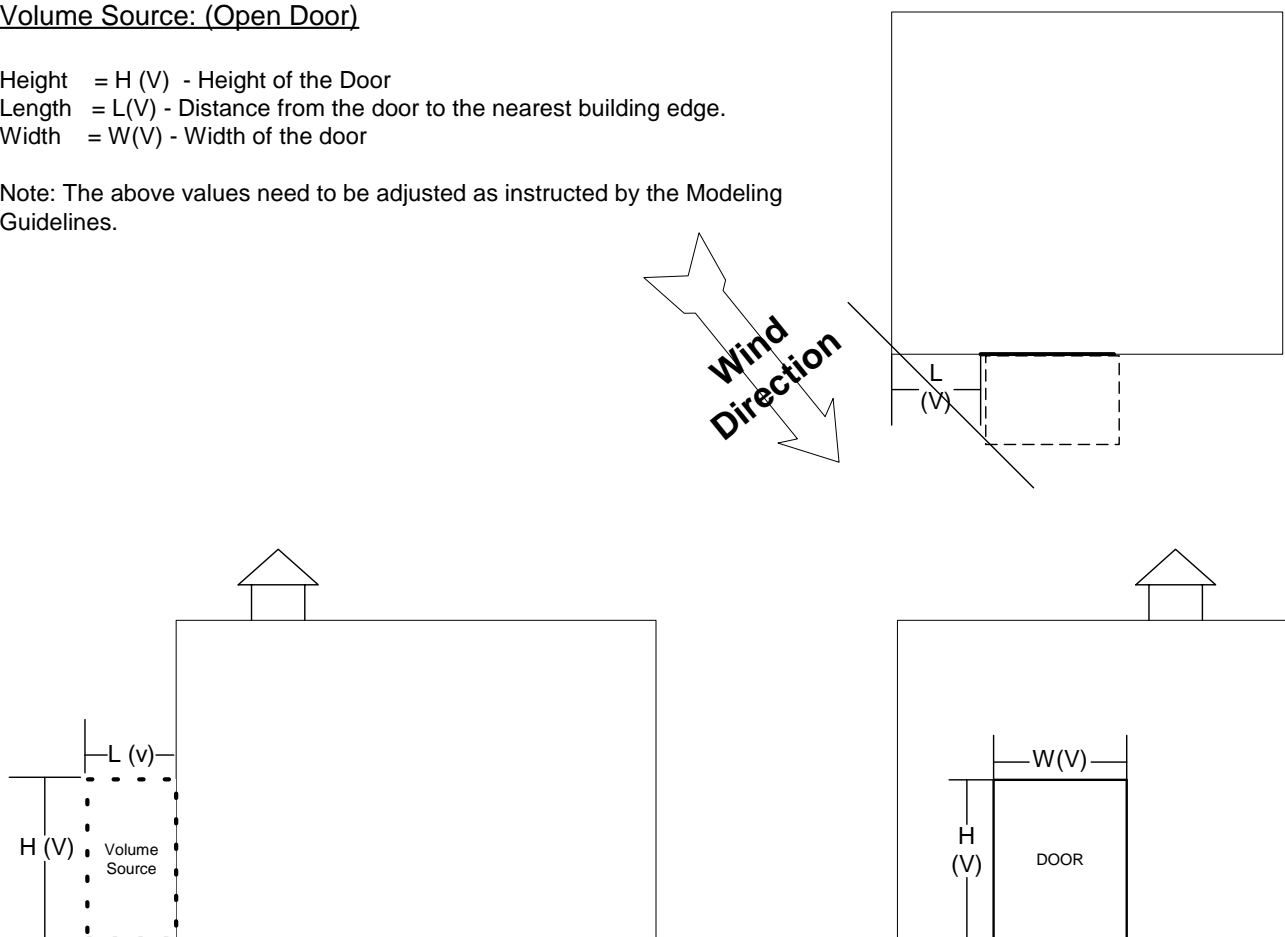
### Volume Source: (Open Door)

Height =  $H(V)$  - Height of the Door

Length =  $L(V)$  - Distance from the door to the nearest building edge.

Width =  $W(V)$  - Width of the door

Note: The above values need to be adjusted as instructed by the Modeling Guidelines.



**Figure 3.5**

## **3.7.3.4 Liquid Storage Tanks**

Storage tanks are generally of two types—fixed roof tanks and floating roof tanks. In the case of fixed roof tanks, most of the pollutant emissions occur from a vent, with some additional contribution from hatches and other fittings. In the case of floating roof tanks, most of the pollutant emissions occur through the seals between the roof and the wall and between the deck and the wall, with some additional emissions from fittings such as ports and hatches.

Approaches for modeling impacts from emissions from various types of storage tanks are outlined below.

### **Fixed roof tanks:**

Model fixed roof tanks as a point (stack) source (representing the vent), which is usually in the center of the tank, and representing the tank itself as a building for downwash calculations.

### **Floating roof tanks:**

Model floating roof tanks as a circle of eight (or more) point sources, representing the tank itself as a building for downwash calculations. Distribute the total emissions equally among the circle of

point sources. Additionally, a floating roof tanks can be modeled as a circle (polygon) area source representing the diameter of the tank with a height of the tank.

#### **All tanks:**

There is virtually no plume rise from tanks. Therefore, the stack parameters for the stack gas exit velocity and stack diameter should be set to near zero for the stacks representing the emissions. In addition, stack temperature should be set equal to the ambient temperature. This is done in ISCST3 and AERMOD by inputting a value of 0.0 for the stack gas temperature.

Note that it is very important for the diameter to be at or near zero. With low exit velocities and larger diameters, stack tip downwash will be calculated. Since all downwash effects are being calculated as building downwash, the additional stack tip downwash calculations would be inappropriate. Since the maximum stack tip downwash effect is to lower plume height by three stack diameters, a very small stack diameter effectively eliminates the stack tip downwash.

**Table 3.2 - Stack parameter values for modeling tanks**

Velocity	Diameter	Temperature
Near zero i.e. 0.001 m/s	Near zero i.e. 0.001m	Ambient – 0.0 sets models to use ambient temperature

### **3.7.4 Variable Emissions**

The ISCST3 and AERMOD models both contain support for variable emission rates. This allows for modeling of source emissions that may fluctuate over time. Emission variations can be characterized across many different periods including hourly, daily, monthly and seasonally. For risk assessments, only the annual average or the maximum hourly emission rates are to be modeled. If a variable emission rate is to be used, the District must be consulted.

#### **3.7.4.1 Wind Erosion**

Modeling of emissions from sources susceptible to wind erosion, such as coal piles, can be accomplished using variable emissions.

The ISCST3 and AERMOD models allow for emission rates to be varied by wind speed. This allows for more representative emissions from sources that are susceptible to wind erosion, particularly waste piles that can contribute to particulate emissions. Once a correlation between emissions and wind speed categories is established, the models will then vary the emissions based on the wind conditions in the meteorological data.

#### **3.7.4.2 Non-Continuous Emissions**

Sources of emissions at some locations may emit only during certain periods of time. Emissions can be varied within the ISCST3 and AERMOD models by applying factors to different time periods.



For example, for a source that is non-continuous, a factor of 0 is entered for the periods when the source is not operating or is inactive. Model inputs for variable emissions rates can include the following time periods:

- Seasonally
- Monthly
- Hourly
- By Season and hour-of-day
- By Season, hour-of-day, and day-of-week
- By Season, hour, and week

### 3.7.4.3 Plant Shutdowns and Start-Ups

Plant start-ups and shutdowns can occur due to maintenance, designated vacation periods, or upset conditions. Emissions during shutdown and startup are usually higher than during normal operation. Process upsets or control equipment breakdowns can also increase emissions. Such upsets can result in the release of uncontrolled emissions. The ISC and AERMOD models allow the use of variable emission rates for hours of the day, day of the week, and season of the year. The example below illustrates the use of this feature to model emissions that vary by the time of the day.

**Example:**

Assume that a gas turbine operates 14 hours per day (1 startup, 1 shutdown, and 12 hours of normal operation)

**Given:**

Emission Rate = 1 g/s (emissions rate during normal operation)

Operation Schedule = 6 AM – 8PM

Startup/Shutdown Emissions are twice that of normal operating emissions

The model will adjust the emissions rate using the data found in the table below:

**Calculation:**

Modeled Emissions Rate \* Emission Rate Adjustment Factor

Emissions Rate for 1 AM – 6 AM = 1 g/s \* 0 = 0 g/s

Emissions Rate for 6 AM – 7 AM = 1 g/s \* 2 = 2 g/s

Emissions Rate for 7 AM – 7 PM = 1 g/s \* 1 = 1 g/s

Emissions Rate for 7 PM – 8 PM = 1 g/s \* 2 = 2 g/s

**Non-Continuous Emissions (Hours of Day):**

Morning Hours		Afternoon Hours	
Hour of the Day	Emissions Rate Adjustment Factor	Hour of the Day	Emissions Rate Adjustment Factor
1:00 am	0	1:00 pm	1
2:00 am	0	2:00 pm	1
3:00 am	0	3:00 pm	1
4:00 am	0	4:00 pm	1
5:00 am	0	5:00 pm	1
6:00 am	2	6:00 pm	1
7:00 am	1	7:00 pm	2
8:00 am	1	8:00 pm	0
9:00 am	1	9:00 pm	0
10:00 am	1	10:00 pm	0
11:00 am	1	11:00 pm	0
Noon	1	Midnight	0

### 3.7.4.4 Seasonal Variations

Industrial processes often fluctuate depending on supply and demand requirements. This affects some sectors seasonally, particularly facilities involved in food processing. For example, soup production makes use of agricultural produce which is at its highest in the late summer. Production schedules for soup production typically ramp up resulting in different emissions during the late summer and early fall than at mid to late winter.

These emission differences can be accounted for by the application of variable emission factors, with control over the following time periods:

- By Season and hour-of-day
- By Season, hour-of-day, and day-of-week
- By Season, hour, week

## 3.8 Building Impacts

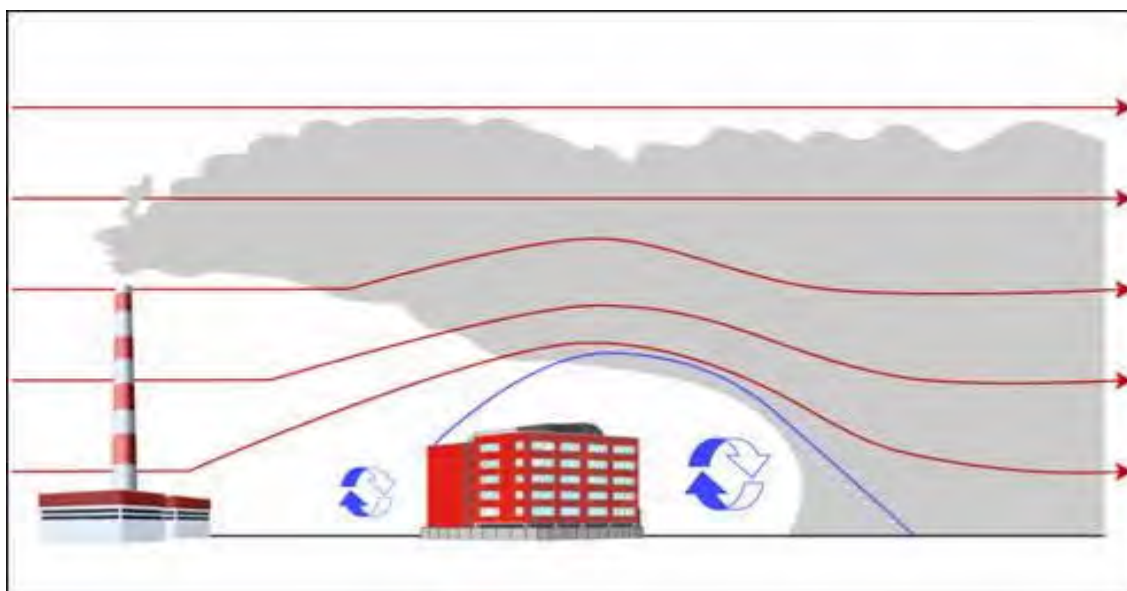
Buildings and other structures near a relatively short stack can have a substantial effect on plume transport and dispersion, and on the resulting ground-level concentrations that are observed. . There has long been a “rule of thumb” that a stack should be at least 2.5 times the height of adjacent buildings. Beyond that, much of what is known of the effects of buildings on plume transport and diffusion has been obtained from wind tunnel studies and field studies.

When the airflow meets a building (or other obstruction), it is forced up and over the building. On the lee side of the building, the flow separates, leaving a closed circulation containing lower wind

speeds. Farther downwind, the air flows downward again. In addition, there is more shear and, as a result, more turbulence. This is the turbulent wake zone (see Figure 3.6).

If a plume gets caught in the cavity, very high concentrations can result. If the plume escapes the cavity, but remains in the turbulent wake, it may be carried downward and dispersed more rapidly by the turbulence. This can result in either higher or lower concentrations than would occur without the building, depending on whether the reduced height or increased turbulent diffusion has the greater effect.

The height to which the turbulent wake has a significant effect on the plume is generally considered to be about the building height plus 1.5 times the lesser of the building height or width. This results in a height of 2.5 building heights for cubic or squat buildings, and less for tall, slender buildings. Since it is considered good engineering practice to build stacks taller than adjacent buildings by this amount, this height came to be called “good engineering practice” (GEP) stack height.



**Figure 3.6 - The building downwash concept where the presence of buildings forms localized turbulent zones that can readily force pollutants down to ground level.**

### **3.8.1 Good Engineering Practice (GEP) Stack Heights and Structure Influence Zones**

The U.S. EPA<sup>26</sup> states that “If stacks for new or existing major sources are found to be less than the height defined by the EPA’s refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined.”

The U.S. EPA’s refined formula for determining GEP stack height is:

$$\text{GEP Stack Height} = H + 1.5L$$

<sup>26</sup> U.S. Environmental Protection Agency, 1990. Stack Heights, Section 123, Clean Air Act, 40 CFR Part 51. U. S. Environmental Protection Agency, Research Triangle Park, NC.

where,

GEP = Good Engineering Practice

H = Building/Tier Height measured from ground to the highest point

L = Lesser of the Building Height (PB) or Projected Building Width (PBW)

Building downwash for point sources that are within the Area of Influence of a building should be considered. For U.S. EPA regulatory applications, a building is considered sufficiently close to a stack to cause wake effects when the distance between the stack and the nearest part of the building is less than or equal to five (5) times the lesser of the building height or the projected width of the building.

$$\text{Distance}_{\text{stack-bldg}} \leq 5L$$

For point sources within the Area of Influence, building downwash information (direction-specific building heights and widths) should be included in your modeling project. Using BPIP-PRIME, you can compute these direction-specific building heights and widths.

**Structure Influence Zone (SIZ):** For downwash analyses with direction-specific building dimensions, wake effects are assumed to occur if the stack is within a rectangle composed of two lines perpendicular to the wind direction, one at 5L downwind of the building and the other at 2L upwind of the building, and by two lines parallel to the wind direction, each at 0.5L away from each side of the building, as shown below. L is the lesser of the height or projected width. This rectangular area has been termed a Structure Influence Zone (SIZ). Any stack within the SIZ for any wind direction is potentially affected by GEP wake effects for some wind direction, or range of wind directions, see Figure 3.7 and Figure 3.8.

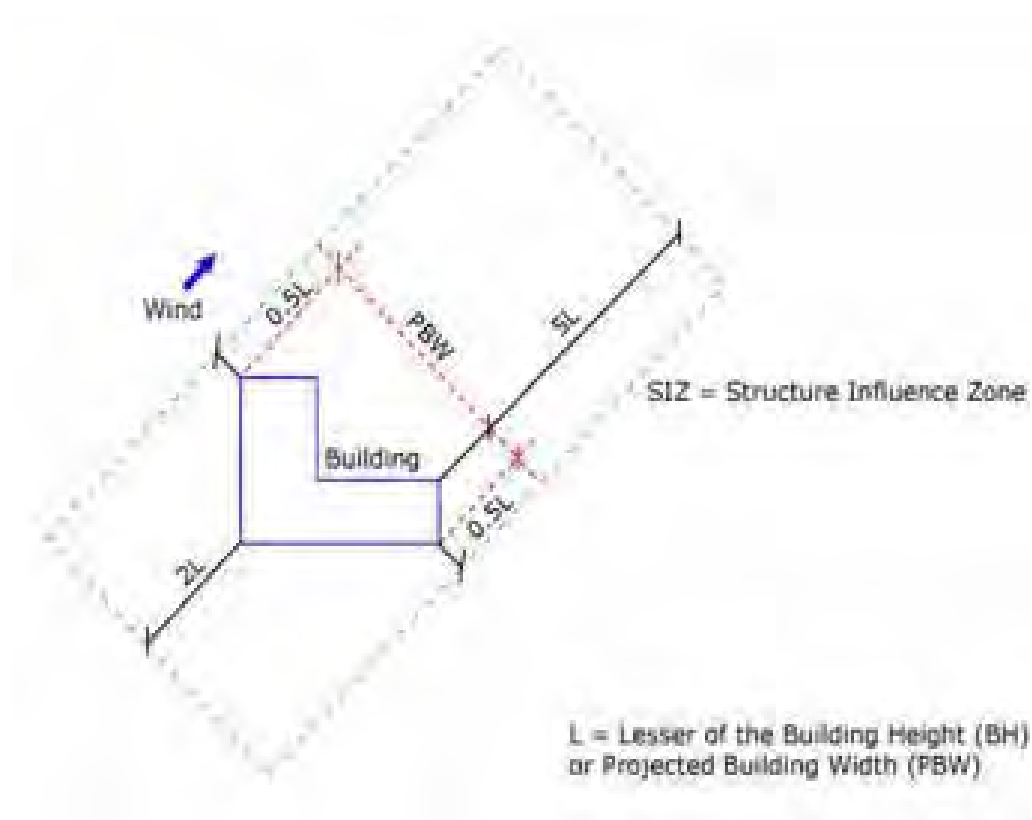


Figure 3.7 - GEP 5L and Structure Influence Zone (SIZ) Areas of Influence

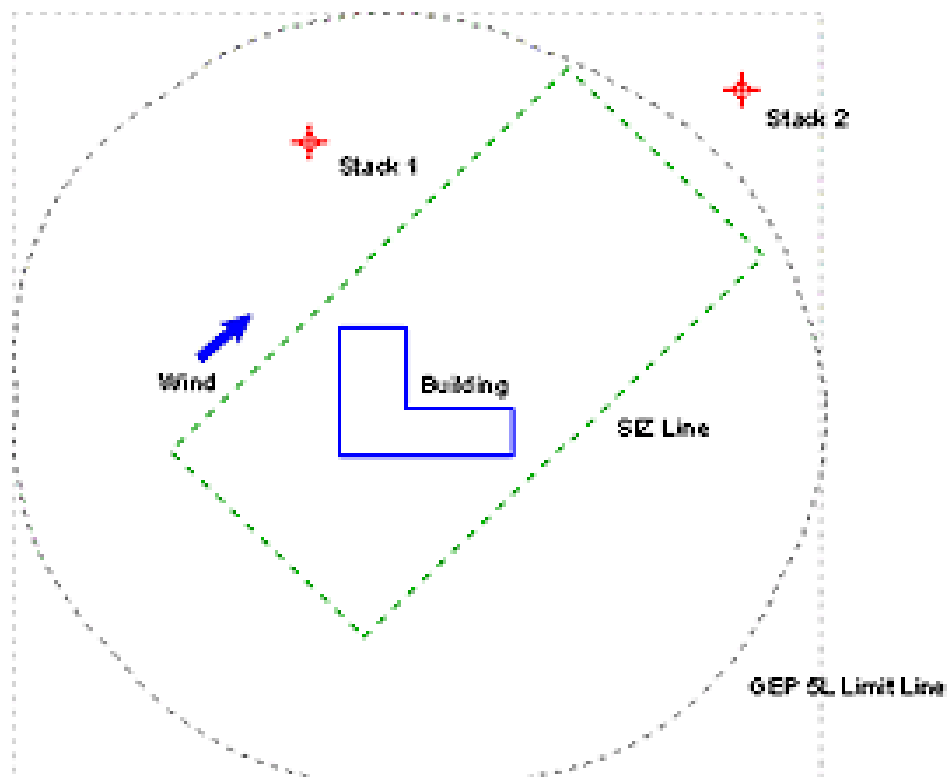


Figure 3.8 -GEP 360° 5L and Structure Influence Zone (SIZ) Areas of Influence

## 3.8.2 Defining Buildings

The recommended screening and refined models all allow for the consideration of building downwash. SCREEN3 considers the effects of a single building while AERMOD and ISCST3/ISC-PRIME can consider the effects of complicated sites consisting of up to hundreds of buildings. This results in different approaches to defining buildings as outlined below.

### 3.8.2.1 SCREEN3 Building Definition

Defining buildings in SCREEN3 is straightforward, as only one building requires definition. The following input data is needed to consider downwash in SCREEN3:

- Building Height: The physical height of the building structure in meters.
- Minimum Horizontal Building Dimension: The minimum horizontal building dimension in meters.
- Maximum Horizontal Building Dimension: The maximum horizontal building dimension in meters.

For Flare releases, SCREEN assumes the following:

- an effective stack gas exit velocity ( $V_s$ ) of 20 m/s,
- an effective stack gas exit temperature ( $T_s$ ) of 1,273 K, and
- an effective stack diameter based on the heat release rate.

Since building downwash estimates depend on transitional momentum plume rise and transitional buoyant plume rise calculations, the selection of effective stack parameters could influence the estimates. Therefore, building downwash estimates for flare releases should be used with extra caution<sup>27</sup>.

If using Automated Distances or Discrete Distances option, wake effects are included in any calculations made. Cavity calculations are made for two building orientations, first with the minimum horizontal building dimension along wind, and second with the maximum horizontal dimension along wind. The cavity calculations are summarized at the end of the distance-dependent calculations (see SCREEN3 User's Guide<sup>32</sup> Section 3.6 for more details).

### 3.8.2.2 AERMOD and ISC-PRIME Building Definition

The inclusion of the PRIME (Plume Rise Model Enhancements) algorithm<sup>28</sup> to compute building downwash has produced more accurate results in air dispersion models. Unlike the earlier algorithms used in ISC3, the PRIME algorithm:

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<sup>27</sup> U.S. Environmental Protection Agency, 1995. SCREEN3 Model User's Guide. EPA-454/B-95-004. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

<sup>28</sup> Schulman, L.L., D.G. Strimaitis and J.S. Scire, 2000: Development and evaluation of the PRIME plume rise and building downwash model. Journal of the Air & Waste Management Association, 50:378-390.

- accounts for the location of the stack relative to the building;
- accounts for the deflection of streamlines up over the building and down the other side;
- accounts for the effects of the wind profile at the plume location for calculating plume rise;
- accounts for pollutants captured in the recirculation cavity to be transported to the far wake downwind (this is ignored in the earlier algorithms); and
- avoids discontinuities in the treatment of different stack heights, which were a problem in the earlier algorithms.

Refined models allow for the consideration of downwash effects from multiple buildings. AERMOD and ISCST3/ISC-PRIME require building downwash analysis to first be performed using BPIP-PRIME<sup>28</sup>. The results from BPIP-PRIME can then be incorporated into the modeling studies for consideration of downwash effects.

The U.S. EPA Building Profile Input Program – Plume Rise Model Enhancements (BPIP-PRIME) was designed to incorporate enhanced downwash analysis data for use with the U.S. EPA ISC-PRIME and current AERMOD models. Similar in operation to the U.S. EPA BPIP model, BPIP-PRIME uses the same input data requiring no modifications of existing BPIP projects. The following information is required to perform building downwash analysis within BPIP:

- X and Y location for all stacks and building corners.
- Height for all stacks and buildings (meters). For building with more than one height or roofline, identify each height (tier).
- Base elevations for all stacks and buildings.

The BPIP User's Guide<sup>29</sup> provides details on how to input building and stack data to the program.

The BPIP model is divided into two parts.

- Part One: Based on the GEP technical support document<sup>30</sup>, this part is designed to determine whether or not a stack is subject to wake effects from a structure or structures. Values are calculated for GEP stack height and GEP related building heights (BH) and projected building widths (PBW). Indication is given to which stacks are being affected by which structure wake effects.
- Part Two: Calculates building downwash BH and PBW values based on references by Tickvart<sup>31,32</sup> and Lee<sup>33</sup>. These can be different from those calculated in Part One. The calculations are performed only if a stack is being influenced by structure wake effects.

In addition to the standard variables reported in the output of BPIP, BPIP-PRIME adds the following:

- BUILDLEN: Projected length of the building along the flow.

<sup>29</sup> U.S. Environmental Protection Agency, 1995. User's Guide to the Building Profile Input Program, EPA-454/R-93-038, Office of Air Quality Planning and Standards, Research Triangle Park, N.C.

<sup>30</sup> U.S. Environmental Protection Agency, 1985. Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) – Revised EPA-450/4-80-023R, U.S. Environmental Protection Agency, Research Triangle Park, NC.

<sup>31</sup> Tickvart, J. A., May 11, 1988. Stack-Structure Relationships, Memorandum to Richard L. Daye, U.S. EPA.

<sup>32</sup> Tickvart, J. A., June 28, 1989. Clarification of Stack-Structure Relationships, Memorandum to Regional Modeling Contacts, Regions I-X, U.S. EPA.

<sup>33</sup> Lee, R. F., July 1, 1993. Stack-Structure Relationships – Further clarification of our memoranda dated May 11, 1988 and June 28, 1989, Memorandum to Richard L. Daye, U.S. EPA.

- XBADJ: Along-flow distance from the stack to the center of the upwind face of the projected building.
- YBADJ: Across-flow distance from the stack to the center of the upwind face of the projected building.

For a more detailed technical description of the EPA BPIP-PRIME model and how it relates to the EPA ISC-PRIME model see the Addendum to ISC3 User's Guide<sup>34</sup>.

## 3.9 Multiple Pollutants

### 3.9.1 Modeling Multiple Pollutants from Multiple Sources

Industrial processes often emit multiple pollutants through one or several emission sources. The U.S. EPA models are not equipped to automatically perform modeling of different pollutants that may share the same emission source but have unique emission rates.

Traditional approaches to this scenario resulted in modelers performing separate model runs for each specific pollutant type, even though all other model site parameters remain the same. For projects consisting of many pollutants, this approach results in the modeler needing not only to be extremely organized but also requires high levels of computer resources as the project would need to be run separately for each pollutant scenario.

An alternative approach is applying unitized emission rate and summation concepts, which drastically reduce the computational time for large multiple pollutant projects.

#### 3.9.1.1 Standard Approaches to Modeling Multiple Toxic Pollutants from Multiple Sources

For industrial processes that emit multiple pollutants through one or several emission sources, the following approach should be followed.

- Dispersion modeling should be conducted as outlined in this guidance document using a unit (normalized) emissions rate of 1 g/s, or 1/g/s/m<sup>2</sup> for area sources.
- All chemical analysis / risk calculations should be processed through the CARB HARP program <http://www.arb.ca.gov/toxics/harp/harp.htm>.
- Exceptions (Must be given prior approval by the district):
  - Analysis of multiple pollutants that only affect one acute toxicological endpoint or the same endpoints.
  - Analyses of multiple pollutants that only affect one chronic toxicological endpoint or the same endpoint and do not have a chronic oral value.
  - Analysis of multiple pollutants that are not multi-pathway (only inhalation)
    - One dispersion modeling run for

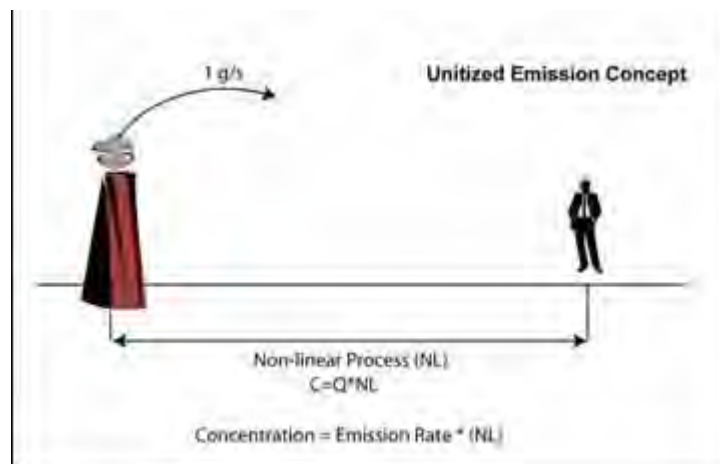
<sup>34</sup> Schulman, et al., 1997. Addendum - User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume 1. Office of Air Quality Planning and Standards, Research Triangle Park, NC.



- Acute Hazard Index,
- Chronic Hazard Index, and
- Cancer Risk.

### 3.9.2 Unitized (Normalized) Emission Rate and Summation Concepts

It is a well-known fact that air dispersion modeling is a non-linear process. The modeled site may have random meteorological variations, the dispersion process is non-linear, and the terrain elevations at the site may assume unlimited shapes. However, once the calculations to a receptor in space are complete, all chemical concentration levels vary linearly with their source release rate. Figure 3.9 helps visualize this concept, by describing an emission rate of 1 g/s.



**Figure 3.9 - Unitized Emission Rate Concept (1 g/s)**

The Unitized Emission Rate Concept only applies to single sources. For assessments with multiple sources the authors recommend that each source be modeled independently, using unitized emission rate (1 g/s). The concentration at the receptor can then be multiplied by the actual chemical emission rate, and the final result from all the sources will be superimposed. This is called the Summation Concept, where the concentration and deposition fluxes at a receptor are the linear addition of the resulting values from each source. Figure 3.10 depicts the Summation concept.



**Figure 3.10 - The Summation Concept for two sources**

A post-processor is needed to effectively process model results that have been performed using unitized emission rate and summation concepts. Final output will provide results for pollutant specific scenarios from multiple sources.

### 3.10 Modeling Roads

There are a number of dispersion models that can be used to predict concentrations from roadway emissions. Some models such as CAL3QHCR were developed solely for use in modeling roadway emissions. They use a line source algorithm. CAL3QHCR is a preferred/recommended U.S. Environmental Protection Agency (EPA) model for roadway modeling that uses local meteorology. EPA also recommends the CALINE3 model. But, CALINE3 does not use local meteorology. It is included in CAL3QHCR. The Industrial Source Complex – Short-Term (ISCST3) and the AERMOD models can be used to model roadways as a line of volume sources. AERMOD is the recommended EPA model. However, some Districts still use ISCST3 because they do not yet have the meteorological data needed for AERMOD. The methodology for modeling using AERMOD is the same as that for using ISCST3. The input data is almost identical because AERMOD was designed to use input similar to that used by ISCST3 and to provide similar outputs. The major differences between the inputs to the two models are the meteorological data sets. During the preparation of this guideline, an analysis was conducted to compare concentrations predicted by all three models for a specific example. This analysis showed that all three models provided similar concentration estimates, and that any of the three models could be used effectively to predict pollutant concentrations and the resulting risk from roadway emissions.

In the discussion below, use of CAL3QHCR is described first. That discussion includes a description of data sources to estimate emissions. The same approach can be used to develop emissions estimates for ISCST3/AERMOD.

## 3.10.1 Modeling Roads using CAL3QHCR

### 3.10.1.1 Introduction

This step by step guidance explains how to use the CAL3QHCR line source model to carry out diesel particulate matter air dispersion modeling, and how to calculate potential cancer risk. Nine potential receptors are assumed to lie directly south of an east-west free-flow freeway with a peak hour traffic count of 11,900 vehicles. The freeway is assumed to be 120 feet wide, with an additional 10 feet on each side to account for the wake of moving vehicles<sup>35</sup>, making for a total link width of 140 feet.

This example represents one specific scenario. For guidance on other CAL3QHCR modeling scenarios not contained herein, contact your local air district or consult the User's Guide to CAL3QHC, Version 2.0<sup>36</sup>.

### 3.10.1.2 Data Sources

This example scenario relies on basic information needed to complete the site specific HRA. Such information includes:

- meteorological data,
- traffic data (from Caltrans), later developed into hourly data,
- vehicle emissions (derived from EMFAC),
- location of the nearest sensitive receptor to the edge of the travel lane, in addition to the generic receptor locations, if required (for example, at 10, 25, 50, 100, 200, 300, 400 and 500 feet) in X-Y coordinates, and
- roadway orientation in terms of its X-Y coordinates (arbitrary origin / 0,0), including length and width.

The above information, including additional information required by the model, is further discussed in the ensuing sections of this document.

### 3.10.1.3 Finding the Peak Hour Traffic Count

The peak hour traffic count nearest to the proposed receptors is used to develop the hourly traffic count information for input into CAL3QHCR. The peak hour traffic count should be found on Caltrans's website at <http://www.dot.ca.gov/hq/traffops/saferesr/trafddata/index.htm>. Select back peak hour for projects south or west of the nearest milepost location. For projects north or east of the nearest milepost location, select ahead peak hour.

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<sup>35</sup> The mixing zone is an area where dispersion results are considered to be inaccurate.

<sup>36</sup> User's Guide to CAL3QHC Version 2.0, EPA-454/R-92-006 (Revised, with CAL3QHCR addendum), September 1995.

For the scenario considered herein, the Caltrans's data indicates a peak hour traffic count of 11,900 vehicles.

#### Running EMFAC to Produce Hourly PM10 Emissions and Data on Vehicle Miles Traveled

The most current version of EMFAC should be run to determine preliminary vehicle miles traveled (VMT) and emissions data. The VMT data will be used to develop the hourly traffic count information required by CAL3QHCR, and the PM10 exhaust emissions data will be used to determine the hourly PM10 emissions rates for input into CAL3QHCR.

The EMFAC run should be based on the following parameters:

- Year: first year of project build out,
- Season: annual,
- Burden: standard, and
- Output Frequency: hourly.

The following data from the EMFAC output file will be used:

- VMT/1000 for each hour,
- PM10 emissions for each hour.

Figure 3.11 is a screen shot of the first page of the EMFAC output file. The circled hourly data is the data that will be used.

This methodology is a **screening method** to determine the cancer risk from diesel exhaust assuming that all vehicles traveling the roadway segment are diesel vehicles.

A refinement of the emission calculations can be made by using data on percentages of truck traffic from Caltrans and assuming that all trucks are diesel. If better data is not available, 10% is sometimes assumed as the diesel truck fraction of vehicles.

To refine the emissions calculations further to account for diesel emissions from diesel trucks, and to account for the emissions of the highest priority toxic substances (1,3 butadiene, acrolein, acetaldehyde, formaldehyde, and benzene) from all vehicles, the procedure in Appendix B should be followed.

Contact the local district to determine which method should be used to estimate diesel truck travel.

**Figure 3.11: Example Scenario EMFAC Output, Page 1**

Version : Emsco2007 V2.3 Nov 1 2006

Run Date : 2008/02/06 15:08:23

Scan Year: 2009 -- All model years in the range 1965 to 2009 selected

Season : Annual

Area : Sacramento Metropolitan AQMD Avereq

I/M Stat : Enhanced Interim (2005) -- Using I/M schedule for area 31 Sacramento (SV)

Emissions: Tons Per Hr=0

	Light Duty Passenger Cars				Light Duty Trucks				Medium Duty Trucks				Heavy Duty Trucks								
	Non-cat	Cat	Diesel	Total	Non-cat	Cat	Diesel	Total	Non-cat	Cat	Diesel	Total	Non-cat	Cat	Total	Trucks	Urban Buses	Motorcycles	Vehicles	All	
Vehicle	7632.	483025.	1673.	492331.	5806.	307893.	8213.	321912.	1391.	117094.	9051.	127537.	1330.	11346.	12677.	18201.	30878.	371.	34494.	100520.	
WM/1000	160.	0.	0.	160.	189.	2.	187.	189.	2.	41.	21.	63.	64.	1.	50.	61.	0.	3.	391.	391.	
	256.	25555.	79.	25809.	198.	16328.	423.	16850.	76.	8729.	3062.	11887.	326.	1629.	1954.	968.	2320.	16.	580.	6884.	
----- Total Organic Gas Emissions -----																					
Run Exh	0.01	0.01	0.00	0.02	0.01	0.01	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.03	0.04	0.00	0.10	
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Start Ex	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.00	0.02	0.00	0.00	0.07	
-----																					
Total Ex	0.01	0.03	0.00	0.04	0.01	0.02	0.00	0.03	0.00	0.02	0.00	0.03	0.01	0.01	0.02	0.04	0.06	0.00	0.01	0.17	
-----																					
Diurnal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Hot Soak	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
Running	0.01	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	
Resting	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	
-----																					
Total	0.02	0.06	0.00	0.08	0.01	0.05	0.00	0.06	0.00	0.03	0.00	0.04	0.01	0.01	0.02	0.04	0.06	0.00	0.02	0.26	
----- Carbon Monoxide Emissions -----																					
Run Exh	0.10	0.36	0.00	0.45	0.08	0.31	0.00	0.39	0.05	0.14	0.02	0.20	0.01	0.01	0.03	0.15	0.18	0.00	0.14	1.37	
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	
Start Ex	0.01	0.21	0.00	0.22	0.01	0.16	0.00	0.17	0.00	0.18	0.00	0.18	0.06	0.19	0.25	0.00	0.25	0.00	0.01	0.82	
-----																					
Total Ex	0.10	0.57	0.00	0.67	0.09	0.47	0.00	0.56	0.05	0.31	0.02	0.38	0.07	0.20	0.28	0.16	0.44	0.00	0.15	2.21	
----- Oxides of Nitrogen Emissions -----																					
Run Exh	0.01	0.04	0.00	0.05	0.00	0.05	0.00	0.06	0.00	0.03	0.11	0.14	0.00	0.01	0.01	0.73	0.74	0.01	0.00	1.00	
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	
Start Ex	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.02	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.06	
-----																					
Total Ex	0.01	0.05	0.00	0.06	0.01	0.06	0.00	0.07	0.00	0.05	0.11	0.16	0.00	0.02	0.02	0.76	0.77	0.01	0.00	1.06	
----- Carbon Dioxide Emissions (000) -----																					
Run Exh	0.00	0.06	0.00	0.06	0.00	0.05	0.00	0.05	0.00	0.03	0.01	0.04	0.00	0.00	0.00	0.09	0.09	0.00	0.00	0.25	
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-----																					
Total Ex	0.00	0.06	0.00	0.06	0.00	0.05	0.00	0.05	0.00	0.03	0.01	0.04	0.00	0.00	0.00	0.09	0.09	0.00	0.00	0.25	
----- PM10 Emissions -----																					
Run Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.03	
Idle Exh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Start Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-----																					
Total Ex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.03	
----- Tire/Wear BrakeWear -----																					
Tire/Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
BrakeWear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
-----																					
Total	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.04	
----- Lead -----																					
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOx	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
----- Fuel Consumption (000 gallons) -----																					
Gasoline	0.08	6.49	0.00	6.57	0.07	5.48	0.00	5.55	0.00	2.91	0.00	2.94	0.03	0.13	0.16	0.00	0.16	0.02	0.07	15.32	
Diesel	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	1.11	1.11	0.00	0.00	0.00	0.00	0.26	0.26	0.07	0.00	9.53	

Title : 2009 info

Version : Emsco2007 V2.3 Nov 1 2006

Run Date : 2008/02/06 15:08:23

Scan Year: 2009 -- All model years in the range 1965 to 2009 selected

Season : Annual

Area : Sacramento Metropolitan AQMD Avereq

I/M Stat : Enhanced Interim (2005) -- Using I/M schedule for area 31 Sacramento (SV)

Emissions: Tons Per Hr=0



### 3.10.1.4 Preparing the Hourly Traffic Count Data

To develop hourly traffic count values needed by CAL3QHCR, first find the highest hourly Vehicle Miles Traveled (VMT) count reported by EMFAC. Figure 3.12 shows an example. In this example, the highest hourly VMT count is 2,618,000 miles, which falls on Hour 17, 5:00 pm. Next, divide each hourly VMT value from EMFAC by the highest hourly VMT count (2,618,000 miles). Each result is known as a normalization factor.

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	A	B	C	D
1	VMT/1000 from EMFAC	HR		Normalization Factors
2	391,000.00	hr 00		0.149350649
3	159,000.00	hr 01		0.060733384
4	185,000.00	hr 02		0.070664629
5	102,000.00	hr 03		0.038961039
6	177,000.00	hr 04		0.067608862
7	316,000.00	hr 05		0.120702827
8	1,218,000.00	hr 06		0.465240642
9	2,456,000.00	hr 07		0.938120703
10	2,322,000.00	hr 08		0.886936593
11	1,464,000.00	hr 09		0.559205500
12	1,536,000.00	hr 10		0.586707410
13	1,923,000.00	hr 11		0.734530176
14	1,982,000.00	hr 12		0.757066463
15	1,957,000.00	hr 13		0.747517189
16	2,246,000.00	hr 14		0.857906799
17	2,286,000.00	hr 15		0.873185638
18	2,407,000.00	hr 16		0.919404125
19	2,618,000.00	hr 17	Highest VMT Hour	1.000000000
20	1,812,000.00	hr 18		0.692131398
21	1,354,000.00	hr 19		0.517188694
22	1,042,000.00	hr 20		0.398013751
23	1,060,000.00	hr 21		0.404889228
24	793,000.00	hr 22		0.302902979
25	597,000.00	hr 23		0.228036669

extended calcs 2008 vmt\_e

Draw AutoShapes

Ready NUM

Figure 3.12: Example Scenario Development of Normalization Factors

Next multiply each normalization factor times the project's peak hour traffic count provided in this example by Caltrans (11,900 vehicles/hour during hour 17, 5:00 pm), Table 3.3. The results are normalized hourly traffic volumes for input into CAL3QHCR.

<b>Time of day</b>	<b>Traffic Count (vehicles/hour)</b>
Hr 00	1777
Hr 01	723
Hr 02	841
Hr 03	464
Hr 04	805
Hr 05	1436
Hr 06	5536
Hr 07	11164
Hr 08	10555
Hr 09	6655
Hr 10	6982
Hr 11	8741
Hr 12	9009
Hr 13	8895
Hr 14	10209
Hr 15	10391
Hr 16	10941
<b>Hr 17</b>	<b>11900</b>
Hr 18	8236
Hr 19	6155
Hr 20	4736
Hr 21	4818
Hr 22	3605
Hr 23	2714

**Table 3. 3: Example Scenario Normalized Traffic Counts**

### **3.10.1.5 Preparing the Hourly Emissions Data**

PM10 emissions data is reported by EMFAC in tons/hour and needs to be converted to grams/hour. The grams/hour values then need to be divided by the overall VMT per hour for each hour (as reported by EMFAC), to obtain grams per vehicle mile needed for input into CAL3QHCR.

### **3.10.1.6 Defining the Calculational Domain for the Input File**

The CAL3QHCR input file requires data that defines the calculational domain. The X-Y coordinates at the beginning and at the end of the roadway section need to be defined. These have an arbitrary origin, with the y axis aligned with north.

Additionally, the width (mixing zone) of the roadway needs to be defined. Always allow for an additional 10 feet added to the edge of nearest travel lane to the receptors to account for the wake of moving vehicles.

The minimum roadway length is 10,000 feet.

The elevation of the roadway compared to the surrounding area needs to be specified. For roadways at grade the height is 0; for elevated roadways the relative height is positive; and for depressed roadways the relative height is negative.

The z-coordinate (receptor breathing height) also needs to be defined. The default recommendation is 1.5 meters, or 6 feet.

In this scenario, the freeway is 120 feet wide, and after accounting for the wake, the total link width becomes 140 feet.

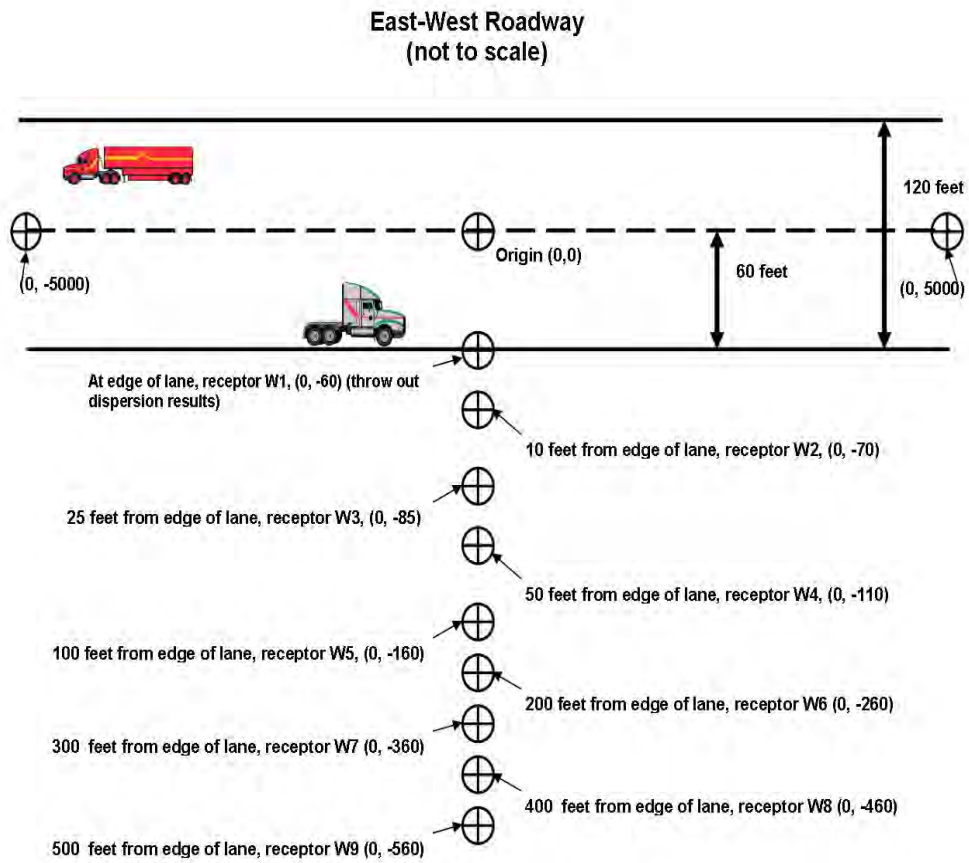
The length of the roadway modeled is 10,000 feet, or 5,000 feet on each side from the center point.

The roadway is at grade.

A receptor has been placed at the edge of the roadway to define the roadway dimensions; however the dispersion results for this receptor should be discarded as they are not accurate at roadway edges. See Figure 3.13 below.

Other parameters required by the model need to be defined. Table 3.4 below discusses recommended and/or default parameters. Any changes to the default recommended values should be thoroughly explained.





**Figure 3.13: Example Scenario East-West Roadway and Receptors Illustration**

**Table 3.4: Other Recommended Parameters for Input into CAL3QHCR**

Parameter	Default	
Calculation averaging time (min)	60	
Surface roughness (cm, from 3 to 400). For mixed uses and others not listed here, the modeler should make a reasonable assumption.	single family	108
	offices	170
	apartments	370
Settling velocity (cm/s)	0	
Deposition velocity (cm/s)	0	
Site setting (U=urban, R=rural)	U	
Form of traffic volume, emission rate data (1=one hour's data, 2=one week of hourly data)	2	
Pollutant (P for PM10 to give output in $\mu\text{g}/\text{m}^3$ )	P	
Hourly ambient background concentration ( $\mu\text{g}/\text{m}^3$ )	0	
Roadway height indicator (AG=at grade, FL=elevated and filled, BR=bridge, DP=depressed)	AG	
Roadway height (ft, 0 if AG, relative height if FL, BR, or DP)	0	

### 3.10.1.7 Preparing the CAL3QHCR Files

#### 3.10.2.7.1 Downloading CAL3QHCR

Download the CAL3QHCR model from EPA's Preferred/Recommended Dispersion Models website at [www.epa.gov/scram001/dispersion\\_prefrec.htm](http://www.epa.gov/scram001/dispersion_prefrec.htm). There are five files needed to run the program:

- input file (.inp),
- batch file (.bat),
- control file (.ctl),
- meteorological data file (.asc), and
- executable file (.exe).

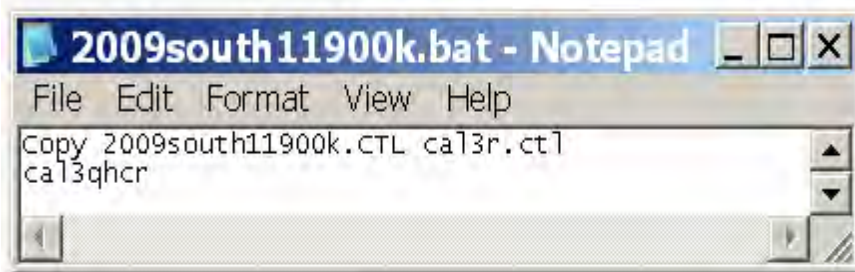
Decide on a name for the run. The name of the example scenario run is "2009south11900k".

Note that in setting up your run, you will be editing over data already present in the files.

Prepare the Batch File (.bat).

The batch file is the DOS file batch command.

Right click on the file to open it for editing. (Note that opening or double clicking on the file will cause the program to run. If this happens, simply delete the files the program creates and start again.) Once the file is open, type in the name of your run after the word “Copy”. Save the file with the name of the run. See Figure 3.14 below for the example scenario batch file.

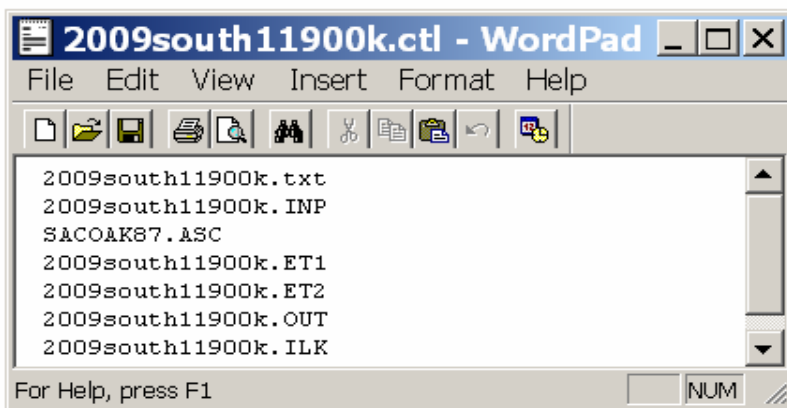


**Figure 3.14: Example Scenario Batch File**

### 3.10.1.7.2 Prepare the Control File (.ctl)

CAL3QHCR looks to the control file to find the file names that are read into the program and outputted by the program.

Type the name of your run in front of each file extension, except the .ASC file, where you will type in the meteorological data file name. Save the control file with the name of your run. See Figure 3.15 below for the example scenario control file.



**Figure 3.15: Example Scenario Control File**

### 3.10.1.7.3 Meteorological File (.asc)

The meteorological file should be in the .asc format. Contact your local air district for the recommended meteorological file. This file will not be edited.

### 3.10.1.7.4 Executable File (.exe)

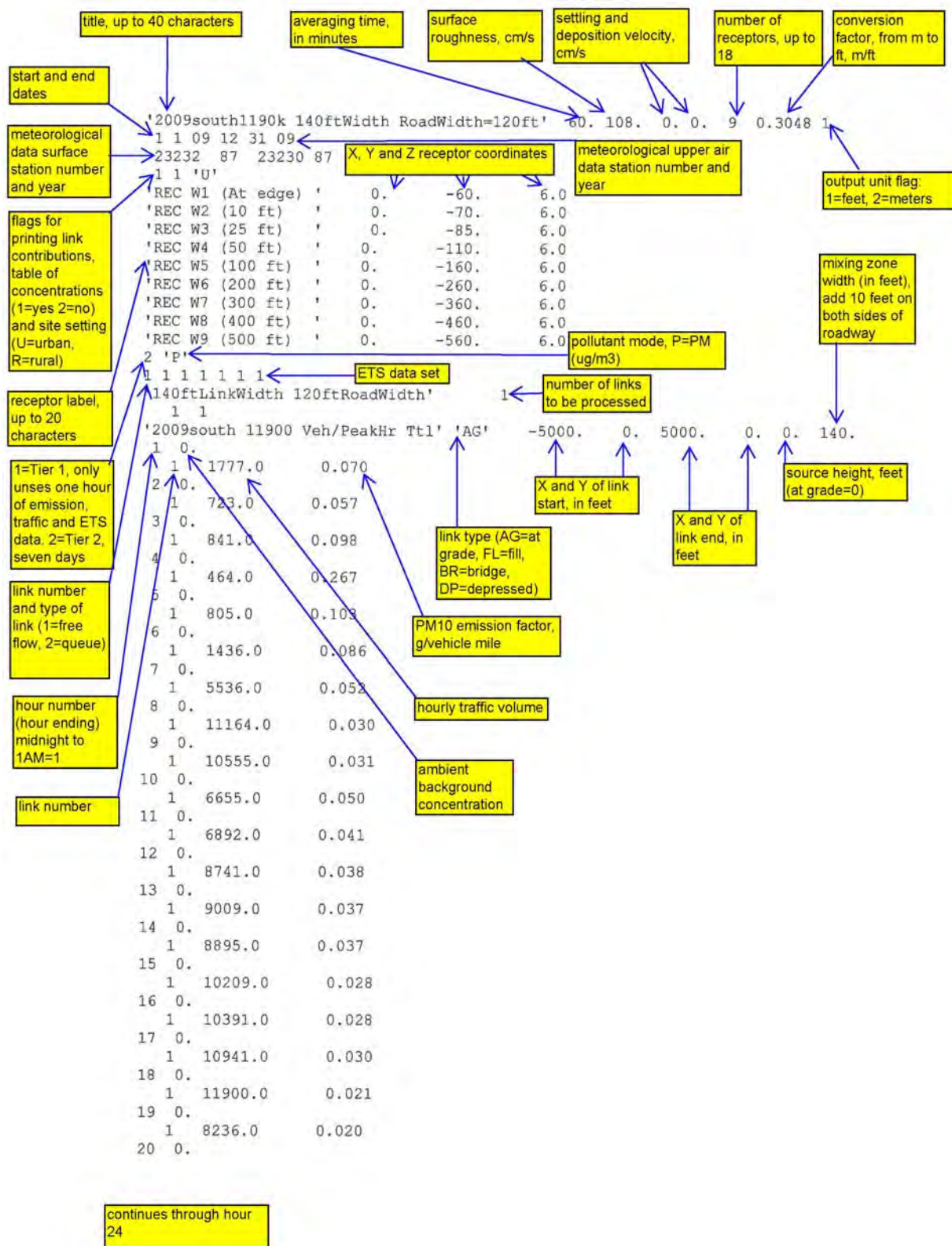
The executable file runs the program. This file will not be edited.

### **3.10.1.7.5 Prepare the Input File (.inp)**

The input file contains scenario parameters.

Prepare the input by editing over an example file provided with the model download, or by editing over a file provided by the local air district that more closely reflects the setup needed for this type of roadway modeling. Save the input file with the name of your run. See Figure 3.16 below for the example scenario input file and input explanations.

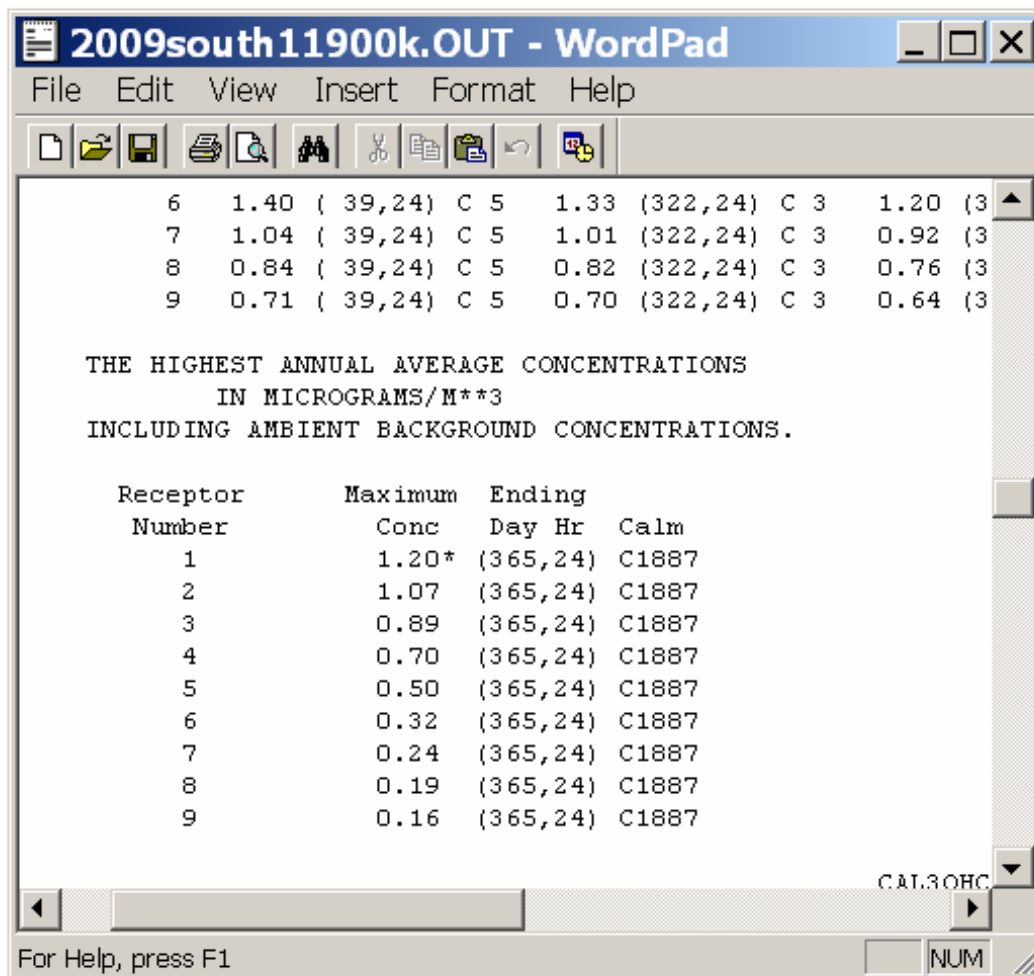
### Figure 3.16: Example Scenario Input File and Input Explanations



### 3.10.1.8 Running the Model and Calculating Potential Cancer Risk

Double click on the .bat file to run the model. The model will produce a series of files with extensions .ET1, .ET2, .ILK, .OUT, .txt, and .ctl. Open the .txt and check to be sure the run was error-free.

The output file (.OUT) will show, among other information, the highest annual average concentrations. See Figure 3.17 below for the relevant section of the example scenario output file.



**Figure 3.17: Example Scenario Output File, Highest Annual Average Concentrations**

The example above shows downwind concentrations of diesel particulate matter at various receptor locations. The cancer risk due for diesel particulate is calculated by assuming that only the inhalation pathway applies. The default cancer risk calculation is based on the 80<sup>th</sup> percentile breathing rate, as recommended by the Office of Environmental Health Hazard Assessment. The cancer risk is calculated for receptor 4 (0.70 ug/m<sup>3</sup>) as follows:

$$\text{Cancer Risk} = S_i * C_i * \text{DBR} * A * \text{EF} * \text{ED} / \text{AT}$$

Where:

$$\begin{aligned} S_i &= \text{Cancer Potency Slope Factor for DPM} &= & 1.1 \text{ (mg/kg-d)}^{-1} \\ C_i &= \text{Concentration in the air of DPM} &= & 0.70 \text{ ug/m}^3 \\ \text{DBR} &= \text{Daily Breathing Rate (default 80}^{\text{th}} \text{ \%ile):} &= & 302 \text{ L/kg-day} \\ & & & \text{(Residential Receptors)} \end{aligned}$$

(Some districts may require the use of the 95<sup>th</sup> \%ile):

$$\begin{aligned} & & &= & 393 \text{ L/kg-day} \\ A &= \text{Inhalation Absorption Rate} &= & 1 \\ \text{EF} &= \text{Exposure Frequency:} &= & 350 \text{ days} \\ & & & \text{(Residential Receptors)} \\ \text{ED} &= \text{Exposure Duration:} &= & 70 \text{ years} \\ & & & \text{(Residential Receptors)} \\ \text{AT} &= \text{Averaging Time (70 years)} &= & 25,550 \text{ days} \end{aligned}$$

Cancer Risk:

$$\begin{aligned} &= (1.1 \text{ (mg/kg-d)}^{-1})(0.70 \text{ ug/m}^3)(302 \text{ L/kg-day})(1)(350 \text{ days})(70 \text{ years})/(25,550 \text{ days}) \\ &= 223 \text{ per million} \end{aligned}$$

### 3.10.1.9 Other CAL3QHCR Features

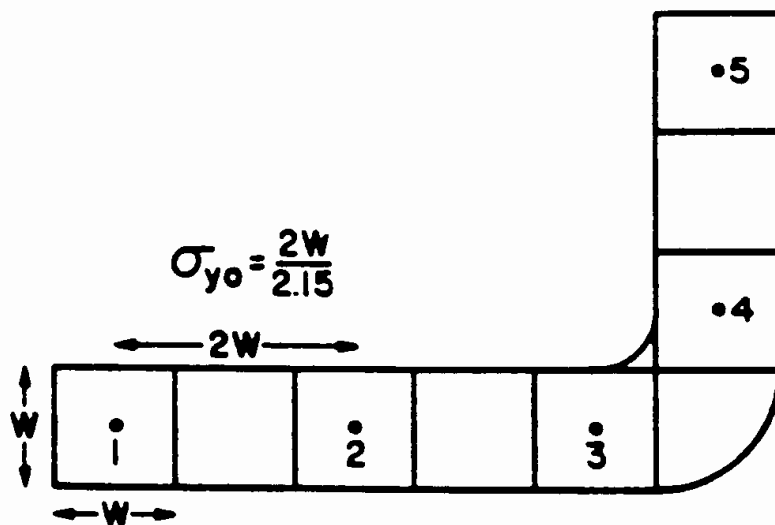
CAL3QHCR offers many other features that allow modeling traffic intersections, traffic signaling, and traffic queuing. Employing these features is quite site-specific. If these features must be employed, the user's guide should be consulted.

### 3.10.2 Modeling Roads using ISCST3 or AERMOD

CAL3QHCR is a roadway model. It can be used only to model highways. Often a project for which a health risk assessment is being prepared has additional sources. For example, a commercial development will have toxic emissions from truck idling, operation of transportation refrigeration units (TRUs), fast food restaurants, gasoline dispensing facilities, and dry cleaning operations. Large commercial operations may also have emergency diesel-fired internal combustion engines. These additional sources could be modeled in ISCST3 or AERMOD and their predicted risks superimposed upon those predicted by CAL3QHCR. Alternatively, all the sources including the roadways could be modeled using ISCST3 and AERMOD. The results of roadway modeling using ISCST3 and AERMOD are consistent with those from using CAL3QHCR. The procedures for using ISCST3 and AERMOD to model emissions from roadways are discussed below.

### 3.10.2.1 Introduction

ISCST3 and AERMOD can be used to predict the concentrations of pollutants emitted from vehicles on roads. These models have 4 basic types of sources (i.e., point, area, volume, and open pit). Emissions from idling vehicles located at a loading dock can be modeled as point sources. Area sources have been used in the past to model emissions from parking lots. The best method for modeling emissions from travelling vehicles is to use a line source or a series of multiple volume sources, as shown below.



View looking down along the length of a road segment ( $L_{RS}$ )

The following steps can be used to construct a line source that represents diesel PM emissions from diesel trucks traveling along a road segment:

1. Determine the total emissions for the diesel trucks traveling along the road segment.

$E_T$  = Emissions total for road segment

2. Using the width of the road as the length of the side ( $W$ ) of a single volume source, determine the number of volume sources along the length of the road by dividing the length of the road by  $2W$ . Round the number of volume sources either up or down.

$W$  = Width of the road

$L_{RS}$  = Length of the road segment

$N$  = Number volume sources

$N = L_{RS} / 2W$

3. Calculate the initial lateral dispersion:



$$\sigma_y = 2W / 2.15$$

3. Estimate the initial vertical dispersion using the height of the truck exhaust divided by 4.3.

$$\begin{aligned}\sigma_z &= H / 4.3 \\ &= 13 \text{ feet} / 4.3 \\ &= 3.01 \text{ feet}\end{aligned}$$

4. Calculate the emission rate for each volume source by dividing the total emissions for the road segment by the number of volume sources.

$$\begin{aligned}E_{VS} &= \text{Emission rate for each volume source} \\ E_{VS} &= E_T / N\end{aligned}$$

5. Model each individual volume source using ISCST3 or AERMOD separately, but as a group, using actual emissions for each volume source.
6. Identify the predicted concentrations at each receptor.
7. Next, calculate the risk at each receptor using the procedure outlined above in Section 3.10.1.8.

### 3.10.2.2 Data Requirements

The data that are required to model roadway emissions using ISCST3 and AERMOD are similar to those required for using CAL3QHCR. They include the following:

- **Meteorological data** – If the air district cannot provide preprocessed meteorological data, then nearby airport or monitored surface data from a meteorological station can be processed for use in ISCST3 or AERMOD. Contact your local district for availability of appropriate met data. Information on processing met data can be found in Appendix A.
- **Traffic data and vehicle emissions** – The same data as discussed above for the CAL3QHCR model are used.
- **Roadway configuration** – The width of the roadway is used as the length of a side for each volume source. Receptors should be located the same as with the CAL3QHCR model.
- **Terrain data** – For ISCST3, elevation data must be entered manually. AERMAP is used to generate the elevations and hill slopes for receptors and sources for input to the AERMOD model. Digital Elevation Model (DEM) files for use in AERMAP are available from a variety of sources.

Third-party software used to prepare the input file for ISCST3, and used to allow the model results to be viewed graphically, can also be used to determine terrain elevations using DEM files.

Once these data are assembled, the model input file can be created.

### 3.10.2.3 Preparing the Model Input File

The input files for ISCST3 and AERMOD are very similar. In the discussion below, only the input file for the ISCST3 model will be described.

The input file must contain the following components or sections:

- CO – for overall job control options
- SO – for source information
- RE – for receptor information
- ME – for meteorological data
- TG – for a terrain grid (optional)
- OU – for output options

Each of these sections is discussed briefly below. For more detailed information, the *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models: Volume I – User Instructions* (EPA-454/B-95-003a) should be consulted.

#### 3.10.2.3.1 Control Option Section

Each section begins with a STARTING command and ends with a FINISHED command. Model options that must be specified include: a title; model options such as default or “regulatory” dispersion options, rural or urban dispersion coefficients, and concentration or deposition estimates; the averaging time (period or annual for carcinogenic risk); the pollutant identification; and the RUNORNOT option. The following is a sample input for the example discussed above:

```
CO STARTING
  TITLEONE 2009south1190k
  MODELOPT DFAULT CONC  URBAN
  AVERTIME PERIOD
  POLLUTID DPM
  TERRHGTS ELEV
  FLAGPOLE 1.80
  RUNORNOT RUN
  ERRORFIL Road.err
CO FINISHED
```

In this sample input file, the regulatory default options are used. The model will calculate concentrations of DPM (i.e., diesel particulate matter) using urban dispersion coefficients. The receptors will all be modeled with a default height of 6 ft or 1.8 m. The model will run to completion and will output an error file.

### 3.10.2.3.2 Source Section

As discussed above, a series of volume sources will be modeled to simulate the roadway. The sample input file for this section is the following:

```
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
** Line Source represented by Separated Volume Sources
** -----
** LINE Source ID = SLINE1
** DESCRSRC 2009south1190k
** Length of Side = 36.58
** Emission Rate = 0.123435368
** Elevated
** Vertical Dimension = 0.85
** SZINIT = 0.20
** Nodes = 2
** 309476.00, 3916500.00, 0.00, 3.66, 0.0
** 312527.00, 3916500.00, 0.00, 3.66, 33.38
** -----
LOCATION L0000001 VOLUME 309494.288 3916500.000 0.00
LOCATION L0000002 VOLUME 309566.060 3916500.000 0.00
LOCATION L0000042 VOLUME 312436.939 3916500.000 0.00
LOCATION L0000043 VOLUME 312508.711 3916500.000 0.00
** End of Line Source
** Source Parameters **
SRCPARAM L0000001 0.00287058995348837 3.66 33.38 0.85
SRCPARAM L0000002 0.00287058995348837 3.66 33.38 0.85
SRCPARAM L0000042 0.00287058995348837 3.66 33.38 0.85
SRCPARAM L0000043 0.00287058995348837 3.66 33.38 0.85
** Variable Emissions Type: "By Hour-of-Day"
** Variable Emission Scenario: "Scenario 1"
EMISFACT L0000001 HROFDY 0.53 0.176 0.351 0.528 0.353 0.526
EMISFACT L0000001 HROFDY 1.227 1.427 1.395 1.418 1.204 1.416
SRCGROUP SRCGP1 L0000001 L0000002 L0000003 L0000004 L0000005 L0000006
SRCGROUP SRCGP1 L0000043
SO FINISHED
```

In the above sample input, all lines with “\*\*” are comments. This file was generated using an interface program for the model. In this interface, the information for the line source is input, and the program automatically generates the individual volume sources. As can be seen from the input file, there are 43 separate volume sources in this “line source”. The location of the center of each volume source and its base elevation (i.e., 0 m) is given on the LOCATION command. The SRCPARAM commands specify the emission rate, the release height, the initial lateral dimension, and the initial vertical dimension. The average emission rate calculated from the information provided above was used. The program divides the emission rate for the line source by the number of volume sources.

A **release height** of 12 ft or 3.66 m was used to approximate the height of the plume from a heavy-duty diesel truck.

The width of the roadway was used as the **length of the side for each volume source**.

The length of the side is used to calculate an initial lateral dimension. For this example, the **initial lateral dimension** is 34.03 m or  $2 \times 36.58/2.15$ . (The initial lateral dimension actually used is 33.38 m to ensure that there are an equal number of volume sources in the length of road. This small difference in the calculated initial lateral dimension and the one actually used would not significantly affect the concentrations estimated.)

Based on this release height, an **initial vertical dimension** of 0.85 m or  $3.66/4.3$  was used.

Variable emission factors (EMISFACT) by the hour of the day (HROFDAY) were used to adjust the average emission rate by the appropriate factor based upon the discussion above for the CAL3QCHR run.

### 3.10.2.3.3 Receptor Section

Receptors were located at the distances specified above in the discussion of CAL3QCHR modeling. The sample input file for this section is the following:

```

RE STARTING
** DESCRREC "FENCEGRD" "Receptors generated from Fenceline Grid"
DISCCART 312530.00 3916454.00 0.00 1.80
DISCCART 312505.15 3916454.00 0.00 1.80
** DESCRREC "FENCEPRI" "Cartesian plant boundary Primary Receptors"
DISCCART 309473.00 3916457.00 0.00 1.80
DISCCART 312530.00 3916457.00 0.00 1.80
DISCCART 312530.00 3916543.00 0.00 1.80
DISCCART 309473.00 3916543.00 0.00 1.80
** DESCRREC "FENCEINT" "Cartesian plant boundary Intermediate Receptors"
DISCCART 309497.85 3916457.00 0.00 1.80
DISCCART 309522.71 3916457.00 0.00 1.80
DISCCART 309473.00 3916478.50 0.00 1.80
RE FINISHED

```

The interface program used allows the automatic creation of a telescopic fenceline grid around a facility. This feature was used to create the receptors in this sample input.

First, primary plant boundary receptors were located around the highway. The “plant boundary” was assumed to be the edge of the roadway (i.e., 10 ft on each side of the road from the roadway’s width).

Intermediate receptors were located at a distance of 25 m between receptors along the edge of the roadway.

Then, tiers of receptors at distances of 10 ft, 25 ft, 50 ft, 100 ft, 200 ft, 300 ft, 400 ft, and 500 ft from the roadway edge were entered.

These grid receptors were converted to discrete receptors, and any extraneous receptors were removed.

Note that specific receptors for residences or other **sensitive receptors** could be modeled directly with the ISCST3/AERMOD model.

The **elevation of receptors** was assumed to be zero.

A **receptor height** of 6 ft or 1.8 m was used to approximate the breathing height.

### 3.10.2.3.4 Meteorology Section

The meteorology section specifies the meteorological data to be used. The sample input file for this section is the following:

```
ME STARTING
  INPUTFIL C:\MODELI~1\SACOK85.asc
  ANEMHGHT 10 METERS
  SURFDATA 23232 1985 SACRAMENTO/EXECUTIVE_ARPT
  UAIRDATA 23230 1985 OAKLAND/WSO_AP
ME FINISHED
```

For this sample input file, the 1985 meteorological data from Sacramento was downloaded from the District's website. In the input file, the name and location of the met data file is specified. The height of the anemometer is given. (Most anemometers at airport weather stations are 10 m high.) And, the station number, year and name of the surface data and upper air stations are identified.

### 3.10.2.3.4 Output Section

The output section specifies the files or reports to be output. The sample input file for this section is the following:

```
OU STARTING
** Auto-Generated Plotfiles
  PLOTFILE PERIOD SRCGP1 ROAD.IS\PE00G001.PLT
OU FINISHED
```

ISCST3/AERMOD have a variety of files and reports that can be output. One of the most useful filetypes that can be output is the plotfile. A plotfile has the following information:

```

* ISCST3 (02035): 2009south1190k
* MODELING OPTIONS USED:
* CONC          URBAN ELEV  FLGPOL DFAULT
*          PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: SRCGP1
*          FOR A TOTAL OF 2236 RECEPTORS.
*          FORMAT: (3(1X,F13.5),1X,F8.2,2X,A6,2X,A8,2X,I8.8,2X,A8)
*          X          Y          AVERAGE CONC      ZELEV      AVE      GRP      NUM HRS      NET ID
*          -----
312530.00000 3916454.00000      0.13119      0.00  PERIOD  SRCGP1      00008760      NA

```

For each receptor and each specified source group, this file contains the highest predicted concentration for the specified averaging time. Multiple files can be created for multiple source groups (which can be single sources or multiple sources depending upon those specified by the user) and for each averaging time modeled. These plotfiles can be used to generate a \*.XOQ file for input into the Hot Spots Analysis and Reporting Program (HARP). They also can be used by graphics programs incorporated into the model interface programs or software such as SURFER to generate isopleths of concentration for a visual display of the results.

### 3.10.2.4 Analyzing Model Results

Concentrations predicted by ISCST3/AERMOD can be used to estimate risk using the procedure discussed above for cancer risk from emissions of diesel particulate matter. The plotfiles generated by the models can be used to create an input file for HARP. Importing the results into HARP can be useful if there are other sources that may contribute to the total risk (e.g., in the case of a commercial development). All sources can be modeled in ISCST3/AERMOD while only the roadway sources can be modeled in CAL3QCHR.

## Chapter 4. Geographical Information Inputs

### 4.1 Comparison of Screening and Refined Model Requirements

Geographical information requirements range from basic for screening analyses to advanced for refined modeling. SCREEN3 makes use of geographical information only for terrain data for complex or elevated terrain where it requires simply distance from source and height in a straight-line. The AERMOD and ISCST3/ISC-PRIME models make use of complete three-dimensional geographic data with support for digital elevation model files and real-world spatial characterization of all model objects.

### 4.2 Coordinate System

#### 4.2.1 Local

Local coordinates encompass coordinate systems that are not based on a geographic standard. For example, a facility may reference its coordinate system based on a local set datum, such as a predefined benchmark. All site measurements can relate to this benchmark which can be defined as the origin of the local coordinate system with coordinates of 0.0 m. All facility buildings and sources could then be related spatially to this origin.

However, local coordinates do not indicate where in the actual world the site is located. For this reason, it is advantageous to consider a geographic coordinate system that can specify the location of any object anywhere in the world with precision. The coordinate system most commonly used for air dispersion modeling is the Universal Transverse Mercator system.

## **4.2.2 UTM**

As described earlier, the Universal Transverse Mercator (UTM) coordinate system uses meters as its basic unit of measurement and allows for more precise definition of specific locations than latitude/longitude. Google Earth may be used to determine the UTM's or latitude/longitude coordinates.

Ensure all model objects (sources, buildings, receptors) are defined in the same horizontal datum. Defining some objects based on a NAD27 (North American datum of 1927) while defining others within a NAD83 (North American datum of 1983) can lead to significant errors in relative locations.

## **4.3 Terrain**

### **4.3.1 Terrain Concerns in Short-Range Modeling**

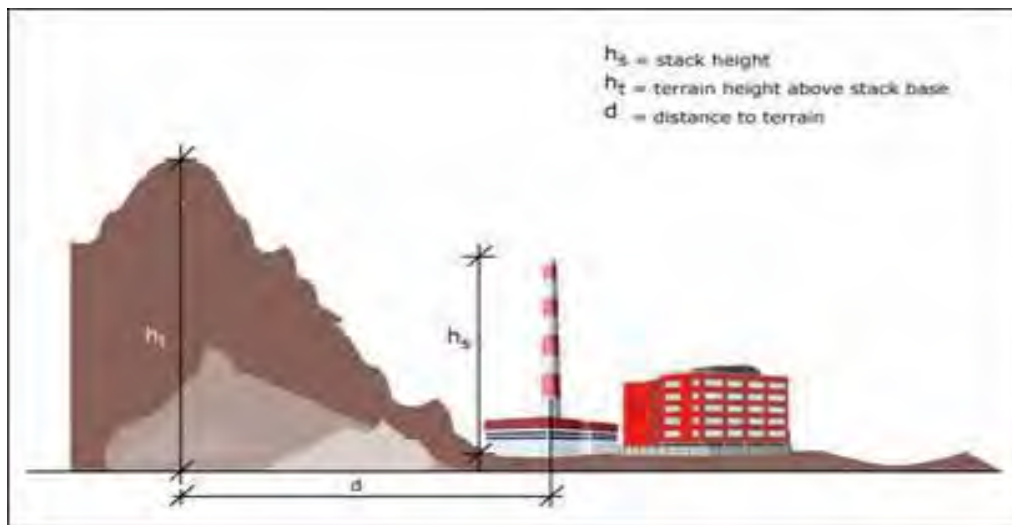
Terrain elevations can have a large impact on the air dispersion and deposition modeling results and therefore on the estimates of potential risk to human health and the environment. Terrain elevation is the elevation relative to the facility base elevation.

The following section describes the primary types of terrain. The consideration of a terrain type is dependant on your study area, and the definitions below should be considered when determining the characteristics of the terrain for your modeling analysis.

### **4.3.2 Flat and Complex Terrain**

The models consider three different categories of terrain as follows:

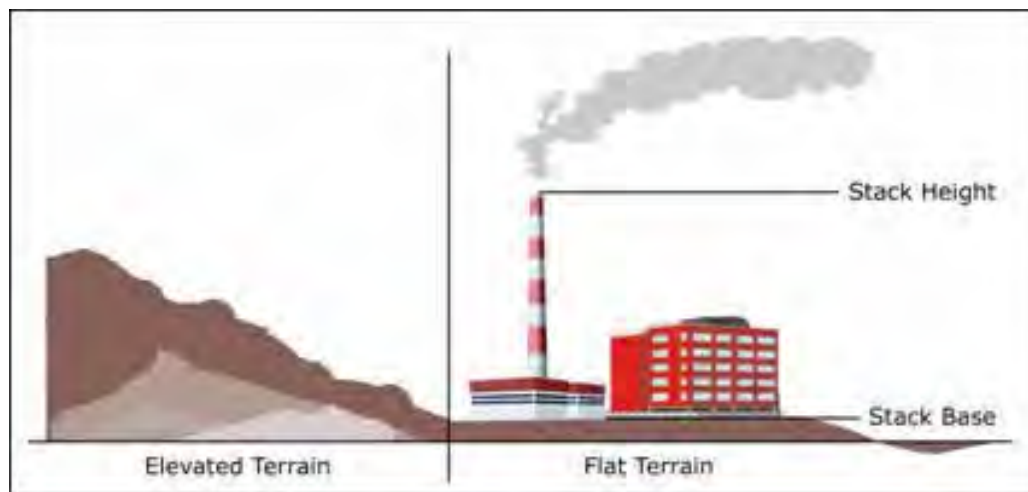
Complex Terrain: as illustrated in Figure 4.1, where terrain elevations for the surrounding area, defined as anywhere within 50 km from the stack, are above the top of the stack being evaluated in the air modeling analysis.



**Figure 4.1 - Complex terrain conditions.**

Simple Terrain: where terrain elevations for the surrounding area are not above the top of the stack being evaluated in the air modeling analysis. The “Simple” terrain can be divided into two categories:

- Simple Flat Terrain is used where terrain elevations are assumed not to exceed stack base elevation. If this option is used, then terrain height is considered to be 0.0 m.
- Simple Elevated Terrain, as illustrated in Figure 4.2 is used where terrain elevations exceed stack base but are below stack height.



**Figure 4.2 –Elevated and flat terrain conditions.**

### 4.3.3 Criteria for Use of Terrain Data

Evaluation of the terrain within a given study area is the responsibility of the modeler. Complex terrain may need to be considered even in areas that appear to be relatively flat. It should be remembered that complex terrain is any terrain within the study area that is above the source release height.



The appropriate terrain environment can be determined through the use of digital elevation data or other geographic data sources. It should be noted that the refined models, ISCST3/ISC-PRIME and AERMOD, have similar run times regardless of whether or not terrain data is used. However AERMAP, the terrain pre-processor for AERMOD, does require additional time. If analysis of the terrain environment is performed using digital terrain data, minimal resources are required to execute a model run using that digital terrain dataset.

### **4.3.4 Obtaining Terrain Data**

Terrain data that are input into the AERMOD and ISCST3/ISC-PRIME models should be provided in electronic form. Digital elevation terrain data is available from a variety of vendors in several different formats.

Digital elevation model (DEM) data are available for free from Lakes Environmental's Web GIS web page <http://www.webgis.com>.

### **4.3.5 Preparing Terrain Data for Model Use**

It is strongly suggested that the 7.5-minute data be used in dispersion modeling rather than the coarse resolution 1 degree data. Keep in mind that the USGS DEMs can be in one of two horizontal datums. Older DEMs were commonly in NAD27 (North American Datum of 1927) while many of the latest versions are in NAD83 (North American Datum of 1983).

#### **4.3.5.1 ISC / HARP**

The ISCST3 model accepts elevation data for receptors and sources. This data should be obtained from the USGS topographic maps or Digital Elevation Model (DEM) files. USGS DEMs are available for California from ARB at (<http://www.arb.ca.gov/toxics/harp/maps.htm>) in 7.5-minute format for use in the ARB HARP program and from Lakes Environmental at <http://www.webgis.com> in 7.5 minute and 1 degree formats.

#### **4.3.5.2 AERMOD**

AERMAP is the digital terrain pre-processor for the AERMOD model. It analyzes and prepares digital terrain data for use within an air dispersion modeling project. AERMAP requires that the digital terrain data files be in native (non SDTS) USGS 1-degree or 7.5-minute DEM format.

## **4.4 Defining Urban and Rural Conditions**

The classification of a site as urban or rural can be based on the Auer method specified in the EPA document *Guideline on Air Quality Models (40 CFR Part 51, Appendix W)*<sup>37</sup>. From the Auer's method, areas typically defined as Rural include:

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<sup>37</sup> U.S. Environmental Protection Agency, 2001. Appendix W to Part 51 Guideline on Air Quality Models, 40 CFR Part 51. U. S. Environmental Protection Agency, Research Triangle Park, NC.

- Residences with grass lawns and trees
- Large estates
- Metropolitan parks and golf courses
- Agricultural areas
- Undeveloped land
- Water surfaces

Auer suggests that an area can be classified as Urban if it has less than 35% vegetation coverage or the area falls into one of the following use types:

**Table 4.1 - Urban Land use**

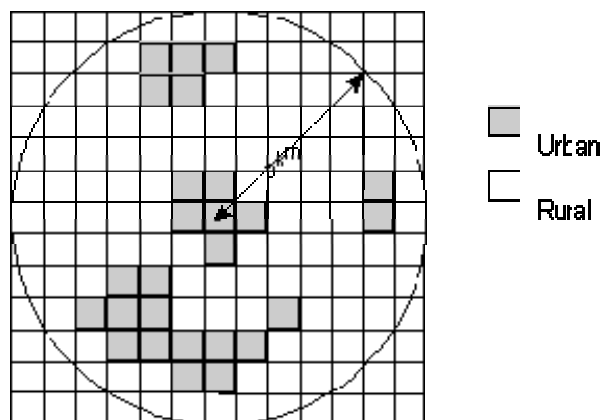
Type	Use and Structures	Vegetation
I1	Heavy industrial	Less than 5%
I2	Light/moderate industrial	Less than 5%
C1	Commercial	Less than 15%
R2	Dense single / multi-family	Less than 30%
R3	Multi-family, two-story	Less than 35%

Follow the Auer's method, explained below, for the selection of either urban or rural dispersion coefficients:

**Step 1:** Draw a circle with a radius of 3 km from the center of the stack or centroid of the polygon formed by the facility stacks.

**Step 2:** If land use types I1, I2, C1, R2, and R3 account for 50% or more of the area within the circle, then the area is classified as Urban, otherwise the area is classified as Rural.

To verify if the area within the 3 km radius is predominantly rural or urban, overlay a grid on top of the circle and identify each square as primarily urban or rural. If more than 50% of the total number of squares is urban than the area is classified as urban; otherwise the area is rural.<sup>35</sup>



An alternative approach to Urban/Rural classification is the Population Density Procedure: Compute the average population density,  $p$ , per square kilometer.

- If  $p > 750$  people/km<sup>2</sup>, select the Urban option,
- If  $p \leq 750$  people/km<sup>2</sup>, select the Rural option.

Of the two methods above, the land use procedure is considered a more definitive criterion. The population density procedure should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied. In this case, the classification should already be Urban and urban dispersion parameters should be used.

Prior to using either of the above methods, contact the district to determine whether the area in question has already been designated as urban or rural.

## **Chapter 5. Meteorological Data**

### **5.0 Comparison of Screening and Refined Model Requirements**

Meteorological data is essential for air dispersion model modeling as it describes the primary environment through which the pollutants being studied migrate. Similar to other data requirements, screening model requirements are less demanding than refined models.

SCREEN3 provides 3 methods of defining meteorological conditions:

- **Full Meteorology:** SCREEN will examine all six stability classes (five for urban sources) and their associated wind speeds. SCREEN examines a range of stability classes and wind speeds to identify the "worst case" meteorological conditions, i.e., the combination of wind speed and stability that results in the maximum ground level concentrations.
- **Single Stability Class:** The modeler can select the stability class to be used (A through F). SCREEN will then examine a range of wind speeds for that stability class only.
- **Single Stability Class and Wind Speed:** The modeler can select the stability class and input the 10-meter wind speed to be used. SCREEN will examine only that particular stability class and wind speed.

Contact the district for guidance if full meteorology is not being used in SCREEN.

See Appendix A for information on preparing meteorological data for refined modeling (AERMOD and ISC).

## **Chapter 6. Receptor Locations**

### **6.0 Receptors**

A receptor is defined as a point where an actual person (residential or worker) may be located for a given period of time. The period of time is based on the type of assessment that is being performed. When an acute (1-hour or longer, as applicable) risk assessment is to be prepared, all locations where a person could be located for a one hour period needs to be identified. When a cancer or chronic risk assessment is to be prepared, all locations where a person could be located for extended periods of time, such as a residence or workplace, need to be identified.

#### **6.0.1 Residential Receptors**

Homes, apartments, motels, trailer parks, residential camp grounds, and other places where people reside for long periods are defined as residential receptors. When a cancer risk is prepared, the exposure period should be 70 years. For acute risk assessments, the exposure period should be 1 hour for those substances with acute toxicity values based on one hour exposure periods.

#### **6.0.2 Worker Receptors**

Worksites, schools, and other locations where people are exposed for long periods of time are defined as worker receptors. When a cancer risk is prepared, the exposure period should be 40 years. For acute risk assessments, the exposure period should be 1 hour for those substances with acute toxicity values based on one hour exposure periods.

#### **6.0.3 Offsite Receptors**

Offsite receptors are included in risk assessments when they are not employed by the project.

#### **6.0.4 Onsite Receptors**

Onsite receptors are included in risk assessments if they are persons not employed by the project.

#### **6.0.5 Sensitive Receptors**

Sensitive receptors are defined as the following:

- Schools
- Daycare facilities other than home based
- Hospitals
- Care facilities (adult/elderly)

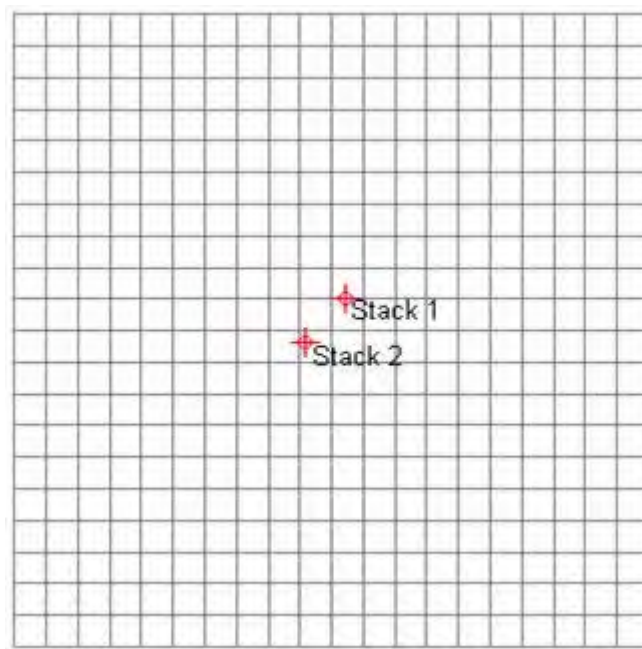
At the present time, the risk assessment calculations do not calculate different risk values for sensitive receptors compared to other receptors. However, sensitive receptors must be identified. Contact the district to determine the area in which sensitive receptors must be identified. Some

commonly used criteria are out to a distance of 2 kilometers from a project emission source or within the 1 in a million risk isopleth.

## 6.1 Receptor Grids

### 6.1.1 Cartesian Receptor Grids

Cartesian receptor grids are receptor networks that are defined by an origin with receptor points evenly (uniform) or unevenly (non-uniform) spaced around the origin. Figure 6.1 illustrates a sample uniform Cartesian receptor grid.



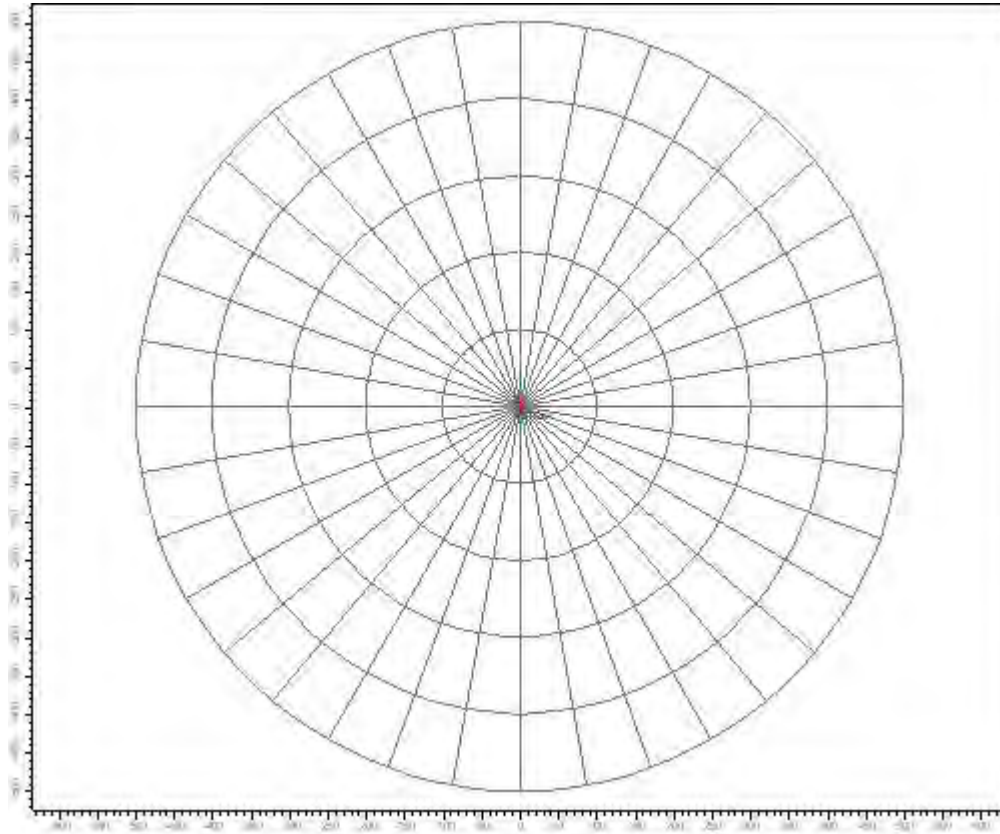
**Figure 6.1 – Example of a Cartesian grid.**

Tall stacks could require grids extending 1 to 3 km, while the grid for shorter stacks (10 to 20 m above ground) might only need to be extended a km or less from the property line.

### 6.1.2 Polar Receptor Grids

Polar receptor grids are receptor networks that are characterized by an origin with receptor points defined by the intersection of concentric rings, which have defined distances in meters from the origin, with direction radials that are separated by specified degree spacing. Figure 6.2 illustrates a sample uniform polar receptor grid.

Polar grids are a reasonable choice for facilities with only one source or one dominant source. However, for facilities with a number of significant emissions sources, receptor spacing can become too coarse when using polar grids. As a result, polar grids should generally be used in conjunction with another receptor grid, such as a multi-tier grid, to ensure adequate spacing.

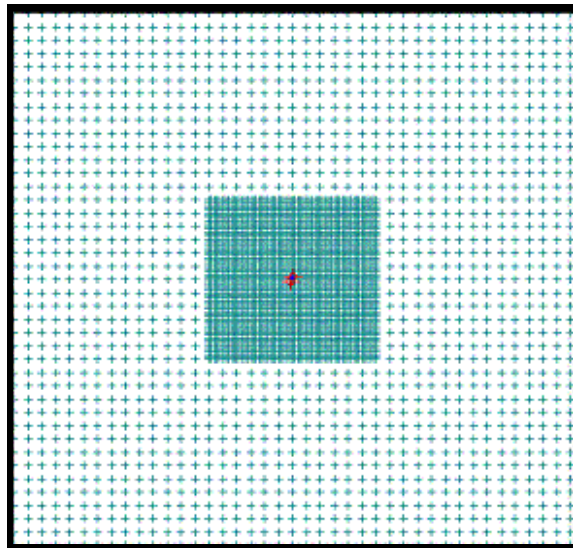


**Figure 6.2 – Example of a polar grid.**

### **6.1.3 Multi-Tier Grids**

Each receptor point requires computational time. Consequently, it is not optimal to specify a dense network of receptors over a large modeling area; the computational time would negatively impact productivity and available time for proper analysis of results. An approach that combines aspects of coarse grids and refined grids in one modeling run is the multi-tier grid.

The multi-tier grid approach strives to achieve proper definition of points of maximum impact while maintaining reasonable computation times without sacrificing sufficient resolution. Figure 6.3 provides an example of a multi-tier grid.



**Figure 6.3 - Sample Multi-Tier Grid with 2 tiers of spacing.**

### **6.1.4 Fence line Receptors**

Unless on-site receptors are present, it is not necessary to model the locations within a property boundary. If on-site receptors may be present, contact the District concerning receptor placement. If a fence line receptor point does not represent an existing or reasonably anticipated person, it is not necessary to consider these results to determine the Maximum Exposed Individual (MEI), but fence line exposure should be considered to determine the Point of Maximum Impact (PMI).

A receptor network based on the shape of the property boundary that has receptors parallel to the boundaries is often a good choice for receptor geometry. The receptor spacing can then progress from fine to coarse spacing as distance increases from the facility, similar to the multi-tier grid.

### **6.1.5 Discrete & Sensitive Receptors**

Receptor grids do not always cover precise locations that may be of interest in modeling projects. Specific locations of concern can be modeled by placing single receptors, or additional refined receptor grids, at desired locations. This enables the modeler to generate data on specific points for which data is especially critical. Examples of specific locations can include:

- Apartments,
- Residential zones,
- Schools,
- Apartment buildings,
- Day care centers,
- Air intakes on nearby buildings,
- Hospitals,
- Parks,
- Care Facilities, or

- Elevated receptors, such as balconies or air intakes on multilevel buildings, as concentrations of toxic substances can be higher there than at ground level.

Depending on the project resolution and location type, these can be characterized by discrete receptors, a series of discrete receptors, or an additional receptor grid.

## **6.2 Variable Receptor Spacing to include the Point of Maximum Impact (PMI)**

The receptor grid must be designed to include the Point of Maximum Impact (PMI). For facilities with more than one emission source, the receptor network should include Cartesian or multi-tier grids to ensure that maximum concentrations are obtained. An indication as to the PMI can be determined by using SCREEN3 or AERSCREEN applied to the most significant sources at a facility.

The model could be first run with a coarser grid, and then run with finer grids in the areas showing the highest impacts. If this method is used, finer grids, as described above, should be used for all areas with high concentrations, not just the single highest area.

The densities of the receptors can progress from fine resolution near the source, centroid of the sources, or most significant source (not from the property line for polar grid) to coarser resolution farther away. Section 6.1.3 shows an example of multiple grid spacing to ensure that the maximum ground level offsite property concentrations are captured.

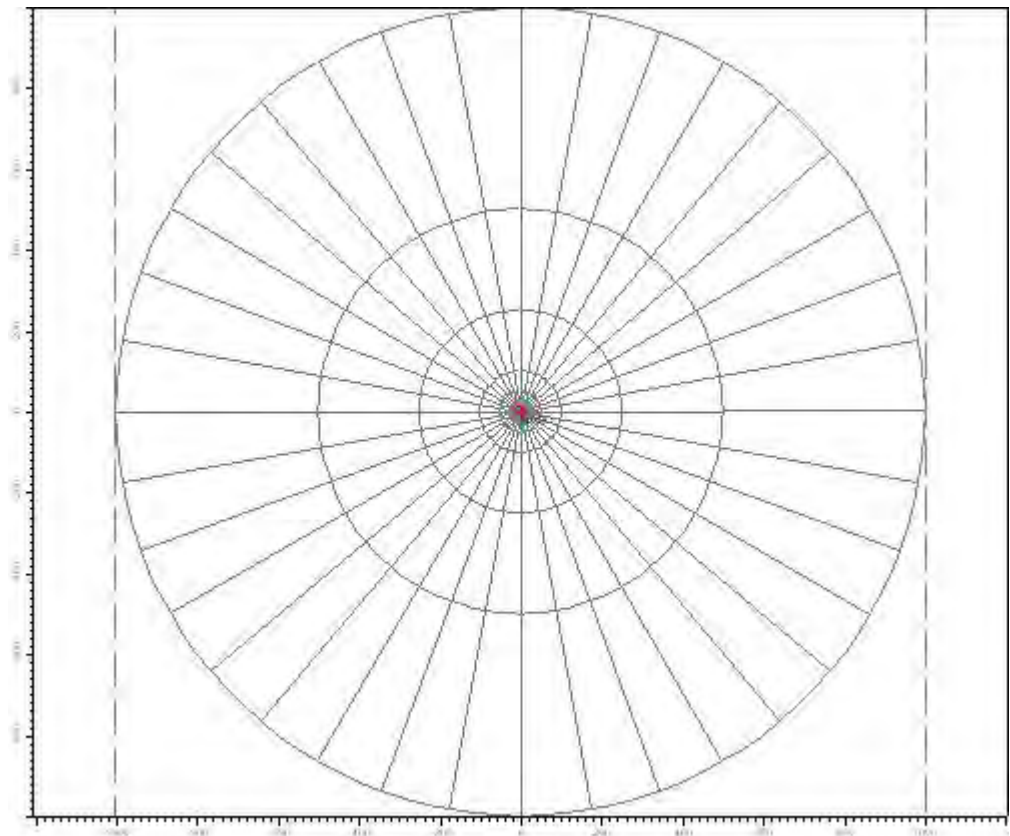
Receptors should also be placed along the property boundaries. The spacing of these receptors depends on the distance from the emission sources to the facility boundaries. For cases with emissions from short stacks or vents and a close property line, a receptor spacing of 25 m might be required. For taller stacks and greater distances to the property boundary, a receptor spacing greater than 25 m might be appropriate.

It is the responsibility of the modeler to demonstrate that the PMI has been identified and that the modeling includes all areas where Hazard Indices are above one, and the cancer risk is above ten per million, or other district standards.

### **6.2.1 Example Polar Grid Spacing**

- 36 Directional Radials
- Radial Distances:
  - 25 m
  - 50 m
  - 100 m
  - 250 m
  - 500 m





**Figure 6.4 – Sample Polar Grid receptor grid layout.**

## **Chapter 7. Other Modeling Considerations**

### **7.0 Alternative Model Use**

Due to some limitations inherent in AERMOD (and most other plume models), there are some situations where the use of an alternative model may be appropriate. Acceptable Alternative Models and their use are further described on EPA's [Support Center for Regulatory Atmospheric Modeling \(SCRAM\)](#) web page.

AERMOD is a steady-state plume model. For the purpose of calculating concentrations, the plume is assumed to travel in a straight line without significant changes in stability as the plume travels from the source to a receptor. At distances on the order of tens of kilometers downwind, changes in stability and wind are likely to cause the accuracy to deteriorate. For this reason, AERMOD should not be used for modeling at receptors beyond 50 kilometers. AERMOD may also be inappropriate for some near-field modeling in cases where the wind field is very complex due to terrain or a nearby shoreline.

AERMOD does not treat the effects of shoreline fumigation. Shoreline fumigation may occur along the shore of the ocean or large lake. When the land is warmer than the water, a sea breeze will form as the warmer lighter air inland rises. As the stable air from over the water moves inland, it is heated from below, resulting in a turbulent boundary layer of air that rises with downwind distance from the shoreline. The plume from a stack source located at the shoreline may intersect

the turbulent layer and be rapidly mixed to the ground, a process called “fumigation,” resulting in high concentrations. In these and other situations, the use of alternative models may be desired.

The use of any alternative model should first be reviewed by the district for suitability to the study application. If an alternative model is used the reasons and argument for its use over a preferred model must be discussed. An understanding of the alternative model, its data requirements, and the quality of data applied with the model must be demonstrated.

## **7.1 Use of Modelled Results in Combination with Monitoring Data**

Monitoring and modeling should be considered complementary tools to assess potential impacts on the local community.

Monitoring data could be used to provide verification of model results if sufficient monitoring data is available at locations impacted by facility emissions. Decisions on the adequacy of the monitoring data would be made on a case-by-case basis. Comparisons between measured and modeled results would depend on the amount of monitored data available. Advance consultation with the district is advisable if a comparison of model results with monitoring data is undertaken.

If model results do not agree with measured data, the facility source characteristics and emission data should be reviewed.

For cases where reliable information is available on the emission rates and source characteristics for a facility, modeled results can identify maximum impact areas and concentration patterns that could assist in siting monitors. Model runs using a number of years of meteorological data would show the variations in the locations and the magnitude of maximum concentrations and can also provide information on the frequency of high concentrations.

The U.S. EPA Guideline on Air Quality Models states that modeling is the preferred method for determining concentrations and that monitoring alone would normally not be accepted for determining emission limitations.

When monitoring data are used to verify modeling results for averaging times from 1 to 24 hours, more robust comparisons would be achieved using a percentile of the data rather than only the maximum concentrations. Percentile comparisons reduce the impacts of outliers in either the monitoring or the model results. For some contaminants, the impact of background sources on measured concentrations might need to be taken into consideration.

## **7.2 Information for Inclusion in a Modeling Assessment**

A suggested checklist of parameters designed to provide an overview of all information that should be submitted for a refined air dispersion modeling assessment is outlined in Appendix B.

The checklist should not be considered exhaustive for all modeling studies; it provides the essential requirements for a general assessment. All sites can have site-specific scenarios that may call for additional information and result in a need for different materials and data to be submitted.

It is the responsibility of the submitter to ensure proper completion and analysis of any air dispersion modeling assessment delivered for review.

## **7.3 Level of Detail of Health Risk Assessments**

Generally, a health risk assessment for CEQA purposes must include all sources of emissions that will emanate from a project. This includes existing and proposed facility-wide emissions. This includes all sources of potential emissions whether or not the project is subject to district permitting requirements. Additionally, all substances that the Office of Environmental Health Hazard Assessment has identified as having toxicity values must be included in the health risk assessment; some districts may allow a less detailed risk assessment.

It is not permissible to omit permitted sources in a CEQA risk assessment, even if these sources will be evaluated during the permit process. The permitting process does not evaluate the cumulative risk associated with the entire facility, only the individual permit unit. A challenge to the completeness of the risk assessments can be made if these sources are not included in the analysis.

It is also not permissible to omit criteria pollutants in the facility risk assessment, assuming that these emissions will be evaluated separately. Criteria pollutants have OEHHA approved RELs that must be included in the chronic and acute hazard indices. Again, a challenge to the completeness of the risk assessments can be made if these substances are omitted.

## **Chapter 8. Exposure Assessment Procedures**

### **8.0 Cancer Risk Assessment Procedure for Inhalation Only Pathway Pollutants**

The following procedure may be used to assess the health risks from facilities for which diesel particulate matter is emitted or other substances identified as only entering the body through the inhalation pathway. Risk Assessments involving substances that enter the body through other pathways must be analyzed for each pathway. A risk assessment involving multipathway substances can to be prepared using the HARP program available through the California Air Resources Board.

Cancer Risk Procedure for Inhalation only Substances:

- Model emissions to determine both the:
  - annual average ground-level concentrations, and the
  - one hour maximum concentration (or other period depending on the acutely toxic substance)
- Create a plot file for these ground-level concentrations.
- Open the plot file using Microsoft EXCEL or another spreadsheet program.
- Copy the data from the plot(s) into Excel.
- To determine the cancer risk, apply the following formula to each ground-level concentrations:

$$\text{Cancer Risk} = S_i * C_i * \text{DBR} * A * \text{EF} * \text{ED} * 10^{-6} / \text{AT}$$

Where:

$S_i$  = Slope Factor for substance i

$C_i$  = Concentration in the air of substance i

DBR = Daily Breathing Rate:

Residential Receptors = 302 L/kg-day (default 80<sup>th</sup> %ile)  
= 393 L/kg-day (95<sup>th</sup> %ile)

Worker Receptors = 149 L/kg-day

A = Inhalation Absorption Rate = 1

EF = Exposure Frequency:

Residential Receptors = 350 days

Worker Receptors = 245 days

ED = Exposure Duration:

See Section 1.3

AT = Averaging Time = 25,550 days

The result will be cancer risk for each source and receptor combination modeled.

For worker exposures, in addition to adjusting the breathing rate, exposure frequency, and exposure duration for workers versus residents, the emission rate must be adjusted to ensure that the worker risk is based upon the pollutant concentrations to which the worker is exposed. For additional information, see Section 8.2.2b of OEHHA's Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, August 2003.

## 8.1 Cancer Risk Assessment Procedure for Multi-Pathway Pollutants

The procedure for preparing a multi-pathway risk assessment can be complex. The HARP User Guide and the OEHHA Air Toxics Hot Spots Program Risk Assessment Guidelines contains a detailed discussion of how to prepare multi-pathway risk assessments. These documents and others can be found on the CARB website at <http://www.arb.ca.gov/toxics/harp/docs.htm>.

## 8.2 Chronic Noncancer Health Impacts

The procedure for determining the impact of chronically toxic substances is described in detail in the OEHHA state guidelines<sup>38</sup>. Noncancer chronic inhalation impacts are calculated by dividing the annual average concentration by the REL (Reference Exposure Level) for that substance. The REL is defined as the concentration at which no adverse noncancer health effects are anticipated. For a single substance, this result of this calculation is called the Hazard Quotient. The following equation is used to calculate the Hazard Quotient:

$$\text{Hazard Quotient} = C_i / \text{REL}_i$$

Where:

$C_i$  = Concentration in the air of substance  $i$

$\text{REL}_i$  = Chronic noncancer Reference Exposure Level for substance  $i$

For multiple substances, the Hazard Index (HI) is calculated. The HI is calculated by summing the HQs from all substances that affect the same organ system. HQs for different organ systems are not added, for example, do not sum respiratory irritation HQs with cardiovascular effects. The following equation is used to calculate the Hazard Index for the eye irritation endpoint:

$$\text{Hazard Index (HI}_{\text{eye}}) = \text{HQ}_{\text{substance 1(eye)}} + \text{HQ}_{\text{substance 2(eye)}}$$

No exposure duration adjustment (e.g., 9/70) should be made for noncancer assessments.

For a chronic noncancer assessment involving multipathway pollutants, the California Air Resources Board HARP model can be used.

## 8.3 Acute Noncancer Health Impacts

The procedure for determining the impact of acutely toxic substances is also described in detail in the OEHHA state guidelines<sup>39</sup>. The calculation of acute noncancer impacts is similar to the procedure for chronic noncancer impacts. In most cases, for a single substance, the acute Hazard Quotient is the highest one hour air concentration divided by the acute REL for that substance. There are a few substances that have acute RELs for exposure periods other than 1 hour. In those cases, the maximum air concentration for the appropriate exposure period (e.g., 8 hours) is divided by the acute REL.

As with the chronic noncancer calculation, for multiple substances that impact the same organ system, the individual substance HQs are summed to determine the HI.

No exposure period adjustments are necessary for acute health impact calculations.

Acute exposures are calculated for the inhalation pathway only.

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<sup>38</sup> OEHHA Air Toxics Hot Spots Program Guidance Manual for the Preparation of Risk, June 2002

# **Appendix A**

## **Meteorological Data**

## **1.0 Preparing Meteorological Data for Refined Modeling**

AERMOD and ISC models require actual hourly meteorological conditions as inputs. The refined models require pre-processed meteorological data that contains information on surface characteristics and upper air definition. This data is typically provided in a raw or partially processed format that requires processing through a meteorological pre-processor. The ISC models make use of a pre-processor called PCRAMMET, while AERMOD uses a pre-processor known as AERMET described further in the following sections.

Airport surface data is available from the National Climatic Data Center (NCDC) and other sources. Mixing height data or upper air data were available from NCDC. If mixing heights have not been calculated for the year of interest, mixing height software is available from EPA for use in calculating mixing heights from upper air data. AERMET is used to process upper air and surface data for use in AERMOD. Unlike PCRAMMET, AERMET produces 2 files: a surface file (\*.sfc) and a profile file (\*.pfl).

### **1.1 Surface Data**

#### **1.1.1 Screening Meteorological Data**

Screening surface data may be used in ISC when no applicable surface data is available for the area to be modeled. Most user interface on the market today can generate screening meteorological data for ISC. Please contact the district before using screening meteorological data to ensure that no data is available for the area of concern.

#### **1.1.2 Hourly Meteorological Data**

Hourly surface data is supported in several formats including:

- **CD-144 – NCDC Surface Data:** This file is composed of one record per hour, with all weather elements reported in an 80-column card image. Table 1.0 lists the data contained in the CD-144 file format that is needed to pre-process your meteorological data.

**Table 1.0 – CD-144 Surface Data Record (80 Byte Record)**

Element	Columns
Surface Station Number	1-5
Year	6-7
Month	8-9
Day	10-11
Hour	12-13
Ceiling Height (Hundreds of Feet)	14-16
Wind Direction (Tens of Degrees)	39-40
Wind Speed (Knots)	41-42
Dry Bulb Temperature (° Fahrenheit)	47-49
Opaque Cloud Cover	79

- MET-144 – SCRAM Surface Data: The SCRAM surface data format is a reduced version of the CD-144 data with fewer weather variables (28-character record). Table 1.1 lists the data contained in the SCRAM file format.

**Table 1.1 - SCRAM Surface Data Record (28 Byte Record)**

Element	Columns
Surface Station Number	1-5
Year	6-7
Month	8-9
Day	10-11
Hour	12-13
Ceiling Height (Hundreds of Feet)	14-16
Wind Direction (Tens of Degrees)	17-18
Wind Speed (Knots)	19-21
Dry Bulb Temperature (° Fahrenheit)	22-24
Total Cloud Cover (Tens of Percent)	25-26
Opaque Cloud Cover (Tens of Percent)	27-28

- The SCRAM data does not contain the following weather variables, which are necessary for dry and wet particle deposition analysis:
  - Surface pressure: for dry and wet particle deposition;
  - Precipitation type: for wet particle deposition only; or
  - Precipitation amount: for wet particle deposition only.



- SAMSON Surface Data: The SAMSON data contains all of the required meteorological variables for concentration, dry and wet particle deposition, and wet vapor deposition.
- NCDC data can be purchase online from the following web site:  
<http://cdo.ncdc.noaa.gov/qclcd/QCLCD>

If the processing of raw data is necessary, the surface data must be in one of the above formats in order to successfully pre-process the data using PCRAMMET or AERMET.

## 2.0 Mixing Height and Upper Air Data

Upper air data, also known as mixing height data, are required for pre-processing meteorological data required to run the ISC models. It is recommended that only years with complete mixing height data be used. In some instances, mixing height data may need to be obtained from more than one station to complete multiple years of data.

Mixing height data are available from:

- SCRAM BBS –download free of charge, mixing height data for the U.S. for years 1984 through 1991.
- WebMET.com –download free of charge, mixing height and upper air data from across North America, including Ontario.
- Free Upper air data can be downloaded from following web site (FSL Format)  
<http://raob.fsl.noaa.gov/>
- Table 2.1 lists the format of the mixing height data file used by PCRAMMET.

**Table 2.1 - Upper Air Data File (SCRAM / NCDC TD-9689 Format)**

Element	Columns
Upper Air Station Number (WBAN)	1-5
Year	6-7
Month	8-9
Day	10-11
AM Mixing Value	14-17
PM Mixing Value (NCDC)	25-28
PM Mixing Value (SCRAM)	32-35

AERMOD requires the full upper air sounding, unlike ISCST3/ISC-PRIME, which only require the mixing heights. The upper air soundings must be in the NCDC TD-6201 file format or one of the FSL formats.

## 2.1 AERMET and the AERMOD Model

The AERMET program is a meteorological preprocessor that prepares hourly surface data and upper air data for use in the U.S. EPA air quality dispersion model AERMOD. AERMET was designed to allow for future enhancements to process other types of data and to compute boundary layer parameters with different algorithms.

AERMET processes meteorological data in three stages:

- The first stage (Stage1) extracts meteorological data from archive data files and processes the data through various quality assessment checks.
- The second stage (Stage2) merges all data available for 24-hour periods (surface data, upper air data, and on-site data) and stores these data together in a single file.
- The third stage (Stage3) reads the merged meteorological data and estimates the necessary boundary layer parameters for use by AERMOD.

Out of this process two files are written for AERMOD:

- A Surface File of hourly boundary layer parameters estimates;
- A Profile File of multiple-level observations of wind speed, wind direction, temperature, and standard deviation of the fluctuating wind components.

## 2.2 PCRAMMET

The PCRAMMET program is a meteorological preprocessor, which prepares NWS data for use in the various U.S. EPA air quality dispersion models such as ISCST3/ISC-PRIME.

PCRAMMET is also used to prepare meteorological data for use by the CAL3QHCR model.

The operations performed by PCRAMMET include:

- Calculating hourly values for atmospheric stability from meteorological surface observations;
- Interpolating the twice daily mixing heights to hourly values;
- Optionally, calculating the parameters for dry and wet deposition processes;
- Outputting data in the standard (PCRAMMET unformatted) or ASCII format required by regulatory air quality dispersion models.

The input data requirements for PCRAMMET depend on the dispersion model and the model options for which the data is being prepared. The minimum input data requirements for PCRAMMET are:

- The twice-daily mixing heights,
- The hourly surface observations of: wind speed, wind direction, dry bulb temperature, opaque cloud cover, and ceiling height.

For dry deposition estimates, station pressure measurements are required. For wet deposition estimates, precipitation type and precipitation amount measurements for those periods where precipitation was observed are required.

The surface and upper air stations should be selected to ensure they are meteorologically representative of the general area being modeled.

## **2.3 Regional Meteorological Data**

The district has/may prepare regional meteorological data sets for use in Tier 2 modeling in several formats. Please contact the District to determine what data is available:

- Regional pre-processed model ready data for AERMOD, with land characteristics for RURAL and URBAN conditions.
- Regional Merge files enabling customized surface characteristics to be specified and processed through AERMET Stage3.
- Hourly surface and upper air data files preprocessed for use in ISCST.

### **2.3.1 Pre-Processing Steps**

Regional data for AERMOD can be processed in 2 forms:

- Merged: Data that has been processed through Stage2 of AERMET (AERMET stages are described in Section 7.1.3) to produce a “Merge” file. This file can then be processed through AERMET Stage3 with custom surface condition data to produce a meteorological data set specific to the site for use with AERMOD (Tier 3).
- Regional: Data that has been processed through Stage3 of AERMET with predefined Land Use characteristics for “Urban” and “Rural” environments. This data is ready for use with AERMOD (Tier 2).

#### **2.3.1.1 Regional Meteorological Data Processing Background**

Regional meteorological datasets are generated in AERMET, Stage3 processing step, using different wind independent surface conditions. It is assumed that surface conditions can be a weighted average over a radius of 3 km from the meteorological station and split into 12 sectors, or processed with other parameters approved by the district. The surface conditions needed are the albedo (A), the Bowen ratio (Bo) and the surface roughness (Zo). These parameter values can be derived from data in Tables 6.1, 6.2, 6.3 and 4.3 of the AERMET User’s Guide<sup>1</sup>.

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<sup>1</sup> U.S. Environmental Protection Agency, 1998. Revised Draft - User’s Guide for the AERMOD Meteorological Preprocessor (AERMET). Office of Air Quality Planning and Standards, Research Triangle Park, NC.

## **2.4 Availability and Use of District Meteorological Data**

The district may provide meteorological data sets that can be used for air quality studies using ISCST or AERMOD. The data sets should not be modified. Use of custom meteorological data that is locally representative of site conditions can be created and applied for Tier 3 modeling analyses with district approval.

Meteorological data quality is of critical importance, particularly for reliable air dispersion modeling using refined models such as AERMOD. Meteorological data should be collected, processed and analyzed throughout the entire creation phase for completeness and quality control. Missing meteorological data and calm wind conditions can be handled by using EPA's missing data guidance document written by Russ Lee or guidance provided by the District.

The following factors determine the appropriateness of a meteorological data set, the:

- proximity of the meteorological site to the area being modeled,
- complexity of the terrain,
- exposure of the meteorological measurement site, and the
- time period of the data collection.

It should be emphasized that both the spatial and temporal aspects of the data set are the key requirement for determining the appropriateness of a meteorological data set. Not one, but all of these factors must be considered.

The meteorological data that is input to a model should be selected based on its appropriateness for the modeling project. More specifically, the meteorological data should be representative of the wind flow in the area being modeled, so that it can properly represent the transport and diffusion of the pollutants being modeled.

## **2.5 Expectations for Local Meteorological Data Use**

Local meteorological data must be quality reviewed and the origin of the data and any formatting applied to the raw data must be outlined. The regulatory agency should review the plans to use local meteorological data prior to submission of a modeling report.

The sources of all of the data used including cloud data and upper air data must be documented. The proponent also needs to describe why the site chosen is representative for the modeling application. This would include a description of any topographic impacts or impacts from obstructions (trees, buildings etc.) on the wind monitor. Information on the heights at which the wind is measured is also required. The time period of the measurements along with the data completeness and the percentage of calm winds should be reported.

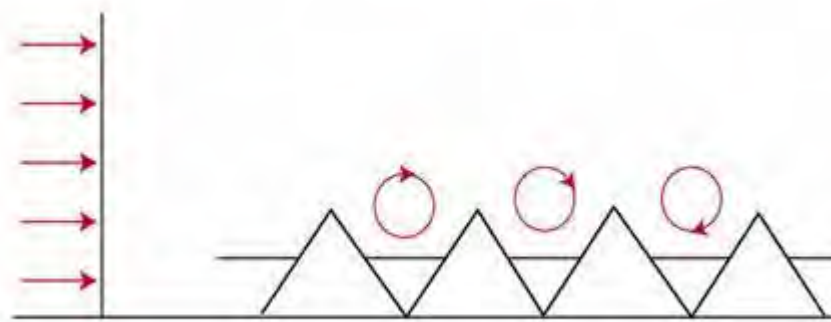
Wind roses showing the wind speed and directions should be provided with the modeling assessment. If wind direction dependent land use was used in deriving the final meteorological file, the selection of the land use should be described.

### 3.0 Land Use Characterization (AERMOD only)

Land use plays an important role in air dispersion modeling from meteorological data processing to defining modeling characteristics such as urban or rural conditions. Land use data can be obtained from digital and paper land-use maps.

These maps will provide an indication into the dominant land use types within an area of study, such as industrial, agricultural, forested and others. This information can then be used to determine dominant dispersion conditions and estimate values for parameters such as surface roughness, albedo, and Bowen ratio.

- **Surface Roughness Length [m]:** The surface roughness length, also referred to as surface roughness height, is a measure of the height of obstacles to the wind flow. Surface roughness affects the height above local ground level that a particle moves from the ambient airflow above the ground into a “captured” deposition region near the ground. This height is not equal to the physical dimensions of the obstacles, but is generally proportional to them. Table 1.4 lists typical values for a range of land-use types as a function of season.



**Figure 1.0 - For many modeling applications, surface roughness can be considered to be on the order of one tenth of the height of the roughness elements.**

EPA has developed a modeling tool called AERSURFACE<sup>2</sup> to aid in obtaining realistic and reproducible surface characteristic values of albedo, Bowen ratio, and surface roughness length, for input to AERMET. The tool uses publicly available national land cover datasets and look-up tables of surface characteristics that vary by land cover type and season. AERSURFACE calculates the following 3 parameters for input into AERMET:

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<sup>2</sup> AERSURFACE User's Guide, EPA-454/B-08-001 January 2008, [http://www.epa.gov/scram001/dispersion\\_related.htm#aersurface](http://www.epa.gov/scram001/dispersion_related.htm#aersurface)

- **Surface Roughness:**  
The determination of the surface roughness length should be based on an inverse distance weighted geometric mean for a default upwind distance of 1 kilometer relative to the measurement site. Surface roughness length may be varied by sector to account for variations in land cover near the measurement site; however, the sector widths should be no smaller than 30 degrees.
- **Bowen Ratio:**  
The determination of the Bowen ratio should be based on a simple unweighted geometric mean (i.e., no direction or distance dependency) for a representative domain, with a default domain defined by a 10km by 10km region centered on the measurement site.
- **Albedo:**  
The determination of the albedo should be based on a simple unweighted arithmetic mean (i.e., no direction or distance dependency) for the same representative domain as defined for Bowen ratio, with a default domain defined by a 10km by 10km region centered on the measurement site.

AERMOD allows wind direction dependent surface characteristics to be used in the processing of the meteorological data. The AERMET procedure also uses the area-weighted average of the land use within 3 km of the site. The selection of wind direction dependent sectors is described in sections 3.1 to 3.3.

Alternative methods of determining surface roughness height may be proposed. The district should review any proposed values prior to use.

**Table 3.1 –USGS NLCD92 Land Cover Categories used in AERSURFACE**

<b>Classification</b>	<b>Class Number</b>	<b>Land Cover Category</b>
<b>Water</b>	<b>11</b>	<b>Open Water</b>
	<b>12</b>	<b>Perennial Ice/Snow</b>
<b>Developed</b>	<b>21</b>	<b>Low Intensity Residential</b>
	<b>22</b>	<b>High Intensity Residential</b>
	<b>23</b>	<b>Commercial/Industrial/Transportation</b>
<b>Barren</b>	<b>31</b>	<b>Bare Rock/Sand/Clay</b>
	<b>32</b>	<b>Quarries/Strip Mines/Gravel Pits</b>
	<b>33</b>	<b>Transitional</b>
<b>Forested Upland</b>	<b>41</b>	<b>Deciduous Forest</b>
	<b>42</b>	<b>Evergreen Forest</b>
	<b>43</b>	<b>Mixed Forest</b>
<b>Shrubland</b>	<b>51</b>	<b>Shrubland</b>
<b>Non-natural Woody</b>	<b>61</b>	<b>Orchards/Vineyards/Other</b>
<b>Herbaceous Upland</b>	<b>71</b>	<b>Grasslands/Herbaceous</b>
<b>Herbaceous Planted/Cultivated</b>	<b>81</b>	<b>Pasture/Hay</b>
	<b>82</b>	<b>Row Crops</b>
	<b>83</b>	<b>Small Grains</b>
	<b>84</b>	<b>Fallow</b>
	<b>85</b>	<b>Urban/Recreational Grasses</b>
<b>Wetlands</b>	<b>91</b>	<b>Woody Wetlands</b>
	<b>92</b>	<b>Emergent Herbaceous Wetlands</b>

**Table 3.2 –AERSURFACE Seasonal Category Description**

<b>Seasonal Category</b>	<b>Season Description</b>	<b>Default Month Assignments</b>
<b>1</b>	<b>Midsummer with lush vegetation</b>	<b>Jun, Jul, Aug</b>
<b>2</b>	<b>Autumn with unharvested cropland</b>	<b>Sep, Oct, Nov</b>
<b>3</b>	<b>Late autumn after frost and harvest, or winter with no snow</b>	<b>Dec, Jan, Feb</b>
<b>4</b>	<b>Winter with continuous snow on ground</b>	<b>Dec, Jan, Feb</b>
<b>5</b>	<b>Transitional spring with partial green coverage or short annuals</b>	<b>Mar, Apr, May</b>

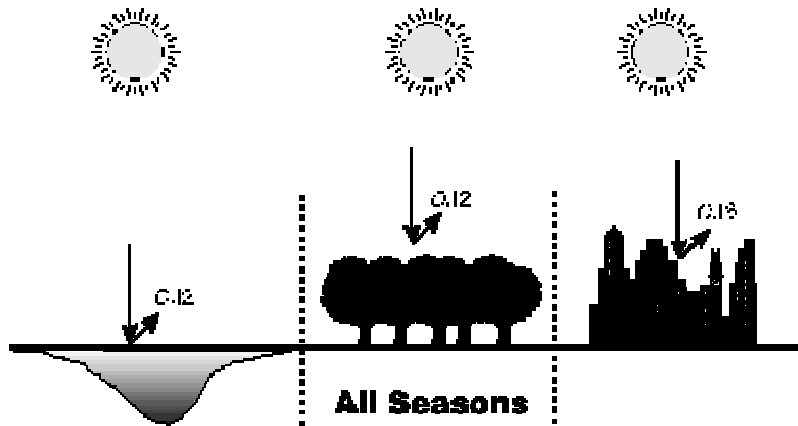
**Table 3.3 AERSURFACE Seasonal Values of Surface Roughness for the  
NLCD92 21-Land Cover Classification System**

Class Number	Class Name	Seasonal Surface Roughness (m)				
		1	2	3	4	5
11	Open Water	0.001	0.001	0.001	0.001	0.001
12	Perennial Ice/Snow	0.002	0.002	0.002	0.002	0.002
21	Low Intensity Residential	0.54	0.54	0.50	0.50	0.52
22	High Intensity Residential	1	1	1	1	1
23	Commercial/Industrial/Transportation (Site at airport)	0.1	0.1	0.1	0.1	0.1
	Commercial/Industrial/Transportation (Not at airport)	0.8	0.8	0.8	0.8	0.8
31	Bare Rock/Sand/Clay (Arid Region)	0.05	0.05	0.05	NA	0.05
	Bare Rock/Sand/Clay (Non-arid Region)	0.05	0.05	0.05	0.05	0.05
32	Quarries/Strip Mines/Gravel Pits	0.3	0.3	0.3	0.3	0.3
33	Transitional	0.2	0.2	0.2	0.2	0.2
41	Deciduous Forest	1.3	1.3	0.6	0.5	1
42	Evergreen Forest	1.3	1.3	1.3	1.3	1.3
43	Mixed Forest	1.3	1.3	0.95	0.9	1.15
51	Shrubland (Arid Region)	0.15	0.15	0.15	NA	0.15
	Shrubland (Non-arid Region)	0.3	0.3	0.3	0.15	0.3
61	Orchards/Vineyards/Other	0.3	0.3	0.1	0.5	0.2
71	Grasslands/Herbaceous	0.1	0.1	0.01	0.005	0.05
81	Pasture/Hay	0.15	0.15	0.02	0.01	0.03
82	Row Crops	0.2	0.2	0.02	0.01	0.03
83	Small Grains	0.15	0.15	0.02	0.01	0.03
84	Fallow	0.05	0.05	0.02	0.01	0.02
85	Urban/Recreational Grasses	0.02	0.015	0.01	0.005	0.015
91	Woody Wetlands	0.7	0.7	0.6	0.5	0.7
92	Emergent Herbaceous Wetlands	0.2	0.2	0.2	0.1	0.2

- Noon-Time Albedo:

Noon-time albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Table 3.4 lists typical albedo values as a function of several land use types and season. For practical purposes, the selection of a single value for noon-time albedo, for a land use types and season combination, to process a complete year of meteorological data is desirable. If other conditions are used, the district should review the proposed noon-time albedo values used to pre-process the meteorological data.





**Table 3.4 AERSURFACE Seasonal Values of Albedo for the NLCD92 21-Land Cover Classification System**

Class Number	Class Name	Seasonal Albedo Values				
		1	2	3	4	5
11	Open Water	0.1	0.1	0.1	0.1	0.1
12	Perennial Ice/Snow	0.6	0.6	0.7	0.7	0.6
21	Low Intensity Residential	0.16	0.16	0.18	0.45	0.16
22	High Intensity Residential	0.18	0.18	0.18	0.35	0.18
23	Commercial/Industrial/Transportation (Site at airport)	0.18	0.18	0.18	0.35	0.18
	Commercial/Industrial/Transportation (Not at airport)	0.18	0.18	0.18	0.35	0.18
31	Bare Rock/Sand/Clay (Arid Region)	0.2	0.2	0.2	NA	0.2
	Bare Rock/Sand/Clay (Non-arid Region)	0.2	0.2	0.2	0.6	0.2
32	Quarries/Strip Mines/Gravel Pits	0.2	0.2	0.2	0.6	0.2
33	Transitional	0.18	0.18	0.18	0.45	0.18
41	Deciduous Forest	0.16	0.16	0.17	0.5	0.16
42	Evergreen Forest	0.12	0.12	0.12	0.35	0.12
43	Mixed Forest	0.14	0.14	0.14	0.42	0.14
51	Shrubland (Arid Region)	0.25	0.25	0.25	NA	0.25
	Shrubland (Non-arid Region)	0.18	0.18	0.18	0.5	0.18
61	Orchards/Vineyards/Other	0.18	0.18	0.18	0.5	0.14
71	Grasslands/Herbaceous	0.18	0.18	0.2	0.6	0.18
81	Pasture/Hay	0.2	0.2	0.18	0.6	0.14
82	Row Crops	0.2	0.2	0.18	0.6	0.14
83	Small Grains	0.2	0.2	0.18	0.6	0.14
84	Fallow	0.18	0.18	0.18	0.6	0.18
85	Urban/Recreational Grasses	0.15	0.15	0.18	0.6	0.15
91	Woody Wetlands	0.14	0.14	0.14	0.3	0.14
92	Emergent Herbaceous Wetlands	0.14	0.14	0.14	0.3	0.14

- Bowen Ratio:

The Bowen ratio is a measure of the amount of moisture at the surface. The presence of moisture at the earth's surface alters the energy balance, which in turn alters the sensible heat flux and Monin-Obukhov length. Table 3.5 lists Bowen ratio values as a function of land-use types, seasons and moisture conditions. Bowen ratio values vary depending on the surface wetness. Average moisture conditions would be the usual choice for selecting the Bowen ratio. If other conditions are used the district should review the proposed Bowen ratio values used to pre-process the meteorological data.

**Table 3.5 AERSURFACE Seasonal Values of Bowen Ratio for the NLCD92 21-Land Cover Classification System - Average moisture conditions**

Class Number	Class Name	Seasonal Bowen Ratio Values-Average				
		1	2	3	4	5
11	Open Water	0.1	0.1	0.1	0.1	0.1
12	Perennial Ice/Snow	0.5	0.5	0.5	0.5	0.5
21	Low Intensity Residential	0.8	1	1	0.5	0.8
22	High Intensity Residential	1.5	1.5	1.5	0.5	1.5
23	Commercial/Industrial/Transportation (Site at airport)	1.5	1.5	1.5	0.5	1.5
	Commercial/Industrial/Transportation (Not at airport)	1.5	1.5	1.5	0.5	1.5
31	Bare Rock/Sand/Clay (Arid Region)	4	6	6	NA	3
	Bare Rock/Sand/Clay (Non-arid Region)	1.5	1.5	1.5	0.5	1.5
32	Quarries/Strip Mines/Gravel Pits	1.5	1.5	1.5	0.5	1.5
33	Transitional	1	1	1	0.5	1
41	Deciduous Forest	0.3	1	1	0.5	0.7
42	Evergreen Forest	0.3	0.8	0.8	0.5	0.7
43	Mixed Forest	0.3	0.9	0.9	0.5	0.7
51	Shrubland (Arid Region)	4	6	6	NA	3
	Shrubland (Non-arid Region)	1	1.5	1.5	0.5	1
61	Orchards/Vineyards/Other	0.5	0.7	0.7	0.5	0.3
71	Grasslands/Herbaceous	0.8	1	1	0.5	0.4
81	Pasture/Hay	0.5	0.7	0.7	0.5	0.3
82	Row Crops	0.5	0.7	0.7	0.5	0.3
83	Small Grains	0.5	0.7	0.7	0.5	0.3
84	Fallow	0.5	0.7	0.7	0.5	0.3
85	Urban/Recreational Grasses	0.5	0.7	0.7	0.5	0.3
91	Woody Wetlands	0.2	0.2	0.3	0.5	0.2
92	Emergent Herbaceous Wetlands	0.1	0.1	0.1	0.5	0.1

**Table 3.6 AERSURFACE Seasonal Values of Bowen Ratio for the NLCD92 21-Land Cover Classification System - Wet moisture conditions**

Class Number	Class Name	Seasonal Bowen Ratio Values- Wet				
		1	2	3	4	5
11	Open Water	0.1	0.1	0.1	0.1	0.1
12	Perennial Ice/Snow	0.5	0.5	0.5	0.5	0.5
21	Low Intensity Residential	0.6	0.6	0.6	0.5	0.6
22	High Intensity Residential	1	1	1	0.5	1
23	Commercial/Industrial/Transportation (Site at airport)	1	1	1	0.5	1
	Commercial/Industrial/Transportation (Not at airport)	1	1	1	0.5	1
31	Bare Rock/Sand/Clay (Arid Region)	1.5	2	2	NA	1
	Bare Rock/Sand/Clay (Non-arid Region)	1	1	1	0.5	1
32	Quarries/Strip Mines/Gravel Pits	1	1	1	0.5	1
33	Transitional	0.7	0.7	0.7	0.5	0.7
41	Deciduous Forest	0.2	0.4	0.4	0.5	0.3
42	Evergreen Forest	0.2	0.3	0.3	0.5	0.3
43	Mixed Forest	0.2	0.35	0.35	0.5	0.3
51	Shrubland (Arid Region)	1.5	2	2	NA	1
	Shrubland (Non-arid Region)	0.8	1	1	0.5	0.8
61	Orchards/Vineyards/Other	0.3	0.4	0.4	0.5	0.2
71	Grasslands/Herbaceous	0.4	0.5	0.5	0.5	0.3
81	Pasture/Hay	0.3	0.4	0.4	0.5	0.2
82	Row Crops	0.3	0.4	0.4	0.5	0.2
83	Small Grains	0.3	0.4	0.4	0.5	0.2
84	Fallow	0.3	0.4	0.4	0.5	0.2
85	Urban/Recreational Grasses	0.3	0.4	0.4	0.5	0.2
91	Woody Wetlands	0.1	0.1	0.1	0.5	0.1
92	Emergent Herbaceous Wetlands	0.1	0.1	0.1	0.5	0.1

**Table 3.7 AERSURFACE Seasonal Values of Bowen Ratio for the NLCD92 21-Land Cover Classification System - Dry moisture conditions**

Class Number	Class Name	Seasonal Bowen Ratio Values-Dry				
		1	2	3	4	5
11	Open Water	0.1	0.1	0.1	0.1	0.1
12	Perennial Ice/Snow	0.5	0.5	0.5	0.5	0.5
21	Low Intensity Residential	2	2.5	2.5	0.5	2
22	High Intensity Residential	3	3	3	0.5	3
23	Commercial/Industrial/Transportation (Site at airport)	3	3	3	0.5	3
	Commercial/Industrial/Transportation (Not at airport)	3	3	3	0.5	3
31	Bare Rock/Sand/Clay (Arid Region)	6	10	10	NA	5
	Bare Rock/Sand/Clay (Non-arid Region)	3	3	3	0.5	3
32	Quarries/Strip Mines/Gravel Pits	3	3	3	0.5	3
33	Transitional	2	2	2	0.5	2
41	Deciduous Forest	0.6	2	2	0.5	1.5
42	Evergreen Forest	0.6	1.5	1.5	0.5	1.5
43	Mixed Forest	0.6	1.75	1.75	0.5	1.5
51	Shrubland (Arid Region)	6	10	10	NA	5
	Shrubland (Non-arid Region)	2.5	3	3	0.5	2.5
61	Orchards/Vineyards/Other	1.5	2	2	0.5	1
71	Grasslands/Herbaceous	2	2	2	0.5	1
81	Pasture/Hay	1.5	2	2	0.5	1
82	Row Crops	1.5	2	2	0.5	1
83	Small Grains	1.5	2	2	0.5	1
84	Fallow	1.5	2	2	0.5	1
85	Urban/Recreational Grasses	1.5	2	2	0.5	1
91	Woody Wetlands	0.2	0.2	0.2	0.5	0.2
92	Emergent Herbaceous Wetlands	0.2	0.2	0.2	0.5	0.2

### 3.1 Wind Direction Dependent Land Use

AERMET also provides the ability to specify land characteristics for up to 12 different contiguous, non-overlapping wind direction sectors that define unique upwind surface characteristics. The following properties of wind sectors must be true:

- The sectors are defined clockwise as the direction from which the wind is blowing, with north at 360°.
- The sectors must cover the full circle so that the end value of one sector matches the beginning of the next sector.

- The beginning direction is considered part of the sector, while the ending direction is not.

Each wind sector can have a unique albedo, Bowen ratio, and surface roughness. Furthermore, these surface characteristics can be specified annually, seasonally, or monthly to better reflect site conditions.

## 3.2 Mixed Land Use Types

Study areas may contain several different regions with varying land use. This can be handled by AERMET through the use of wind sector specific characterization, as described in the previous section.

For models such as ISCST3/ISC-PRIME that do not take advantage of sector-specific characterization, the most representative conditions should be applied when land use characteristics are required.

The surface characteristics need to be assessed in a circle with a radius of one to three kilometers from the source. Contact the District to determine the appropriate parameters for meteorological data in accordance with EPA guidance. Data should be chosen for a meteorological data site with surface characteristics similar to those of the area around the source. To prepare the surface data, use the AERSURFACE module of AERMOD or perform a site survey using the standard land uses defined in the AERSURFACE documentation and the default surface roughness length for those land uses.

The surface characteristics are determined by assessing the land use across the monitoring site area and applying the appropriate values to the land characteristic parameters. A weighted average is then computed based on the area of each land use category.

**For example:** If the area under review is 15% cultivated land, 5% desert shrub land, and 80% Urban, the same weighted percentages would be used to derive a weighted average albedo, Bowen ratio, and surface roughness parameters.

## 3.3 Seasonal Land Use Characterization

Land use characteristics can be susceptible to seasonal variation. For example, winter conditions can bring increased albedo values due to snow accumulation.

AERMET allows for season-specific values for surface roughness, albedo, and Bowen ratio to be defined. Other models, such as ISCST3/ISC-PRIME, do not support multiple season surface characteristics to be defined. In such a case, the most representative conditions should be applied when land use characteristics are required.

### **3.4 Standard and Non-Default Surface Characteristics**

The generation of local meteorological data files can incorporate site-specific surface characteristics. It should be noted that any local meteorological files generated for air dispersion modeling should provide a clear reasoning for the values used to describe surface characteristics. The district should review any proposed surface characteristics prior to submission of a modeling report.

## **Appendix B**

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The following information must be submitted with a risk assessment. It provides the essential requirements for a general assessment. Site-specific scenarios may call for additional information and result in a need for different materials and data to be submitted. It is the responsibility of the submitter to ensure proper completion and analysis of any air dispersion modeling assessment delivered for review. *Consultation with your local air district is strongly recommended.*

## **1.0 General Information**

### **1.0.1 Submittal Date**

### **1.0.2 Facility/Project Name**

### **1.0.3 Facility/Project Location**

### **1.0.4 Risk Assessor Name**

## **1.1 Hazard Identification**

### **1.1.1 Table of all toxic air contaminants (TAC) emitted by the Facility/Project including:**

- CAS number,
- Chemical name(s) – include appropriate common names,
- Physical state as emitted.

### **1.1.2 Table of carcinogens,**

### **1.1.3 Table of acutely toxic TACs, and**

### **1.1.4 Table of chronically toxic non-carcinogenic TACs.**

### **1.1.5 Table showing the processes and the TACs emitted from each process.**

## **1.2 Exposure Assessment**

### **1.2.1 Air Dispersion Model Options**

#### **1.2.1.1 Model Used**

- AERMOD - version number,
- ISCST - version number,
- Other Model - Specify name, version number, and reason for use.

#### **1.2.1.2 Regulatory Options Used**

- Yes
- No - Provide justification for use of non-regulatory options. Note that use of non-regulatory options requires prior approval from the regulatory agency.

#### **1.2.1.3 Dispersion Coefficients Used, and How they were Determined**

- Urban
- Rural

(Urban or Rural conditions can be determined through the use of an Auer Land Use or Population Density analysis.)

#### **1.2.1.4 Coordinate System Used**

- UTM Coordinates
- Local Coordinates
- Other

(AERMOD requires UTM coordinates be used to define all model objects. Use of an alternative coordinate system requires advance consultation with the regulatory agency.)

### **1.2.2 Source Information**

#### **1.2.2.1 Source Summaries**

Create tables which show the following point, area, volume, line, or flare modeling parameters. Following the tables must be a description of the reasoning for each modeling parameter chosen.

#### Point Sources Summary

- Source name
- Source location coordinates
  - X (m)
  - Y (m)
- Table showing the names of each TAC modeled and max hourly and annual emission rate in grams per second.
- Stack heights in meters
- Stack Diameter in meters
- Stack Exit Temperature in degrees K
- Stack Exit Velocity in meters per second
- Stack direction
  - Vertical exhaust direction
  - Horizontal exhaust direction
- Rain Cap Present  
If the stack is either horizontal in orientation or has a rain cap, stack parameters must be adjusted as per guidance.
- Operating Schedule.  
Create tables showing how the normal emission rates vary by source.

#### Area Sources Summary

- Source name
- Source location coordinates (Southwest Vertex):
  - X (m)
  - Y (m)
- Table showing the names of each TAC modeled and emission rate in grams per second-meter<sup>2</sup>.
- Exhaust height in meters
- Easterly Dimension in meters
- Northerly Dimension in meters
- Initial Vertical Dimension in meters
- Angle from North in degrees.
- Operating Schedule.  
Create tables showing how the normal emission rates vary by source.

#### Volume Sources Summary

- Source name
- Source location coordinates (Center of Source):
  - X (m)
  - Y (m)
- Table showing the names of each TAC modeled and emission rate in grams per second.
- Source height in meters
- Initial Horizontal Dimension in meters
- Initial Vertical Dimension in meters

- Operating Schedule.  
Create tables showing how the normal emission rates vary by source.

Line Sources Summary (CAL3QHCR specific; for step by step guidance according to SMAQMD recommendations, see CAPCOA's CEQA Risk Assessment Guidelines)

- Source name (highway, freeway, or major roadway)
- Roadway compass orientation (in terms of x,y; arbitrary origin of 0,0)
- Location of nearest receptor to source and other receptors as required by local air district
- Calculation averaging time (such as 60 min)
- Surface roughness (cm, from 3 to 400)
- Settling velocity (cm/s)
- Deposition velocity (cm/s)
- Site setting, rural or urban
- Form of traffic volume (recommended: 1 for one hour's data)
- Pollutant (P for PM10)
- Hourly ambient background (0 or as recommended by air district)
- Roadway height indicator (AG for at grade; FL for elevated and filled; BR for bridge; DP for depressed)
- Roadway height (AG is 0)

Other input parameters are required for CAL3QHCR. See CAPCOA's CEQA Risk Assessment Guidelines or contact your local air district.

#### 1.2.2.2 Emissions Profile during Abnormal Operations Start-Up or Shutdown

Create table showing how abnormal emission rates vary by source. Abnormal emission rates include start-up or shutdown.

#### 1.2.2.3 Building Downwash

- Describe whether the stack(s) are located within 5L of a structure that is at least 40% of the stack height (L is the lesser of the height or the maximum projected building width for a structure).
- If it is, then prepare a building downwash analysis using the current version of the Building Profile Input Program – PRIME (BPIP-PRIME) and include results in air dispersion modeling assessment.

#### 1.2.2.4 Scaled Plot Plan

Provide a scaled plot plan, preferably in electronic format, displaying:

- Emission release locations,
- Buildings (On site and neighboring),
- Tanks (On site and neighboring),
- Property boundaries,
- Model receptor locations,
- Sensitive receptors locations,
- Fenceline receptors locations.

#### 1.2.2.5 Sensitive Receptors locations

Describe the location and nature of all nearby sensitive receptors (e.g. residences, schools, hospitals, etc...)

#### 1.2.2.6 Points of Maximum Impact

Demonstrate that the actual point of maximum impact, residential point of maximum impact, and the offsite worker point of maximum impact have been reached.

### 1.2.3 Terrain Conditions

#### 1.2.3.1 Elevated or complex terrain

Describe whether the modeled area contains elevated or complex terrain, and provide a discussion on the approach used to determine terrain characteristics of the assessment area.

#### 1.2.3.2 Digital Terrain Data

Describe whether the data for digital terrain is:

- CDED 1-degree,
- CDED 15-minute,
- USGS 7.5-minute Ontario dataset, or
- Other, and describe other.

#### 1.2.3.3 Elevation data import

Describe the technique used to determine elevations of receptors and related model entities such as sources.

### 1.2.4 Meteorological Data

#### 1.2.4.1 Regional Meteorological data

Specify what Regional Meteorological data set was used and note the period of the record.

#### 1.2.4.2 Was a Regional Meteorological Merge data file used?

Specify the Meteorological Data Set Merge file used and summarize land characteristics specified in its processing. This information should be reviewed by the District prior to submission of a modeling report.

#### 1.2.4.3 Meteorological data preparation

Specify the Meteorological Data files used and summarize all steps and values used in processing these standard meteorological data files. This information should be reviewed by the District prior to submission of a modeling report.

#### 1.2.4.4 Local Meteorological data

Specify the source, reliability, and representativeness of the local meteorological data as well as a discussion of data QA/QC and processing of data. State the time period of the measurements, wind direction dependent land use (if used), and any topographic or shoreline influences. This information should be reviewed by the District prior to submission of a modeling report.

#### 1.2.4.5 Wind Information

The following items should be provided and discussed where applicable:

- Speed and direction distributions (wind roses),
- Topographic and/or obstruction impacts,
- Data completeness,

- Percentage of calms

#### 1.2.4.6 Temperature, clouds, and upper air data

The following items should be provided and discussed where applicable:

- Data completeness,
- Mixing layer heights,
- Diurnal and seasonal variations.

#### 1.2.4.7 Turbulence

The following should be provided and discussed if site specific data is being used:

- Frequency distributions,
- Diurnal and seasonal variations.

### 1.2.5 Dispersion Model Results

#### 1.2.5.1 Modeling files

The following electronic model input and output files are to be provided:

- BPIP-PRIME - Input and Output files.
- ISCST3/ISC-PRIME or AERMOD - Input and Output files.
- ISCST3/ISC-PRIME or AERMOD - Plot files
- SCREEN3 - Input and Output files if applicable

#### 1.2.5.2 Meteorological Data

The electronic meteorological data files must be provided.

#### 1.2.5.3 Terrain Data

Digital elevation terrain data files must be provided if included in the analysis.

#### 1.2.5.3 Plots and Maps

Include the following:

- Drawing/site plan with modeling coordinate system noted (digital format preferred).
- Plots displaying concentration/deposition results across study area.

#### 1.2.5.5 Emission Summary

An emission summary table must be provided.

#### 1.2.5.6 Discussion

The results overview should include a discussion of the following items, where applicable:

- The use of alternative models,
- The use of any non-default model options,
- Topographic effects on the predictions,
- All predicted concentrations based on the REL based exposure period.

## 1.3 Toxicity Data

### 1.3.1 Toxicity Values for Each TAC Emitted

A table must be provided that shows the following data for each TAC emitted:

- The cancer potency factors,
- The acute and chronic RELs,
- The averaging times for the acute RELs,

- The pathways the TAC enters the body, and
- The date these factors were updated.

### **1.3.2 Target Organ Systems for Each Acute and Non-Carcinogenic Chronic Substance**

A table must be provided that shows the target organs and body systems each acute and non-carcinogenic chronic impact.

## **1.4 Risk Characterization**

### **1.4.1 Points of Maximum Impact**

The following points of maximum impact need to be identified:

- The Points of Maximum Impact (PMI),
- The Maximum Exposed Individual - Residential (MEIR), and
- The Maximum Exposed Individual – Worker (MEIW).

At these locations the following data must be provided:

- Locations (UTM coordinates, or Latitude/Longitude coordinates, or other coordinates),
- Cancer risk, acute and chronic hazard indices,
- Sources and pollutants that contribute to risks which exceed the district's cancer risk, or acute, or chronic hazard index significance levels.

### **1.4.2 Exposure Pathways**

Identify each pathways used to determine the cancer risk and chronic hazard indices. Provide all assumptions used for pathways (e.g., the percentage of home-grown vegetables consumed locally, etc...).

### **1.4.3 Graphical Presentations**

Maps must be provided which show the following:

- Locations of sensitive receptors,
- Location of PMI, MEIR, and MEIW for cancer, acute, and non-cancer chronic risks,
- Isopleth lines showing cancer risk, acute, and chronic hazard indices in magnitudes specified by the Air District (e.g., cancer risk starting at 10 per million and increasing by tens per million.)

### **1.4.4 Guidelines and Software**

Specify:

- Describe whether these CAPCOA Guidelines have been applied or other Guidelines were applied,
- The risk assessment software utilized (e.g., Hot Spots Analysis and Reporting Program or HARP),
- If risk assessment software other than HARP is used, then and provide a demonstration that the results will show the same results as HARP,
- Discuss any software used to import model results into HARP.

## **2.0 Modeling Files**

The following files from the air quality dispersion model and risk assessment software should be provided:

Air quality dispersion model (if HARP is not used)

- Input file (\*.inp, \*.ADI, \*.dat)
- Output file (\*.out, \*.ADO, \*.lst)
- Meteorological files

- Plotfiles

Building Downwash Analysis (BPIP) (if HARP is not used)

- Input file
- Output file

Risk assessment software (i.e., HARP):

- Transaction files for the facilities, buildings, and property boundaries (\*.tra)
- Transaction files for the source receptors (\*.rec)
- Facility database for included facilities building, and property boundaries (\*.mdb) as an alternative to the transaction files
- Health factor database (Health.mdb)
- ISC Workbook file with all ISC parameters (\*.isc)
- ISC input file generated by HARP when ISC is run (\*.inp)
- ISC output file generated by HARP when ISC is run (\*.out)
- List of error messages generated by ISC (\*.err)
- Plot file generated by ISC (\*.plt)
- Representative meteorological data used for the facility air dispersion modeling (\*.met)
- Any digital elevation model files (if applicable) (\*.dem)
- Average and maximum  $\chi/Q$  for each source-receptor combination; generated by ISC (\*.xoq)
- ISC binary output file (FOR REFINED ACUTE ANALYSIS ONLY); holds  $\chi/Q$  data for each hour (\*.bin)
- Source/receptor file; contains list of sources and receptors for the ISC run; generated by HARP when you set up ISC (\*.src)
- Emission Rate files (if changes were made to database) (\*.ems)
- Site-specific parameters used for all receptor risk modeling (\*.sit)
- (Screening) Adjustment factor files (IF SCREEN MET IS USED) (\*.adj)
- Point estimate risk reports generated by HARP; this file is updated automatically each time you perform one of the point estimate risk analysis functions ((e.g., acute, chronic, cancer, derived (adjusted). Etc.)) (\*.rsk)
- Database for Census (population) file (census.mdb)
- Map file used to overlay facility and receptors (\*.map)
- HARP Exception Report (ExceptionReport.txt)
- Risk result text files for key receptors (STANDARD REPORT SET) (\*.txt)
- STOCHASTIC Raw sample file (\*.csv)
- STOCHASTIC Sample file (\*.spl)
- STOCHASTIC Summary report (\*.txt)
- Equivalent files for software other than HARP