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A TIERED MODELING APPROACH FOR ASSESSING THE RISKS DUE TO SOURCES OF HAZARDOUS AIR POLLUTANTS

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1.0 INTRODUCTION

1.1 Background and Purpose

Title III of the Clean Air Act Amendments of 1990 (CAAA) sets forth a framework for regulating major sources of hazardous (or toxic) air pollutants which is based on the implementation of MACT, the maximum achievable control technology, for those sources. Under this framework, prescribed pollution control technologies are to be installed without the *a priori* estimation of the health or environmental risk associated with each individual source. The regulatory process is to proceed on a source category-by-source category basis, with a list of source categories to be published by the end of 1991, and a schedule for their regulation to be published a year later. After the implementation of MACT, it will be incumbent on the United States Environmental Protection Agency (EPA) to assess the residual health risks to the population near each source within a regulated source category. The results of this residual risk assessment will then be used to decide if further reduction in toxic emissions is necessary for each source category (refer to §112(f) of the CAAA). These decisions will hinge primarily on a determination of the lifetime cancer risk for the "maximum exposed individual" for each source as well as the determination of whether the exposed population near each source is protected from noncancer health effects with an "ample margin of safety". The determination of lifetime cancer risk involves the estimation of long-term ambient concentrations of toxic pollutants whereas the determination of noncancer health effects can involve the estimation of long-term and short-term ambient concentrations.

Since the measurement of long-term and short-term ambient concentrations for each toxic air pollutant (189 pollutants as listed in §112(b)) in the vicinity of each source is a prohibitively expensive task, it is envisioned that the process of residual risk determination would involve performing analytical simulations of toxic air pollutant dispersion for all sources (or a subset of sources) within each source category. Such simulations will subsequently be coupled with health effects information and compared to available population data to quantify human exposure, cancer risk, noncancer health risks, and ecological risks.

In addition to mandating the residual risk assessment process, the CAAA provide for the exemption of source categories and pollutants from the MACT-based regulatory process if it can be demonstrated that the risks associated with that source category or pollutant are below specified levels of concern. EPA-approved risk assessments would need to be performed to justify such an exemption, and the CAAA provide for petition processes to approve or deny claims that a source category or a specific pollutant should not be subject to regulation.

The purpose of this document is to provide guidance on the use of EPA-approved procedures which may be used to assess risks due to the atmospheric dispersion of emissions of hazardous air pollutants. It is likely that the techniques described herein will be useful with respect to several decision-making processes associated with the implementation of CAAA Title III (e.g., petition to add or delete a pollutant from the list of hazardous air pollutants, petition

to delete a source category from the list of source categories, demonstration of source modification offsets, etc.). In addition, these procedures may serve as the basis for the residual risk determination process described above. The guidance addresses the estimation of long-term and short-term ambient concentrations resulting from the atmospheric dispersion of known emissions of hazardous air pollutants, and subsequently addresses the techniques currently used to quantify the cancer risks and noncancer risks associated with the predicted ambient concentrations. It describes a tiered approach which progresses from simple conservative screening estimates (provided in the form of lookup tables) to more complex modeling methodologies using computer models and site-specific data. In addition to providing guidance to assist in the CAAA Title III implementation process, it is being provided to the general public to assist State and local air pollution control agencies as well as sources of hazardous air pollutants in their own assessments of the impacts of these sources.

While the methods described herein comprise the most up-to-date means for assessing the impacts of sources of toxic air pollution, they are subject to future revision as new scientific information becomes available, possibly as a result of the risk assessment methodology study being conducted by the National Academy of Sciences (NAS) under mandate of section 112(o) of the CAAA (report due to Congress from NAS in May, 1993).

1.2 Risk Assessment in Title III

As mentioned above, several provisions of CAAA Title III describe the need to consider ambient concentration impacts and their associated health risks in establishing the regulatory process for sources of toxic air pollutants. Specifically, these are:

1. A pollutant may be deleted via a petition process from the list of hazardous or toxic pollutants subject to regulation if the petition demonstrates (among other things) that "ambient concentrations ... of the substance may not reasonably be anticipated to cause any adverse effects to the human health." (§112(b)(3)(C))

2. A pollutant may be added to the list if a petition demonstrates that "ambient concentrations ... of the substance are known to cause or may reasonably be anticipated to cause adverse effects to human health."(§112(b)(3)(B))

3. An entire source category may be deleted from the list of source categories subject to regulation if a petition demonstrates, for the case of carcinogenic pollutants, that "no source in the category ... emits (carcinogenic) air pollutants in quantities which may cause a lifetime risk of cancer greater than one in one million to the individual in the population who is most exposed to emissions of such pollutants from the source," (§112(c)(9)(B)(i)) and, for the case of noncarcinogenic yet toxic pollutants, that "emissions from no source in the category ... exceed a level which is adequate to protect public health with an ample margin of safety and no adverse environmental effect will result from emissions from any source." (§112(c)(9)(B)(ii))

4. Within eight years after a source category has been subject to a MACT regulation, EPA must determine whether additional regulation of that source category is necessary based on an assessment of the residual risks associated with the sources in that category. Based on such an assessment, additional regulation of the source category is deemed necessary if "promulgation of such standards is required in order to provide an ample margin of safety to protect the public health" with respect to noncancer health effects, or if the MACT standards "do not reduce lifetime excess cancer risks to the individual most exposed to emissions from a source in the category or subcategory to less than one in one million" with respect to carcinogens, or if a determination is made "that a more stringent standard is necessary to prevent ... an adverse environmental effect." (§112(f)(2)(A))

In the context of these provisions, decisions are to be made based on whether or not the predicted impact of a source exceeds some level of concern. For comparison to specified levels of concern, source impacts are quantified in four ways:

1. lifetime cancer risk;

2. chronic noncancer hazard index;

3. acute noncancer hazard index, and;

4. frequency of acute hazard index exceedances.

These impact measures are discussed in more detail in the next few paragraphs. It is worth noting at this point that insofar as knowledge is available regarding the effects of specific hazardous pollutants on the environment, it may be possible to use ecological hazard index values to quantify such impacts. Such calculations may proceed on a track which is parallel to the calculation of health hazard index values. However, until specific methodologies for ecological risk assessment are adopted, the techniques identified in this document will remain limited to the assessment of human health risks due to inhalation of hazardous air pollutants.

For carcinogenic pollutants, the level of concern is the risk of an individual contracting cancer by being exposed to ambient concentrations of that pollutant over the course of a lifetime, or lifetime cancer risk. For the purposes of §112(c), the criterion specified in the CAAA is 1 in 1,000,000 lifetime cancer risk for the most exposed individual, or the individual exposed to the highest predicted concentrations of a pollutant. (For other purposes, the lifetime cancer risk specifying the level of concern may be higher or lower.) Lifetime cancer risks are calculated by multiplying the predicted annual ambient concentrations (in $\mu g/m^3$) of a specific pollutant by the unit risk factor or unit risk estimate (URE)[1] for that pollutant, where the unit risk factor is equal to the upper bound lifetime cancer risk associated with inhaling a unit concentration (1 $\mu g/m^3$) of that pollutant. Since predicted annual pollutant concentrations around a source vary as a function of position, so do lifetime cancer risk estimates. Thus, decisions involving whether the impact of a source or group of sources is above some level of concern typically focus on the

highest predicted concentration (and hence the highest predicted lifetime cancer risk) outside the facility fenceline. The EPA has developed unit risk factors for a number of possible, probable, or known human carcinogens, and will be developing additional cancer unit risk factors as more information becomes available. For the purposes of this document, cancer risks resulting from exposure to mixtures of multiple carcinogenic pollutants will be assessed by summing the cancer risks due to each individual pollutant, regardless of the type of cancer which may be associated with any particular carcinogen.[2]

For pollutants causing noncancer health effects from chronic or acute exposure, the levels of concern are chronic and acute concentration thresholds, respectively, which would be derived from health effects data, taking into account scientific uncertainties. For purposes of estimating potential long-term impacts of hazardous air pollutants, EPA has derived for some pollutants (and will derive for others) chronic inhalation reference concentration (RfC)[1] values, which are defined as estimates of the lowest concentrations of a single pollutant to which the human population can be exposed over a lifetime without appreciable risk of deleterious effects. For purposes of specific chronic noncancer risk assessment, EPA may designate the RfC value, or some fraction or multiple thereof, as the appropriate long-term noncancer level of concern. For purposes of specific acute noncancer risk assessment, the EPA may designate acute reference thresholds as the appropriate short-term noncancer level of concern. For the purposes of this document, long-term noncancer levels of concern will be referred to as chronic concentration thresholds, and short-term noncancer levels of concern will be referred to as acute concentration thresholds. For ease of implementation, acute concentration thresholds will be designated for 1-hour averaging times. This does not necessarily mean that exposure data indicate deleterious health effects from exposure times of 1 hour, but rather that the 1-hour acute concentration threshold has been derived such that it is protective of the exposure duration of concern.

The risk with respect to long- or short-term deleterious noncancer health effects associated with exposure to a pollutant or group of pollutants is quantified by the hazard index. The chronic noncancer hazard index is calculated by dividing the modeled annual concentration of a pollutant by its chronic concentration threshold value. The acute noncancer hazard index is calculated by dividing the modeled 1-hour concentration of a pollutant by its acute concentration threshold value. If multiple pollutants are being evaluated, the (chronic or acute) hazard index at any location is calculated by dividing each predicted (annual or 1-hour) concentration at that location by its (chronic or acute) concentration threshold value and summing the results.[2] If the hazard index is greater than 1.0, this represents an exceedance of the level of concern at that location. For pollutants which can cause deleterious health effects from acute exposures, exceedances of a level of concern may occur at any location and at any time throughout the modeling period. Thus, the frequency with which any location experiences an exceedance also becomes a measure of the risk associated with a modeled source. Frequency of acute hazard index exceedances is only addressed by the most refined analysis methods referred to in this document.

Information on UREs and RfCs is accessible through the Integrated Risk Information System (IRIS), EPA Environmental Criteria and Assessment Office (ECAO) in Cincinnati, Ohio, (513) 569-7254.

1.3 Overview of Document

This document is divided into three major sections, each section addressing a different level of sophistication in terms of modeling, referred to as "tiers". The first tier is a simplified screening procedure in which the user can estimate maximum off-site ground-level concentrations without extensive knowledge regarding the source and without the need of a computer. The second tier is a more sophisticated screening technique which requires a bit more detailed knowledge concerning the source being modeled and, in addition, requires the execution of a computer program. The third tier involves site-specific computer simulations with the aid of computer programs and detailed source parameters. Since the effects of toxic air pollutants may be of concern from both a long-term and a short-term perspective, each tier is divided into two parts. The first part addresses dispersion modeling to assess long-term ambient concentrations (important from a cancer-causing or chronic noncancer effects standpoint) and the second addresses dispersion modeling for the estimation of short-term concentrations (important from an acute toxicity perspective).

It should be noted that this document is intended to be used in conjunction with the User's Guides for the models described: SCREEN[3], TOXST[4], and TOXLT[5]. It is not intended to replace or reproduce the contents of these documents. In addition, the reader may wish to consult the "Guideline on Air Quality Models (Revised)"[6] for more detailed information on the consistent application of air quality models. Modelers may also wish to use the EPA's TSCREEN[7] modeling system to assist in the Tier 2 computer simulation of certain toxic release scenarios. It should be noted, however, that toxic pollutant releases which TSCREEN treats as heavier-than-air are not to be modeled using techniques described herein. Atmospheric dispersion of such pollutants requires a more refined analysis, such as those described in Reference 8. Model codes, user's guides, and associated documentation referred to in this document can be obtained through the Technology Transfer Network (TTN) of the EPA's Office of Air Quality Planning and Standards (OAQPS), and access information is provided in Appendix A.

The modeling tiers are designed such that the concentration estimates from each tier should be less conservative than the previous one. This means that, for a given situation, a Tier 1 modeled impact should be greater than, or more conservative than, the Tier 2 modeled impact, and the Tier 2 modeled impact should be more conservative than the Tier 3 modeled impact. Progression from one tier of modeling to the next thus involves the use of levels of concern, as defined above. For example, if the results of a Tier 1 analysis indicate an exceedance of a level of concern with respect to either (1) the maximum predicted cancer risk, (2) the maximum predicted chronic noncancer hazard index, or (3) the maximum predicted acute hazard index, the analyst may wish to perform a Tier 2 analysis. If all three of these impact measures are below their specified levels of concern, there should be no need to perform a more refined

simulation, and thus, there should be no need to progress to the next tier of modeling. Since the establishment of levels of concern for each specific hazardous air pollutant is not a part of this effort, this document will refer to generic levels of concern, and users will need to consult subsequent EPA documents to determine the specific levels of concern for their particular pollutant or pollutant mixture and for the particular purpose of their modeling efforts.

1.4 General Modeling Requirements, Definitions, and Limitations

This document describes modeling methodologies for point, area, and volume sources of atmospheric pollution. A point source is an emission which emanates from a specific point, such as a smokestack or vent. An area source is an emission which emanates from a specific, well-defined surface, such as a lagoon, landfarm, or open-top tank. Sources referred to as having "fugitive" emissions (e.g., multiple leaks within a specific processing area) are typically modeled as area sources. The methods used in this document are generally considered to be applicable for assessing impacts of a source from the facility fenceline out to a 50 km radius of the source or sources to be modeled. There is no particular upper or lower limit on emission rate values for which these techniques apply.

For the purposes of this document, "source" means the same thing as "release", and "air toxic" means the same thing as "hazardous air pollutant". It should be noted that "area source" as defined in the previous paragraph is not the same as the "area source" defined by the CAAA. Modeling techniques described in this document are specifically intended for use in the simulation of a finite number of well-defined sources, not for simulation of a large number of ill-defined small sources distributed across a large region, as might well be the case for some "area sources" specified in the CAAA. Simulation of the acute and chronic impacts of such area sources may utilize the RAM model[9] and the CDM 2.0 model[10], respectively. Consult the "Guideline on Air Quality Models (Revised)"[6] for additional information. The reader should note that relatively small, well-defined groups of sources, however, may be modeled using the techniques described herein.

This document does not address the simulation of facilities located in complex terrain. Those interested in modeling facilities with possible complex terrain effects are directed to consult the "Guideline on Air Quality Models (Revised)"[6] or their EPA Regional Office modeling contact for assistance in this area (see listing in Appendix B).

In order to conduct an impact assessment, it is necessary to have estimates of emission rates of each pollutant from each source or release point being included in the assessment. Emission rates may be best estimated from experimental measurements or sampling, where such test methods are available. Alternatively, mass balance calculations or use of emission factors developed for specific types of processes may be used to quantify emission rates. The procedures discussed in this document do not address the emission estimation process. Guidance for source-specific emission rate estimation and emission test methods is available in other EPA documentation (e.g., see References 11 through 15). Additional information concerning specific emission measurement techniques is available through the OAQPS TTN (see Appendix A).

Since many sources of hazardous air pollutants are intermittent in nature (e.g., batch process emissions), the techniques in this document have been developed to allow the treatment of intermittent sources as well as continuous types of sources. It is important to understand the different treatment of emission rates for both types of sources when carrying out either the analysis of a long-term impact or a short-term impact. In a long-term impact analysis, the emission rate used for modeling is based on the amount of pollutant emitted over a 1 year period, regardless of whether the emission process is a continuous or intermittent one. In addition, to assess the worst-case impact of a source or group of sources, long-term emission rates used in model simulations should reflect the emission rates for a plant or process which is operating at full design capacity. In a short-term impact analysis, the emission rate used for modeling is based on the maximum amount of pollutant emitted over a 1 hour period, during which the source is emitting. The Tier 1 and Tier 2 procedures evaluate the combined worst-case impacts of intermittent sources as if they are all emitting at the same time, whereas the Tier 3 procedures incorporate a more realistic treatment of intermittent sources by turning them on and off throughout the simulation period according to user-specified frequency of occurrence of each release. This frequency of occurrence should reflect the normal operating schedule of the source when operating at maximum design capacity.

In addition to emission rate estimates, it is necessary to have quantitative information about the sources to conduct a detailed impact assessment. Tier 1 analyses require information about the height of the release above ground level and the shortest distance from the release point to the facility fenceline. Higher tiers of analysis require additional information including, but not limited to:

Stack height
Inside stack diameter
Exhaust gas exit velocity
Exhaust gas exit temperature
Dimensions of structures near each source
Dimensions of ground-level area sources
Exact release and fenceline location
Exact location of receptors for determining worst-case impacts
Land use near the modeled facility
Terrain features near the facility
Duration of short-term release
Frequency of short-term release

Where appropriate, this document will address the best means of obtaining these input data. In some more complex cases, the modeling contact at the nearest EPA Regional Office may need to be consulted for specific modeling guidance (see listing in Appendix B).

Depending on the specific purpose of the impact assessment, it may be difficult for the modeler to decide which sources (or release points) and which pollutants should be included in a particular analysis or simulation. Since these questions pertain to the particular purposes for

which the impact assessment is being performed, they are not addressed by this document. Instead, this document refers to and provides guidance for modeling various scenarios including single-source, multiple-source, single-pollutant, and multiple-pollutant scenarios. Subsequent EPA documents will address the questions of which sources and which pollutants should be included in an impact analysis for a specific regulatory purpose.

2.0 TIER 1 ANALYSES

2.1 Introduction

Tier 1 analysis of a stationary source (or group of sources) of toxic pollutant(s) is performed to address the question of whether or not the source has the potential to cause a significant impact. This "screening" analysis is performed by using tables of lookup values to obtain the "worst-case" impact of the source being modeled. The analysis is performed to assess both the potential long- and short-term impacts of the source. If the predicted screening impacts are less than the appropriate levels of concern, no further modeling is indicated. If the predicted screening impacts are above any levels of concern, further analysis of those impacts at a higher Tier may be desirable to obtain more accurate results.

The Tier 1 "lookup tables" have been created as tools which may be easily used to estimate conservative impacts of sources of toxic pollutants with a minimal amount of information concerning those sources. The normalized annual and 1-hour concentration tables were created based on conservative simulations of toxic pollutant sources with Gaussian plume dispersion models. In this context, "conservative" simulations use conservative assumptions regarding meteorology, building downwash, plume rise, etc.

2.2 Long-term Modeling

Long-term modeling of toxic or hazardous air pollutants is aimed at the estimation of annual average pollutant concentrations to which the public might be exposed as the result of emissions from a specific source or group of sources. From the EPA regulatory viewpoint, this "public" does not include employees of the facility responsible for the emissions (this is the jurisdiction of the Occupational Safety and Health Agency, OSHA). Thus, the impact assessment focuses on estimating concentrations "off-site", or outside the facility boundary. For carcinogens, the calculation of cancer risk proceeds by multiplying annual concentrations by pollutant-specific cancer potency factors derived from health effects data. The impacts of pollutants with chronic noncancer effects are generally assessed by comparing predicted annual concentrations with chronic threshold concentrations which are again derived from experimental health data. For the purposes of protecting the general public against "worst-case" pollutant concentrations, the analysis is focused on predicting the worst-case, or maximum annual average concentrations.

2.2.1 Maximum Annual Concentration Estimation

A long-term Tier 1 analysis requires the following information:

1. annual average emission rate of each pollutant from each source included in the simulation (T/yr). These emissions do not have to be continuously emitted, but rather should represent the total amount of pollutant which is generated by this source in a year.

Note that the tons used in this regard are English tons (1 T. = 2000 lb.). Also note that, for Tier 1 analyses, the emission rate from an area source represents the total emissions from the area, not the emissions per square unit area.

2. height of the release point above ground (m), for each point source.

3. source types (point or area). Point sources typically include exhaust vents (pipes or stacks), or any other type of release that causes toxic materials to enter the atmosphere from a well-defined location, at a well-defined rate. Area sources may also be well-defined, but differ from point sources in that the extent over which the release occurs is substantial.

4. maximum horizontal distance across each area source (m).

5. nearest distance to property-line (m). Concentration estimates are needed at locations that are accessible to the general public. This is typically taken to be any point at or beyond the property-line of a facility. Estimate the distance from the point of each release to the nearest point on the fenceline. (This need not be the same fenceline point for each release.) If the source is characterized as an area source, this distance should be measured from the nearest edge of the area source, not from the center.

Once these five items are determined for each release (or source), screening estimates of normalized maximum annual concentrations resulting from each release are obtained from Table 1 using the following procedure.

1. For an area source, select the "side length" in the table (10m, 20m, 30m) which is less than or equal to the maximum horizontal distance across the source.

2. For a point source, select the largest "emission height" in the table (0m, 2m, 5m, 10m, 35m, or 50m) that is less than or equal to the estimated height of release.

3. Select the largest distance in the table (10m, 30m, 50m, 100m, or 200m) that is less than or equal to the nearest distance to the property-line.

4. Take the appropriate normalized maximum annual concentration for this release height and distance from the table, and multiply by the emission rate of each toxic substance (T/yr) in the release to obtain the concentration estimate ($\mu g/m^3$). DO NOT INTERPOLATE TABLE VALUES.

For example, consider the situation in which a toxic pollutant A is released at a rate of 11.6 T/yr from a vent-pipe that is 40m tall, and which is attached to a building that is 4m tall, 10m long, and 5m wide. The nearest boundary of the facility is located 65m from the pipe. A value of 35m should be selected for the emission height, because all larger entries in the table exceed the

TABLE 1. NORMALIZED MAXIMUM ANNUAL CONCENTRATIONS, ($\mu g/m^3$)/(T/yr)

Source type[a]	Emission height, m	Side length,[b] m	Normalized maximum concentration at or beyond:[c]					
			10 m	30 m	50 m	100 m	200 m	500 m
A	0	10	9.56E+2	3.02E+2	1.64E+2	6.48E+1	2.32E+1	5.53E+0
A	0	20	5.15E+2	1.83E+2	1.07E+2	4.78E+1	1.91E+1	5.04E+0
A	0	30	3.51E+2	1.31E+2	7.92E+1	3.74E+1	1.61E+1	4.58E+0
P	0	--	5.41E+3	7.92E+2	3.25E+2	9.67E+1	2.91E+1	6.08E+0
P	2	--	1.87E+2	1.42E+2	1.35E+2	7.28E+1	2.64E+1	5.96E+0
P	5	--	9.62E+1	7.46E+1	5.18E+1	2.72E+1	1.48E+1	5.18E+0
P	10	--	2.77E+1	2.44E+1	2.11E+1	1.36E+1	7.17E+0	2.88E+0
P	20	--	6.91E+0	4.52E+0	4.52E+0	3.80E+0	2.44E+0	1.06E+0
P	35	--	2.26E+0	2.26E+0	1.13E+0	1.11E+0	8.98E-1	4.41E-1
P	50	--	1.11E+0	1.10E+0	1.11E+0	4.69E-1	4.23E-1	2.53E-1

[a]Source type P= Point source, type A = Area source.
[b]Side length of square area source.
[c]Distance downwind of an area source indicates distance from downwind edge of the area source.

actual height of release of 40m. Concentrations should be estimated for a distance of 50m, because once again, all greater entries in the table exceed the actual distance of 65m. The appropriate normalized maximum annual concentration is 1.13 ($\mu g/m^3$)/(T/yr). Multiplying by the emission rate of 14.6 T/yr results in a maximum annual concentration estimate for screening purposes equal to 16.5 $\mu g/m^3$.

2.2.2 Cancer risk assessment

Once the maximum annual concentration has been estimated for each release being modeled, upper bound lifetime maximum individual cancer risk may be estimated by multiplying the maximum annual concentration estimates of each carcinogenic pollutant by the unit cancer risk factor for that pollutant and then summing results. This approach assumes that all cancer risks are additive, regardless of the organ system which may be affected. It should be noted that this approach assumes that all worst-case impacts occur at the same location. While this assumption may not be very realistic, it does help to insure that Tier 1 results are conservative, and, therefore protective of the public.

As an example of this approach, suppose one is simulating a plant which emits 2 pollutants, A and B, through 4 different stacks such that pollutant A is released from stacks 1 and 2, and pollutant B is released from stacks 2, 3, and 4. In this example, stack 1 is the same as that described in the example above. After going through the above procedure to estimate the maximum annual concentrations of each pollutant from each stack, the results are:

Source	Compound	Max impact
Stack 1	Pollutant A	16.5 $\mu g/m^3$
Stack 2	Pollutant A	5.49 $\mu g/m^3$
Stack 2	Pollutant B	2.35 $\mu g/m^3$
Stack 3	Pollutant B	4.13 $\mu g/m^3$
Stack 4	Pollutant B	24.9 $\mu g/m^3$

Suppose that the unit cancer risk factors for pollutants A and B are known to be 1.0×10^{-7} and 2.0×10^{-7} $(\mu g/m^3)^{-1}$, respectively. The Tier 1 maximum cancer risk is calculated for the individual releases and pollutants and summed as follows:

Source	Compound	Max impact	Max risk
Stack 1	Pollutant A	16.5 $\mu g/m^3$	1.65×10^{-6}
Stack 2	Pollutant A	5.49 $\mu g/m^3$	5.49×10^{-7}
Stack 2	Pollutant B	2.35 $\mu g/m^3$	4.70×10^{-7}
Stack 3	Pollutant B	4.13 $\mu g/m^3$	8.26×10^{-7}
Stack 4	Pollutant B	24.9 $\mu g/m^3$	4.98×10^{-6}
		Total risk	8.48×10^{-6}

If we are assessing the impact of this group of sources in relation to the CAAA specified level of concern of 1 X 10^{-6} lifetime cancer risk, and since the maximum Tier 1 risk is greater than the CAAA specified concern level of 1 X 10^{-6}, this source warrants further modeling on the basis of cancer risk (note that this does not rule out the need to investigate acute or chronic noncancer risks).

2.2.3 Chronic Noncancer Risk Assessment

For all pollutants which pose a chronic noncancer threat to health, an assessment of the magnitude of this threat is made using the hazard index approach. The chronic noncancer hazard index is calculated by summing the maximum annual concentrations for each pollutant divided by the chronic threshold concentration value for that pollutant. If the calculated hazard index is greater than 1.0, the release or releases being simulated may pose a threat to the public, and further modeling may be indicated. It should again be noted that, for the sake of erring conservatively, this approach assumes that the worst-case impacts of all releases occur at the same location.

As an example of the above procedure, suppose that pollutants A and B in the example above pose a chronic noncancer health risk, and their respective chronic concentration threshold values are 20.0 and 5.0 $\mu g/m^3$, respectively. The chronic noncancer hazard index would be formulated as follows:

Source	Compound	Max impact	Hazard index
Stack 1	Pollutant A	16.5 $\mu g/m^3$	0.825
Stack 2	Pollutant A	5.49 $\mu g/m^3$	0.275
Stack 2	Pollutant B	2.35 $\mu g/m^3$	0.470
Stack 3	Pollutant B	4.13 $\mu g/m^3$	0.826
Stack 4	Pollutant B	24.9 $\mu g/m^3$	4.980
		Total hazard index	7.376

In this case, one of the individual hazard index values exceeds 1.0, the total hazard index for the modeled facility exceeds 1.0, and further modeling at a higher Tier may be desired.

2.3 Short-term Modeling

Short-term modeling of toxic or hazardous air pollutants is aimed at the estimation of 1-hour average pollutant concentrations to which the public might be exposed as the result of emissions from a specific source or group of sources. Again, from the EPA regulatory viewpoint, this "public" does not include employees of the facility responsible for the emissions (this is the jurisdiction of OSHA). Thus, the impact assessment focuses on estimating concentrations "off-site", or outside the facility boundary. From the short-term perspective, the

health effects of most concern vary, but they are those which create detrimental health effects as the result of short-term exposure to toxic pollutants. The risks associated with such exposures are generally assessed by comparing 1-hour predicted concentrations with acute threshold concentrations which are derived from experimental health data. For the purposes of protecting the general public against "worst-case" pollutant concentrations, the analysis is focused on predicting the worst-case, or maximum 1-hour average concentrations.

2.3.1 Maximum Hourly Concentration Estimation

A short-term Tier 1 analysis requires the following information:

1. maximum 1-hour average emission rate of each pollutant from each source included in the simulation (g/s). If the release is a continuous, constant-rate emission, then this value is equivalent to the release rate for long-term modeling, except that it is expressed in g/s instead of T/yr. (To convert from T/yr to g/s, divide by 34.73; to convert from g/s to T/yr, multiply by 34.73.) If the release is intermittent, such as a batch process, this value is equivalent to the maximum number of grams emitted during any hour when the release is occurring divided by 3600. Again note that, for Tier 1 analyses, the emissions from an area source represent the total emissions from that source, not just the emissions per unit surface area.

2. height of each release above ground (m), for point sources.

3. source types (point or area). Point sources typically include exhaust vents (pipes or stacks), or any other type of release that causes toxic materials to enter the atmosphere from a well-defined location, at a well-defined rate. Area sources may also be well-defined, but differ from point sources in that the extent over which the release occurs is substantial.

4. maximum horizontal distance across each area source (m).

5. nearest distance to property-line (m). Concentration estimates are needed at locations that are accessible to the general public. This is typically taken to be any point at or beyond the property-line of a facility. Estimate the distance from the point of each release to the nearest point on the fenceline. (This need not be the same fenceline point for each release.) If the source is characterized as an area source, this distance should be measured from the nearest edge of the area source, rather from than the center of the area source.

Once these five items are determined for each release, screening estimates of maximum 1-hour average concentrations resulting from each release are obtained from Table 2 using the following procedure.

1. For area sources, select the "side length" in the table (10m, 20m, 30m) which is less than or equal to the maximum horizontal distance across the source.

2. For point sources, select the largest "emission height" in the table (0m, 2m, 5m, 10m, 35m, or 50m) that is less than or equal to the estimated height of release.

3. For each source, select the largest distance in the table (10m, 20m, 50m, 100m, or 200m) that is less than or equal to its nearest distance to the property-line.

4. Take the normalized maximum 1-hour average concentration for this release and fenceline distance, and multiply by the emission rate of each toxic pollutant (g/s) in the release to obtain the maximum off-site 1-hour average concentration estimates ($\mu g/m^3$). DO NOT INTERPOLATE TABLE VALUES.

For example, again consider the situation in which a toxic material A is released from a vent-pipe that is 40m tall, and which is attached to a building that is 4m tall, 10m long, and 5m wide. The nearest boundary of the facility is located 65m from the pipe. For the short-term assessment, it has been determined that the maximum emissions of A that can occur during any hour of the year is 1800g, therefore the emission rate for short-term assessment is 1800g/3600s = 0.50 g/s. A value of 35m is again selected for the emission height, because all larger entries in the table exceed the actual height of release. Concentrations are estimated for a distance of 50m, because once again, all greater entries in the table exceed the actual distance of 65m. The appropriate normalized maximum 1-hour average concentration is 3.94E+2 ($\mu g/m^3$)/(g/s). Multiplying by the emission rate of 0.50 g/s results in a maximum hourly concentration estimate for screening purposes equal to 197 $\mu g/m^3$.

2.3.2 Acute Hazard Index Assessment

For all pollutants which pose a threat to health based on acute exposure, an assessment of the magnitude of this threat is made using the acute hazard index approach, similar to that used in chronic noncancer risk assessment. In this case, however, the acute hazard index is calculated by summing the maximum 1-hour concentrations for each pollutant divided by the acute concentration threshold value for that pollutant. It should again be noted that, for the sake of erring conservatively, this approach assumes that the worst-case impacts of all releases can occur simultaneously at the same location. Similar to the chronic risk assessment, if the calculated hazard index is greater than 1.0, the release or releases being simulated may pose a significant threat to the public, and further modeling at a higher Tier may be indicated.

TABLE 2. NORMALIZED MAXIMUM 1-HOUR AVERAGE CONCENTRATIONS, ($\mu g/m^3$)/(g/s)

Source type[a]	Emission height, m	Side length,[b] m	Normalized maximum concentration at or beyond:[c]					
			10 m	30 m	50 m	100 m	200 m	500 m
A	0	10	3.32E+5	1.05E+5	5.70E+4	2.25E+4	8.07E+3	1.92E+3
A	0	20	1.79E+5	6.36E+4	3.72E+4	1.66E+4	6.62E+3	1.75E+3
A	0	30	1.22E+5	4.54E+4	2.75E+4	1.30E+4	5.59E+3	1.59E+3
P	0	--	1.88E+6	2.75E+5	1.13E+5	3.36E+4	1.01E+4	2.11E+3
P	2	--	6.51E+4	4.92E+4	4.69E+4	2.53E+4	9.18E+3	2.07E+3
P	5	--	3.34E+4	2.59E+4	1.80E+4	9.44E+3	5.13E+3	1.80E+3
P	10	--	9.61E+3	8.49E+3	7.36E+3	4.71E+3	2.49E+3	1.00E+3
P	20	--	2.45E+3	1.57E+3	1.57E+3	1.32E+3	8.46E+2	3.67E+2
P	35	--	7.84E+2	7.84E+2	3.94E+2	3.85E+2	3.12E+2	1.53E+2
P	50	--	3.84E+2	3.84E+2	3.84E+2	1.63E+2	1.47E+2	8.77E+1

[a]Source type P= Point source, type A = Area source.

[b]Side length of square area source.

[c]Distance downwind of an area source indicates distance from downwind edge of the area source.

As an example of the acute hazard index approach, consider the same plant being simulated in Section 2.2.2, but this time the maximum 1-hour concentrations are determined using the procedure in Section 2.3.2 to be the following:

Source	Compound	Max 1-hr impact
Stack 1	Pollutant A	197 $\mu g/m^3$
Stack 2	Pollutant A	257 $\mu g/m^3$
Stack 2	Pollutant B	110 $\mu g/m^3$
Stack 3	Pollutant B	301 $\mu g/m^3$
Stack 4	Pollutant B	367 $\mu g/m^3$

Further suppose that pollutants A and B pose health problems from acute exposures with acute threshold concentration values of 200 and 100 $\mu g/m^3$, respectively. The acute hazard index is calculated as follows:

Source	Compound	Max 1-hr impact	Hazard index
Stack 1	Pollutant A	197 $\mu g/m^3$	0.985
Stack 2	Pollutant A	257 $\mu g/m^3$	1.285
Stack 2	Pollutant B	110 $\mu g/m^3$	1.100
Stack 3	Pollutant B	301 $\mu g/m^3$	3.010
Stack 4	Pollutant B	367 $\mu g/m^3$	3.670
		Total hazard index	10.050

In this case, 4 of the individual hazard index values exceeds 1.0, the total hazard index for the modeled plant exceeds 1.0, and further modeling at a higher Tier may be desired.

3.0 TIER 2 ANALYSES

3.1 Introduction

Tier 2 analysis of a stationary source (or group of sources) of toxic pollutant(s) may be desired if the results of a Tier 1 analysis indicate an exceedance of a level of concern with respect to one or more of the following: (1) the maximum predicted cancer risk; (2) the maximum predicted chronic noncancer hazard index, or; (3) the maximum predicted acute hazard index. Note that in situations where only one or two of the Tier 1 criteria are exceeded, only those analyses which exceed the Tier 1 criteria may need to be performed at the higher Tier. For example, if the Tier 1 analysis showed cancer risk and chronic noncancer risks to be of concern while the acute risk analysis showed no cause for concern, only long-term modeling for cancer risk and chronic noncancer risk may need to be performed at Tier 2. Tier 2 analyses are slightly more sophisticated than Tier 1 analyses, and therefore require additional input information as well as a computer for their execution. Tier 2 analyses are structured around the EPA's SCREEN model and its corresponding documentation[3]. The SCREEN model source code and documentation is available through the OAQPS TTN (see Appendix A).

Again, similar to the Tier 1 analysis, if any of the predicted impacts from Tier 2 are above the appropriate levels of concern, further modeling is indicated at a higher Tier.

3.2 Long-term Modeling

Long-term Tier 2 modeling utilizes the SCREEN[3] model to estimate 1-hour maximum concentrations, and then utilizes a conservative conversion factor to derive maximum annual concentration values from the SCREEN predictions[16,17]. These maximum annual concentration estimates are used to assess cancer risk and chronic noncancer risk exactly as in Sections 2.2.2 and 2.2.3 of this document.

3.2.1 Maximum Annual Concentration Estimation

In addition to the information required to perform a Tier 1 long-term analysis, a Tier 2 analysis requires the following information:

1. the inside diameter of the stack at the exit point (m).

2. the stack gas exit velocity (m/s)

3. the stack gas exit temperature (K)

4. a determination of whether the area surrounding the modeled facility is urban or rural. This is usually assessed on the basis of land use in the vicinity of the facility.

Refer to the "Guideline on Air Quality Models (Revised)"[6] for additional guidance on this determination.

5. downwash potential. Downwash effects must be included in dispersion estimates for point (stack) sources whenever the point of release is located on the roof of a building or structure, or within the lee of a nearby structure. The potential for downwash is determined in the following way. First, estimate the heights and maximum horizontal dimensions* of the structures nearest the point of release. For each structure, determine which of these two dimensions is less, and call this length L. If the structure is less than 5L away from the source, then this structure may cause downwash. For every structure satisfying this criterion, calculate a height by multiplying L by 1.5, and adding this to the actual height of the structure. If any calculated height exceeds the height of the release, then downwash calculations must be made for that release.

Once these items are determined for each release being modeled, estimates of maximum concentrations from each release are obtained through individual SCREEN runs for each release. Recommendations for each SCREEN run are as follows:

1. The emission rates used for Tier 1 long-term modeling should be converted from T/yr to g/s (divide T/yr by 34.73). Area source emission rates should be converted to $g/s/m^2$ by dividing by the total area of the source.

2. Choose the default atmospheric temperature of 293K.

3. For each release, exercise the automated distance array choosing as the minimum receptor distance the appropriate nearest fenceline distance for that release, and choosing 50 km as the maximum receptor distance. The maximum concentration for that release will then be chosen as the maximum at or beyond the nearest fenceline distance.

4. The option for flagpole receptors should not be used.

5. For each release, the maximum 1-hour concentration should be noted.

6. Maximum annual concentrations should be calculated for each release by multiplying predicted maximum 1-hour concentrations by 0.08.

As an example of the Tier 2 long-term analysis, consider Stack 1 from the Tier 1 example. To consider downwash possibilities, the maximum horizontal dimension is first estimated as $\{(10m)^2 + (5m)^2\}^{1/2} = 11.2m$. The dimension L is then 4m, and the maximum stack height for which downwash is possible would be 4m + 1.5 X 4m = 10m. Since the

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* Note: The maximum horizontal dimension is defined as the largest possible alongwind distance the structure could occupy.

actual stack height is 40m, downwash need not be considered in the SCREEN simulation. The emission rate specified in the example of 14.6 T/yr is converted to g/s to be used in the SCREEN simulation, resulting in an emission rate of 14.6/34.73 = 0.42 g/s. In addition to the actual stack height (40m) and minimum fenceline distance (65m), input parameters for the SCREEN simulation are:

Inside stack diameter	0.5m
Stack gas exit velocity	5.6 m/s
Stack gas exit temperature	303 K
Plant location	urban

The results from the SCREEN simulation indicate that the maximum 1-hour concentration at or beyond 65m is 32.5 $\mu g/m^3$, occurring 165m downwind. Using the recommended conversion factor of 0.08, the maximum annual concentration is estimated as 2.6 $\mu g/m^3$ (this value can be contrasted with the Tier 1 estimation of 16.5 $\mu g/m^3$).

3.2.2 Cancer Risk Assessment

Maximum annual concentrations for all releases of carcinogens should be multiplied by the appropriate unit cancer risk factor and summed to estimate the maximum cancer risk. It should be noted that this approach, as in Tier 1, presumes that all worst-case impacts occur at the same location. While this assumption may not be very realistic, it does help to insure that the results of a Tier 2 analysis are conservative and therefore protective of the public. More receptor-specific risk calculations are addressed in the Tier 3 analyses.

Borrowing again from the Tier 1 example, maximum annual impacts for each source and pollutant combination are estimated using the SCREEN model. Risk estimates are then made by summing the risk due to each release, regardless of downwind distance to maximum impact. The results are:

Source	Compound	Max impact	Max risk
Stack 1	Pollutant A	2.60 $\mu g/m^3$	2.60×10^{-7}
Stack 2	Pollutant A	1.34 $\mu g/m^3$	1.34×10^{-7}
Stack 2	Pollutant B	0.58 $\mu g/m^3$	1.16×10^{-7}
Stack 3	Pollutant B	0.62 $\mu g/m^3$	1.24×10^{-7}
Stack 4	Pollutant B	3.70 $\mu g/m^3$	7.40×10^{-7}

		Total risk	1.38×10^{-6}

For this example, the maximum lifetime cancer risk estimated using the Tier 2 methods is a factor of 6 lower than that estimated in the Tier 1 analysis. However, the cancer risk level still exceeds 1 X 10^{-6}, indicating that modeling at a higher Tier may be desirable.

3.2.3 Chronic Noncancer Risk Assessment

As in Tier 1, maximum annual concentrations are divided by their chronic concentration threshold values and summed to calculate the hazard index values. Again, this approach conservatively assumes that all worst-case impacts occur at the same location.

Continuing with the example, the chronic noncancer hazard index is recalculated using the Tier 2 estimated long-term impacts. Threshold concentration values for chronic noncancer effects again are taken as 20.0 and 5.0 $\mu g/m^3$ for pollutants A and B, respectively. The following results:

Source	Compound	Max impact	Hazard index
Stack 1	Pollutant A	2.60 $\mu g/m^3$	0.130
Stack 2	Pollutant A	1.34 $\mu g/m^3$	0.067
Stack 2	Pollutant B	0.58 $\mu g/m^3$	0.116
Stack 3	Pollutant B	0.62 $\mu g/m^3$	0.124
Stack 4	Pollutant B	3.70 $\mu g/m^3$	0.740
		Total hazard index	1.177

The chronic noncancer hazard index estimated in Tier 2 is a good deal less than that estimated for the same sources in Tier 1. Even though none of the individual source/pollutant combinations exceeds a chronic threshold concentration value, the total hazard index exceeds 1.0, and further analysis at Tier 3 is indicated for chronic noncancer effects.

3.3 Short-term Modeling

Short-term Tier 2 modeling utilizes the SCREEN[3] model to estimate 1-hour maximum concentrations directly. These maximum 1-hour concentration estimates are used to assess acute hazard index values exactly as in Section 2.3.2 of this document.

3.3.1 Maximum Hourly Concentration Estimation

In addition to the information required to perform a Tier 1 short-term analysis, a Tier 2 analysis requires the following information for stack sources:

1. the inside diameter of the stack at the exit point (m).

2. the stack gas exit velocity (m/s)

3. the stack gas exit temperature (K)

4. a determination of whether the area surrounding the modeled facility is urban or rural. This is usually assessed on the basis of land use in the vicinity of the facility. Refer to the "Guideline on Air Quality Models (Revised)"[6] for additional guidance on this determination.

5. downwash potential. Downwash effects must be included in dispersion estimates for point sources whenever the point of release is located on the roof of a building or structure, or within the lee of a nearby structure. The potential for downwash is determined in the following way. First, estimate the heights and maximum horizontal dimensions of the structures nearest the point of release. For each structure, determine which dimension is less, and call this length L. If the structure is less than 5L away from the source, then this structure may cause downwash. For every structure satisfying this criterion, calculate a height by multiplying L by 1.5, and adding this to the actual height of the structure. If any calculated height exceeds the height of the release, then downwash calculations must be used for that release.

Once these items are determined for each release being modeled, estimates of maximum concentrations from each release are obtained through individual SCREEN runs for each release. Recommendations for each SCREEN run are as follows:

1. Choose the default atmospheric temperature of 293K.

2. Area source emission rates reflect the total emission rate from divided by the area of the source.

3. For each release, exercise the automated distance array choosing as the minimum receptor distance the appropriate nearest fenceline distance for that release, and choosing 50 km as the maximum receptor distance. The maximum concentration for that release will then be chosen as the maximum at or beyond the nearest fenceline distance.

4. The option for flagpole receptors should not be used.

5. For each release, the maximum 1-hour concentration should be noted.

Using this approach with the Stack 1 example, the SCREEN model is exercised with the stack parameters specified in Section 3.2.1. The maximum short-term emission rate of 0.50 g/s (see Section 2.3.1), however, is used to estimate the maximum 1-hour source impact. The results of the SCREEN model indicate that the maximum 1-hour concentration is 38.8 $\mu g/m^3$, again occurring 165m downwind.

3.3.2 Acute Hazard Index Assessment

As in Tier 1, maximum 1-hour concentrations are divided by their acute threshold concentration values and summed to calculate the acute hazard index values. Again, this approach conservatively assumes that all worst-case impacts can occur simultaneously at the same location.

To illustrate this procedure, short-term impacts from the example plant are assessed using the hazard index approach. Again the acute threshold concentration values are taken as 200 and 100 $\mu g/m^3$, respectively. The results are:

Source	Compound	Max 1-hr impact	Hazard index
Stack 1	Pollutant A	34.8 $\mu g/m^3$	0.174
Stack 2	Pollutant A	70.5 $\mu g/m^3$	0.352
Stack 2	Pollutant B	29.9 $\mu g/m^3$	0.299
Stack 3	Pollutant B	50.0 $\mu g/m^3$	0.500
Stack 4	Pollutant B	60.4 $\mu g/m^3$	0.604
		Total hazard index	1.925

For this example, the acute hazard index estimated in Tier 2 is roughly 20% of that estimated for the same sources in Tier 1. However, since the total hazard index exceeds 1.0, further analysis at Tier 3 is indicated for health effects resulting from acute exposures.

4.0 TIER 3 ANALYSES

.1 Introduction

Tier 3 analysis of a stationary source (or group of sources) of toxic pollutant(s) may be esired if the results of a Tier 2 analysis indicate an exceedance of a level of concern with spect to one or more of the following: (1) the maximum predicted cancer risk; (2) the aximum predicted chronic noncancer hazard index, or; (3) the maximum predicted acute azard index. Tier 3 analysis of a stationary source (or group of sources) of toxic pollutant(s) performed to provide the most scientifically-refined indication of the impact of that source. his Tier involves the utilization of site-specific source and plant layouts as well as eteorological information. In contrast to the previous Tiers, Tier 3 allows for a more realistic mulation of intermittent sources and combined source impacts. In addition, results from short-rm analyses indicate not only if a risk level of concern can be exceeded, but how often that vel of concern might be exceeded during an average year. Dispersion modeling for the Tier analysis procedure is based on use of the EPA's Industrial Source Complex (ISC2) model[18], id as such utilizes many of the same techniques recommended in the "Guideline on Air Quality lodels (Revised)"[6] approach to the dispersion modeling of criteria pollutants.

To facilitate the dispersion modeling of toxic air pollutants, the EPA has developed OXLT (TOXic modeling system Long-Term)[5] for refined long-term analyses, and TOXST OXic modeling system Short-Term)[4] for refined short-term analyses. The TOXLT system corporates the ISCLT2 (long-term) directly to calculate annual concentrations and the TOXST stem incorporates the ISCST2 (short-term) model directly to calculate hourly concentrations. odes and user's guides for both TOXLT and TOXST are available via electronic bulletin board ee Appendix A).

2 Long-term Modeling

Long-term Tier 3 modeling uses the TOXLT[5] modeling system to estimate maximum nual concentrations and maximum cancer risks. The TOXLT modeling system uses the CLT2 model to calculate these annual concentrations at receptor sites which are specified by e user. A post-processor called RISK subsequently calculates lifetime cancer risks and chronic ncancer hazard index values at each receptor.

2.1 Maximum Annual Concentration Estimation

In addition to the information required to perform a Tier 2 long-term analysis, the er 3 long-term analysis requires the following information:

1. five years of meteorological data from the nearest National Weather Service (NWS) station. These data are for the most recent, readily-available consecutive five year period. NWS data are available through the electronic bulletin board (see Appendix A). Alternatively, one or more years of meteorological data from on-site measurements may

The results of the dispersion modeling indicated the following maximum annual off-site concentrations for each of the source/pollutant combinations:

Source	Compound	Max impact	Location
Stack 1	Pollutant A	.788 $\mu g/m^3$	X
Stack 2	Pollutant A	.305 $\mu g/m^3$	Y
Stack 2	Pollutant B	.131 $\mu g/m^3$	Y
Stack 3	Pollutant B	.172 $\mu g/m^3$	Z
Stack 4	Pollutant B	.976 $\mu g/m^3$	Z

It should be noted that the maximum concentrations from each source/receptor combination were not co-located. The positions of the maximum concentration from each source are indicated on Figure 1 corresponding to the letters X, Y, and Z in the table above. In general, the Tier 3 maximum concentration values are 25 to 30% as high as the Tier 2 values.

4.2.2 Cancer Risk Assessment

Concentrations from the ISCLT2 master file inventory are used by the RISK post-processor to calculate cancer risks at each receptor site in the ISCLT2 receptor array. RISK can then provide summaries of the calculated risks according to user specifications. Use of the RISK post-processor requires the following considerations:

1. As stated above, emission rate multipliers for each pollutant from each source should be provided as inputs to the RISK post-processor such that the product of the base emission rate input to ISCLT2 and the emission rate multiplier input to RISK equals the emission rate being modeled.

2. Unit cancer risk factors are provided to RISK either in the RISK post-processor input file or through an interactive process in TOXLT.

3. The RISK post-processor output options should be exercised to provide the total cancer risk at each receptor due to all pollutants, as well as individual pollutant or source contributions to these receptor-specific risks.

If the maximum predicted lifetime cancer risk in the receptor grid is less than the designated level of concern (e.g., 1 X 10^{-6}), placement of additional receptors in the ISCLT2 receptor array should be considered as a means of ensuring that the simulation is not underestimating maximum risk. If the maximum cancer risk in the receptor array is greater than the designated level of concern, additional runs of the RISK post-processor may be performed using reduced emission rate multipliers to assess the impacts of possible emission control scenarios. If the analysis shows no cancer risk greater than the designated level of concern and the receptor array is deemed adequate, the modeled source is considered to be in compliance

with the specified criterion. In the case of non-compliance, it may be desirable on the part of the modeler to conduct a more refined analysis. Section 5.0 if this document discusses some of the possibilities for further modeling refinements.

The output of the RISK post-processor for the example plant indicates that the maximum lifetime cancer risk outside the plant boundary is 4.2×10^{-7}, located at point W on Figure 1. Such a result would indicate that the facility would not cause a significant cancer risk to the public, according to the cancer risk level specified by the CAAA of 1990.

4.2.3 Chronic Noncancer Risk Assessment

In this assessment, concentrations from the ISCLT2 master file inventory are used by the RISK post-processor to calculate chronic noncancer hazard index values for a specific noncancer effect at each receptor site in the ISCLT2 receptor array. RISK can then provide summaries of the calculated index values according to user specifications. A separate RISK simulation should be performed for each chronic noncancer effect being considered. Use of the RISK post-processor requires the following considerations:

1. As stated above, emission rate multipliers for each pollutant from each source should be provided as inputs to the RISK post-processor such that the product of the emission rate input to ISCLT2 and the emission rate multiplier input to RISK equals the actual emission rate being modeled.

2. Chronic threshold concentration values for the specific noncancer effect are provided to RISK either in the RISK post-processor input file or through an interactive process in TOXLT.

3. The RISK post-processor output options should be exercised to provide the total noncancer hazard index at each receptor due to all pollutants, as well as individual pollutant or source contributions to these receptor-specific hazard indices.

If the maximum hazard index value in the receptor grid exceeds 1.0, emission reduction scenarios can be performed (again, using reduced emission rate multipliers) to determine how this hazard index value can be reduced below 1.0. If the maximum hazard index value in the receptor grid does not exceed 1.0, the source(s) being modeled is considered to be in compliance with the specified criteria. In the case of non-compliance, it may be desirable on the part of the modeler to conduct a more refined analysis. Section 5.0 if this document discusses such possibilities.

Using the chronic noncancer threshold concentration values for pollutants A and B of 20.0 and 5.0 $\mu g/m^3$, respectively, the RISK post-processor was exercised for the example facility to obtain a maximum hazard index value of 0.27 located at point Z on Figure 1. This result, which is approximately 30% of the Tier 2 result, would indicate that the facility does not present a significant chronic noncancer risk in its current configuration.

4.3 Short-term Modeling

Short-term Tier 3 modeling uses the TOXST modeling system[4] to estimate maximum hourly concentrations and the receptor-specific expected annual number of exceedances of short-term concentration thresholds. For multiple pollutant scenarios, this amounts to the number of times the acute hazard index value exceeds 1.0. The model uses the ISCST2 model to calculate these hourly concentrations at receptor sites which are specified by the user. Acute hazard index values are subsequently calculated at each receptor by the TOXX post-processor, in which a Monte Carlo simulation is performed for intermittent sources to assess the average number of times per year the acute hazard index value exceeds 1.0 at each receptor.

4.3.1 Maximum Hourly Concentration Estimation

In addition to the information required to perform a Tier 2 analysis, the Tier 3 short-term analysis requires the following information:

1. five years of meteorological data from the nearest National Weather Service (NWS) station. These data are for the most recent, readily-available consecutive five year period. NWS data are available through the electronic bulletin board (see Appendix A). Alternatively, one or more years of meteorological data from on-site measurements may be substituted. These data should be obtained and quality-assured using procedures consistent with the "Guideline on Air Quality Modeling (Revised)"[6].

2. plant layout information, including all emission point and fenceline locations. This information should be sufficiently detailed to allow the modeler to specify emission point and fenceline receptor locations within 2 meters of their actual locations.

3. pollutant-specific data concerning deposition or reactivity, if applicable.

4. source-specific data concerning the annual average number of releases and their duration for all randomly-scheduled intermittent releases.

Once these data have been obtained, an input file should be prepared for execution of the ISCST2 model using the guidance available in the ISC2 User's Guide[18]. The ISCST2 model should then be executed using the TOXST system. Procedures utilized should also be consistent with the TOXST User's Guide[5] (available through the electronic bulletin board, see Appendix A). Specific recommendations concerning the development of these inputs include:

1. Maximum hourly emission rates are used for the analysis. The TOXST modeling system uses "base emission rates" and "emission rate multipliers" to specify the emission rate for each pollutant/source combination. Thus, for a given pollutant and source the emission rate equals the base emission rate (specified in the ISCST2 input file) times the emission rate multiplier for that pollutant/source combination (specified in the TOXX input file). The input file to the ISCST2 program should contain the same emission rates

used in previous modeling tiers for each source, and the input file to the TOXX post-processor should be provided unit emission rate multipliers (1.0). If more than one pollutant is being emitted from the same source, that source may be included once in the ISCST2 input file with a unit emission rate (1.0) and the individual pollutant emission rates may be provided to the TOXX post-processor. (It should be noted that this may complicate the interpretation of the printed ISCST2 output. Alternatively, multiple pollutants from the same source may be modeled as individual sources with actual emission rates in ISCST2 and unit emission rates in TOXX. This may require more computing time, but may allow direct interpretation of concentration predictions in the ISCST2 printed output. Regardless of which method is used, the modeler should take care that the product of the emission rate used in ISCST2 and the emission rate used in TOXX equals the emission rate of the pollutant and source being modeled.)

2. All continuous sources of the same pollutant should be modeled as one ISCST2 source group. Each intermittent source operating independently from one another should be modeled as a separate ISCST2 source group. All intermittent sources of the same pollutant emitting at the same time may be modeled in the same ISCST2 source group. However, each source of more than one pollutant should be modeled as a source group by itself.

3. Input parameters in the ISCST2 input file should be set in accordance with the TOXST User's Guide. The regulatory default mode should be used. The ISCST2 output options should be chosen to provide summary results of the top 50 impacted receptors for each source group. (As noted earlier, if unit emission rates are being used in ISCST2, interpretation of the concentration impacts as absolute may be inappropriate.)

4. Meteorological input files for ISCST2 may be created from NWS meteorological data using the RAMMET program (this program and a description of its use are available on the electronic bulletin board, see Appendix A).

5. A polar or rectangular receptor grid may be used, but with sufficient detail to accurately estimate the highest concentrations from each source. The design of the receptor network should consider the short-term results of the earlier modeling tiers such that the highest resolution of receptors is in the vicinity of the highest predicted impacts. Additional receptors may need to be added in sufficient detail to accurately resolve the highest concentrations.

6. Where appropriate, direction-specific building downwash dimensions should be included for each radial direction.

7. The ISCST2 model option to create a TOXFILE output for post-processing should be chosen. The concentration threshold value (called "pcutoff") used to reduce the size of this binary concentration output file should be chosen appropriately to eliminate

predicted concentration values below possible concern. Although it may be set higher, a good rule of thumb for setting this value is:

$$pcutoff = \frac{LACT}{\sum_{i=1}^{n} (Npol)_i}$$

where LACT is the lowest acute concentration threshold value in the group of pollutants being modeled, and $Npol_i$ is the number of pollutants emitted from ISCST2 source group i.

The printed ISCST2 output will indicate the top 50 impacts for each ISCST2 source group, and the TOXFILE will contain all of the concentrations above the cutoff value from each ISCST2 source group at each receptor.

The ISCST2 model was exercised for the example facility. The maximum 1-hour concentrations for each source/pollutant combination were determined to be as follows:

Source	Compound	Max impact	Location
Stack 1	Pollutant A	34.5 $\mu g/m^3$	Q
Stack 2	Pollutant A	67.9 $\mu g/m^3$	R
Stack 2	Pollutant B	29.1 $\mu g/m^3$	R
Stack 3	Pollutant B	39.2 $\mu g/m^3$	S
Stack 4	Pollutant B	47.5 $\mu g/m^3$	S

The locations of the predicted maximum 1-hour concentrations are shown in Figure 2. The maximum impacts from each source were only slightly lower than those from the Tier 2 analysis.

4.3.2 Acute Hazard Index Exceedance Assessment

Concentrations from the ISCST2 master file inventory are used by the TOXX post-processor to calculate acute hazard index values for each hour of a multiple-year simulation period at each receptor site in the ISCST2 receptor array. The program then counts the number of times a hazard index value exceeds 1.0 (an exceedance) and prints out a summary report which indicates the average number of times per year an exceedance occurs at each receptor. The use of the TOXX post-processor requires the following considerations:

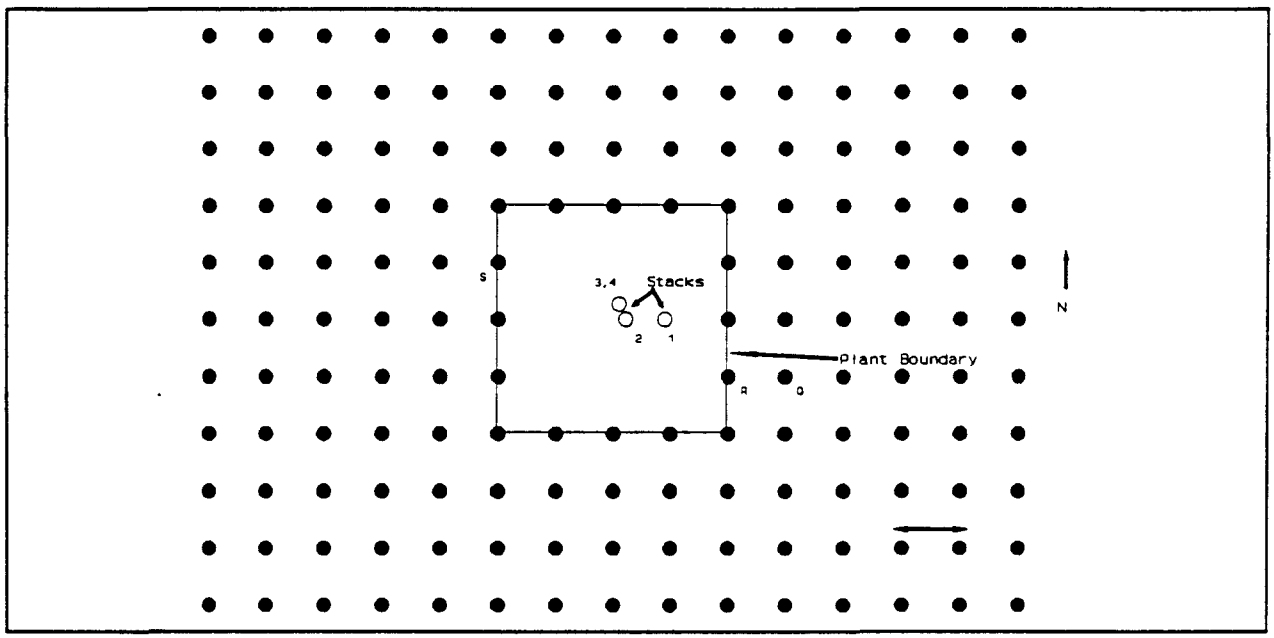

Figure 2. Schematic of Example Facility with Short-Term Impact Locations

1. As stated above, in most cases unit emission rate multipliers for each pollutant from each source are used as inputs to the TOXX post-processor.

2. Acute threshold concentration values are provided to TOXX as the health effects thresholds in the TOXX post-processor input file.

3. The TOXX output option should be chosen to output the exceedances in polar grid format. Exceedance counts at discrete fenceline receptors will appear at the end of this table in the order in which discrete receptor locations were input to ISCST2.

4. If only one pollutant is being modeled, the additive exceedance calculation option should not be chosen. If multiple pollutants are being modeled, the additive exceedance calculation option should be chosen. The TOXX post-processor should be set to perform 400 or more simulation years (maximum 1000). Unless otherwise specified by EPA guidance, background concentrations for toxic air pollutants should be set equal to 0.

5. The frequency of operation for each emission source is specified by providing values for the probability of the source switching on and the duration of the release. For each continuous emission, the probability of the source switching on is 1.0, and for each intermittent emission source, the probability of the source switching on is equal to the average number of releases per year divided by 8760 (the number of hours in a non-leap year). The duration of release for each continuous source should be set equal to 1.0, and the duration of release for each intermittent release should be specified as the nearest integer hour which is not less than the release duration. (For example, if the average release duration is less than 1 hour, the duration of release should be set equal to 1; if

the average release duration is 3.2 hours, the duration of release should be set equal to 4.0)

If the maximum number of acute hazard index exceedances in the receptor grid is less than some specified value (e.g., 0.1, equivalent to an average of 1 hourly exceedance every 10 years), the modeled source is considered to be in compliance with the acute threshold concentration criteria. However, resimulation with placement of additional receptors in the ISCST2 receptor array should be considered as a means of assuring that the simulation is not underestimating the maximum acute hazard index. If the maximum number of hazard index exceedances in the receptor array is greater than the specified value, additional runs of the TOXX post-processor with reduced emission rate multipliers may be performed to assess the impacts of possible emission control scenarios. In the case of non-compliance, it may be desirable on the part of the modeler to conduct a more refined analysis. Section 5.0 of this document discusses such possibilities.

The TOXX post-processor was exercised for the example facility using the results from the ISCST2 simulation. The frequency of operation for each source ranged from 0.14 to 0.84, reflecting the actual yearly frequency of "on" time for each source. The output showed that none of the receptors experienced an impact resulting in a hazard index value of 1.0 or greater. Comparing this result with the Tier 2 result indicates that the hazard index never exceeds 1.0 because in a Tier 3 analysis the maximum impacts are seen not to occur at the same place and time. This indicates that the facility does not cause a significant health risk from acute exposures in its current configuration.

5.0 ADDITIONAL DETAILED ANALYSES

If any Tier 3 analyses indicate non-compliance with any of the user-specified criteria, it may be desirable to conduct an additional, more refined analysis. This may mean the use of on-site meteorological data or it may mean that a more appropriate modeling procedure is deemed applicable for the specific case. The determination of an appropriate alternative modeling procedure can only be made in a manner consistent with the approach outlined in the "Guideline on Air Quality Models (Revised)"[6].

In some cases, the EPA may allow exposure assessments to incorporate available information on actual locations of residences, potential residences, businesses, or population centers for the purpose of establishing the probability of human exposure to the predicted levels of toxic pollution near the source being modeled. In such cases, use of the Human Exposure Model (HEM II)[19] with the ISCLT dispersion model is preferred. Again, if the use of other modeling procedures is desired, the approval of a more appropriate alternative modeling procedure can only be made in a manner consistent with the approach outlined in Section 3.2 of the "Guideline on Air Quality Models (Revised)"[6].

6.0 SUMMARY OF DIFFERENCES BETWEEN MODELING TIERS

To summarize the major differences between the 3 modeling tiers described in this document, Table 3 below briefly lists the input requirements, output parameters, and assumptions associated with each tier. This Table may be used to quickly determine whether a given scenario may be modeled at any particular tier. Within each tier, cancer unit risk estimates, chronic noncancer concentration thresholds, and acute concentration thresholds are required to convert concentration predictions into cancer risks, chronic noncancer risks, and acute noncancer risks, respectively.

Modeling Tier	Input Requirements	Output Parameters	Major Assumptions
Tier 1	emission rate, stack height, minimum distance to fenceline	maximum off-site concentrations, worst-case cancer risk or worst-case noncancer hazard index (short- and long-term)	Worst-case meteorology, worst-case downwash, worst-case stack parameters, short-term releases occur simultaneously, maximum impacts co-located, cancer risks additive, noncancer risks additive
Tier 2	emission rate, stack height, minimum distance to fenceline, stack velocity, stack temperature, stack diameter, rural/urban site classification, building dimensions for downwash calculation	maximum offsite concentrations, worst-case cancer risk and/or worst-case noncancer hazard index (short- and long-term)	Worst-case meteorology, short-term releases occur simultaneously, maximum impacts co-located, cancer risks additive, noncancer risks additive
Tier 3	emission rate, stack height, actual fenceline and release point locations, stack velocity, stack temperature, stack diameter, rural/urban site classification, local meteorological data, receptor locations for concentration predictions, frequency and duration of short-term (intermittent) releases	concentrations at each receptor point, long-term cancer risk estimates, chronic noncancer hazard index estimates at each receptor point, annual hazard index exceedance rate at each receptor	cancer risks additive, noncancer risks additive

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APPENDIX A
ELECTRONIC BULLETIN BOARD ACCESS INFORMATION

The Office of Air Quality Planning and Standards (OAQPS) of the EPA has developed an electronic bulletin board network to facilitate the exchange of information and technology associated with air pollution control. This network, entitled the OAQPS Technology Transfer Network (TTN), is comprised of individual bulletin boards that provide information on OAQPS organization, emission measurement methods, regulatory air quality models, emission estimation methods, Clean Air Act Amendments, training courses, and control technology methods. Additional bulletin boards will be implemented in the future.

The TTN service is free, except for the cost of the phone call, and may be accessed from any computer through the use of a modem and communications software. Anyone in the world wanting to exchange information about air pollution control can access the system, register as a system user, and obtain full access to all information areas on the network after a 1 day approval process. The system allows all users to peruse through information documents, download computer codes and user's guides, leave questions for others to answer, communicate with other users, leave requests for technical support from the OAQPS, or upload files for other users to access. The system is available 24 hours a day, 7 days a week, except for Monday, 8-12 a.m. EST, when the system is down for maintenance and backup.

The model codes and user's guides referred to in this document, in addition to the document itself, are all available on the TTN in the bulletin board entitled SCRAM, short for Support Center for Regulatory Air Models. Procedures for downloading these codes and documents are also detailed in the SCRAM bulletin board.

Documentation on EPA-approved emission test methods is available on the TTN in the bulletin board entitled EMTIC, short for the Emission Measurement Testing Information Center. Procedures for reading or downloading these documents are also detailed in the EMTIC bulletin board.

The TTN may be accessed at the phone number (919)-541-5742, for users with 1200 or 2400 bps modems, or at the phone number (919)-541-1447, for users with a 9600 bps modem. The communications software should be configured with the following parameter settings: 8 data bits; 1 stop bit; and no (N) parity. Users will be asked to create their own case sensitive password, which they must remember to be able to access the network on future occasions. The entire network is menu-driven and extremely user-friendly, but any users requiring assistance may call the systems operator at (919)-541-5384 during normal business hours EST.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

This document provides modeling guidance to support risk assessments as applied to stationary sources of hazardous air pollutants. The guidance focuses on procedures which may be used in support of the petition processes described in Title III of the Clean Air Act Amendments of 1990. The analysis approach described herein is a tiered one, in which each subsequent modeling tier requires additional site-specific information to produce a less conservative estimate of the risk associated with a given stationary source (or group of sources). The modeling approach begins with Tier 1 screening tables which require only source emission rates, stack heights, and nearest fenceline distances to estimate maximum cancer and/or noncancer risks. Tier 2 utilizes additional source parameters (including stack diameter, exit gas temperature and velocity, and nearby building dimensions) with the SCREEN computer program to develop more refined estimates of maximum risks. Tier 3 utilizes site-specific meteorological data, plant layout information, and release frequency data with the TOXST and TOXLT computer models to provide additional refinement to these assessments.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Air Pollution Atmospheric Dispersion Modeling Risk Assessment		

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