DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF LAND RECYCLING AND WASTE MANAGEMENT

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TITLE: Risk Assessment Guidelines for Facilities Burning Hazardous Waste

AUTHORITY: Hazardous Sites Cleanup Act (Act 108)

POLICY: DEP identifies the methodology that it believes is most appropriate for quantifying the risk from both inhalation and non-inhalation pathways of exposure to hazardous waste burning.

PURPOSE: This guidance was developed to aid in evaluating four types of hazardous waste burning: (1) Commercial hazardous waste incinerators, (2) boilers and industrial furnaces subject to 40 CAR Parts 260 through 271 of the rules of the Environmental Protection Agency, (3) hazardous waste incinerators subject to Chapters 127 and 264 of the rules and regulations of the Department and (4) HSCA and Superfund Cleanup sites which propose to use on-site incineration for remediation.

APPLICABILITY: This document is not intended to provide a comprehensive description of the information and activities the Department will consider in making decisions on the permitting of hazardous waste burning operations. Rather, it provides detailed information on the reisk assessment that applicants will be reuired to submit as part of their air quality permit application. In addition to the risk assessment described in this document, the Department will require the applicant to meet all other premitting requirements.

DISCLAIMER: The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements.

The policies and procedures herin are not an adjudication or a regulation. There is no intent on the part of DEP to give the rules in these policies that weight or deference. This document establishes the framework within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

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I. SCOPE

A. Introduction

This risk assessment guidance document will aid the Department of Environmental Protection in evaluating the risk associated with the release of toxic substances to the atmosphere from the burning of hazardous waste. It identifies the methodology that the Department believes is most appropriate for quantifying the risk from both inhalation and noninhalation pathways of exposure. It was developed to aid in evaluating four types of hazardous waste burning: (1) commercial hazardous waste incinerators, (2) boilers and industrial furnaces subject to 40 CAR Parts 260 through 271 Of the rules of the Environmental Protection Agency, (3) hazardous waste incinerators subject to chapters 127 and 264 of the Rules and Regulations of the Department and (4) HSCA and Superfund Cleanup sites which propose to use onsite incineration for remediation.

Because of the significant variations anticipated in the sizes, duration of incineration and types of wastes to be burned at each of these facilities, the need for risk assessment will be evaluated on a casebycase basis.

The document: is not intended to provide a comprehensive description of the information and activities the Department will consider in making decisions on the permitting of hazardous waste burning operations. Rather, it provides detailed information on the risk assessment that applicants will be required to submit as part of their air quality permit application. In addition to the risk assessment described in this document, the Department will require the applicant to meet all other permitting requirements.

This is one of two documents that will guide the Department in making air quality permitting decisions for these facilities. This document provides technical guidance on the assumptions and default factors that should be incorporated into the air Duality risk assessment analysis. The second guidance document (a risk management guidance document) will provide a comprehensive discussion of all the factors the Department will consider in deciding whether to approve the burning of hazardous waste.

This document provides guidance rather than mandated methodology. The Department recognizes the need to tailor the risk assessment to each site. This provides increased assurance that all factors contributing to the risk are appropriately evaluated. In addition, it was not made a regulation in recognition of the changing nature of risk assessment. The Department plans to allow modifications and improvements in the risk assessment methodology as scientific data are available to support the use of assumptions that differ from those included in the guidelines.

B. Activities covered be this document

This document provides guidance on the methodology that should, be used to quantify the air quality related risk associated with five different scenarios, one chronic and four acute. The one chronic scenario will provide an estimate of the risk associated with long term exposure. The scenario will use maximum operating; conditions and conservative (i.e. protective) exposure and doseresponse assumptions to develop an upper bound risk assessment. In addition, the sensitivity and uncertainty analysis will .identify the key factors which would influence the risk fromeach route of exposure and provide the range of risk due to the variations of those key factors.

The four acute scenarios will provide estimates of the risk associated with short term exposures that range from normal operation to a catastrophic event.

The risk assessment for all scenarios should include all stack and fugitive air emissions from on-site equipment and activity associated, with the handling, storage, processing and burning of the hazardous waste. In addition, the risk assessment should include the air emissions resulting from the onsite disposal of any hazardous waste or ash. At an existing Facility, the risk assessment should identify the risk due to the emission from the combustor/incinerator absent the hazardous waste burning, the burning of hazardous waste, the burning of residual waste (if any) and the burning of municipal waste (if any).

The assessment resulting from the evaluation detailed in this document should identify all plausible pathways of exposure and the amount of risk presented by each pathway. This includes the risk from direct exposure to chemicals released in the air and deposited on water or soil. The risk from indirect exposure pathways such as incorporation into the food chain should also be quantified and included in the risk assessment. The risk to both human health and the environment should be included in the risk assessment.

C. Types of pollutants covered by this assessment

Two categories of pollutants are emitted from the burning of hazardous waste: criteria and non-criteria.

The criteria pollutants are those for which National Ambient Air Quality standards have been promulgated. The standards are the maximum concentrations of the pollutants in the outside air essential to protect human health. They are set by the EPA to include a margin of safety. These pollutants include: sulfur dioxide, particulate matter less than 10 microns in size, nitrogen dioxide, ozone, lead and carbon monoxide. The risk imposed by these pollutants are evaluated in accordance with the Department’s comprehensive Chapter 127 review and are not covered in this document. The potential carcinogenic effects of specific components of particulate matter, precursors to ozone and the neurobehavioral effects of lead are covered in this risk assessment guidance document as non-criteria pollutants.

The non-criteria pollutants are the ones which are covered in this risk assessment guidance document. These are pollutants for which National Ambient Air Quality Standards have not been developed. These include: toxic metals, dioxins, furans, and organic substances that are not destroyed or are formed during the combustion process. The risk assessment methodology outlined in this document should be used to identify the substances that need to be considered in the risk assessment and the methodology that should be used to estimate the amount of risk posed by these substances.

D. Activities this document does not cover

This guidance document does not estimate or include the risk associated with transportation of hazardous waste to the facility with the exception of evaluating the risk of an accident which could occur at the facility. Offsite risk is addressed in the waste management permit application.

It is also beyond the scope of this document to provide guidance on the risk of burning any waste which is classified as explosive. Proposals to dispose of these wastes through burning would need to be evaluated on a case-by-case basis using different methodology.

E. Preparation of review of this document

This document was prepared by the Department and has been subject to review by members of the Department’s Air and Waste Quality Technical Advisory Committee. A notice of the availability of this document was published in the Pennsylvania Bulletin to solicit public comment. In addition, copies of the document were sent to individuals and organizations that have expressed an interest in hazardous waste burning or that have expertise in risk assessment methodology.

F. Applicability

The guidance provided in this document applies to: (1) commercial hazardous waste incinerators (2) the burning of hazardous waste in boilers or industrial furnaces subject to 40 CFR Parts 260 through 271 of the rules of the Environmental Protection Agency (3) hazardous waste incinerators subject to chapters 127 and 264 of the Rules and Regulations of the Department and (4) HSCA and Superfund cleanup sites which propose to use onsite incineration for remediation

II. OVERVIEW OF RISK ASSESSMENT

The risk assessment methodology, in general, uses a protective approach. This protective approach is incorporated in the scenarios to be analyzed and the methodology for calculating risk. The guidelines specify five scenarios to be analyzed, one long term and four short term. The methodology used to quantify the risk in these scenarios is structured to estimate the upper bound of risk. (The maximum risk is calculated so that: there is reasonable assurance that the real risk is less than the calculated risk.) This approach provides a measure of assurance that any approval to burn hazardous waste will result in less actual risk than the amount on which the decision to issue the permit was based.

The guidance presented in this document is based on methodology that will identify the pollutants of concern, the scenarios that should be analyzed and the plausible exposure pathways specific to a site or facility. The following summaries the steps in this methodology:

A. Identification of Pollutants of concern

The waste streams that will be burned at the facility should be evaluated for chemical composition, and each chemical should be characterized. In those circumstances where the chemicals to be burned at the facility can vary from day to day and minute to minute, the applicant should, based on the waste analysis plan, include the use of feasible worst case chemical surrogate waste streams in identifying the pollutants of concern. The potential formation of pollutants during and after burning of the hazardous waste should be considered. In addition, waste handling, storage, and processing should be evaluated to identify any potential for the release of toxic substances into the atmosphere. The pollutants of concern should include carcinogens and noncarcinogens.

B. Facility Operation Scenarios to be Analyzed

Chronic risks due to the operation of a facility should be assessed for “plausible maximum” risk assessment. The plausible maximum scenario should consider:

maximum operating conditions

predictable operating problems (e.g. pollution control and combustion equipment malfunction)

Acute risk due to operation of the facility must be assessed for four scenarios normal maximum operation, an equipment malfunction (pollution control or combustion equipment), a moderate, onsite accident and a catastrophic event.

C. Emission Estimate and Dispersion Modeling

The accuracy of the overall risk estimation is dependent on the accuracy of the emission estimates for each substance that could be released to the atmosphere. This in turn is dependent on the accurate characterization of the waste streams and combustion control processes. The emission estimates are based on factors such as the maximum amount of waste that can be burned, the efficiency and expected failure rate of air pollution control devices, the expected number of emergency bypasses, the expected formation of products of incomplete combustion (PIC), and the destruction and removal efficiency (DRE) of principal organic hazardous constituents (POHC).

Atmospheric dispersion models are used to calculate the geographic dispersion and deposition of gases and particulates that are emitted from the stack and from all other locations on the premises. Input variables include the emission estimates, stack height, meteorological data, terrain elevation, particulate size, deposition velocity and other facility specific factors. The results of the modeling are predicted ambient air concentration and deposition rates that cause ground level contamination around the source.

D. Multipathway Exposure Assessment

Both direct and indirect pathways that contribute to the total multipathway exposure are assessed in this step. Direct pathways include inhalation, dermal exposure and ingestion of water, crops and soil on which the pollutants have been directly deposited. Indirect pathways are those that result from assimilation of the pollutants into food sources, and may include fish ingestion, meat, poultry, eggs, dairy products, and cow's and mother's milk. Additional pathways also may be present on a site specific basis.

The guidance for calculating the risk associated with each of these pathways includes standard exposure assumptions. Some of the assumptions are site specific, and some require additional fate and transport modeling such as surface runoff. Nevertheless, if scientific data are available to support the use of assumptions that differ from those included in the guidelines, the different assumptions may be used upon submission to the Department of adequate supporting documentation, during the protocol approval process.

In addition, standard EPA fate and transport motels may be used to more accurately predict concentrations of contaminants in various media. For example, the models described in "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/690/003) are acceptable for those pathways covered by that manual. However, they must be used with the scenarios and exposure assumptions set forth in the Department's Risk Assessment Guidelines.

Expected exposure pathways are as follow:

Inhalation assumes continuous exposure and an average adult's respiration rate during moderate activity.

Soil Ingestion assumes that the concentration of contaminants in indoor dust is the same as outside soil.

Dermal Absorption assumes a reasonable amount of time that a person is outside (e.g. frostfree days) and includes absorption from both soil and water (swimming).

Produce uses generic or sitespecific product consumption rates and includes both home gardens and locallygrown commercial produce/fruit, if the area produces and sells produce locally.

Animal Products uses local animal product consumption rates, after first calculating the dose to the animal.

Drinking water assumes water consumption rates for surface and groundwater as appropriate and includes dermal and inhalation dosages from bathing and other household water use

Mother's Breast Milk assumes the mother is an aggregate pathway; that she can excrete contaminants in her milk; that she breast feeds a baby for a period of one year and that the child lives at the same location until a mature adult.

For calculating inhalation risk, the assumption should be made that all toxic substances remain suspended in the air and are available for inhalation. For calculating deposition risk, organic pollutants and metallic vapors should be considered as condensed particulates, while gaseous pollutants should be assumed to be adsorbed or absorbed onto particulate matter in accordance with the dispersion modeling requirements contained in Chapter 5. Only approved EPA dispersion, deposition and transport models should be used. Finally, exposures are assumed to last for a standard 70 year lifetime, not just for the projected life of the facility.

E. Risk Screening Procedure

Air contamination sources which have relatively minor risk are exempted from the multipathway exposure assessment when:

Carcinogens: Aggregate inhalation risk from all substances is more tahn one in ten million

Noncarcinogens: Inhalation risk from any substance is not more than one hundreth of the corresponding reference dose.

The ambient air concentrations of toxic substances should be calcluated using the "plausible maximum exposure" risk assessment of chronic exposure, the normal maximum operation for acute exposure in the guidance for air emmission dispersion modeling.

Note that the screening process applies to aggregate site-specific risk, not to individual chemicals or pathways.

F. Human Health Risk Assessment

When the exposure via each pathway has been determined, the concentration or dose of each substance should be combined with its toxicity factors. The results should be presented in tabular form, so that the risks posed by each chemical, by each pathway can be used to make risk management decisions. Carcinogenic risk is presented as individual risk, and non-carcinogenic risk is presented as a fraction of individual reference doses.

G. Ecological Risk Assessment

Ecological risk assessment is a very important component of risk assessment. Ecological Risk, in combination with applicable environmental exclusionary siting criteria and the consideration of environmental assessment consdierations found at 25 PA Code section 269.50, would result in a comprehensive environmental assessment. Because specific guidelines or qualitative risk assessment information are under development by EPA, comprehensive methodology for assessing environmental risk will not be presented here. Ecological risk assessment remains a goal of the agency and methods will be incorporated into future risk assessments as they are developed.

At a minimum, the applicant should consider the ecological risk from the proposed facility within the guidelines of Section 269.50. Where one of the identified environmental features listed within this section occurse within the specified distances, the risk associated with this feature should be evaluated.

H. Sensitivity and Uncertainty Analyses

The risk assessment should display the uncertainty associated with the results using a probalistic distribution around major input variables that have paramaetric properties (such as emission estimates). At least the mean, standard deviation and the percentiles of the distribution of possible results should be reported.

The sensitivity analysis should vary both the input parameters and exposure assumptions to determine how much an effect each has on appropriate pathways and on the final aggregate risk. It should include an estimate of the effect that the most influential variables have on the risk assessment.

The uncertainty analysis should include a narrative description of the sources of uncertainty and an estimation of the magnitude of their effect. The sensitivity and uncertainty analysis should be performed and presented separately for each route of exposure.

I. Application of Completed Risk Assessments

The health and ecological risk assessments, along with the sensitivity and uncertainty analyses, will be used by the Department in reviewing air quality permit applications to burn hazardous waste. The Department's decisions on whether to approve any hazardous waste burning will be guided by the risk management document.

III. POLLUTANTS OF CONCERN

The risk assessment document should include an evaluation of the risk associated with the potential release to the atmosphere of any basic pollutants from the handling, storage, processing or burning of hazardous waste. The potential pollutants identified should include both carcinogenic and noncarcinogenic pollutants and account for the potential risk that would result from all processes associated with the burning of hazardous waste. The following activities need to be analyzed to identify potential pollutants.

The chemical composition of the waste streams using feasible worst case chemical surrogate waste streams.

Pre-combustion activities (transfers, storage, mixing/blending, feeding), and post-combustion disposal or use, including substances identified through other facility permits.

Combustion and emergency stack use (POHC, PIC, metals, total hydrocarbons, particulates, acids and other pollutants.)

Other activities on the site, such as recycling and on-site landfilling.

The risk assessment should identify the characteristics of each waste stream to be burned. The characteristics identified should include, but are not limited to: moisture content, BTU content, flash point, viscosity, waste feed particle size, presence and anticipated concentration of the elements Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur and Phosphorus, the pH, and the presence and anticipated concentrations of halogens, total halides, heavy and/or toxic metals, and specific toxic substances. Chemicals burned as fuel (i.e. containing greater than 8000 BTU/lb.) are to be included in this description. Any on-site mixing or blending methods to burn "batches" of waste should be described. The description of mixes should include a determination of BTU and the other listed characteristics. Both annual average composition and potential range of variability should be described.

Formation of PICs under various operating conditions of the particular type of combuster should be described. The correlation of PIC formation, DRE and POHC with temperature variation, chlorine content and total halides in the waste, carbon monoxide and total hydrocarbons should be documented.

Examples of the types of pollutants that could be emitted from the burning of hazardous waste should be accounted for and include, but are not limited to: toxic metals, acid aerosols, PCBs (polychlorinated biphenyls), chlorobenzenes and chlorophenols, pesticides, insecticides, fungicides, dioxins/furans, PICs and those organic substances which may be difficult to burn (POHCs). The Department may identify and address additional pollutants of concern during review of a specific application.

Toxic pollutants and hazardous wastes for which the Department has regulatory implementation responsibilities are listed in the following federal statutes: Clean Air Act (List of Hazardous Air Pollutants), Clean Water Act (List of Priority Pollutants), Safe Drinking Water Act (List of MCL chemicals), Resource Conservation and Recovery Act (Lists of Hazardous Waste) and the Department's regulations.

Hazardous waste is divided into two broad types: listed and characteristic. Listed hazardous wastes contain one or more of approximately 400 substances that are toxic, ignitable, corrosive or reactive. Waste may be listed as hazardous if it comes from non specific sources ("F" waste), from specific industrial processes ("k" waste), certain discarded commercial products ("U" waste), or is a discarded, acutely hazardous commercial product ("p" waste).

Characteristic hazardous waste exhibits properties of ignitability, corrosivity, reactivity, or contains certain materials that leach at higher than specifiers levels (toxicity characteristic). waste types tend to be listed as generic categories, such as "spent halogenated solvents used in degreasing" or "still bottoms."

Each waste "batch" should be tested for specific chemical composition in the manner described at the beginning of this chapter.

IV. FACILITY OPERATION SCENARIOS TO BE ANALYZED

A. Chronic Risks

The following scenario should be analyzed to quantify the chronic health effects (cancer and non-cancer effects):

> "Plausible Maximum Risk Assessment. The risk assessment should use maximum operating conditions and the conservative exposure and dose response assumptions discussed in this document. In addition, expected failures in the air pollution control and combustion equipment and the use of a bypass stack should be considered in the assessment. The maximum operating conditions should be the maximum rated capacity of the facility or the operating limitations included in the permit application. The plausible maximum risk assessment: should provide an upper bound risk assessment. The risk quantified would very likely be substantially greater than the actual risk expected from the operation of the hazardous burning unit.

Chronic risks for the plausible maximum risk assessment should be assessed on the basis of maximum annual air contaminant emission rates determined using the maximum hourly operating rates requested in the plan approval application (i.e. hours of operation, maximum amount of waste that would be burned per flour, etc.). The annual emission rates used in this assessment also are to reflect predictable operating problems (suboptimal operating conditions), such as process upsets, emergency bypasses and air pollution control equipment malfunctions. A detailed explanation of the suboptimal operating conditions, the expected frequency and duration of their occurrence and their impact on the determination of the annual emission rate values used in the risk assessment should be provided with the assessment.

Any permit issued will limit the facilities operation to the information used in the plausible maximum risk assessment. Any subsequent request for operation increases or major modifications in operation levels will require modifying the plausible maximum risk assessment for evaluation of that request.

B. Acute Risks

Four scenarios should be analyzed to describe acute health effects. The four scenarios are: maximum normal operation; an equipment malfunction; an onsite accident; and a catastrophic event. The assessment should discuss the likelihood, duration and implications to human health and the environment of each scenario, and should include the air emissions from any and all likely release routes (air, land, and water).

1. Normal maximum operation. This scenario should be based on the maximum hourly emission rates that would occur from the facility operating at the maximum rated capacity or the maximum operating conditions requested in the permit application. It does not include malfunctions.

2. An equipment malfunction. This scenario should analyze any disruption of the combustion process in which the contents of the combustion chamber are exhausted through a bypass stack, or the failure of a major component that results in a substantial reduction in the effectiveness of the air pollution control equipment. The potential effects of a power outage should also be considered.

3. An onsite accident. This scenario should analyze a rupture of a storage tank, spill of a volatile substance during handling or storage or an event of a similar magnitude. It should include the release of a volatile carcinogen and an acute irritant, where these wastes are proposed for incineration, and should identify both the incremental cancer risk as well as the acute noncancer risk. Include the nearest waterway as a possible recipient of liquids spilled onsite, where it is feasible that a spill at the facility could reach the nearest waterway. Transportation accidents occurring at the facility should be evaluated under this scenario.

4. A catastrophic event. This scenario should analyze an explosion and fire to storage tanks, or an event of a similar magnitude. Fault tree analysis including both human error and equipment failure, should be provided as well as the severity of the consequences of the event.

The situations to be considered for the moderate and catastrophic event scenarios should be based on, but are not limited to, those situations addressed in 25 Pa. Code §264.51264.56 pertaining to Preparedness, Prevention & Contingency Plans (i.e. fire, explosion, emission or discharge of hazardous waste or hazardous waste constituents to air, soil, surface water or groundwater).

AIR EMISSION ESTIMATES AND DISPERSION MODELING

A. Emission Estimates

The emission data for each of the pollutants of interest are to be reported for individual emitting processes within the facility. *Emitting* processes include, but are not limited to, the handling, storage, processing, burning and the onsite disposal of any hazardous waste or ash. The emission factors used in calculating emissions and the emission quantification method used (i.e. source test results or an alternative estimation method) for each emission factor should also be reported. Information regarding the hours of operation should be reported for each emitting process.

The emission estimates are required to be submitted as total annual emissions. For acute scenarios of less than one hour, emission rates during the release period should be provided. The emission estimate also should include the frequency of hourly maxima. These emission estimates should be completed for the scenarios that are required to be analyzed as part of the risk assessment.

For each stationary process unit that handles, stores, processes, or burns hazardous waste, a total mass balance of major substances must be performed. The mass balance should indicate how much of each chemical in the feed is burned or released to the atmosphere and all other waste streams. The mass balance should include the fugitive emissions, stack exhaust, scrub/wash water, ash, etc.

An analytical scan of the emissions should be performed, wherever possible, to identify the individual organic substances being emitted. It is understood that the emissions could contain some groups of organic compounds that are very difficult to separate into individual substances. The mass fraction of the groups of organic compounds that cannot be separated into individual substances should be determined. Dioxins and furan should not be included in the groups of organic compounds that cannot be separated.

Tables showing emission estimates and toxicity factors for each substance should be presented. For identified substances without potency factors, their mass should be included in the total mass of unidentified emissions, and the total unidentified mass should be assigned toxicity factors equal to he average toxicity of the identified substances.

The distributions of metals among air emissions, fly ash, and bottom ash should consider particle size range, chemical specifications, chlorine con cent of the caste, temperature, oxidation efficiency and how volatile forms of the metals (especially lead, cadmium, mercury, ‘arsenic) are formed. If no actual monitoring data is available, the metal emission should be based on worst case chemical surrogate waste streams, and the massbalance with predicted rtitioning should be presented. A discussion of surface area weighting or massweighting for particulate adsorption should be included.

Exhaust Conditions

In addition to emission quantities from all emission points, the mode of release of air contaminants such as fugitive, stack or roof nitors and the exhaust parameters (temperature, velocity, release weight, etc.) should be reported. The release parameters required are specific to the model utilized for each emission point.

Modeling Requirements

The acquisition of site representative meteorological data by the applicant should be considered as soon as possible after the proposed site and facility meets preliminary siting criteria. Whereas some smaller facilities may be granted air quality permits based on screening r quality dispersion modeling, it is more likely that the majority of proposed facilities will require. refined modeling utilizing at least year of meteorology. Therefore, it is recommended that the applicant consult with the Department's meteorologist early in the application process.

Not less than one year of siterepresentative meteorological data will be acceptable for refined air quality modeling. This policy is applicable to both simple and complex terrain modeling domains. In most cases meteorological data from nearby airports are not suitable for risk assessment modeling.

The Department recommends that the applicant use the procedures for e siting of meteorological observation networks outlined in the EPA publication No. EPA450/487007 "Ambient Air Monitoring Guidelines for prevention of Significant Deterioration", 1987. Even if the proposed facility does not meet the criteria for a PSD analysis, the guidance is applicable to all air quality monitor and meteorological data acquisition siting requirements. Another EPA document in planning a meteorological data acquisition site is A450/487013 "OnSite Meteorological Program Guidance for Regulatory Modeling Applications." This guidance document outlines in detail Meteorological instrumentation options and quality assurance procedures.

The Department requires that a formal protocol defining the Meteorological data acquisition program be submitted for approval before collection commences. This protocol should define items such as the site location, general topographical description, height of the proposed tower, and description of the meteorological instruments to be installed. A description of. quality assurance procedures to be used in the acquisition program should also be submitted.

Prior to beginning any refined air Duality modeling, the Department squires that the applicant: develop a modeling protocol and submit it to he Department meteorologist for review. The protocol should include a description of the models proposed for use in the analysis. For refined modeling, one year of onsite meteorological data should bee used as input to the selected model. This protocol also should include a description of the facility, emission estimates, exhaust parameters, a plot plan of the proposed facility and the dimensions of buildings adjoining the source stack.

The selection of the model/models to be used in the dispersion analysis is site/facility dependent. Reference Document II provides information regarding model selection. Due to the continuing state of specialty model development, the applicant should consult the Department meteorologist for guidance. Decisions regarding model selection are made on a casebycase basis according to facility/site specific parameters.

VI. MULTIPATHWAY EXPOSURE ASSESSMENT

This section of the risk assessment provides guidance on the calculation of the dose of each chemical received by various receptors through each major pathway or route of exposure.

Before proceeding with the actual risk assessment, the applicant should submit to the Department a risk assessment protocol which defines the general approach! the sitespecific pathways and input parameters (or methods by which these will be obtained), any parameter for which documentation for use of alternative values will be requested, and other items described in these guidelines.

A. <u>General assumptions</u>

The risk assessment should be based on the following assumptions:

1. For inhalation, all toxic pollutants should be assumed to be in a form that is respirable including all particulates and organic vapors. The dispersion modeling should assume that there will be complete plume reflection.

2. For noninhalation routes of exposure, all toxic pollutants should be assumed to be in a form that will be deposited on the surface. The dispersion modeling should assume that deposition will account for all pollutants in the plume. Deposition velocity shall be estimated by the methods of Sehmel and Hodgson.

3. The emission rate is or should be assumed to be constant for a 70 year period. The risk assessment should consider the release of toxic pollutants to the atmosphere from all applicable sources at the site. Stack and fugitive air emissions from the handling, storage, processing and burning of hazardous waste and the onsite disposal of any hazardous waste or ash should be included in the Risk Assessment.

<u>Description of the site and surrounding area</u>

The applicant should qualitatively describe the area surrounding the location of the proposed facility. The description should include: land use patterns (present and anticipated) 2) population characteristics including sensitive receptors (such as schools, nursing homes, hospitals) 3) ecological undeveloped areas (wetlands, watersheds, etc.) and 4) nearby industrial or commercial activity. The study area is defined as the area for *which* excess lifetime cancer risk from all pollutants is equal to or greater than 10-7 from inhalation. The study area must be approved by the Department prior to submittal of final risk assessment report.

<u>Zone of intact</u>

To depict the potential toxic impacts, the applicant should provide maps of normalized concentration isopleths for each of the following: the annual average ground level concentration of pollutants; 2) the annual average ground level deposition rate; 3) the 1 hour maximum ground level concentration; and 4) the less than 1 hour acute exposure Concentration. The annual average maps should also identify the points If maximum concentration and reposition. Figures 1, 2A, SIB, 3 and 4 Provide examples for this mapping.

The annual average ground level concentration map should be accompanied by a map which converts the concentration isopleths to aggregate inhalation risk isopleths for carcinogenic and noncarcinogenic pollutants. The risk isopleth map should be correlated with a table specifying the concentration and inhalation risk associated with each pollutant, including unidentified emissions (see Table 1 for an example) Figure 5 provides an example of these maps.

The maps should also show the area in which the total excess lifetime cancer risk from inhalation is equal to or greater than 107, and the location and risk of the hypothetical individual with maximum inhalation exposure.

(Note that this process males the risk to ensure that all the significant risk areas in the impact area have been identified; it does not identify the acceptable levels of risk.

For the non-carcinogens, the maps should also show the area in which the total risk from inhalation is greater than one hundredth of the reference dose for the substance that poses the greatest risk. The isopleths should be normalized for noncarcinogens and keyed to a table that shows the percent of reference dose for each non-carcinogen, including unidentified emissions. (see Table 2 for an example)

In addition, each, map should identify locations where sensitive receptors may be present on a regular basis (such as schools, nursing homes, hospitals, etc.) within the following zones: 1) the 10 (6) (1 in 1,000,000) risk zone, 2) 1 mile of the facility boundaries and 3) 1 mile of the maximum hour ground level concentration.

The annual average ground level deposition map should also identify the location of the point of maximum deposition. Tables should be provided which list the risk resulting from carcinogens and noncarcinogens (including unidentified emissions) for each route of exposure and each pollutant in different zones or at specific locations. (see Tables 3 and 4 for examples)

D. Land use within the impact area

1. Residential exposure scenarios and assumptions should be used whenever there are or may be residences near the site. Under this land use scheme, residents are expected to be in frequent:, repeated contact with contaminated media. The assumptions in this case account for daily exposure over the long term.

   a. Agricultural scenarios (for farm families) include assumptions of homegrown produce, milk, meat, poultry and eggs, and also includes assumptions of pasturage and homegrown livestock feed. Assumptions for farm families are the same as other families except they are assumed to produce 75% of their own total diet.

   In rural areas a hybrid of the two scenarios will pertain to many residents, such as the fraction of diet grown and consumed locally.

3. Recreational land use includes hunting and fishing, and other outdoor activities. These should be developed on a sitespecific basis. It also includes “trespassers” or “site visitors.” Recreational use should account for hunting and fishing seasons, but should not ignore the potential for subsistence (outofseason) catches. Factors which limit exposures can also be included, such as a school year which limits outdoor activities, but plausible maximum exposure should be used.

This document also contains several tables and figures. If you would like to have them, please call our office and request a paper copy of this document.

VII. INSIGNIFICANT RISK SCREENING PROCEDURE

This section sets forth a screening procedure that can be used to exempt from the multipathway exposure assessment those sources or facilities which have relatively minor risk.

Any hazardous waste burning operation that would result in ambient air concentrations of toxic substances that meet the following criteria air concentration of toxic substances that meet the following criteria shall be exempt from preparing the multipathway exposure assessment.

Carcinogens Aggregate inhalation risk from all substances of not more than one in ten million.

Non-carcinogens Inhalation risk from each substance of not more than one hundredth of the corresponding reference dose.

The ambient air concentrations of toxic substances should be calculated using the "plausible maximum" risk assessment, and the guidance for air emission dispersion modeling. The risk should be calculated for the Maximum Exposed Individual.

VIII. HUMAN HEALTH RISK ESTIMATION

After the exposure (or dose) of each pollutant is calculated, the maximum individual excess lifetime cancer risk, and estimated acute and chronic noncancer health effects should be calculated. Exposure should be assumed to continue for 70 years.

The risk assessment should include a discussion of the adverse health effects associated with each major pollutant and/or pollutant class, including teratogenicity, carcinogenicity, mutagenicity, immunotoxicity, neurotoxicity, reproductive effects and wildlife or ecological effects where known. Primary or secondary references should be given.

In addition, the risk associated with organic compounds that cannot be separated into individual substances should be assumed to have a toxicity equivalent to the weighted average toxicity of the substances which are separately evaluated.

A. Estimation of Cancer Risk

Risk = Dose x Slope Factor

or Risk = Ground Level Concentration x Unit Risk

Sources of unit risk factors or cancer potency slope factors should generally be limited to EPA documents. The preferred source is IRIS (EPA's Integrated Risk Information System), an informational database that contains EPAwide consensus on the carcinogenicity classification of many chemicals, their references doses and potency factors, and summaries of the data that were used during the deliberations. A secondary source is HEAST (quarterly Health Effects Assessment Summary Tables), also prepared by EPA. Any other source of toxicity factors, should none exist in either of the EPA databases, should be documented.

All carcinogens for which a cancer potency factor has been calculated, should be included in the risk assessment. For carcinogens (class A, B and C) for which no potency factor has been calculated, a Reference Dose divided by 10 should be used for the carcinogenic routes of exposure. Substances which have been determined to be carcinogenic by only one route of exposure may use the reference dose for the noncarcinogenic routes.

B. Estimation of Non-Cancer Risk

Acute and chronic noncancer health risks are determined by comparing the exposure doses to health effect levels.

The noncancer effects should be estimated using a hazard index approach. The hazard index is defined as the ratio of actual intake of any chemical to its "reference dose". The reference dose is the concentration calculated by EPA to generally be below that which would be expected to cause any adverse health effects in the most sensitive tissue in the most sensitive subpopulation over a lifetime of exposure.

Some carcinogens also have noncancer toxicity, i.e. they also have reference concentrations as well as cancer potency factors. These should be used in assessing noncancer risk.

Chronic Effects should be estimated using the annual average concentrations and comparing them to reference doses or reference concentrations.

For short-term or Svelte effects, the magnitude and frequency of hourly maxima expected during "normal" operations should be addressed separately, and compared to acute or subchronic inhalation values (available in EPABIF rules, CAPCOA, CARB) and shortterm drinking water health advisories (EPA), as appropriate. In addition, under the accident scenarios, acute exposures due to accidental releases should also be compared to these standards. Both types of comparisons should address known locations of sensitive receptors.

C. Risk Reporting

1. Chronic Inhalation Disks (Plausible Maximum Scenario)

The annual average ground level concentration map as required in section VI (C) should be converted to a series of risk based isopleths in two maps. One map should be for carcinogenic risks (Table l) and the other for noncarcinogenic risks (Table 2). These maps are generated by combining the actual average concentration with the chemical specific potency factors (unit risk, cancer slope or reference dose as appropriate) from all pollutants where the applicant determines a

chemical to be not applicable for a particular pathway, explanation should be provided which explains why the chemical was determined not to be applicable.

For example: a normalized isopleth concentration of x ug/m^3 would be converted, into cumulative cancer risk as follows: An emission rate of 1 gm/sec produces a ground level concentration (GLC) of x ug/m^3.

For Carcinogens:

risk = x * E1 * Pf1 + E2 * Pf2 + ...]

where: E1 = emission rate of pollutant 1 (gram/sec).

Pfl = potency factor (unit risk estimate) of pollutant l (mg/m3)1.

For noncarcinogens:

DoseInhalation (mg/kg/day) = 20 m^3/day * GLC = GLC * 0.000286

70 kg * 1000

Reference dose (RfD) is expressed as mg/kg/day

Hazard index (HI) = DI/RfD

risk = Hl = x * 0.000286 [(E1 / Rfdl) + (E2 / RfD2),+ ...]

2. Inhalation Tables

The risk isopleth maps should be correlated with tables specifying the concentration and chronic inhalation risk associated with all pollutants.

3. Non-Inhalation Chronic Risks

The maximum risk from each pathway for both carcinogens and noncarcinogens must be computed and the location of the maximum risk for each pathway must be identified.

For example: For soilbased pathways, (such as soil ingestion, dermal absorption of soil and homegrown produce) the maximum risks will be calculated using the maximum deposition rate of the pollutants on the soil. For the waterbased pathways, (such as fish intake or ingestion of water) the actual deposition rates on the water bodies will be used. If several water bodies are present in the study area, the risk from each water body must be calculated and identified in the risk assessment. The maximum risk from each pathway for each pollutant should be presented in a table. In this table the cumulative risk from al' pollutants for each pathway shall also be included.

4. Average Chronic Risk From the Study Area

The risks for each pathway for the study area should be calculated using the areaweighted average ground level air concentrations over the study area and the areaweighted average deposition rates of all pollutants. The deposition rates of the pollutant are also averaged over the study area. The emission rates of the pollutants are derived from the "plausible maximum" scenario. The resultant risk from each pathway for each pollutant should be presented in a table. In this table the cumulative risk from all pollutants for each pathway should also be included,. (see Table 3 for an example)

<u>References</u>

1. EPA. Methodology for Assessing Health Risk Associated with Indirect Exposure to Combustor Emissions. January 1990 (EPA A/600/690003)

2. EPIC. Exposure Factors Handbook, July 1989 (EPA/600/889/043)

3. EPA. Superfund Public Health Evaluation Manual, October, 1986. (EPA/540/l86/060). and: Supplemental Guidance: "Standard Default Exposure Assumptions." OSWER Directive 9285.603.

4. EPA. Superfund Exposure Assessment Manual. April 1988 (EPA/540/188/001).

5. ERA. The Risk Assessment Guidelines of 1986. April, 1987 (EPA/600/887/045).

6. EPA. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." OSWER Directive 9285.603.

7. CAPCOA (AB 2588 Risk Assessment Committee of the California Air Pollution Control Officers Association). Air Toxics "Hot Spots" Program Risk Assessment Guidelines. January 1991.

8. CAPCOA Air Toxics Assessment: Volume I: Toxic Air Pollutant Sources Assessment Manual. October, 1987.

9. EPA. Hazardous Waste Incineration Guidance Series, volumes I through VI.

10. ERA. Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (part A) [a revision of #2].

11. Travis CC and Cook SC. <u>Hazardous Waste Incineration and Human Health</u>, CRC Press, Boca Raton, FL. 1989.

12. EPA. Proposed rule regulating use, disposal of sludge from pulp, paper mills using chlorine bleaching processes (40 CFR Part 744, May 10, 1991), and supporting documents.

13. EPA. Final rule regulating the Burning of Hazardous Waste in Boilers and Industrial Furnaces (40 CFR Parts 260, 261, 264, 265, 266, 270, and 271, February 21, 1991).

Reference Document 1

ACRONYMS AND DEFINITIONS

BIF EPA Boilers and Industrial Furnaces air emission standards for the burning of hazardous waste, final rules, 22191

CAPCOA, California Air Pollution Control Officers Association

CARB, California Air Resources Board

CEM. Continuous Emission Monitoring

DEP Pennsylvania Department of Environmental Resources

Dioxin Polychlorinated and Tetrachlorinated DibenzopDioxins

DRE Destruction and Removal Efficiency

EPA U.S. Environmental Protection Agency

Furan Polychlorinated and Tetrachlorinated Dibenzofurans

GLC Ground Level Concentration

HC Hydrocarbons

HEAST EPA's quarterly Health Effects Assessment summary tables

Hexavalent in this document refers to chromium in its valence state of 6.

HWI Hazardous Waste Incinerator

IARC International Agency for Research on Cancer

IRIS EPA's Integrated Risk Information System

Isopleth the line on a map which outlines a zone of risk or pollutant concentration level

MEI Maximum Exposed Individual

NAAQS National Ambient Air Quality Standards

NPDES National Pollutant Discharge Elimination System

OSWER Office of Solid Waste and Emergency Response

PAH Polyaromatic Hydrocarbons

PCB- Polychlorinated Biphenyl

PCDD/PCDF - Polychlorinated Dibenzo-p-Dioxins/Dibenzofurans

PIC - Product of Incomplete Combustion

POHC - Principle Organic Hazardous Constituent

PSD - Prevention of Significant Deterioration

RAFT - Risk Assessment Fate and Transport Modeling System

RfC - Reference Concentration

TCDD/TCDF - Tetrachlorinated Dibenzo-p-Dioxins/Dibenzofurans

TEF - Toxicity Equivalent Factor (for PCDD/DF)

TRI - Toxics Release Inventory

Reference Document 2

RECOMMENDED AIR QUALITY MODELS AND PROCEDURES FOR REFINED RISK ASSESSMENT

There are numerous models which may be used in determining risk assessment impact. Only a few have been listed below. In general, the Department requests that the applicant use recognized “guideline” models in the analysis. (These “guideline” models have been developed specifically by the Environmental Protection Agency to address a great variety of impacts. The models are reviewed and tested rigorously before attaining the status of “guideline”.) The models used are sitespecific and decisions regarding the applicability of a given model should be made on a casebycase basis. Therefore, the Department requires that the applicant discuss the models proposed for the analysis before dispersion modeling is performed.

Guideline models are designed to estimate groundlevel concentrations of pollutants in simple or complex terrain. (Simple terrain refers to receptor points at or below the stack height of the emission source. Complex terrain refers to receptor points that are located above the source height of the emitter.)

For certain facilities with relatively low potential hazardous waste emissions the applicant may wish to consider using the EPA guideline model SCREEN or TSCREEN. SCREEN is a computer model update the manual procedures originally contained in the original Volume 10 of the “‘Guidelines for Air Quality Maintenance Planning and Analysis” and the later Vol. 10R. The program can be used to generate estimates of groundlevel concentrations from stationary sources under various operating conditions in simple or complex terrain. Options are available that consider building effects, receptors above groundlevel, and fumigation. The SCREEN morel produces estimates of maximum 1h groundlevel concentrations of the pollutant. An estimate of the annual concentration may be determined by multiplying the onehour value by a factor of 0.08.

TSCREEN is a screening model which is used to estimate ambient concentrations from various toxic/hazardous instantaneous or continuous emissions. This model is described in a ‘‘Users Guide to TSCREEN, A Model for Screening Toxic Air Pollutant Concentrations” EPA450/490013. This computer model supplements the document “A Workbook of screening Techniques for Assessing Impacts of Toxic Air Pollutants” EPA450/488-009.

The guideline models ISCST, ISCLT and COMPLEX 1 currently serve as the basic models for use in risk assessment studies. Users guides for these models are referenced in “Guideline on Air Quality Models (revised).” EPA450/278027R and Supplement A.

The models listed above should be used when refined air quality modeling is required to support the permit application. These models their guideline form are normally used to develop estimates of groundlevel concentrations (ug/m3) for the inhalation phase of the analysis. Studies based upon operating e experience have shown most hazardous waste particulate emissions to be less than 2 micrometers in diameter during normal operation. Therefore, these emissions can be treated as gaseous for the purposes of modeling. The annual groundlevel concentrations produced by these models are referenced to tabular concentrations with predetermined carcinogenic riskspecific doses.

Quite frequently within the Commonwealth, the proposed site is located in an area where a combination of simple and complex terrain exist within the modeling domain. In this event, the applicant will be required to model the proposed facility utilizing the "intermediate terrain" concept. Further guidance on this procedure is provided in EPA modeling documents.

The EPA recently announced toxic analysis versions of ISCST and ISLET names TOXST and TOXLT, respectively. These computer codes are referenced, but not described in the document, "A Tiered Modeling Approach for Assessing the Risks Due to Sources of Hazardous Air Pollutants", March 1992(EPA450/492001). Users guides for these models are in preparation, but are listed as references below. Unlike the basic ASCOTS and ISCLT models, these models have been expanded to develop master files for postprocessing for risk assessment. TOXST estimates maximum 1hourly groundlevel concentrations and receptorspecific expected annual number of exceedances of shortterm concentration thresholds. Acute hazard index values are calculated at each receptor by the TOXX postprocessor in which a Monte Carlo simulation is performed for intermittent sources.

TOXLT uses STAR meteorological data to produce estimates of annual sroundlevel concentrations at user specific receptors. A postprocessor called RISK subsequently calculates lifetime cancer risks and chronic non-cancer hazard index values at each receptor.

Certain portions of the risk assessment application will require the development of deposition estimates as input to multi~pathway analyses described elsewhere in this document. Deposition values calculated by the guideline models are normally expressed in terms of grams per square meter per year. Although both ASCOTS and ISCLT have dry deposition options, there is general agreement among regulatory agencies and consultants that these algorithms should not be used to develop deposition estimates. It is recommended that the guideline computer codes be altered to allow for the calculation of deposition velocity based on particle size, surface characteristics and atmospheric conditions. These techniques are based upon the work of Sehmel and Hodgson and have been adopted for computer applications by the California Air Resources Board.

Because wet deposition processes do contribute to the total groundlevel concentration of a toxic pollutant, the applicant is encouraged to include this potential effect in the deposition part of the analysis. However, the integration of precipitation data into the standard dispersion equations in order to assess the "washout" of pollutants in a plume is difficult. In addition to hourly meteorological data normally used in a computer model, detailed information on precipitation events in the source area is required. The scavenging process is dependent upon particle size, the physical and chemical characteristics of the particle, and the precipitation rate. Hanna et al. (1982) and Yamartino (1985) provide additional details on the topic.

For complex terrain analyses, the deposition algorithms discussed above may be applied to the guideline models COMPLEX 1 and RTDM. However, risk assessments based upon these models must be carefully evaluated because of the assumptions present in all Gaussian complex terrain models.

The applicant is not restricted to using the models listed above. Several other models may be considered for plantspecific and sitespecific applications. In addition, models developed subsequent to the release of this guidance document and applicable to a particular project should be submitted to the Department meteorologist for review. A brief list of specialized models follows:

1) INTOXX (Integrated Toxic Expected Exceedance).

   This model utilizes the dispersion output from ASCOTS to develop estimates of "expected exceedances" of defined "thresholds" from intermittent releases of airborne toxic chemicals. The main model TOXX simulates random, intermittent emissions and estimates expected exceedances. It can combine separate calculations of exceedance of multiple threshold concentrations in a single execution and calculate exceedances from the combined effects of simultaneous releases of two to eight toxic pollutant species.

2) INPUFF

INPUFF is a Gaussian integrated puff model designed to estimate accidental (instananeous) or continuous releases from a stack. Estimates of groundlevel concentration can be made for multiple point sources for up to 100 receptors and 144 separate meteorological periods.

REFERENCES

"Screen Procedures for Estimating the Air Quality Impact of Stationary Sources", EPA450/488010, August 1988 (DRAFT).

OR

"The SCREEN Model User's Guide (In preparation) EPA450/492006.

"User's Guide to TSCREEN, A Model for Screening Toxin Air Pollutant Concentrations" EPA4507490013.

"A Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants" EPA450/488009.

"A Tiered Modeling Approach for Assessing the Risks Due to Sources of Hazardous Air Pollutants", March 1992. EPA450/492001.

"Toxic Modeling System ShortTerm (TOXST) User's Guide" EPA450/492002.

"Toxic Modeling LongTerm (TOXLT) User's Guide" EPA450/492003.

"Deposition Rate Calculations for Air Toxic Source Assessments" CARB, Air Quality Modeling Section. September 16, 1987

"A Model for Predicting Dry Deposition of Particles and Gases to Environmental Surfaces." Sehmel, G.A. and W.H. Hodgson, 1978. Battelle Pacific Northwest Laboratories, U.S. Department of Energy PNLSA6721

"Handbook on Atmospheric Diffusion". Steven R. Hanna, Gary A. Briggs, and Rayford P. Hosker. 1982. Technical Information Center, U.S. Department of Energy.

"Handbook of Applied Meteorology". Edited by D.D. Houghton. 1985. John Wiley and Sons

Reference Document 3

EXPOSURE ALGORITHMS AND EXPOSURE FACTORS

Exposure algorithms and recommended default values are presented below. Exposure factors should be the default values provided in this document, or in EPA or CAPCOA manuals. If sitespecific values are calculated (which is required for some pathways), they should be "plausible maximum values" and submitted to the Department for review in advance. If scientific data are available to support the use of assumptions and default values that differ from those included in the guidelines, the different assumptions may be approved upon the submission to the Department of adequate supporting documentation. However, the Department recommends, for the sake of consistency, the use of simple (and usually the most conservative or protective) assumptions. Not all of. the CERCLA assumptions used in the Exposure Factors Handbook are considered appropriate for application to airborne exposures.

NOTE: The risk assessment should use 70 years as the anticipated exposure period for carcinogens. The exposure period should not be based on the expected facility life or the “average.’ length of residential occupancy.

SPECIFIC EXPOSURE PATHWAYS

A. Estimating Concentration. in Air, Soil and Water

1. Air

GLC = Emission rate (g/sec) x X/Q ($ug/m^3/g/sec$)

GLC = ground level concentration (ug/m^3)

X/Q = Dilution factor provided by dispersion modeling

2. Soil

C(soil) = Dep * [l.0exp(Ks*Tc)] *10^5

Z * BD * Ks

C(soil) = soil concentration of pollutant after total time period of deposition (ug/kg)

Dep = annual deposition rate of pollutant ($g/m^2/yr$)

Ks = soil loss constant (yr^{-1})

Tc = total time period over which deposition occurs 70 years individual not affected by mothers milk pathway . See assumption #3.

26 years mother’s exposure in breast milk pathway

44 years adult in mother’s milk pathway

Z = depth of incorporation (cm)

1 cm (play grounds, residential);.15 cm (agricultural)

BD = solid bulk density (g/cm^3)

Ks = Ksl + Ksd + Ksv

Ksl = Soil loss constant due to leaching (yr^{-1})

Ksd = Soil loss constant due to degradation (yr^{-1})

Ksv = Soil loss constant due to volatilization (yr^{-1})

Ksl = P + I Ev

Z * [1.0 + (BD * Kd/)]

P = average annual precipitation (cm/yr)

I = average annual irrigation (cm/yr)

Ev = average annual evapotranspiration (cm/yr)

= soil volumetric water content (ml/cm^3)

Z = soil depth from which leaching removal occurs (cm)

BD = soil bulk density (g/cm^3)

Kd = soil water partitioning coefficient (m1/g)

Ksd = ln2/tl/2

t1/2 = pollutant halflife due to degradation in soil (yr)

Ksv = Ke * Kt * 31,536 s/yr

Ke = equilibrium constant (cm^{-1})

Kt = gas phase transfer coefficient (cm/sec)

Ke = $\underline{3.1536 * 10^{10} * H * 10^{3}}$

Z * Kd * R * T * BD

H = Henry's law constant ($atmm^3/mole$)

Z = soil depth (cm)

Kd = soil water partitioning coefficient (ml/g)

R = ideal gas constant (latm/mole degrees K)

T = temperature (K)

BD = soil bulk density (g/cm^3)

$Kt = 0.482 * u^{0.78} * N^{0.67} * de^{0.11}$

Kt = gas phase mass transfer coefficient (cm/s)

u = wind speed (m/s)

N = Schmidt number for gas phase

de = effective diameter of contaminated area (m)

N = $\underline{a}$

pa * Da

a = viscosity of air (g/cms)

pa = air density (g/cm^3)

Da = diffusion coefficient of pollutant in air (cm^2/s)

Assumptions: 1) Pollutants are uniformly mixed in the soil; 2) The mother is exposed for her first 25 years, the infant is exposed for 1 year of breast feeding while the mother's exposure continues, and then the adult resides there far 44 more years (for a total of 70 years as the exposure period); 3) The average concentration of pollutants accumulated at the 35 year time period should be assumed to remain constant and be used in the risk calculations for the entire 70 year period.

3. Surface Water Concentration

The surface water concentration of a given pollutant is based on runoff and soil erosion, as well as direct deposition of pollutants onto the water body.

This pathway does not include discharges from the facility covered by a NPDES permit, if any.

C(water) = C(deposition) + C(runoff)

C(deposition) = concentration in water due to direct deposition onto water (ug/1)

C(deposition) = $\underline{\text{Dep * WBIA * } 10^3}$

DV

Dep = Annual deposition rate of pollutant ($g/m^2/yr$)

WBIA . Site specific area of water receiving fallout (m^2)

DV = Site specific dilution volume for water body per year or mean annual flow rate ($m^{3/}yr$)

For lake: mean lake volume (m^3/yr) + mean annual outflow from the lake

For river: mean annual flow (m^3/yr)

C (runoff) = $\underline{\text{Xe * WSIA * Mm * } 10^{-1}}$

DV * BD * Z

C (runoff) = Concentration in water due to soil run off (ug/l)

Xe = Soil loss rate per unit area watershed over time (kg/km^2yr)

WSIA = Watershed impact area (km^2)

Mm = Maximum contaminant mass per area of soil (kg/km^2)

DV = Site specific dilution volune for water body per year or mean annual flow rate (m^3 /yr)

For lake: mean lake volume (m^3/yr) + mean annual outflow from the lake

For river: mean annual flow (m^3/yr)

Z = Depth of incorporation (cm)

BD = Soil bulk density (g/cm^3)

Xe = R * K * LS * C * Ps * 908.18 Kg/ton * l/(4.047*10^3) acre/Km^2

R = Erosivity (rainfall/runoff) factor (yr^{-1})

R is the erosion potential for average annual rainfall at a given location

K = Soil erodability fator (ton/acre)

K is an experimentally determined value using the predominant soil type at the location

LS = Topographic or slope length factor (unitless)

C = Cover management factor (unitless)

This factor represents the vegetative crop, crop sequence, crop rotation and tilling practices

Ps = supporting practice (sediment delivery) factor (unitless)

This factor depends on the agricultural techniques such as contouring and terracing

Mm = Dep * [1 exp (kl * Tc)] /kl

Where:

Dep = annual deposition for contaminant (kg/km^2yr).

kl = firstorder loss rate (yr^{-1}).

Tc = total time period over which deposition occurs

70 years see assumption #2

The firstorder loss rate, kl, can be calculated by adding the loss rates due to infiltration (k1I), erosion (klE), and degradation (K1D):

k1 = klI + klE + klD

The equations for klI, klE, and klD are as follows:

klI = IR / (* Z * [l + (BD * Kd /)])

Where:

klI = firstorder loss rate for infiltration (yr^{-1})

IR = infiltration rate (cm/yr)

= volumetric water content of the soil (ml/cm^3)

Z = depth of incorporation (cm)

BD = bulk density of soil (kg/m^3)

Kd = distribution coefficient (m^3/kg).

klE = $\underline{Xe * Kd * ED * 10^{-4}}$

(BD * Z) [+ (Kd * BD)]

Where:

klE = firstorder loss rate for erosion (yr^{-1}).

All other terms are previously defined (including units).

klD = ln2/tl/2

Where:

k1D = firstorder loss rate for degradation (yr^{-1}).

t1/2 = contaminant halflife due to degradation in soil (yr).

Assumption: 1) All contaminants entering the receiving water are absorbed to eroded particles and do not partition between soil particles and water. 2)The average concentration of pollutants accumulated at the 35 year time period should be assumed to remain constant and be used in the risk calculations for the entire 70 year period.

B. Concentration in vegetation and Animal Products

1. Concentration in Vegetation

= deposition x bioavailability + translocation or uptake.

C(veg) = C(depveg) * BIO + C(trans)

C(veg) = average concentration in and on specific types of vegetation (ug/kg).

C(depveg) = concentration due to direct .deposition

C(depveg) = Dep * IF/k*Y) * (1exp{kT})

Dep = Deposition per day ($ug/m^2/d$)

IF = Interception fraction

root crops = 0

leafy crops = .2

vine crops, fruit = .1

k = Weathering constant (l/d)

0.693/14 (d)

Y = Yield (kg/m^2)

T = Growth period (d)

40 90 days, depending on crop

BIO = Bioavailability (chemicalspecific; see CAPCOA)

C(trans) = concentration due to root translocation or uptake (ug/kg).

= C(soil) * UF

UF = uptake factor based on soil concentration (see CAPCOA)

Assumption: no loss through metabolic degradation within the plant.

2. Concentration in Animal Products

= (Inhalation + water ingestion + feed ingestion + pasture/grazing ingestion + soil ingestion) x Transfer coefficient.

AnimInhal = RR * GLC

RR = animal specific respiration rate (see CAPCOA)

Assumption: all inhaled material is 100% absorbed.

AnimWater WI * %SW * C(water)

WI = Animal specific water ingestion (see CAPCOA)

%SW = percentage of daily water intake from the contaminated source: site specific based on survey.

AnimFeed = (1 %G) * FI * L * C(feed)

%G = percent of diet provided by grazing site specific

FI = Feed ingestion rate (kg/d) (see CAPCOA)

L = percent of nonpasturage part of the animal's diet that is produced locally site specific.

C(feed) calculated from vegetation pathway above.

AnimPasture = %G * C(grass) * FI

%G Percent of diet provided by grazing site specific

C(grass) = concentration in grass, through vegetation pathway above.

FI = pasturage ingestion rate (see CAPCOA)

AnimSoil = SI * C(soil)

SI = 3% of the grazing animals diet consists of soil.

Transfer Coefficient see CAPCOA (assumes that this factor is the same for all exposure routes, that cow's milk and goat's milk are the same, that all meat is the same, and that eggs and meat are the same).

3. Concentration in fish = (concentration in water) x Bioconcentration

C(fish) = C(water) * BCF

Bioconcentration and Bioaccumulation factors are available in EPA documents and in CAPCOA Table 1 and EPA manuals. Assumes that all contaminants in water are available for bioaccumulation in a soil or ash matrix.

ESTIMATING EXPOSURE DOSES

Once the concentration of each contaminant in the air, water, soil, crops, and so on has been estimated, the dose to a person at that location via each route of exposure is estimated, using the following generic equation:

Dose = <u>C x IR x EF x ED</u>

BW x AT

C = Concentration of the chemical in each medium, (conservative estimate of the media average contacted over the exposure period)

IR = Intake/Contact Rate (upperbound value)

EF = Exposure Frequency (upperbound value)

ED = Exposure Duration (upperbound value)

BW = Body Weight (average value = 70Kg)

AT = Averaging Time

1. Inhalation Dose

DoseInhal (mg/kg/day) = RR * GLC / Body weight * 1000

GLC = Ground level concentration (ug/m^3).

RR = Respiration rate for 70 kg adult = 20 m^3/day

1000 = Micrograms to milligram conversion factor

Assumption: 100 % of the inhaled material is absorbed

2. Soil Ingestion

Dosesoil = C(soil) * I(soil) * GI * BIO * 10^{-6} / BW * loon

Dose is expressed as mg/kg/d

C(soil) = average soil concentration (ug/kg)

I(soil) = soil ingestion rate = 150 mg/d (this is the average of children's rate (200 mg) and adults' rate (100 mg).

GI = Gastrointestinal absorption (see CAPCOA; assume 100% if no data is available) .

RIO = Bioavailability (see COCOA; for most substances it is all bioavailable, therefore BIO = 1)

BW = 70 kg body weight

3. Dermal Absorption (soil, swimming)

Dermal absorption from either soil/dust or water includes factors for exposed skin area, loading rate of soil/dust onto the skin, concentration of contaminant and ability of the contaminant to absorb through shin. Absorption through the skin while swimming also includes the average amount of time swimming (in the impact area's lakes), and from soil may include a reasonable amount of time spent outdoors. If there is a household water pathway, dermal absorption during bathing should be included.

Dosedermal = <u>C * SA * SL * ABS</u>

Body weight * 10^9

C = Soil or water SA = Surface area of exposed skin = 4656 cm^2

SL = Soil loading on skin = 1.45 $mg/cm^2/d$

ABS = fraction absorbed through skin of permeability constant see CAPCOA

Body weight = 70 kg

10^9 = Micrograms to kilogram conversion factor

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5. Animal Products (Fish, Meat, Poultry, Dairy, Eggs, Cow's Milk)

This pathway sums all local animalproduct dietary pathways, (according to the land use scenarios). The contribution of each animal product to a typical local diet must be determined on a site specific basis. No loss of contaminant during preparation is assumed to occur.

Doseanim C(anim) * I(anim) * GI * L / BW * 1000

C(anim) = concentration in any applicable animal product

I(anim) = intake rate of each animal product

milk = 300 g/d

meat (including poultry, eggs) = 75 g/d

fish (recreational) = 20.85 gm/day,

from freshwater or estuarine sources

Note: 100g = 3.5 ounces

GI = gastrointestinal absorption, as above

L = Fraction of animal products produced locally

For farm families, L = 75%.

BW = 70 kg body weight

Note: For small waterbodies or for areas of localized contamination in large waterbodies site specific data is recommended. Site specific or seasonal factors must be approved by the Department Toxicologist.

Assumptions: 1) no loss during preparation, 2) as dietary habits change, these values may change (if documented).

6. Drinking water

This pathway is appropriate if the impact area includes a potential impact on any surface water or groundwater source that is used as drinking water. It assumes ingestion of 2 liters of water a day over a lifetime.

Dosewater = C(water) * I(water) * GI * BIO / BW * 1000

I(water) = daily water ingestion (2 Liters/d)

GI and BIO (as above)

BW = 70 kg

7. Mother'' Breast Milk

This is an aggregate pathway that assumes (very conservatively) a woman is exposed for her first 25 years of life to the maximum permitted facility emissions, that she then has a child whom she breast feeds for l year while the exposures continue, and that the child then continues to live for 44 years at the same location with exposures as calculated for other children and adults. Substances which accumulate in fat (PCBs and PCDD/PCDFs) are generally of the most concern by this pathway.

Dosemilk = C(milk) * I(milk) * 365 d * l year / 25,000 * BW

C(milk) = concentration in mother's milk

= AI * T l/2 * fl * f2 / (f3 * .693)

AI = aggregate intake by mother through all paths

T l/2 = half life of the contaminant in the mother

f1 = fraction of the contaminant partitioning to fat (assume 90%).

f2 = % fat in mothers milk (assume 4%)

f3 = % of mother's body weight that is fat (assume 33%).

(milk) = Daily intake rate of breast milk by infant (assume .9 kg/d)

BW = body weight of infant (assume 6.5 kg)

8. Examples of other pathways to be developed on a sitespecific basis

If a land use survey within the zone of impact indicates that there may be other routes of exposure, these routes of exposure should also be presented. The Department can provide specific advice on the development or use of acceptable algorithms. For example, if household water is a potential route of exposure, then exposure to volatile contaminants through nondrinking routes (showering, cooking, etc.) can be significant. If swimmable water is impacted, then swimming will be a relevant pathway (dermal absorption and water ingestion while swimming).

SPECIAL NOTE ON DIOXIN

Because of the special concerns about: dioxins/furans, the Department will pay special attention to exposure estimates for these compounds. Both human and wildlife food chain modeling from agricultural exposure to dioxin are discussed in EPA's Proposed Rule Regulating Use, Disposal of Sludge from Pulp, Paper Mills Using Chlorine Bleaching Processes, 56 FR 21802, May 10, 1991. The Department will evaluate the results of this modeling in relation to the most current information. For risk assessment purposes, EPA's TEF approach should be used. ("Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of PCDDs and PCDFs (389) EPA 625/389/016.")

References:

EPA: Exposure Factors Handbook (1989)

Standard Default Exposure Factors (1991)

Calif: CAPCOA Air Toxics "Hot Spots' Program (1991)

PADEP: Risk Assessment Fate and Transport Modeling System (RAFT) (1990)