New Jersey Department of Environmental Protection

Division of Air Quality

Technical Manual 1003

Guidance on Preparing a Risk Assessment for Air Contaminant Emissions

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Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 Purpose of Document

The four types of risk assessments that a facility may have to conduct are: 1) Risk Screening Worksheet Assessment; 2) Refined Risk Assessment; 3) Facility Wide Risk Assessment; and 4) Comprehensive Exposure Risk Assessment (CERA). The first three assessments (Risk Screening Worksheet, Refined Risk, and Facility Wide Risk) are the most commonly required assessments and evaluate only the inhalation pathway for air toxics. One of these three types of risk assessments will be required to obtain an air pollution control (APC) permit if any air toxics are emitted above their applicable reporting thresholds.

The CERA evaluates the health impacts of air toxics from multiple pathways, including inhalation, ingestion, and dermal. CERA is typically performed for facilities, such as hazardous waste incinerators and Superfund sites, that are regulated by several Federal and state programs and that require the development of a distinct, multidisciplinary health risk protocol. The Department will work closely with the facility as well as other regulatory agencies to create a comprehensive case-by-case risk evaluation. Because of the CERA's complexity, it is beyond the scope of this Technical Manual.

This document provides instructions on how to conduct the risk assessments required to obtain an air pollution control (APC) permit from the New Jersey Department of Environmental Protection (Department). Detailed descriptions about how to perform and interpret the results for these three types of assessments are provided in Section 2.0 "Risk Assessments." Appendix A "Acronyms & Glossary" defines terms used throughout this manual. Appendix B "The Risk Assessment Process" provides detailed information on the calculations, assumptions, and procedures used in the risk assessments. Appendix C "Methodology and Assumptions Used to Generate the Risk Screening Worksheet" provides information used to develop the Risk Screening Worksheet for Stationary Sources (Section 2.1.1). Appendix D "References" provides supporting documentation used to develop this manual.

Pursuant to N.J.A.C. 7:27-8.5(b), for preconstruction permit applications, and N.J.A.C. 7:27-22.3(cc), for operating permit applications, health risk assessments are required for Air Toxic emissions listed for new or modified equipment and at the time of Title V operating permit renewals. For Title V permit renewals, a facility-wide health risk assessment is not required if the facility has already completed one for a previous renewal, unless there have been changes to emissions, stack parameters, risk factors, or dispersion models since the last time a facility-wide health risk assessment was conducted. Applicability determinations are made at the time of permit application. Additional information on applicability can be found at the Air Quality Permitting Program, Division of Air Quality (DAQ) website http://www.state.nj.us/dep/aqpp.

1.2 Purpose of Risk Assessment

Risk assessment is a scientific process used to estimate the probability of adverse health effects resulting from human exposure to hazardous substances. The Department utilizes risk assessment to:

A. Evaluate potential air toxics risks remaining (residual health risk), either from individual source operations or from entire facilities, after applicable pollution controls; and

B. Make decisions regarding permitting, control, and/or regulation of air toxics.

1.3 Description of Air Toxics

Air toxics are natural or man-made pollutants that when emitted into the air may cause an adverse health effect. Evidence of adverse health effects is based on human and animal exposure studies. The Federal 1990 Clean Air Act (CAA) Amendments created a list of air toxics, called "hazardous air pollutants" or "HAP," as well as regulations to limit HAP emissions. Air toxics that must be evaluated are listed on the NJDEP Division of Air Quality "Risk Screening Worksheet for Long-Term Carcinogenic and Noncarcinogenic Effects and Short-Term Effects" (Worksheet). The Worksheet evaluates HAPs, as well as other air contaminants, such as hydrogen sulfide and ammonia.

The Worksheet's air toxics list excludes "criteria pollutants" that have been established by National or New Jersey Ambient Air Quality Standards. The exceptions to this are: lead, some specific volatile organic compounds (VOCs), and specific heavy metals. Lead, which is a criteria pollutant, is also considered to be an air toxic due to its ability to cause significant adverse health effects at very low exposures. Specific VOCs, which are listed as HAPs, fall under the VOC criteria pollutant category. And specific heavy metals, which are listed as HAPs, are included in the particulate matter criteria pollutant category.

1.4 Risk Assessment Procedures

In most cases, potential residual health risk is initially determined using the Worksheet, which can be found at the Department's Risk Screening tools webpage, www.state.nj.us/dep/aqpp/risk.html. The Worksheet is used by facilities prior to the submittal of an application and by Department staff. If the health risk for the application is determined by the Worksheet to be negligible, no further investigation of the health risk is necessary. If the Worksheet indicates a health risk that is not negligible, the facility should evaluate changes that can be made to the source operation(s) to lower the risk level. If changes cannot be made to lower the Worksheet risk to a negligible level, then a refined risk assessment must be conducted.

Risk screening procedures are outlined in Section 2.1.1 "The Risk Screening Worksheet for Stationary Sources" and Section 2.1.2 "The Risk Screening Worksheet for Nonroad Diesel

Engines." Section 2.2 "Refined Risk Assessment" provides the information required to conduct this type of assessment and outlines the procedures to follow by a facility requesting the Department to conduct the assessment. Section 2.3 "Facility Wide Risk Assessment" discusses the evaluation of the cumulative air health impact of all source operations at a facility. These procedures evaluate the incremental inhalation risk from exposure to the permitted air toxic emissions. They do not consider the existing risk of cancer and other maladies associated with smoking, occupational or domestic exposures, dietary habits, inherited traits, or other factors that impact health and wellbeing; nor do they consider health risks from other nearby air toxics sources or existing levels of toxics in the ambient air.

2.0 RISK ASSESSMENTS

2.1 Risk Screening

The Department's Risk Screening procedure uses generalized worst-case assumptions and straight forward worksheet calculations to estimate cancer and non-cancer health risks from the inhalation of air toxics listed in a permit application. In lieu of source specific dispersion modeling, normalized air impact values are used to estimate dispersion of emitted air toxics and the resulting ambient air concentrations. The screening process is designed to minimize the likelihood of erroneously approving source operations that could potentially pose a significant health risk by overestimating the risk. This ensures that any source operation that requires further evaluation will be identified. Because the procedure is both quick and conservative, it allows the Department to estimate risk from a greater number of sources than would be possible if a refined risk assessment based on atmospheric dispersion modeling was required for every application.

2.1.1 The Risk Screening Worksheet for Stationary Sources

The Worksheet is used for the risk screening assessment of stationary sources. For source operations emitting air toxics, one Worksheet should be completed for each emission point. However, based on the assumptions made when generating the model, the following sources may not use this Worksheet: (1) sources without stacks, such as certain dry cleaners, degreasers, storage tanks, and gasoline stations, (2) sources with stacks with a horizontal or downward discharge direction, or (3) sources with stack heights less than 10 feet. See Appendix C for a complete list of assumptions. For information on how to evaluate risk from other kinds of sources, contact the Department at 609-292-6722.

The Worksheet is an Excel spreadsheet which can be found at the Department's "Risk Screening Tools" webpage at www.nj.gov/dep/aqpp/risk.html. The Excel spreadsheet is a protected file, meaning that changes are allowed only to certain cells. Information can only be typed into the yellow cells. It is also a "read only" file, which will not save any changes to the original file. To input and save new data, the file must be saved under a different name, and this should be entered into the "File name (.xls)" section on the Worksheet.

The Worksheet consists of two sheets, as indicated by the tabs at the bottom of the screen. The first sheet contains the risk screening worksheet calculations (“Risk”). The second sheet (“CAS Index”) contains a numerical listing of all the Chemical Abstract Service (CAS) numbers for the air toxics listed in the Worksheet. If an air toxic cannot be found alphabetically in the risk sheet, the "CAS Index" sheet of the Worksheet should be checked to see if it is listed under another name. The “CAS Index” also contains synonyms for certain common air toxics. Note that accurate identification of air toxics is critical to a risk assessment.

The Worksheet uses current unit risk factors (URF) and reference concentrations (RfC) based on assumptions of continuous chronic exposure to carcinogenic and noncarcinogenic air toxics. For noncarcinogenic air toxics with short term averaging periods, the exposure time is assumed to be 1, 8, or 24 hours, depending on the air toxic. To evaluate risk, the appropriate ambient air concentration is estimated.

The facility must provide information by inputting data into the yellow cells. To the extent possible, the background information on the source operation should be provided. This includes Facility and Activity Identification Numbers, Facility Name and Location, File name, Emission Unit ID, Equipment ID, Operating Scenario, and Emission Point ID.

The following information must be entered for the resulting air toxic concentrations and risk estimates to be automatically calculated:

1. Stack height, in feet;
2. Distance to the nearest property line, in feet;
3. Chemical-specific maximum annual emission rate (Q) in tons/year; and
4. Chemical-specific maximum hourly emission rate (Q_h) in pounds/hour.

The facility should ensure that the Worksheet is consistent with the data provided in the Air Pollution Control (APC) permit application.

When stack height and distance to property line are typed into the Worksheet, the file will automatically select the appropriate normalized annual air impact value (C’) and 1-hour air impact value (C'_{st}). Appendix C “Methodology and Assumptions Used to Generate the Air Impact Values for the NJDEP Risk Screening Worksheet” outlines the procedures/background information used to develop the Worksheet and describes the methodology used to develop air impact values.

The incremental cancer risks (IR) and hazard quotients (HQ) will be calculated automatically after the air toxics emission rates and all other necessary information are entered. A “Negl.”(Negligible) or “FER” (Further Evaluation Required) will also appear for each unit risk factor, and for each long-term and short term reference concentration that is evaluated.

The Worksheet will generate a “Negl.” result if: 1) the air toxic is a carcinogen and the incremental risk is less than 1E-06; or 2) the air toxic is a noncarcinogen and any short or long-term hazard quotients are less than 1. If all air toxics receive a "Negl." result, the risk assessment is considered complete, and no further evaluation is required. If the Worksheet generates a "FER" result for any air toxic, the facility should evaluate if the risk level can be reduced through mitigating actions. Mitigating actions that could lower risk levels include, but are not limited to, the following:

1. Reducing air toxic emissions through:

    i. Installation of an APC device or improving the efficiency of an existing APC device.
    ii. Replacing the air toxic substance with a non-toxic or less toxic substance.
    iii. Decreasing the annual operative hours.
    iv. Decreasing the annual or hourly throughput.

2. Increasing the stack height.

3. Relocation of the source to a location further from the property line.

Please note that it is at the facility's discretion whether to evaluate ways to lower the Worksheet risk levels.

If the risk levels need further review after this evaluation, refined risk assessment must be conducted. Only those air toxics with a "FER" result need to undergo a refined risk assessment as outlined in Section 2.2.

2.1.2 The Risk Screening Worksheet for Nonroad Diesel Engines

To determine the health risk from the emission of diesel particulate matter emissions, the "Cancer Risk Screening Worksheet for Nonroad Diesel Engines" (Diesel Worksheet) should be used instead of the Worksheet if:

1. The stack discharge direction is up;

2. The capacity of the engine is 50 horsepower or greater; and

3. The stack height is at least 15 feet for an engine less than or equal to 600 horsepower; or the stack height is at least 25 feet for an engine greater than 600 horsepower

The Diesel Worksheet is not to be used for HAP other than diesel particulate matter. The Diesel Worksheet can be found at: http://www.state.nj.us/dep/aqpp/risk.html. It is designed to calculate diesel particulate emissions and assume an appropriate plume rise for diesel engines. The Diesel Worksheet contains step-by-step instructions for completing this risk screening in the second tab of the Excel file, along with details for interpreting the results in the third tab of the Excel file.

If the Diesel Worksheet shows an unacceptable risk, the risk from the engine must then be determined using a refined risk assessment, as outlined in Section 2.2.

2.2 Refined Risk Assessment

The refined risk assessment consists of a refined atmospheric dispersion modeling analysis for new or modified sources that estimates ambient air concentrations more accurately than the Worksheet by using stack- and source-specific data as well as representative meteorological data. The refined risk assessment often predicts air toxic concentrations that are lower than those estimated with the Worksheet. The Department normally uses the USEPA refined model AERMOD for these evaluations. However, models such as SCREEN3 and AERSCREEN can be proposed on a case-by-case basis for use in a refined risk assessment protocol. The decision to allow proposed air quality models to be used will be based on the unique characteristics of the equipment and stack parameters being evaluated. It is recommended that the Department be consulted during protocol development.

Ambient air monitoring can be proposed for use in a refined risk assessment protocol for an individual source operation or for a facility-wide risk assessment protocol. The decision to allow ambient air monitoring results to be used will be based on the unique characteristics of the equipment and stack parameters being evaluated. The fence line ambient air monitoring program must have been reviewed and approved by the Department for the data to be considered for a modeling waiver.

The Department will conduct the refined risk assessment unless the facility specifies that they will perform the analysis. The current fee schedules are available at N.J.A.C. 7:27-8.6 or N.J.A.C. 7:27-22.31, which are posted on the Department's website at http://www.state.nj.us/dep/aqm/rules27.html..

A refined risk assessment evaluating carcinogenic risk as well as short- and long-term non-carcinogenic risks is required for each individual air toxic with a "FER" result from the Worksheet or Diesel Worksheet. The health risk for each air toxic must be determined: 1) at the receptor with the highest predicted air concentration in the 5-year simulation (AERMOD); and 2) at sensitive receptors (nearest residence, daycare centers, hospitals, nursing homes, playgrounds, etc.) located within the defined modeling grid.

Section 2.2.1 describes in detail the information needed by the Department to conduct the refined risk assessment for the facility. Section 2.2.2 is a guide for a facility that chooses to perform its own refined risk assessment.

2.2.1 Facility Opts to Have the Department Perform the Refined Risk Assessment

A plot plan (also called land survey/site plan) of the facility property must be provided with the modeling protocol. The preparation and submittal of a plot plan to a regulatory agency in New Jersey is governed by the State Board of Professional Engineers and Land Surveyors and is codified in the New Jersey Administrative Code at Title 13, Chapter 40. In accordance with

N.J.A.C. 13:40-5.1 (J) (n), all land surveys, construction plans, and maps prepared to show topographic data or planimetric data and delineate property lines submitted to the Department must bear the signature and impression seal of the licensed land surveyor or professional engineer. Thus, a full-size paper copy is required. Any plot plan submitted in the modeling protocol must show the facility's property line and the location of all sources and stacks that will be included in the modeling analysis. The plot plan shall also identify fences and other barriers, if any, which would deter public access.

The plot plan must be of sufficient detail (showing all building dimensions) to enable a determination of Good Engineering Practice (GEP) formula stack height and the potential for building downwash considerations for stack heights less than GEP formula heights. The grade elevation and height above grade for each structure must be indicated as well as the stack base elevation. In complex cases where there are a number of existing structures or tiers that must be considered in the GEP analysis, photographs or three-dimensional sketches may also be required as additional documentation.

In summary, the applicant must provide a detailed plot plan of the site with the following information:

- Depiction of the site, drawn to scale (with the scale indicated), certified by a New Jersey professional engineer or land surveyor.

- An indication of true north. If plant north is shown on the plot plan, the relationship between true north and plant north must be provided.

- Location of: All proposed emission points (stacks, vents, etc.)
All buildings and structures on-site
The facility property line
The facility fence line (if any)

- Location of buildings and structures immediately adjacent to the applicant's property, if they are located near enough to the proposed emission points to potentially cause downwash effects.

- Base elevation, height, width, and length of all buildings and structures.

- Location of nearby residences and other sensitive receptors, such as hospitals, nursing homes, schools, and day care centers. This information can be provided on separate figure(s).

Incomplete plot plans will be returned for correction. The plot plan must be in the form of a physical, paper copy. An electronic file will not be accepted. Contact the Department at 609-292-6722 if specific guidance is needed concerning the plot plan.

2.2.2 Facility Opts to Perform its Own Refined Risk Assessment

An applicant that opts to perform the refined risk assessment must submit an atmospheric dispersion modeling protocol in accordance with procedures outlined in the Technical Manual 1002 "Guidance on Preparing an Air Quality Modeling Protocol." This manual can be downloaded at http://www.state.nj.us/dep/aqpp/techman.html. The protocol must be approved by the Department before the refined modeling study is performed. The protocol information must be consistent with the information in the permit application for the protocol to be deemed complete.

2.2.3 Determining Health Risks

Dose Response Assessment
Dose-response assessment is the characterization of the relationship between a chemical exposure, or dose, and the incidence and severity of an adverse health effect. It takes into consideration factors that influence this relationship, including intensity and pattern of exposure, and age and lifestyle variables that may affect susceptibility. It may also involve extrapolation from high-dose to low-dose responses, and from animal to human responses. This information is gathered from epidemiological or laboratory studies done by federal or state agencies, health organizations, academic institutions, and others.

Dose-response assessment as utilized in the air permitting process involves the quantification (in terms of severity or likelihood) of toxicological effects of individual chemicals on humans. The dose-response relationship is evaluated differently for carcinogenic (cancer-causing) and non-carcinogenic substances.

For carcinogens, it is assumed that there is a linear relationship between an increase in dose or exposure concentration and an increase in cancer risk, with no threshold. This is expressed as a potency slope or slope factor (SF), in units "per milligram (of chemical) per kilogram (of body weight) per day" or $(mg/kg/day)^{-1}$. To evaluate risks from inhalation of carcinogenic substances, USEPA and other regulatory agencies use potency slopes to develop unit risk factors (URFs). A URF can be defined as the upper-bound excess probability of contracting cancer as the result of a lifetime of exposure to a carcinogen at a concentration of 1 $\mu g/m^3$ in air. URF units are "per microgram (of chemical) per cubic meter (of air)" or $(ug/m^3)^{-1}$.

For inhalation effects from noncarcinogens, dose-response data are used to develop reference concentrations (RfCs), for both long-term (chronic) and short-term exposures. Unlike carcinogens, noncarcinogens are assumed to have thresholds for adverse effects, meaning that injury does not occur until exposure has reached or exceeded some concentration (a threshold). An RfC is derived from a no-observed adverse effect level (NOAEL) or lowest-observed adverse effect level (LOAEL) determined through human or animal exposure studies. Since actual thresholds for the general population cannot be precisely determined, uncertainty or safety factors are applied to the NOAEL or LOAEL. This assures that the RfC is set at a level that is expected to be protective of sensitive populations (the elderly, infirm, or very young). Short-term RfCs are developed to prevent health effects from exposure periods of 24 hours or less. RfCs are expressed in units of $\mu g/m^3$. (Note: California's air program refers to these values as "Reference

Exposure Levels (RELs)," while USEPA uses the term RfC.) Oral exposures are evaluated using reference doses or RfDs, which have units of mg/kg/day.

To develop URFs, RfCs, SFs, and RfDs, toxicological studies are evaluated by groups assigned for this purpose within USEPA and other agencies. These risk values are then usually peer-reviewed, and gathered into databases. USEPA maintains the Integrated Risk Information System (IRIS), which is available on-line at www.epa.gov/iris. Another primary source of risk numbers is the California Office of Environmental Health Hazard Assessment (OEHHA). Their data is available on-line at www.oehha.ca.gov. Within NJDEP, DAQ compiles the inhalation information available from IRIS and other appropriate sources into lists of URFs and RfCs. These are periodically updated and are available at www.nj.gov/dep/aqpp/risk.html.

Cancer Risk

Cancer risk for each air toxic is determined by multiplying the maximum annual average ambient air concentration predicted by AERMOD with the air toxic-specific URF:

$$\text{Cancer Risk} = C \times URF$$

where:
C = Annual air concentration from AERMOD ($\mu g/m^3$), of the unique air toxic
URF = Inhalation unit risk factor $(\mu g/m^3)^{-1}$, of the unique air toxic

URF values for each air toxic can be found on the "Toxicity Values for Inhalation Exposure" document available for download at www.nj.gov/dep/aqpp/risk.html.

Short-Term and Long-Term Non-Cancer Risk (Hazard Quotient)

The hazard quotient for long-term non-cancer risk is calculated by dividing the maximum annual average ambient air concentration predicted by AERMOD by the long-term air toxic-specific RfC:

$$\text{Hazard Quotient} = C/RfC$$

where:
C = Annual average ambient air concentration from AERMOD ($\mu g/m^3$), of the unique air toxic
RfC = Reference concentration ($\mu g/m^3$), of the unique air toxic

RfC values for each air toxic can be found on the "Toxicity Values for Inhalation Exposure" document available at www.nj.gov/dep/aqpp/risk.html. The Reference Concentration (RfC) column should be used for the long-term non-cancer risk calculation. The Short Term RfC column should be used for the short-term non-cancer risk.

To assess short-term non-cancer risk, the short term RfC is to be compared with the maximum average ambient air concentration averaged over the period given in the "RfC Averaging Time" column in the "Toxicity Values for Inhalation Exposure" document for the air toxic in question:

$$\text{Hazard Quotient}_{short\text{-}term} = C_{st}/RfC_{st}$$

where:
C_{st} = Short-term average ambient air concentration from AERMOD ($\mu g/m^3$), of the unique air toxic
RfC_{st} = Short-term reference concentration ($\mu g/m^3$), of the unique air toxic

2.2.4 New or Modified Source Operations Risk Management Guidelines

Risk management guidelines are designed to interpret the results of risk assessments and to differentiate between risk levels that are negligible and those that are unacceptable. The Department risk management guidelines for new or modified source operations are summarized below in Tables 2-1 and 2-2.

Table 2-1. Cancer Risk Guidelines for New or Modified Sources

Risk Level	Outcome
Risk ≤ 1 in a million ($1x10^{-6}$)	Negligible risk.
1 in a million < Risk < 100 in a million	Case-by-case review by Risk Management Committee.
Risk ≥ 100 in a million ($1x10^{-4}$)	Unacceptable risk.

Table 2-2. Long-and Short-Term Non-Cancer Risk Guidelines for New or Modified Sources

Risk Level	Outcome
Hazard Quotient ≤ 1	Negligible risk.
Hazard Quotient > 1	Case-by-case review by Risk Management Committee.

If all evaluated health risks fall into the "negligible" category, no further risk assessment or modification to the APC permit is needed. If any of the evaluated health risks do not fall into the "negligible" category, the Risk Management Committee Review will evaluate the impact and make appropriate recommendations for mitigation (see Section 3.0 for details).

2.3 Facility Wide Risk Assessment

The facility wide risk assessment consists of a refined modeling analysis that includes all source operations that emit air toxics listed in the permit. This analysis uses stack- and source-specific data as well as representative meteorological data. The USEPA refined model AERMOD is normally used in these evaluations. For each unique air toxic, a model simulation estimates the cumulative impact from multiple stacks or operations within the facility.

Applicants performing a facility wide risk assessment must submit an atmospheric dispersion modeling protocol in accordance with procedures outlined in Technical Manual 1002 "Guidance on Preparing an Air Quality Modeling Protocol." This manual can be downloaded at http://www.state.nj.us/dep/aqpp/techman.html. The information contained in the protocol must be consistent with the information in the permit application for the protocol to be deemed complete. The protocol must be approved by the Department before the facility wide modeling study is performed. After the modeling study is complete, the Facility Wide Cancer, and Short- and Long-Term Non-Cancer Risk Guidelines listed below in Table 2-3 and 2-4 should be used to determine cancer and non-cancer risks (i.e. Hazard Quotient). Appendix B provides additional information on the risk assessment process.

Models such as SCREEN3 and AERSCREEN can be proposed on a case-by-case basis for use in a facility wide risk assessment protocol. The decision to allow proposed air quality models to be used will be based on the unique characteristics of the equipment and stack parameters being evaluated. It is recommended that the Department be consulted during protocol development.

The risk screening worksheet can be used as a preliminary alternative to conduct a facility wide risk assessment for air toxic emissions. It should be noted that this methodology and its results are subject to the review and approval of the Department. For example, if there are multiple stacks releasing an air toxic, the screening worksheet can be used to assess the cancer and non-cancer risks from the facility's emissions of this air toxic by assuming all of the facility's emissions of the air toxic are emitted from each individual stack. Thus, separate risk screening worksheets (one for each stack) must be submitted assuming that all the facility's air toxic emissions are released from each individual stack. The risk screening worksheet for the stack with the greatest cancer and/or non-cancer risks is used to determine whether further evaluation is required. The results will be compared to the guidelines in Tables 2-3 and 2-4 of the following section.

2.3.1. Facility Wide Risk Assessment Guidelines

As stated in the previous section, risk management guidelines are designed to interpret the results of risk assessments and to differentiate between health risk levels that are negligible and health risk levels that are unacceptable. The Department Risk Management Committee guidelines for facility wide risk assessments are summarized below in Table 2-3 and 2-4:

Table 2-3. Facility Wide Cancer Risk Guidelines

Risk Level	Outcome
Risk ≤ 10 in a million ($1x10^{-5}$)	Negligible risk.
10 in a million < Risk < 100 in a million	Case-by-case review by Risk Management Committee.
Risk ≥ 1000 in a million ($1x10^{-3}$)	Unacceptable risk.

Table 2-4. Facility Wide Long- and Short-Term Non-Cancer Risk Guidelines

Risk Level	Outcome
Hazard Quotient ≤ 1	Negligible risk.
Hazard Quotient > 1	Case-by-case review by Risk Management Committee.

If all evaluated health risks fall into the "negligible" category, no further risk assessment or modification to the APC permit is needed. If any of the evaluated health risks do not fall into the "negligible" category, the Risk Management Committee Review will evaluate the impact and make any appropriate recommendations (see Section 3.0 for details).

A facility submitting an Initial Operating Permit must evaluate health risk for each equipment individually and facility wide. For the individual analysis, the procedures and guidelines described in Section 2.1 and 2.2 must be followed. For the facility wide analysis, the procedures and guidelines described in Section 2.3 must be followed.

If such a new facility was proposed with one or more source operation with a risk over 1 in a million, the health risks posed by the equipment would be reviewed by the Risk Management Committee. The RMC would evaluate if all contingencies have been evaluated to lower the risk. In cases such as this, the RMC may conclude that the facility could be constructed, but that a risk reduction plan be developed and implemented by the facility to reevaluate annually methodologies to reduce the health risks.

The "10 in a million" standard applies only to existing equipment whose air toxic emissions are subject to a facility wide risk assessment. It is meant to address "residual risks" which are the health and environmental risks that remained after implementation of all air pollution control standards which were in effect when the equipment was first permitted. This process is consistent with Section 112 of the Federal Clean Air Act which evaluates residual risk within eight years of the implementation of a MACT standard.

3.0 RISK MANAGEMENT COMMITTEE REVIEW

If the outcome of a refined risk assessment or a facility wide risk assessment is not "negligible," the permit application and air quality dispersion modeling results will be forwarded to the Department's Risk Management Committee (RMC). The RMC includes supervisory staff from each of the following: air quality evaluation section; the appropriate permitting section (Pre-Construction Permits or Operating Permits); and the appropriate regional air enforcement office. Additionally, supervisors may assign staff to provide technical expertise.

The RMC evaluates the application and related materials to identify risk reduction strategies that may facilitate permit approval. The RMC may consider, but are not limited to the following factors: overall impact on the sensitive receptor population; the uncertainties associated with the health risk; compliance history; previous compliance efforts by the facility; new and pending regulations; and cost analysis. Based upon the RMC's analysis of the above-listed factors, the RMC may recommend actions such as:

1. Applying better air pollution controls to lower emissions;

2. Modifying stack parameters to increase dispersion (for example, increase the stack height); and/or

3. Implementing applicable risk minimization strategies to reduce risk in the surrounding community.

The permitting section will discuss the RMC's recommendations with the facility. The permit application is reevaluated based on the facility's response. If the facility agrees to make modifications that lowers the health risk to a negligible level, no further input from the RMC is necessary. However, if the facility's proposed modifications do not lower the risk to a negligible level, the RMC may reconvene to discuss the facility's response and to determine whether the facility should be required to implement additional strategies to reduce the risk levels.

APPENDIX A

ACRONYMS & GLOSSARY

Air Toxics: Also known as toxic air pollutants or hazardous air pollutants, these are chemicals that cause or may cause serious effects in humans, and may be emitted into the air in quantities that are large enough to cause adverse health effects. These effects cover a wide range of conditions from lung irritation to birth defects to cancer. Health concerns may be associated with both short and long-term exposures to these pollutants. Many are known to have respiratory, neurological, immune or reproductive effects, particularly for more susceptible sensitive populations such as children. There are 187 air toxics listed as "hazardous air pollutants" in the 1990 Clean Air Act.

Carcinogen: A chemical for which there is some evidence (either in animals or humans) that it may cause cancer.

Department: New Jersey Department of Environmental Protection

Exposure: Contact with a substance through inhalation, ingestion or some other means for a specific period of time.

Hazardous Air Pollutants (HAP): In general, an "air toxic." Specifically, this also refers to any of the 187 air toxic pollutants listed in the 1990 Clean Air Act amendments 42 U.S.C. §7412(b). This list is incorporated into N.J.A.C. 7:27-17.

Hazard Quotient: An estimate of the potential for a detrimental non-cancer health effect from exposure to a chemical.

Non-carcinogen: A pollutant that can cause adverse health effects other than cancer.

Reference Concentration (RfC): An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful effects during a lifetime. It can be derived from various types of human or animal data, with uncertainty factors generally applied to reflect limitations of the data used.

Slope Factor (SF): An upper-bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate is usually expressed in units of proportion (of a population) affected per mg/kg-day.

Unit Risk Factor (URF): The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a chemical at a concentration of 1 $\mu g/m^3$ in air. For example, if a chemical's URF is 2×10^{-6} ($\mu g/m^3$), then a person exposed daily for a lifetime to 1 µg of the chemical in 1 cubic meter of air would have an increased risk of cancer equal to 2 in a million.

USEPA: United States Environmental Protection Agency.

Volatile Organic Compounds (VOCs): Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions as defined by the EPA at 40 CFR 51.100(s), and incorporated into N.J.A.C. 7:27-8 and 22. VOCs include gasoline, and industrial chemicals such as benzene, solvents such as toluene and xylene. Many VOCs are also HAPs.

APPENDIX B

THE RISK ASSESSMENT PROCESS

Risk Assessment Process

In 1986, the USEPA established risk assessment guidelines in order to provide consistency and technical support between USEPA and other regulatory agencies. The guidelines were based on recommendations from the National Research Council (NRC 1983). NRC divided the risk assessment process into four steps, which are described below.

Step 1 - Hazard Identification

Hazard identification is the process used to determine the potential human health effects from exposure to an air toxic. This is based on information provided by the scientific literature. For air toxics sources, hazard identification involves identifying whether a hazard exists, and if so, identifying the exact pollutants of concern. Hazard Identification takes into consideration whether a pollutant is a potential human carcinogen or is associated with other types of adverse health effects. For hazard identification in relation to an air permit, the following is considered:

A. Which contaminants will be emitted from the source;
B. Which of these contaminants have known health effects; and
C. The specific toxicological effects of these air toxics.

Step 2 - Dose-Response Assessment

Dose-response assessment is the characterization of the relationship between a chemical (air toxic) exposure, or dose, and the incidence and severity of an adverse health effect. It takes into consideration factors that influence this relationship, including intensity and pattern of exposure, and age and lifestyle variables that may affect susceptibility. It may also involve extrapolation from high-dose to low-dose responses, and from animal to human responses. This information is gathered from epidemiological or laboratory studies done by federal or state agencies, health organizations, academic institutions, and others.

Dose-response assessment as utilized in the air permitting process involves the quantification (in terms of severity or likelihood) of toxicological effects of individual chemicals on humans. The dose-response relationship is evaluated differently for carcinogenic (cancer-causing) and non-carcinogenic substances.

For carcinogens, it is assumed that there is a linear relationship between an increase in dose or exposure concentration and an increase in cancer risk, with no threshold. This is expressed as a **potency slope** or **slope factor** (SF), in units "per milligram (of chemical) per kilogram (of body weight) per day" or $(mg/kg/day)^{-1}$. To evaluate health risks from inhalation of carcinogenic substances, USEPA and other regulatory agencies use potency slopes to develop **unit risk factors** (URFs). A URF can be defined as the upper-bound excess probability of contracting cancer as the result of a lifetime of exposure to a carcinogen at a concentration of 1 $\mu g/m^3$ in air. URF units are "per microgram (of chemical) per cubic meter (of air)" or $(\mu g/m^3)^{-1}$.

Step 3 - Exposure Assessment

The exposure assessment step determines the extent (intensity, frequency, and duration, or dose) of human exposure to a chemical in the environment. There are three components to the exposure assessment:

A. Estimation of the maximum quantity of each pollutant emitted from the source of concern (based on data from previously existing sources or engineering estimates);
B. For each contaminant emitted from a source, estimation of the resulting maximum annual average and (where applicable) maximum short-term average ambient air concentrations, using dispersion models, or air impact values based on dispersion models; and
C. Estimation of the amount of contaminant taken in by a human receptor.

Step 4 - Risk Characterization

Risk characterization is the final step in risk assessment. At this step, human health risk is calculated and described based on the information gathered in the first three steps. The risk characterization also includes some consideration of uncertainty, scientific judgment, and the major assumptions that were made, especially regarding exposure. Human health risk estimates for inhalation of carcinogens are based on the following calculation:

Cancer Risk = C x URF

where:
C = maximum annual average ambient air concentration of a pollutant, $\mu g/m^3$
URF = pollutant-specific inhalation unit risk factor, $(\mu g/m^3)^{-1}$

Human health risk estimates for inhalation of non-carcinogens are based on the following calculations:

Hazard Quotient = C/RfC

where:
C = maximum ambient air concentration, $\mu g/m^3$
RfC = pollutant-specific reference concentration, $\mu g/m^3$

The averaging time for non-carcinogen concentrations can be either annual, or a specific number of hours, depending on the basis of the reference dose (see the list of averaging times for short-term inhalation exposure in the "Toxicity Values for Inhalation Exposure" document available at http://www.state.nj.us/dep/aqpp/risk.html).

APPENDIX C

METHODOLOGY AND ASSUMPTIONS USED TO GENERATE THE AIR IMPACT VALUES FOR THE NJDEP RISK SCREENING WORKSHEET

Below is a summary of the methodology and assumptions used to generate the normalized air impact values for the Worksheet for point sources.

Dispersion Model
Model runs were made with AERMOD (Version 15181).

Land Use
AERMOD was run in both the rural and urban modes. In the urban mode, a population parameter of 1,000,000 was used.

Meteorological Data
The 2010-2014 meteorological data from three different surface National Weather Service stations were used. The sites were: Newark International Airport, Philadelphia International Airport, and Trenton Mercer Airport. Both the Trenton and Philadelphia data sets used concurrent upper air data from Sterling, VA while the Newark site was paired with upper air data from Brookhaven, NY. For a detailed description of the methodology used to compile the data as well as the meteorological datasets, refer to "NJDEP Processed Meteorological Files (2010-2014) For Use in AERMOD Dispersion Modeling Analyses" dated July 2015. These files are available from the DAQ upon request.

Stack Parameters and Emission Rates
The stack parameters and emission rates used to generate the normalized air impact values are listed in Table C-1. The stack exit velocity and exit temperature values were selected so that plume rise would be minimal. Emissions were assumed to occur 24 hours per day, 365 days per year. The stack was located in the middle of the building.

<u>Table C-1. Stack Parameters and Emission Rates</u>

Parameter	Value
Annual Emission Rate	1 ton/year (0.23 lb/hr)
1-Hour Emission Rate	1 lb/hr
Stack Heights (ft)	15, 20, 25, 30, 40, 50, 75, 100, 150, 200, 250
Stack Diameter	1 ft (0.305 m)
Exit Velocity	0.33 ft/sec (0.1 m/sec)
Exit temperature	80^{o}F (300^{o}K)

Building Downwash
The building dimensions were selected so that the plume was subjected to significant amounts of downwash. The building dimensions used are listed in Table C-2. All stacks were well below the GEP stack height of 2.5 times higher than the building height. For stacks with heights 15 feet

(ft) and 20 ft, the stack was assumed to be a factor of 1.25 times higher than the building height. For all other stack heights (25 ft through 250 ft), the stack was assumed to be a factor of 1.5 times higher than the building height. For stack heights between 15 and 50 ft, the building's horizontal dimensions were assumed constant at 50 ft. As stack heights increased above 50 ft, the building's horizontal dimensions also increase. The assumed building's horizontal dimensions are also shown in Table C-2.

The USEPA's Building Profile Input Program (BPIP-PRIME) was used to generate building downwash parameters for input into AERMOD.

Table C-2. Stack Heights and Assumed Building Dimensions

Stack Height (ft)	Building Height (ft)	Building Width and Length (ft)
15	12	50 x 50
20	16	50 x 50
25	16.7	50 x 50
30	20	50 x 50
40	26.7	50 x 50
50	33.4	50 x 50
75	50	75 x 75
100	66.7	100 x 100
150	100	150 x 150
200	133.4	200 x 200
250	166.7	200 x 200

Receptor Grid

Modeling was performed assuming flat terrain. A polar receptor grid was used that was centered on the stack (midpoint of the building) with 36 radials spaced every 10 degrees. The spacing of receptors along the radials were as follows: 20 ft, 30 ft, 40 ft, 50 ft, 60 ft, 70 ft, 80 ft, 90 ft, 100 ft, 150 ft, 200 ft, 250 ft, 300 ft, 400 ft, 500 ft, 600 ft, 700 ft, 800 ft, 900 ft, 1000 ft, 1500 ft, 2000 ft, 2500 ft, and 3000 ft.

Modeling Methodology

The AERMOD model was run with USEPA's regulatory default parameters and the parameters discussed above. AERMOD was run at hourly, daily, and annual time periods. Conversion factors were used to scale the hourly predictions to longer-term averaging times of 4 hours (0.92), 6 hours (0.87), 7 hours (0.84), 8 hours (0.82), and 24 hours (0.4).

Modeling Results

Table C-3 summarizes the worst-case scenario for each stack height and each averaging time. The normalized annual air impact values as a function of stack height (15 to 250 ft) and distance from the stack (out to 3000 ft) are listed in Table C-4 and shown graphically in Figure C-1.

In the Worksheet, the normalized annual concentration obtained using a 1 ton/year emission rate will be multiplied by the source's annual ton per year Air Toxic emission rate in order to predict a long-term Air Toxic concentration. These concentrations are then used to estimate cancer risk and long-term hazard indices. Only those stack heights and distances explicitly listed in Table C-4 were modeled for annual impacts. When other stack height or distance from the stack values are input into the Worksheet, linear interpolation is used to estimate the air impact value for that stack height and/or distance from the stack.

The hourly air impact values as a function of stack height (15 to 250 ft) and distance from the stack (out to 3000 ft) are listed in Table C-5 and shown graphically in Figure C-2.

In the Worksheet, the hourly concentration obtained using a 1 lb/hour emission rate will be multiplied by the source's allowable lb/hr Air Toxic emission rate in order to predict a short-term Air Toxic concentration. These concentrations and the conversion factors listed earlier are then used as a basis for estimate short-term hazard indices (1-24 hours). Only those stack heights and distances explicitly listed in Table C-4 were modeled for 1-hour impacts. When other stack height or distance from the stack values are input into the worksheet, linear interpolation is used to estimate the normalized concentration for that stack height or distance from the stack.

A daily simulation was used to check that the 0.4 conversion factor used to calculate the 24-hour time period, described above, is conservative. The daily simulation results are not used in the Worksheet because the scaling approach is more conservative.

Table C-3. Worst-Case Impact Scenarios

Stack Height (ft)	Annual Average Conc.	Hourly Average Conc.
15	Trenton 2011 met., Rural, 130° radial	Trenton 2011 met., Rural, 180° radial
20	Trenton 2011 met., Rural, 130° radial	Trenton 2013 met., Rural, 360° radial
25	Trenton 2011 met., Rural, 130° radial	Trenton 2013 met., Rural, 360° radial
30	Trenton 2011 met., Rural, 130° radial	Trenton 2013 met., Rural, 360° radial
40	Trenton 2011 met., Rural, 130° radial	Trenton 2013 met., Rural, 360° radial
50	Trenton 2011 met., Rural, 130° radial	Newark 2011 met., Rural, 350° radial
75	Trenton 2011 met., Rural, 130° radial	Newark 2013 met., Urban, 270° radial
100	Trenton 2011 met., Rural, 120° radial	Newark 2013 met., Urban, 270° radial
150	Trenton 2011 met., urban, 120° radial	Newark 2013 met., Urban, 270° radial
200	Trenton 2011 met., Rural, 120° radial	Newark 2013 met., Urban, 270° radial
250	Trenton 2011 met., Urban, 120° radial	Newark 2014 met., Urban, 300° radial

Table C-4. Annual Air Impact Values per ton/yr of Emissions for Stack Heights 15-250 ft (μg/m^3)

Distance (ft)	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	75 ft	100 ft	150 ft	200 ft	250 ft
20	58.431	43.137	47.508	37.647	24.546	16.617	6.529	3.367	1.359	0.720	0.436
30	55.324	41.135	45.073	35.921	23.505	16.045	6.451	3.353	1.359	0.720	0.436
40	51.084	38.296	41.735	33.489	22.013	15.187	6.308	3.318	1.356	0.720	0.436
50	46.488	35.120	38.080	30.758	20.308	14.174	6.108	3.265	1.349	0.719	0.436
60	42.157	32.048	34.586	28.081	18.620	13.097	5.864	3.194	1.338	0.717	0.436
70	38.464	29.369	31.598	25.793	17.181	12.127	5.596	3.109	1.324	0.713	0.435
80	35.716	27.351	29.509	24.147	16.117	11.383	5.313	3.012	1.306	0.709	0.434
90	33.573	25.733	27.733	22.713	15.178	10.714	5.026	2.908	1.286	0.703	0.432
100	31.600	24.215	26.099	21.378	14.302	10.119	4.764	2.799	1.263	0.696	0.430
150	23.368	18.263	19.141	15.849	10.509	7.408	3.879	2.308	1.122	0.651	0.414
200	9.289	9.302	6.896	7.529	7.747	5.923	3.122	1.983	0.972	0.593	0.390
250	6.809	5.635	4.905	4.244	3.011	2.325	2.641	1.692	0.865	0.532	0.361
300	5.345	4.493	3.885	3.396	2.456	1.869	2.282	1.455	0.783	0.478	0.333
400	3.620	3.126	2.671	2.375	1.769	1.368	0.790	1.166	0.629	0.409	0.287
500	2.598	2.351	1.981	1.791	1.370	1.066	0.613	0.439	0.528	0.348	0.249
600	1.896	1.829	1.512	1.403	1.099	0.863	0.498	0.347	0.459	0.300	0.210
700	1.536	1.444	1.171	1.123	0.907	0.721	0.417	0.289	0.275	0.265	0.185
800	1.309	1.154	0.923	0.912	0.769	0.616	0.361	0.247	0.158	0.240	0.170
900	1.136	0.925	0.746	0.749	0.659	0.536	0.313	0.216	0.137	0.172	0.154
1000	1.003	0.766	0.670	0.617	0.567	0.470	0.277	0.191	0.121	0.092	0.104
1500	0.604	0.487	0.449	0.350	0.289	0.261	0.173	0.119	0.075	0.056	0.046
2000	0.394	0.351	0.332	0.266	0.173	0.160	0.119	0.085	0.053	0.040	0.033
2500	0.272	0.263	0.250	0.213	0.140	0.106	0.088	0.064	0.041	0.030	0.025
3000	0.209	0.203	0.192	0.174	0.118	0.084	0.066	0.050	0.033	0.024	0.020

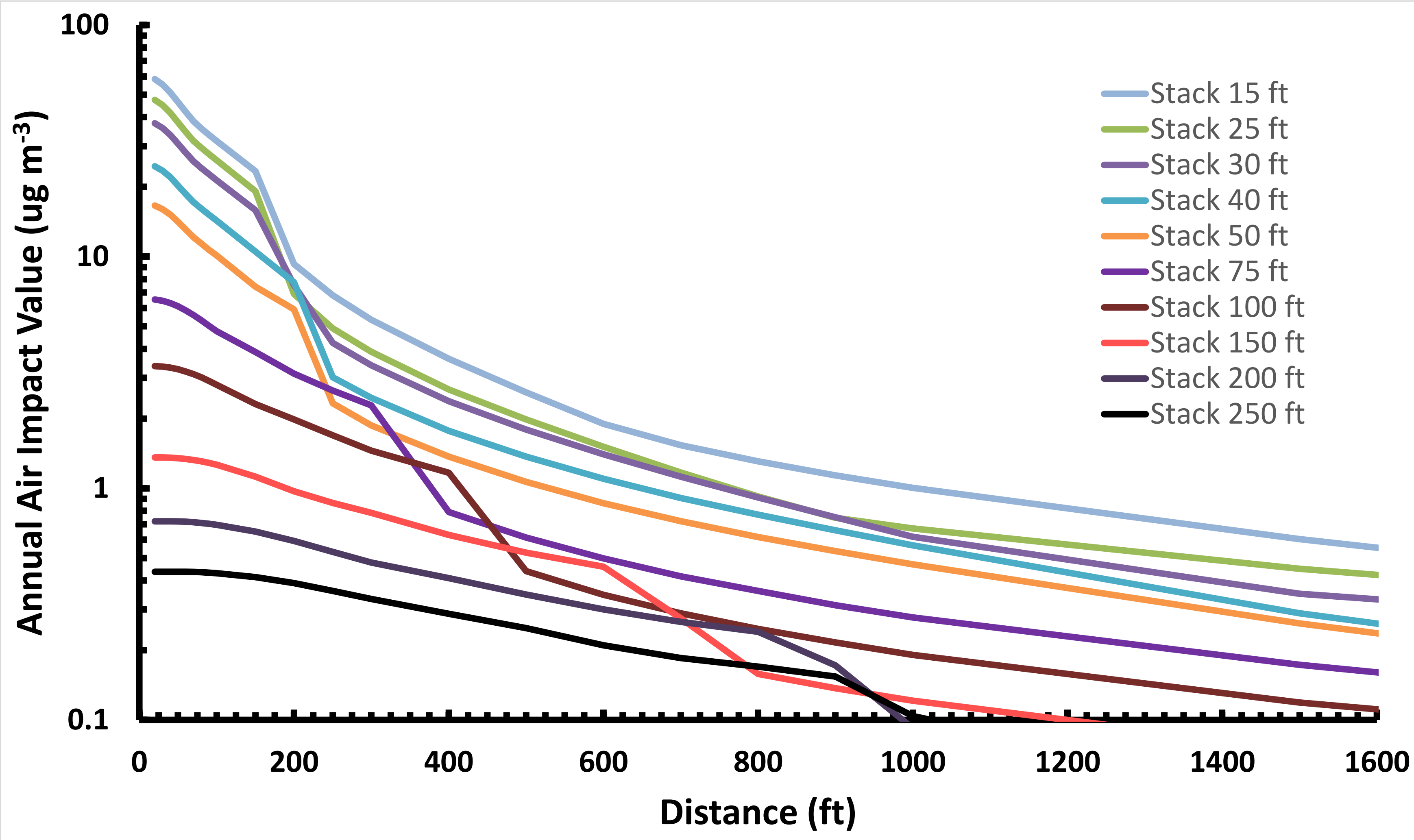

Figure C-1. Annual air impact value (µg/m^3) as a function of distance (ft) for all simulated stack heights (ft). The impact values are the worst-case impact scenarios from Trenton, Philadelphia, and Newark locations considering both urban and rural terrain settings. Simulations were run using AERMOD Version 15181 and meteorology datasets from 2010-2014 at each site.

Table C-5. Hourly Air Impact Values per lb/hr of Emissions for Stack Heights 15-250 ft (μg/m³)

Distance (ft)	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	75 ft	100 ft	150 ft	200 ft	250 ft
20	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
30	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
40	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
50	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
60	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
70	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
80	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
90	3029.5	2166.6	2156.7	1606.9	954.4	641.1	289.7	167.5	75.9	43.5	28.7
100	3026.5	2162.2	2152.0	1603.5	952.4	641.1	289.7	167.5	75.9	43.5	28.7
150	2210.6	1826.1	1970.7	1497.6	939.3	640.4	289.7	167.5	75.9	43.5	28.7
200	1069.0	930.0	663.5	731.4	720.7	559.7	289.5	167.5	75.9	43.5	28.7
250	917.1	711.4	571.7	481.4	398.3	321.9	278.4	167.4	75.9	43.5	28.7
300	803.8	626.7	502.7	430.0	358.4	290.5	257.7	167.3	75.9	43.5	28.7
400	641.6	505.9	403.3	353.4	297.1	242.6	153.8	147.2	75.8	43.5	28.7
500	529.5	422.0	335.6	298.5	252.3	208.6	134.9	95.8	73.2	43.4	28.7
600	468.5	359.6	289.2	257.3	218.2	182.0	118.9	87.0	66.4	43.4	28.6
700	434.8	314.5	268.1	227.2	191.5	160.7	106.2	79.3	51.9	40.1	28.6
800	407.2	290.7	250.2	212.0	170.1	143.5	95.6	72.5	44.9	37.9	28.6
900	383.1	272.4	234.5	198.9	158.3	129.2	86.5	66.9	42.3	34.3	27.9
1000	360.4	258.6	219.3	187.4	149.2	120.2	78.9	61.9	39.8	27.8	24.3
1500	261.1	207.1	168.5	140.7	116.1	94.5	56.1	44.0	30.4	22.4	17.9
2000	204.5	169.0	132.0	112.5	94.5	78.3	47.8	33.5	24.3	18.5	15.4
2500	163.3	139.7	108.2	93.1	72.3	64.1	42.5	28.8	20.2	15.6	13.4
3000	136.3	118.3	89.3	79.1	61.3	50.9	37.8	26.3	16.9	13.6	11.8

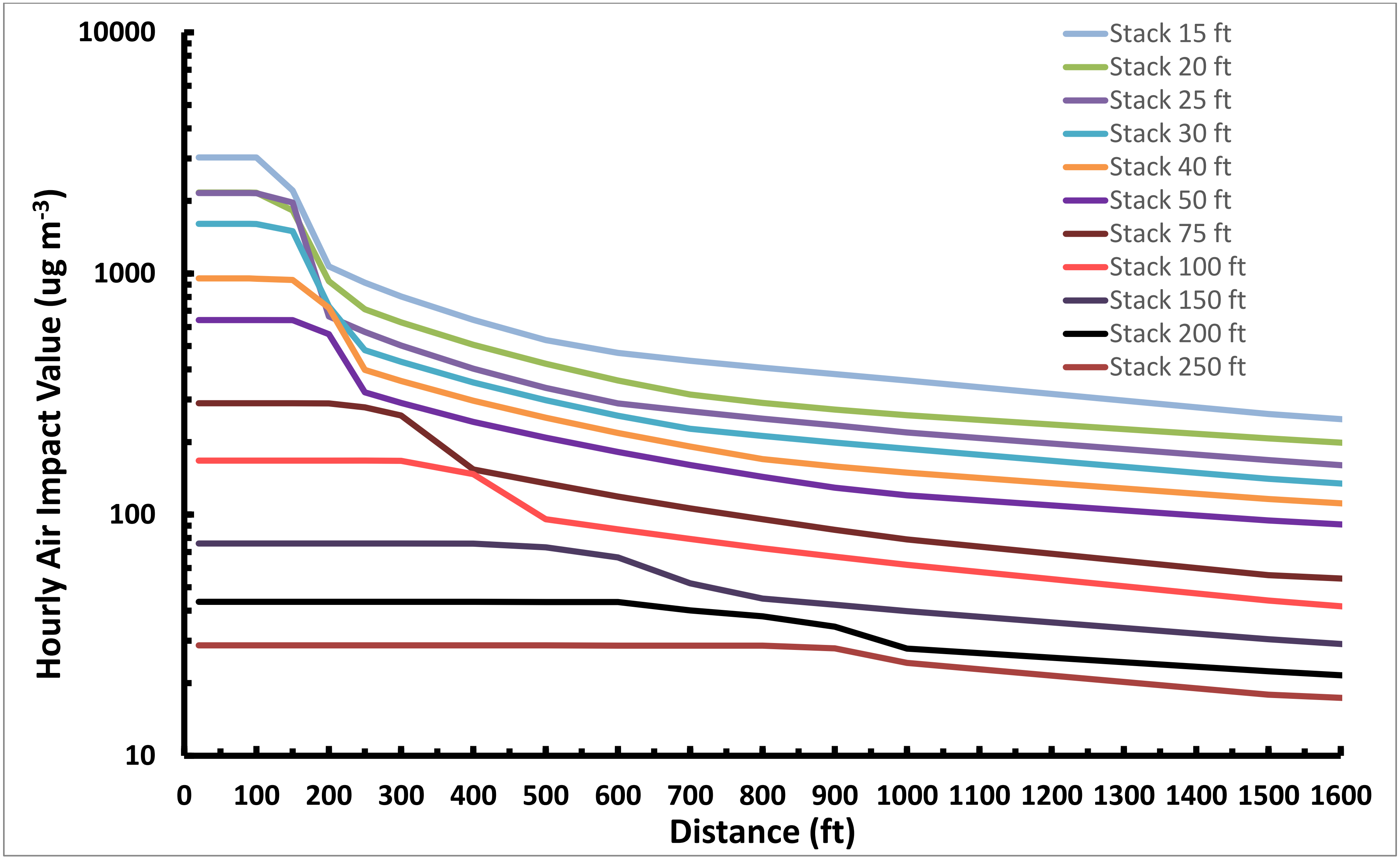

Figure C-2. Hourly air impact value (µg/m^3) as a function of distance (ft) for all simulated stack heights (ft). The impact values are the worst-case impact scenarios from Trenton, Philadelphia, and Newark locations considering both urban and rural terrain settings. Simulations were run using AERMOD Version 15181 and meteorology datasets from 2010-2014 at each site.

Conservatism in the Modeling of Air Impact Values and Risk Screening Worksheet

- The highest impact predicted from either the urban or rural mode was used for the risk assessment.
- The highest impact predicted from any of the thirty model simulations for each stack height was used.
- Of the 36 wind directions modeled, the direction for which the receptor radial had the highest concentrations was selected.
- Minimal plume rise was assumed.
- All stack heights were well below their GEP stack heights and subject to large amounts of building downwash.
- The stacks were located in the center of the building. When evaluating all wind directions, this location will produce the maximum amount of downwash.
- Emissions were assumed to occur continuously 24-hours a day, 365 days a year.

APPENDIX D

REFERENCES

California Air Toxics Hot Spots Guidelines, www.oehha.ca.gov/air/hot_spots/index.html.

National Research Council (NRC) 1983. *Risk Assessment in the Federal Government: Managing the Process*. National Academy Press, Washington, D.C.

New Jersey Administrative Code, Title 7, Chapter 27, Subchapter 8 (N.J.A.C. 7:27-8). Permits and Certificates.

N.J.A.C. 7:27-17. Control and Prohibition of Air Pollution by Toxic Substances.

N.J.A.C. 7:27-18. Control and Prohibition of Air Pollution from New or Altered Sources Affecting Ambient Air Quality.

NJDEP 2016. *AQPP Technical Manual 1002: Guidance on Preparing an Air Quality Modeling Protocol*. Trenton, NJ.

NJDEP July 2015. *Processed Meteorological Files (2010-2014) For Use in AERMOD Dispersion Modeling Analyses*.

NJDEP Risk Screening Tools, www.nj.gov/dep/aqpp/risk.html.

U.S. Environmental Protection Agency (USEPA) 1997. *Exposure Factors Handbook – August 1997*. National Center for Environmental Assessment, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12464.

USEPA 2005. *Guidelines for Carcinogen Risk Assessment*, March 2005. Risk Assessment Forum, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=116283.

USEPA 2008. *Child-Specific Exposure Factors Handbook*, September 2008. National Center for Environmental Assessment, http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=56747.

USEPA. Integrated Risk Information System (IRIS), www.epa.gov/iris.