An Overview of Methods for EPA's National-Scale Air Toxics Assessment

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Acknowledgements

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Contents

List of Exhibits

Common Acronyms and Abbreviations

µg/m^3	microgram/cubic meter
AERMOD	atmospheric dispersion model developed by the American Meteorological Society and the U.S. Environmental Protection Agency's Regulatory Model Improvement Committee
ASPEN	Assessment System for Population Exposure Nationwide
ATRA	Air Toxics Risk Assessment
ATSDR	Agency for Toxic Substances and Disease Registry
CHAD	Consolidated Human Activity Database
CMAQ	Community Multiscale Air Quality
DDE	dichlorodiphenyldichloroethylene
EC	exposure concentration
EMS-HAP	Emissions Modeling System for Hazardous Air Pollutants
EPA	Environmental Protection Agency
HAP	hazardous air pollutant
HAPEM	Hazardous Air Pollutant Exposure Model
HAPEM-MS	Hazardous Air Pollutant Exposure Model for Mobile Sources
HEM	Human Exposure Model
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
ISCLT2	Industrial Source Complex Long-Term, version 2
MACT	Maximum Achievable Control Technology
mg/kg-day	milligram/kilogram/day
MM5	Mesoscale Model
MOBILE	Mobile Source Emission Factor
MOVES	Motor Vehicle Emissions Simulator
NATA	National-scale Air Toxics Assessment
NEI	National Emissions Inventory
NMIM	National Mobile Inventory Model
OAQPS	Office of Air Quality Planning and Standards
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PM	particulate matter
POM	polycyclic organic matter
RfC	reference concentration
RTR	Risk and Technology Review
SCC	Source Classification Code
SIC	Standard Industrial Classification
URE	unit risk estimate

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1 BACKGROUND AND INTRODUCTION

1.1 What Is the Purpose of this Document?

This document provides an introduction to the U.S. Environmental Protection Agency's (EPA) **National-scale Air Toxics Assessment** (NATA), an ongoing comprehensive evaluation of **air toxics** in the United States. It presents the approaches EPA uses to conduct NATA, including descriptions of how

- emissions data are compiled and prepared for use as model inputs,
- ambient concentrations of air toxics are estimated,
- exposures to air toxics for populations are estimated,
- toxicity values are selected and assigned to air toxics,
- human health risks and hazards are characterized, and
- variability and uncertainty are addressed.

Specifically, this document summarizes the data sources, methods, models, and assumptions used in NATA that have been published in various EPA reports and have been available on EPA's NATA Web site (http://www.epa.gov/ttn/atw/natamain/index.html). Presenting this information in one place provides those interested in NATA a more convenient resource than has been available in the past.

General procedures are described for the four assessments completed to date – including the most recent, which used an emissions inventory representative of 2005 − as are the important refinements made for each. A list of references and numerous links to additional documents is included (Section 8) so that readers can readily access more detailed technical information on the emissions inventories, **dispersion models**, exposure models, and toxicity values used for the assessments.

Several other sources of information are provided as appendices to this document:

- Appendix A – a glossary of the key terms that NATA uses and their definitions (these terms appear in bold font the first time they are used in this document);
- Appendix B – a list of air toxics included in the 2005 NATA, with information on their principal sources;
- Appendix C – a table presenting a crosswalk for the hazardous air pollutants (HAPs)[1] included in the **National Emissions Inventory** (NEI), the substances for which toxicity values have been defined for NATA, and the corresponding HAP category for each NEI HAP;

[1] The term hazardous air pollutant refers to those pollutants defined in the 1990 Clean Air Act Amendments that cause or could cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. The 1990 Clean Air Act required EPA to control 190 hazardous air pollutants. Currently, the list includes 187 HAPs (EPA 2008c). Although the terms HAPs and air toxics are sometimes used interchangeably, air toxics as used in this document refers to all HAPs currently listed in the Clean Air Act plus diesel particulate matter (PM).

- Appendix D – tables showing the emission speciation assumptions used for **chromium** and mercury, and tables showing the Maximum Achievable Control Technology (MACT) source categories and other source groupings;
- Appendix E – an explanation of how the 2005 NEI emissions data were processed and used for the 2005 NATA;
- Appendix F – details on how **background concentrations** of air toxics were derived and addressed in NATA;
- Appendix G – a table presenting the average ratios of exposure concentration to ambient concentration used in the 2005 NATA;
- Appendix H – a table showing toxicity values used for the 2005 NATA; and
- Appendix I – discussions of **polycyclic organic matter** (POM) species and modeling assumptions.

This document does *not* provide quantitative results for any specific NATA and thus presents no exposure or risk estimates. Results and other specific information for NATA, including for the 2005 NATA and previous assessments, are found on the NATA Web site (http://www.epa.gov/ttn/atw/natamain/index.html).

1.2 What Is NATA?

NATA is a state-of-the-science screening tool that is used to help evaluate the human health risks posed by air toxics across the United States. EPA developed this tool so that state, local, and tribal agencies could prioritize air toxics, emission sources, and locations of interest for further study.

NATA assembles information on air toxics, characterizes emissions, and prioritizes air toxics and locations that merit more refined analysis and investigation. This information is used to plan, and assist with the implementation of, national, regional, and local efforts to reduce toxic air pollution. Using general information about sources to develop estimates of risks, NATA provides screening-level estimates of the risk of cancer and other potentially serious health effects as a result of inhaling air toxics. The resulting risk estimates are purposefully more likely to be *overestimates* of health impacts than underestimates, and thus they are health protective.

NATA uses emissions data compiled for a single year as inputs for modeling ambient air concentrations and estimating health risks. Results include estimates of ambient and exposure concentrations of air toxics and estimates of cancer risks and potential **non-cancer health effects** associated with chronic **inhalation** exposure to air toxics. The estimates are generated within each state, at both the county- and **census-tract** levels.

NATA provides a "snapshot" of outdoor air quality and the risks to human health that might result if air toxic emission levels were to remain at the same levels as those estimated for the assessment year. The estimates reflect only risks associated with chronic (relatively long-term) exposures to the inhalation of air toxics at the population level. The assumptions and methods used to complete the national-scale assessments limit the types of questions that NATA can answer reliably. These limitations, described throughout later sections of this document and summarized in Section 7, must be considered when interpreting the NATA results or when using them to address questions posed outside of NATA.

NATA results are useful for prioritizing air toxics and emission sources, identifying locations of interest that require additional investigation, providing a starting point for local-scale assessments, focusing community efforts to reduce local emissions of air toxics, and informing the design of new monitoring programs or the re-design of existing ones. NATA results also can provide general answers to questions about emissions, ambient air concentrations, and exposures and risks across broad geographic areas (such as counties, states, the nation) at a moment in time.

NATA was designed to answer questions such as the following:

- Which air toxics pose the greatest potential risk of cancer or adverse non-cancer effects across the entire United States?
- Which air toxics pose the greatest potential risk of cancer or adverse non-cancer effects in specific areas of the United States?
- Which air toxics pose less, but still significant, potential risk of cancer or adverse non-cancer effects across the entire United States?
- When risks from inhalation exposures to all outdoor air toxics are considered in combination, how many people could experience a **lifetime cancer risk** greater than levels of concern (e.g., **1 in a million**)?
- When potential adverse non-cancer effects from long-term exposures to all outdoor air toxics are considered in combination for a given target organ or system, how many people could experience exposures that exceed the reference levels intended to protect against those effects (i.e., a **hazard quotient** equal to or greater than 1)?

1.3 What Is the History of NATA?

EPA's first national-scale air toxics study was the Cumulative Exposure Project (Caldwell et al. 1998), which was developed based on estimates of air toxics emissions present before the Clean Air Act was amended in 1990. The Cumulative Exposure Project provided estimates of outdoor air toxics concentrations in each of the more than 60,000 continental U.S. census tracts.

For the first NATA, the Cumulative Exposure Project framework was enhanced to include estimates of population exposure and health risk. The first NATA used a more refined inventory of air toxics emissions developed for 1996, known at that time as the **National Toxics Inventory**. This assessment was submitted for a technical peer review in January 2001 to a panel of EPA's **Science Advisory Board** (EPA 2001b). The panel provided detailed comments later that year on the validity of the overall approach, the elements of the assessment (including the data, models, and methods used), and the manner in which these components were integrated into a national-scale assessment (EPA 2001a). EPA incorporated many of the Science Advisory Board's suggestions into the assessment and published the results of that assessment in 2002. Since then, three assessments have been completed, based on inventories representative of air toxic emissions in 1999, 2002, and 2005, respectively. In general, the scope of NATA has progressively expanded with subsequent versions, and some methods have been refined and improved. Exhibit 1-1 summarizes the four NATAs EPA has conducted to date.

1.4 How Do States and EPA Use NATA Results?

NATA was designed as a screening assessment and functions as a tool to inform both national and more localized efforts to collect air toxics information, to characterize emissions, and to help prioritize air toxics and geographic areas of interest for more refined data collection and analyses.

Exhibit 1-1. NATAs EPA Has Conducted to Date

Inventory Year	Year Completed/ Published	Air Toxics Modeled[a,b]	Key Attributes
1996	2002	**33 –** 32 HAPs, focusing on those of concern in **urban** areas; plus **diesel PM**	• **ASPEN** used to model ambient concentrations • **HAPEM**4 used to model inhalation exposures
1999	2006	**177 –** 176 HAPs, including all those with chronic health toxicity values at the time; plus diesel PM	• ASPEN used to model ambient concentrations • HAPEM5 used to model inhalation exposures • Doubled the number of emission sources covered compared to 1996 NATA
2002	2009	**181 –** 180 HAPs, including 4 with additional health information; plus diesel PM	• ASPEN and HEM (with ISC) used to model ambient concentrations • HAPEM5 used to model inhalation exposures
2005	2010	**179**[c] – 178 HAPs, for which emissions data and chronic health toxicity values are available; plus diesel PM	• Emissions inventory updated to include recent information on industrial sources, residual risk assessments, lead emissions from airports, and other sources • ASPEN and HEM (with AERMOD, a more refined dispersion model) used to model ambient concentrations; HEM used for more source types than in 2002 • Exposure factors derived from 2002 NATA used to estimate inhalation exposures • CMAQ model used to estimate **secondary formation** of acetaldehyde, acrolein, formaldehyde, and decay of 1,3-butadiene to acrolein

[a] Note that "air toxics" and "HAPs" are sometimes used interchangeably. In this document, however, air toxics refers to HAPs plus diesel PM. HAPs are those air toxics which EPA is required to control under Section 112 of the 1990 Clean Air Act Amendments (EPA 2007a). Diesel PM is not a HAP, and EPA does not currently have enough evidence to develop a **unit risk estimate** for it, although some evidence exists that localized high lifetime cancer risks are associated with exposure to diesel PM. Given these concerns, the adverse non-cancer effects of diesel PM are estimated in NATA (using an IRIS **RfC**) but its cancer risks are not.

[b] The number of air toxics included in a NATA emission inventory can be slightly larger than the number of air toxics actually modeled. Some air toxics are not modeled because of uncertainty in the emissions numbers or in the ability to model air concentrations or health risk accurately. For example, asbestos and radionuclides are included in the 2005 NATA emission inventory but not modeled and they are not included in the counts presented in this table.

[c] Fewer air toxics were included in the 2005 NATA than in the 2002 NATA because fewer were reported to the 2005 NEI.

Notes:

HAPs = hazardous air pollutants; diesel PM = diesel particulate matter; ASPEN = Assessment System for Population Exposure Nationwide; HAPEM4, HAPEM5 = Hazardous Air Pollutant Exposure Model, version 4 and version 5; HEM = Human Exposure Model; NATA = National-scale Air Toxics Assessment, CMAQ = Community Multiscale Air Quality model. ISC and AERMOD are Gaussian dispersion models.

Ultimately, NATA results are intended to focus resources on air toxics, locations, or populations that are associated with the greatest potential health risks. Thus, the goal of NATA is to identify those air toxics of greatest potential concern with regard to their contribution to population risk. The results are used to set priorities for the collection of additional air toxics information, including emissions and monitoring data. NATA was designed to help guide efforts to reduce toxic air pollution and to provide information that can be used to further the already significant emissions reductions achieved in the United States since 1990.

EPA uses NATA to identify those air toxics and source sectors (e.g., **stationary sources**, mobile sources) having the highest exposures and health risks. The assessment results also help to identify geographic patterns and ranges of risks across the country. Specifically, EPA uses NATA results to

- identify pollutants and industrial source categories of greatest concern,
- improve understanding of health risks posed by air toxics,
- help set priorities for the collection of additional information,
- set priorities for improving emission inventories,
- expand and prioritize EPA's air toxics monitoring network,
- support communities in designing their own local assessments,
- enhance targeted risk reduction activities, and
- link air toxics to the Criteria Pollutant Program (EPA 2009m).

1.5 How NATA Results Should Not Be Used

As described in Section 1.2, NATA is a screening-level assessment that was designed to answer specific types of questions. The underlying assumptions of NATA and the methods limit the range of questions that can be answered reliably. NATA results should not be used independently to characterize or compare risk at local levels (e.g., between neighborhoods), nor should they be used to estimate exposure or health risks for individuals or groups within small geographic areas such as census blocks or to design control measures for specific emissions sources or pollutants.

NATA evaluations use emissions data for a single year as inputs to models that yield concentration and risk estimates. These estimates reflect chronic exposures. Given these characteristics, NATA results should not be used for the following:

- as a definitive means to pinpoint specific risk values within a census tract,
- to characterize or compare risks at local levels such as between neighborhoods,
- to characterize or compare risk among states,
- to examine trends from one NATA year to another,
- as the sole basis for developing risk reduction plans or regulations,
- as the sole basis for determining appropriate controls on specific sources or air toxics, or
- as the sole basis to quantify benefits of reduced air toxic emissions.

The limitations of the assessment methods prevent NATA from serving as a stand-alone tool. Furthermore, although results are reported at the census tract level, average risk estimates are far more uncertain at this level of spatial resolution than at the county or state level. For analysis of air toxics in smaller areas, such as census blocks or in a suspected "hotspot," other tools such as site-specific monitoring and local-scale assessments coupled with refined and localized data should be used.

These caveats are integral to the proper interpretation of NATA results. NATA results should be used to address only those questions for which the assessment methods are suited. Moreover, as noted above, NATA results from different assessment years generally should not be compared to each other. From one assessment to the next, EPA has improved its methodology and incorporated additional data that enhance the utility of the results. Specifically, each subsequent assessment has offered the following relative to the previous NATA:

- a better and more complete inventory of emission sources,
- an overall increase in the number of air toxics evaluated,[2] and
- updated health data for use in risk characterization.

Successive improvements in methodology and improved data make comparing earlier assessments with later assessments inappropriate. Differences in emissions, ambient concentrations, or risks observed in the results of two assessments might be due either to improvement in the assessment methodology or to actual changes in emissions, populations, or other "real-life" characteristics.

NATA is not used solely as the source of information leading to regulations or guiding the enforcement of existing rules. Thus, even though some of the methods used to conduct NATA are similar to those used in air-related risk assessments conducted under the Clean Air Act mandate (such as residual risk assessments of HAP emissions from point sources, or assessments of exposures to criteria pollutants for evaluations of National Ambient Air Quality Standards), NATA fundamentally differs from such assessments in that it is not a regulatory program.

1.6 What Does NATA Not Include?

EPA developed NATA to inform both national and more localized efforts to collect information and to characterize air toxics emissions (e.g., prioritize air toxics or geographic areas of interest for monitoring and community assessments). Because of this targeted objective, tools other than NATA might be more appropriate for assessing health risks outside the specific purpose of NATA (e.g., for evaluating risks from either a broader or more specific perspective). To further define and clarify what NATA should not be used for, this section describes some of the important data and results that are not included in NATA.

- NATA does not include information that applies to specific locations. The assessment focuses on variations in air concentration, exposure, and risk among geographic areas such as census tracts, counties, and states. All questions asked, therefore, must focus on the variations among these geographic areas (census tracts, counties, etc.). Moreover, as previously mentioned, results are far more uncertain at the census tract level than for larger geographic areas such as states or regions. (Section 7 discusses reasons for the higher uncertainty at small geographic scales such as census tracts.) Additionally, NATA does not include data appropriate for addressing epidemiological questions such as the relationship between asthma or cancer risk and proximity of residences to point sources, roadways, and other sources of air toxics emissions.
- The results do not include impacts from sources in Canada or Mexico. Thus, the results for states bordering these countries do not reflect sources of transported emissions that could be significant.
- NATA does not include results for individuals. Within a census tract, all individuals are assigned the same ambient air concentration, chosen to represent a typical ambient air concentration. Similarly, the exposure assessment uses **activity patterns** that do not fully reflect the actual variations among individuals.

[2] Although the number of air toxic categories evaluated in 2005 decreased slightly relative to the number evaluated in 2002 (as noted in Exhibit 1-1), the number of individual substances and the total emissions mass assessed remained approximately the same.

- The results do not include exposures and risk from all compounds. For example, of the 179 air toxics modeled for the 2005 NATA (some of which encompass multiple substances), only 140 air toxics have been assigned dose-response values. The remaining 39 do not have adequate data in EPA's judgment to quantitatively assess their impacts on health, and, therefore, do not contribute to the aggregate cancer risk or target organ-specific hazard indices. Of particular significance is that the assessment does not quantify cancer risk from diesel particulate matter (PM), although EPA has concluded that the general population is exposed to levels close to or overlapping with levels that have been linked to increased cancer risk in epidemiology studies. NATA does, however, model non-cancer effects of diesel PM.
- The results do not include the six air pollutants, known as "criteria pollutants" (particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead), for which the Clean Air Act requires EPA to set National Ambient Air Quality Standards.
- The results do not reflect all pathways of potential exposure. The assessment includes risks only from direct inhalation of the emitted air toxics compounds. It does not consider air toxics compounds that might then deposit onto soil, water, and food and subsequently enter the body through ingestion or skin contact.
- The results do not include multipathway exposures because sufficiently refined tools and data required to model multipathway concentrations and human exposures for many air toxics on the national scale are not readily available for use.
- The estimates do not consider exposures that might occur indoors, through the skin (dermal exposure), or by eating or drinking (ingestion exposure).
- The assessment results reflect exposure at outdoor, indoor, and in-vehicle locations, but only to compounds released into the outdoor air, which could subsequently penetrate into buildings and vehicles. The assessment does not include exposure to air toxics emitted indoors, such as those from stoves, those that out-gas from building materials, or those from evaporative benzene emissions from cars in attached garages. The assessment also does not consider toxics released directly to water and soil.
- The assessment does not fully reflect variation in background ambient air concentrations. Background ambient air concentrations are average values over broad geographic regions.
- The assessment might not accurately capture sources that have episodic emissions (e.g., facilities with short-term deviations in emissions resulting from startups, shutdowns, malfunctions, and upsets). The models assume emission rates are uniform throughout the year. Short-term (acute) exposures and risks also are not included in NATA.
- With the exception of formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene (which transforms into acrolein), atmospheric transformation and losses from the air by deposition are not accounted for in NATA.
- The evaluations to date have not assessed ecological effects, given the complexity of the varied ecosystems across the vast geographic area that NATA targets.

1.7 What Is the Overall NATA Process?

The methods applied in conducting NATA are consistent with the general risk assessment framework used throughout EPA. This section provides background information on EPA's risk

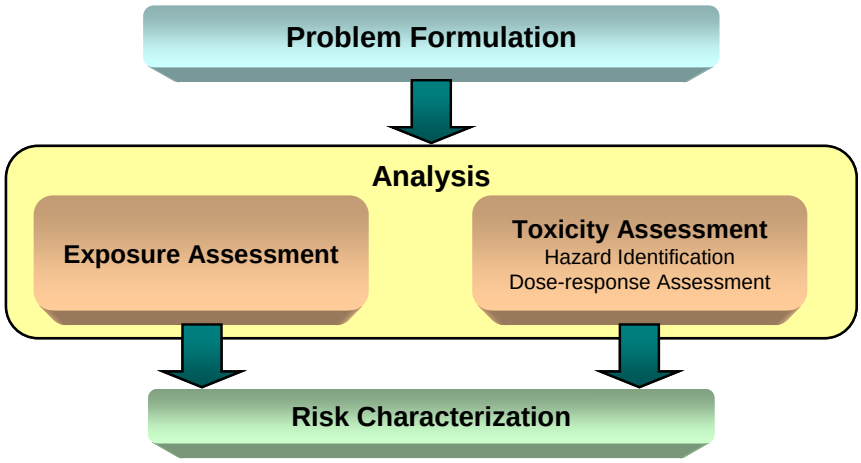
assessment framework and summarizes the NATA process. The analytical components of this process are then described in greater detail in subsequent sections.

EPA has published a series of guidelines (EPA 2010f) that establishes and explains the recommended methods for assessing human health risks from environmental pollution. Included in this series are recommendations for **carcinogen** risk assessment, exposure assessment, chemical mixtures risk assessment, and other major EPA-wide risk assessment guidelines. In addition, EPA developed the three-volume Air Toxics Risk Assessment (ATRA) Reference Library (EPA 2004a,c; EPA 2006d) as a reference for those conducting air toxics risk assessments. This library provides information on the fundamental principles of risk-based assessment for air toxics, how to apply those principles in various settings, and strategies for reducing risk at the local level. EPA's guidelines and methods are consistent with the National Research Council's recommendations on conducting risk assessments (NRC 1983, 1994).

As described in more detail in these guidelines and documents, EPA's risk assessment process has three phases (Exhibit 1-2), the second of which has two parts.

- The first phase (problem formulation) comprises the initial planning and scoping activities and definition of the problem, which results in the development of a conceptual model.
- The second phase (analysis) includes two components:
  - Exposure assessment; and
  - Toxicity assessment.
- The third phase is risk characterization, a synthesis of the outputs of the exposure and toxicity assessments to characterize health risks for the scenario described in the initial phase.

Exhibit 1-2. The General Air Toxics Risk Assessment Process



guide or "road map" to the assessment. It defines the physical boundaries, potential sources and emitted air toxics, potentially exposed populations, chemical fate and transport processes, expected routes of exposure, and potential health effects.

This document is concerned primarily with describing the analysis phase of the general air toxics risk assessment process (and specifically with describing the analyses conducted for NATA). The analysis phase is the stage at which the risk assessment processes are used to evaluate the problem at hand. The planning and scoping activities and problem formulation EPA conducts before carrying out the analyses, however, are critical in that they set the course for the assessment and inform EPA's decisions regarding specific methods, models, and data sources to use. The conceptual model developed for NATA – which is the product of the first phase – is described in the following section. An overview of the analytical steps then follows in Section 1.9. Detailed descriptions of each step are presented in the sections that comprise the rest of this document.

1.8 What Is the Scope of NATA?

The national-scale assessment described in this document is consistent with EPA's definition of a cumulative risk assessment as "an analysis, characterization, and possible quantification of the combined risks to health or the environment from multiple agents or stressors" (EPA 2003; p. 6). EPA's Framework for Cumulative Risk Assessment (EPA 2003) emphasizes that a conceptual model is an important output of the problem formulation phase of a cumulative risk assessment. The conceptual model defines the actual or predicted relationships between exposed individuals, populations, or ecosystems and the chemicals or stressors to which they might be exposed. Specifically, the conceptual model lays out the sources, stressors, environmental media, routes of exposure, receptors, and endpoints (i.e., measures of effects) relevant to the problem or situation that is being evaluated. This model takes the form of a written description and a visual representation of the relationships among these components (EPA 2003). The conceptual model sometimes can include components that are not specifically or quantitatively addressed by an assessment, but that are nevertheless important to consider.

Section 2.4 of the report for the 1996 NATA presented to EPA's Science Advisory Board for review (EPA 2001b) included a conceptual model. Some of the specifics included in that conceptual model have since evolved as sequential assessments have been completed (for example, the number of air toxics evaluated has increased substantially since the 1996 NATA). The fundamental components included in NATA and the relationships among them, however, have been generally consistent for all four NATAs completed to date. Moreover, the conceptual model described in this document is very similar to the one presented in the documentation for the 1996 NATA.

NATA is national in scope, covering the United States, Puerto Rico, and the U.S. Virgin Islands. It focuses on long-term inhalation exposures to air toxics. In general, NATA is intended to provide EPA with the best possible national-scale population-level estimates of exposure to and risks associated with air toxics, taking into account data availability, technical capabilities, and other potentially limiting factors. The conceptual model for the 2005 NATA is presented in Exhibit 1-3. Each component included in the model is described briefly in the sections that follow.

1.8.1 Sources of Air Toxic Emissions that NATA Addresses

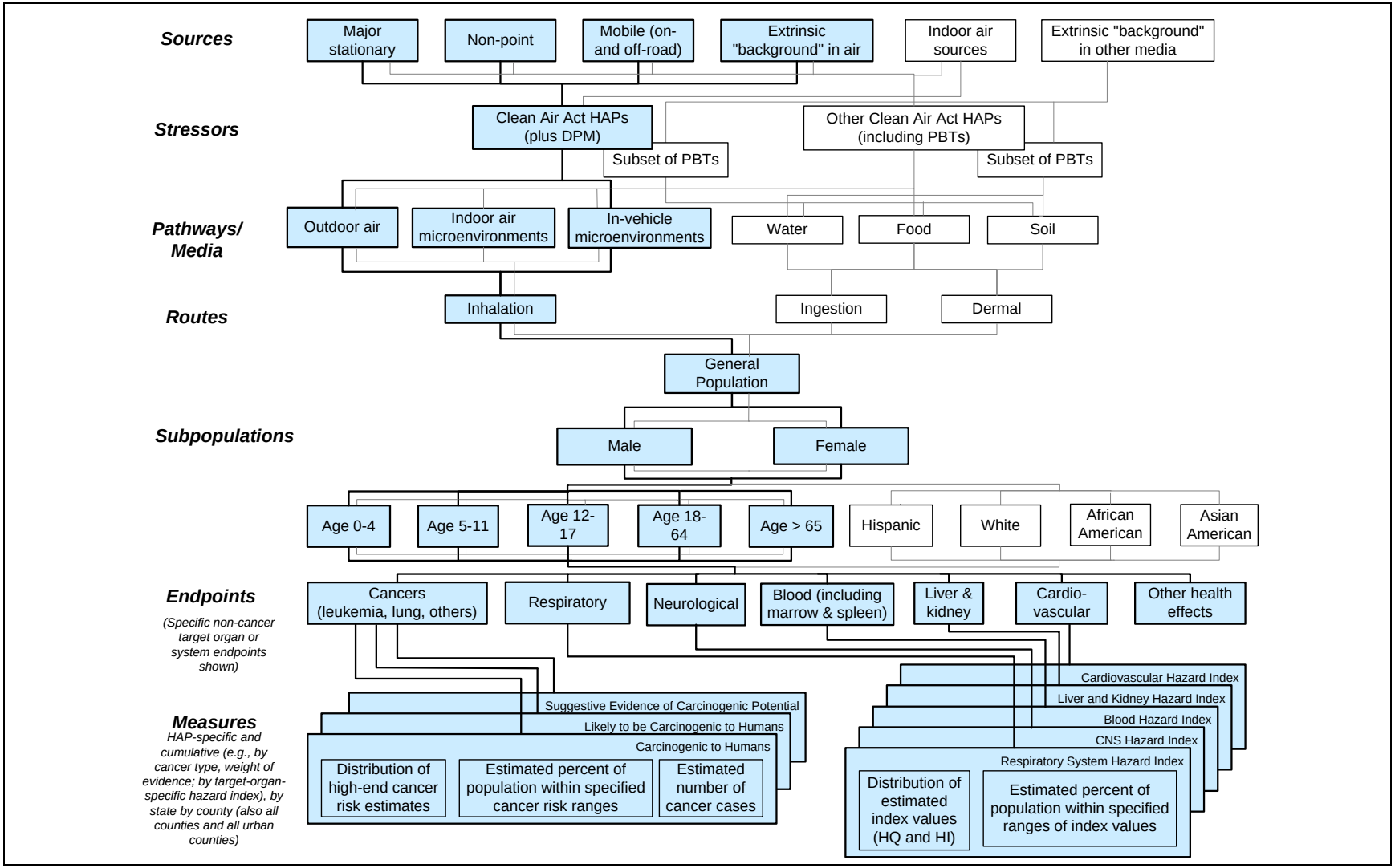
Sources of air toxic emissions included in NATA are point, non-point, mobile **on-road** and off-road, and background sources located in the United States, Puerto Rico, and the U.S. Virgin Islands. Examples of point sources are large waste incinerators and factories. Non-point sources include dry cleaners, gasoline stations, and small manufacturing facilities. Mobile sources include vehicles found on roads and highways, such as cars and trucks, and **non-road** vehicles such as marine vessels and trains.

Background sources can include natural sources and anthropogenic air toxics emitted in prior years that persist in the environment, or air toxics emitted from distant sources and transported farther than 50 kilometers. EPA limits the exposure assessment and risk characterization to sources included in available emission inventories. Details on emission sources are presented in Section 2.

1.8.2 Stressors that NATA Evaluates

The stressors evaluated through NATA can include any of the 187 HAPs defined in the 1990 Clean Air Act (190 HAPs were included originally but 3 have since been removed from the list). The set of air toxics included in NATA is determined by the emission and toxicity data available at the time of the assessment. Diesel PM, an indicator of diesel exhaust, is included in the set of stressors for NATA.

Exhibit 1-3. Conceptual Model for NATA



Blue boxes indicate elements included in the 2005 NATA; clear boxes indicate elements that could be included in future assessments. In the "Sources" included here, "Major stationary" includes both **major and area sources** as defined for regulatory purposes in the Clean Air Act. "Non-point" refers to smaller (and sometimes less discrete) sources that are typically estimated on a top-down basis (e.g., by county). Additional explanation of source types included in NATA is presented in Section 2. DPM refers to diesel particulate matter. PBTs refers to chemicals that are persistent, bioaccumulative, and toxic. HQ and HI refer to hazard quotient and **hazard index**, respectively.

The initial NATA completed using the 1996 data included the 33 air toxics (including diesel PM) identified by EPA as those air toxics that present the greatest threat to public health in the largest number of urban areas. Collectively, these air toxics appeared highly likely to encompass most of the total air toxics-related risk to human populations, and they were included to help fulfill EPA's assessment commitments under the Integrated Urban Air Toxics Strategy. The three NATAs conducted since 1996 have included air toxics beyond this set of 33.

The 2005 NATA emissions inventory includes emissions for 181 air toxics. This assessment does not include the class of compounds known as dioxins because, at the time of the assessment, EPA was still reviewing the current dioxin inventory and the exposure and human health assessment of dioxin. Also, the most significant exposure route for dioxin is ingestion, not inhalation, so dioxin's relative contribution to NATA's inhalation risk estimates likely would not be large. Dioxins are expected to be included in future NATAs that evaluate ingestion and inhalation exposures. Although the 2005 NATA emissions inventory includes radionuclides and asbestos, they were not modeled for NATA. For these two materials, ambient concentrations and inhalation exposures used in risk assessments typically are not expressed using mass-based concentrations, given methods used to develop the toxicity values that match each material's specific toxicological characteristics. Health risks of radionuclides are estimated using specific activity (a measure of radioactivity, which occurs as energy is emitted in the form of radiation from unstable atoms), and air concentrations of asbestos often are measured in terms of numbers of fibers per unit volume. NEI currently is not compatible with emissions reported in units other than mass, and therefore suitable emissions data have not been compiled for these substances on a national scale.

As shown in Exhibit B-2 of Appendix B to this document, the 2005 NATA also did not include four HAPs that were included in the 2002 NATA: 1,2-diphenylhydrazine, *beta*-propiolactone, hexamethlyphosphoramide, and parathion. These four HAPs are not included in the 2005 assessment because no emissions of these substances were reported in the 2005 NEI. One air toxic, 2-Acetylaminofluorene, was reported to the 2005 NEI but not to the 2002 NEI, so it is included in the 2005 NATA but was not included in the 2002 NATA. Finally, 2,3,7,8-tetrachlorodibenzo-p-dioxin, chloramben, and N-nitroso-N-methylurea were not included in the 2005 NATA (see Exhibit B-2 in Appendix B to this document for details).

1.8.3 Exposure Pathways, Routes, and Time Frames for NATA

Exposure to air toxics from all sources is determined by a multiplicity of interactions among complex factors, including the locations and nature of the emissions, the emission release conditions, local meteorology, locations of receptor populations, and the specific behaviors and physiology of individuals in those populations. The particular combination of air toxics that people inhale, and the chemical interactions among those air toxics, influence the risks associated with these exposures. This high level of complexity makes aggregating risk across both substances and sources useful for depicting the magnitude of risks associated with inhalation of air toxics.

The dispersion modeling step of NATA includes evaluating the transport of emitted particles and gases through the air to receptors within 50 kilometers of sources. Transformation of substances in the atmosphere (also referred to as secondary formation) and losses of substances from the air by deposition are included in the modeling, where data are available. For air toxics with sufficient ambient monitoring data, or with emissions data primarily due to point sources, background concentrations are estimated. Taking into account fate and transport of emissions and the presence of some background concentrations, NATA estimates outdoor ambient concentrations across the nation.

NATA focuses on exposures due to inhalation of ambient air. Human receptors are modeled to account for an individual's movement among **microenvironments** such as residences, offices, schools,

exterior work sites, and automobiles, where concentration levels can be quite different from general outdoor concentrations. The exposure assessment estimates air concentrations for each substance within each modeled microenvironment. The exposure assessment also accounts for human activities that can affect the magnitude of exposure (e.g., exercising, sleeping). This component of NATA accounts for the difference between ambient outdoor concentrations and the exposure concentrations (i.e., long-term average concentrations to which people are actually exposed after taking into account human activities).

To date, NATA has not estimated air toxic concentrations in water, soil, or food associated with deposition from air, or the bioaccumulation of air toxics in tissues. Similarly, NATA has not estimated human exposures to chemicals via ingestion or dermal contact. EPA considers these pathways to be important but refined tools and data required to model multipathway concentrations and human exposures on the national scale are not yet readily available for use for many air toxics.

NATA estimates average annual outdoor concentrations that are used to develop long-term inhalation exposures for each of the air toxics. For cancer, the exposure duration is assumed to be a lifetime (i.e., 70 years for the purposes of this analysis). Chronic (long-term) non-cancer health effects are estimated using the same annual average exposure estimate and duration. Subchronic and acute (lasting less than 24 hours) exposures are not estimated in NATA because the emissions data base contains only annual total emissions. If the emission inventories are later expanded to cover short-term (e.g., hourly, daily) emission rates, EPA would consider incorporating shorter exposure times into NATA.

1.8.4 Receptors that NATA Characterizes

NATA characterizes average risks to people belonging to distinct human subpopulations. The population as a whole is divided into **cohorts** on the basis of residential location, life stage (age), gender, and daily activity pattern. A cohort is generally defined as a group of people within a population who are assumed to have identical exposures during a specified exposure period. Residential locations are specified according to U.S. Census tracts, which are geographic subdivisions of counties that vary in size but typically contain about 4,000 residents each. Life stages are stratified into five age groups: 0–4, 5–11, 12–17, 18–64, and 65 and older. Daily activity patterns specify time spent in various microenvironments (e.g., indoors at home, in vehicles, outdoors) at various times of day. For each combination of residential census tract, age, and gender, 30 sets of age- and gender-appropriate daily activity patterns are selected to represent the range of exposure conditions for residents of the tract. A population-weighted typical exposure estimate is calculated for each cohort, and this value is used to estimate representative risks, as well as the range, for a **"typical"** individual residing in that tract. Risk results for individual cohorts are not included in the outputs of NATA.

To date, NATA evaluations have not included non-human receptors (e.g., wildlife and native plants). The complexity of the varied ecosystems across the vast geographic area that is the scope of NATA precludes considering potential adverse ecological impacts at this time. Local- and urban-scale assessments could be developed to include non-human receptors, contingent on the availability of necessary resources, data, and methodologies. EPA currently, however, has no plans to include non-human receptors in NATA.

1.8.5 Endpoints and Measures – Results of NATA

NATA reports estimated cancer risks and non-cancer hazard indices attributed to modeled sources. Key measures of cancer risk developed for the 2005 NATA include:

- upper-bound estimated lifetime individual cancer risk, and
- estimated numbers of people within specified risk ranges (e.g., number of individuals with estimated long-term cancer risk of 1 in 1 million or greater or less than 10 in 1 million).

For non-cancer effects, the key measures presented in the 2005 NATA are hazard indices summed across all air toxics modeled for each of the five following target organs or systems:

- respiratory,
- neurological (central nervous system),
- blood,
- liver and kidney, and
- cardiovascular endpoints.

NATA characterizes cancer risk and potential non-cancer effects based on estimates of inhalation exposure concentrations determined at the census-tract level. This approach is used only to determine geographic patterns of risks within counties, and not to pinpoint specific risk values for each census tract. EPA is reasonably confident that the patterns (i.e., relatively higher levels of risk within a county) represent actual differences in overall average population risks within the county. EPA is less confident that the assessment pinpoints the *exact locations* where higher risks exist, or that the assessment captures the highest risks in a county. EPA provides the risk information at the census-tract level rather than just the county level, however, because the county results are less informative (in that they show a single risk number to represent each county). Information on variability of risk within each county would be lost if tract-level estimates were not provided. This approach is consistent with the purpose of NATA, which is to provide a means to inform both national and more localized efforts to collect air toxics information and to characterize emissions (e.g., to help prioritize air toxics and geographic areas of interest for more refined data collection such as monitoring). Nevertheless, the assumptions made in allocating mobile-and non-point source emissions within counties can result in significant uncertainty in estimating risk levels, even though general spatial patterns are reasonably accurate.

1.9 What Are the Steps Involved in NATA?

Consistent with the general approach for air toxics risk assessment illustrated in Exhibit 1-2, the analysis phase of NATA includes two main components: estimating exposure and estimating toxicity. The outputs of these analyses are used in the third phase, risk characterization, which produces health risk estimates that can be used to inform research or risk management. These two phases (analysis and risk characterization) represent the "core" of EPA's assessment activities associated with NATA. This set of activities is referred to here as the "NATA risk assessment process."

The NATA process can be characterized by four sequential components:

1. Compiling the nationwide inventory of emissions from outdoor sources;
2. Estimating ambient outdoor concentrations of the emitted air toxics across the nation;
3. Estimating population exposures to these air toxics via inhalation; and
4. Characterizing potential health risks associated with these inhalation exposures.

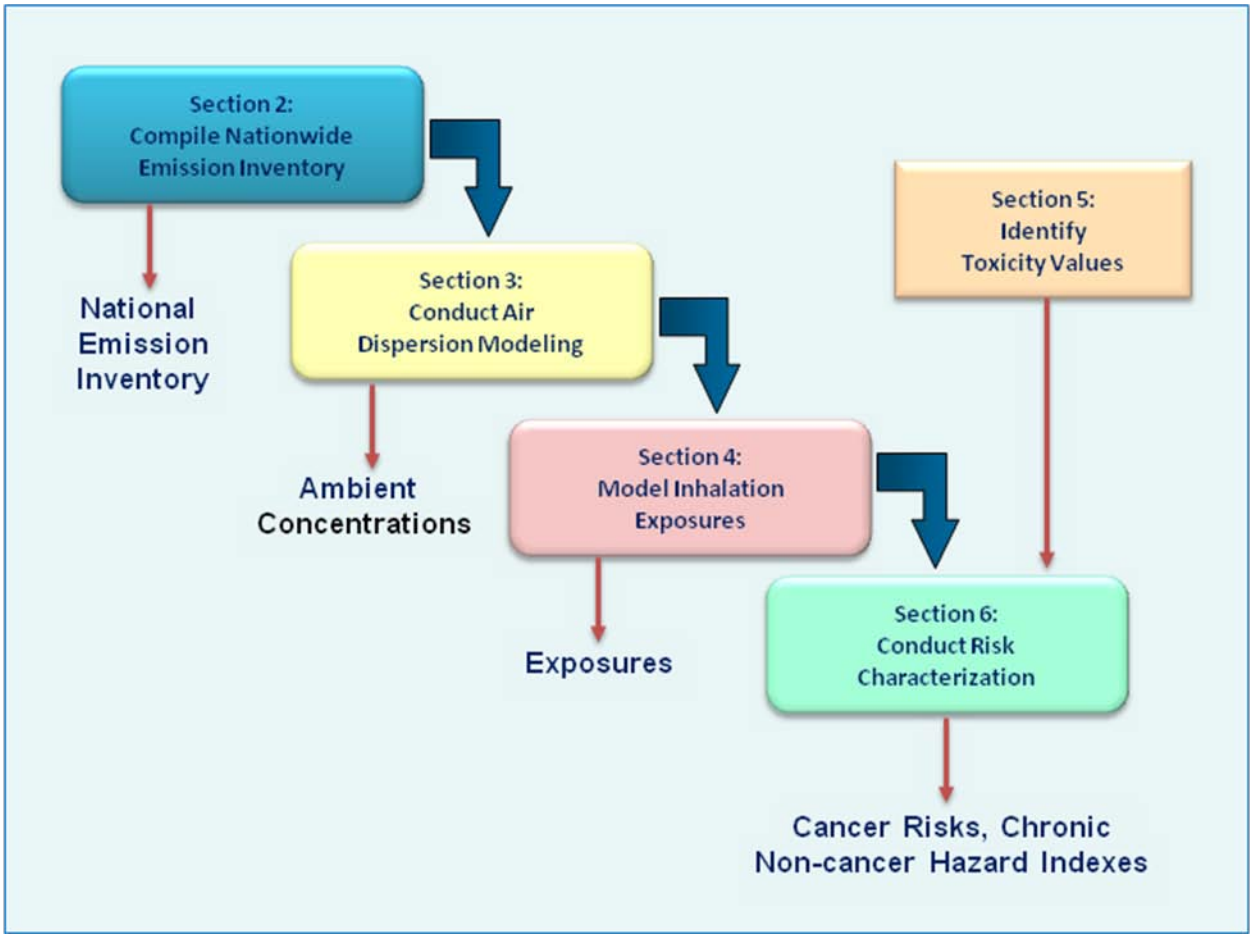
The fourth component (risk characterization) also requires that quantitative dose-response or other toxicity values be identified for each air toxic included in the assessment. These values are taken from those developed by other EPA and non-EPA programs. Although this step does not require a "new" quantitative dose-response assessment to be conducted as part of NATA, it does require that EPA make important scientific and policy decisions regarding the appropriate values to be used in NATA. Because

these decisions are critical to the risk results, the identification of appropriate dose-response values is also described in this technical support document as a fifth assessment component.

Collectively, these five components make up the NATA risk assessment process illustrated in Exhibit 1-4. The development of the emission inventory, dispersion modeling of emissions, inhalation exposure modeling, and risk characterization components must be conducted sequentially − the completion of each step requires outputs from the previous step. Toxicity values are required to carry out the risk characterization calculations. Cancer risks and the potential for non-cancer health effects are estimated using available information on health effects of air toxics, risk assessment and risk characterization guidelines, and estimated population exposures.

Each of these five components is described briefly here and explained in detail in the remainder of this document.

Exhibit 1-4. The NATA Risk Assessment Process



- **Section 2, Compiling the Nationwide Inventory**, provides an explanation of the source types and air toxics included in the NATA emissions inventory. It also describes the processes EPA carries out to compile the inventory for NATA.

- **Section 3, Estimating Ambient Concentrations of Air Toxics**, presents the models and procedures used to estimate ambient concentrations of air toxics, with links and references included to technical manuals and other detailed documentation for the models used for NATA.
- **Section 4, Estimating Exposures for Populations**, explains the processes used to estimate population-level exposure to outdoor ambient levels of air toxics, taking into account information on activities and other characteristics that can affect inhalation exposures.
- **Section 5, Characterizing Effects of Air Toxics**, describes the dose-response values used for NATA, the sources from which these values are obtained, and assumptions made specific to NATA.
- **Section 6, Characterizing Risks and Hazards in NATA**, provides an overview of the calculations used to estimate cancer risk and potential non-cancer hazard.
- **Section 7, Variability and Uncertainty Associated with NATA**, explains uncertainties and limitations associated with the NATA process that must be considered when interpreting NATA results.

As noted at the beginning of this section, this document is intended to serve as a resource accompanying the most recent national-scale assessment − the 2005 NATA. Accordingly, although the following sections present information on the NATA process that is generally applicable to all previous NATAs, references to specific technical processes and supporting details typically emphasize what was done for the 2005 NATA.

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2 COMPILING THE NATIONWIDE INVENTORY

The systematic compilation of a detailed, nationwide inventory of air toxics emissions is the first major step in the NATA risk assessment process. This section describes the inventory developed for NATA and summarizes the processes of compiling the inventory and refining selected data fields in preparation for modeling. Section 2.1 summarizes the types of emissions included in the inventory. Subsequent sections describe how emissions are prepared for each major source type included in NATA.

2.1 What Emissions Are Included in NATA, and How Are They Prepared for Modeling?

NATA is intended to model the outdoor emissions of all HAPs and diesel PM (together called "air toxics" in this document) from all anthropogenic sources that are in the NEI (EPA 2008a). Sometimes "air toxics" and "HAPs" are used interchangeably. In this document, however, "air toxics" refers to the HAPs that EPA is required to control under Section 112 of the 1990 Clean Air Act (EPA 2007a) plus diesel PM. The 1990 Clean Air Act Amendments (EPA 2007a) required EPA to control 190 HAPs (EPA 2008d) and provided for revisions to be made to that list. Currently, the list includes 187 HAPs. Diesel PM is not a HAP, and EPA currently does not have sufficient evidence to develop a unit risk estimate for it. Some evidence does indicate that localized high lifetime cancer risks are, however, associated with exposure to diesel PM. Given such concern, the potential adverse non-cancer effects associated with diesel PM are estimated in NATA (using an IRIS RfC) but its cancer risks are not.

Health concerns are associated with both short- and long-term exposures to air toxics. Most are known to have respiratory, neurological, immune, or reproductive effects, particularly for more sensitive populations such as children.

Each emission source included in NATA is categorized for the assessment in one of six source types. The emission source types modeled for NATA are shown in Exhibit 2-1. These source types provide a convenient framework for presenting information regarding both the development of the NATA emissions inventory (discussed in this section) and the modeling techniques used to estimate ambient air concentrations (discussed in Section 3).

EPA compiles NEI using a variety of data sources, including the following:

- State and local air toxics inventories, developed by state and local air pollution control agencies;
- Existing data bases related to EPA air toxics regulatory programs (including the various market-based EPA regulatory programs (EPA 2010c);
- The EPA Toxic Release Inventory (EPA 2010g) data base, which is a publicly available EPA data base with HAP and ammonia emissions data for certain industries;
- Estimates developed by EPA using mobile-source methodologies (EPA 2010h);
- Activity, fuel, and vehicle data from local, state, and federal agencies (e.g., Department of Energy, Federal Aviation Administration, Department of Transportation);
- Emissions estimates generated from emission factors and activity data;

Exhibit 2-1. Emission Source Types Modeled for NATA

Emission Source Type	Definitions, Examples, and Spatial Resolution of Emissions Inventory
Point [a]	• Stationary sources for which the locations are known, such as large waste incinerators and factories. Also includes emissions related to airports. • Stationary sources are inventoried at the stack level in NEI and modeled at this level for NATA. Airport-related sources are inventoried at the airport level in NEI and are allocated to the runway level for NATA.[b] In the future, airport-related sources might be inventoried at the runway level in NEI.
Non-point	• Stationary sources that are not incorporated into the point-source component of NEI, typically because their locations cannot be accurately measured at the facility level. • Includes prescribed burns, dry cleaners, small manufacturers, and other sources for which there might not be accurate means of measuring or estimating emissions. • The collective non-point emissions are inventoried at the county level in NEI. Note that emissions from wildfires are not modeled for NATA (although they are included in NEI). • For NATA modeling, emissions are allocated to the census-tract level.
On-road mobile	• Vehicles found on roads and highways, such as cars, trucks, and buses. • Inventoried at the county level using NEI and other recent data; allocated to census-tract areas for NATA modeling.
Non-road mobile	• Mobile sources not found on roads and highways, such as airport ground support equipment, trains, lawn mowers, construction vehicles, and farm machinery. • Inventoried at the county level in NEI; allocated to census-tract areas for NATA modeling.
Background	• The contributions to outdoor air toxics concentrations resulting from natural sources, persistence in the environment of past years' emissions, and long-range (>50-kilometer) transport from distant sources. • These are not part of NEI, but rather are calculated or estimated outside of NEI.
Secondary formation and decay	• Secondary formation and decay of air toxics from the reaction in the environment of emitted "primary" air toxics. • These are not part of NEI; they are modeled outside of NEI.

[a] In results presented online for assessments for the 2002 and earlier NATA inventories, point sources were divided into major sources and area sources and were sometimes referred to as stationary sources. Major sources are defined in the CAA as stationary sources that have the potential to emit either at least 10 tons per year of a HAP or at least 25 tons per year of any combination of HAPs. Area sources are stationary sources for which the locations are known but that emit at levels below the major source emissions thresholds. This terminology is not used in the 2005 NATA, and stationary source emissions are referred to only as point-source or non-point-source emissions. Point sources in the NATA results refer to those sources, including smaller sources, for which a specific location for their emissions is identified by latitude and longitude descriptions, and non-point sources are those stationary sources that are not point sources.

[b] Although airport-related emissions are inventoried and modeled as point sources, their results in the 2005 NATA are presented with the non-road mobile-source type. In previous versions of NATA, their results were presented with the point-source type.

- Revisions to source inventories made in response to various Risk and Technology Review (RTR; EPA 2010e) requests, where agencies and industries can provide extensive reviews of emissions inventories and screening-level analyses;
- Emissions estimates generated as part of EPA's analyses supporting the development of standards to control emissions of air toxics from area sources (EPA 2010b) as defined by the 1990 Clean Air Act (i.e., sources that emit less than 10 tons annually of a HAP or less than 25 tons annually of a combination of HAPs); and
- The NATA review process.

When developing inventories, EPA gives preference to emissions data resulting from direct measurements over those generated from emissions factors and activity data. As appropriate, state and

locally generated information is given preference over existing data from EPA regulatory development data bases, which in turn are given preference over other reporting systems such as the Toxic Release Inventory. The most current, quality-assured NEI is typically used at the time of a NATA analysis. Some older data might be included if those data are still considered representative of current emissions. The most current and scientifically acceptable supplementary data (e.g., mobile-source models, traffic and fuel data, census data, and meteorological data) are used where appropriate. Sections 2.1 through 2.5 in this chapter describe how NEI and other, supplementary data are compiled for each specific emissions source type included in the NATA risk assessment. Changes made to NEI data in preparation for NATA modeling include implementing any new data changes since the last official version of NEI and tailoring the data to modeling protocols specific to NATA activities where appropriate. Because of these changes, the emissions inventory used for the modeling analyses conducted for NATA is not exactly the same as the NEI. Some of these changes made specifically for the 2005 NATA are presented in Appendix E to this document.

It is important to understand the nature of the differences between NEI and the NATA emissions inventory and the reasons behind these differences. The NEI is a major emission inventory developed by EPA for a range of users and purposes. In contrast, the NATA emissions inventory is a data set specifically compiled and configured for use in the modeling conducted for NATA (using NEI as the starting point), and certain procedures are followed to develop the NATA emissions inventory. As a result of these procedures, the NATA emissions inventory and NEI are different in a few key ways. Some of the differences are substantive changes made to values in NEI based on updated information and different data sources. Examples of these types of changes include:

- Adjustments to emission rates based on recent analyses conducted for other EPA programs and projects, such as RTR and the development of emission standards for area source categories;
- Corrections and updates implemented as a result of the reviews and quality assurance of draft versions of NATA; and
- Updates to mobile-source emissions for some air toxics based on the results of analyses using the Motor Vehicle Emissions Simulator (MOVES) model.

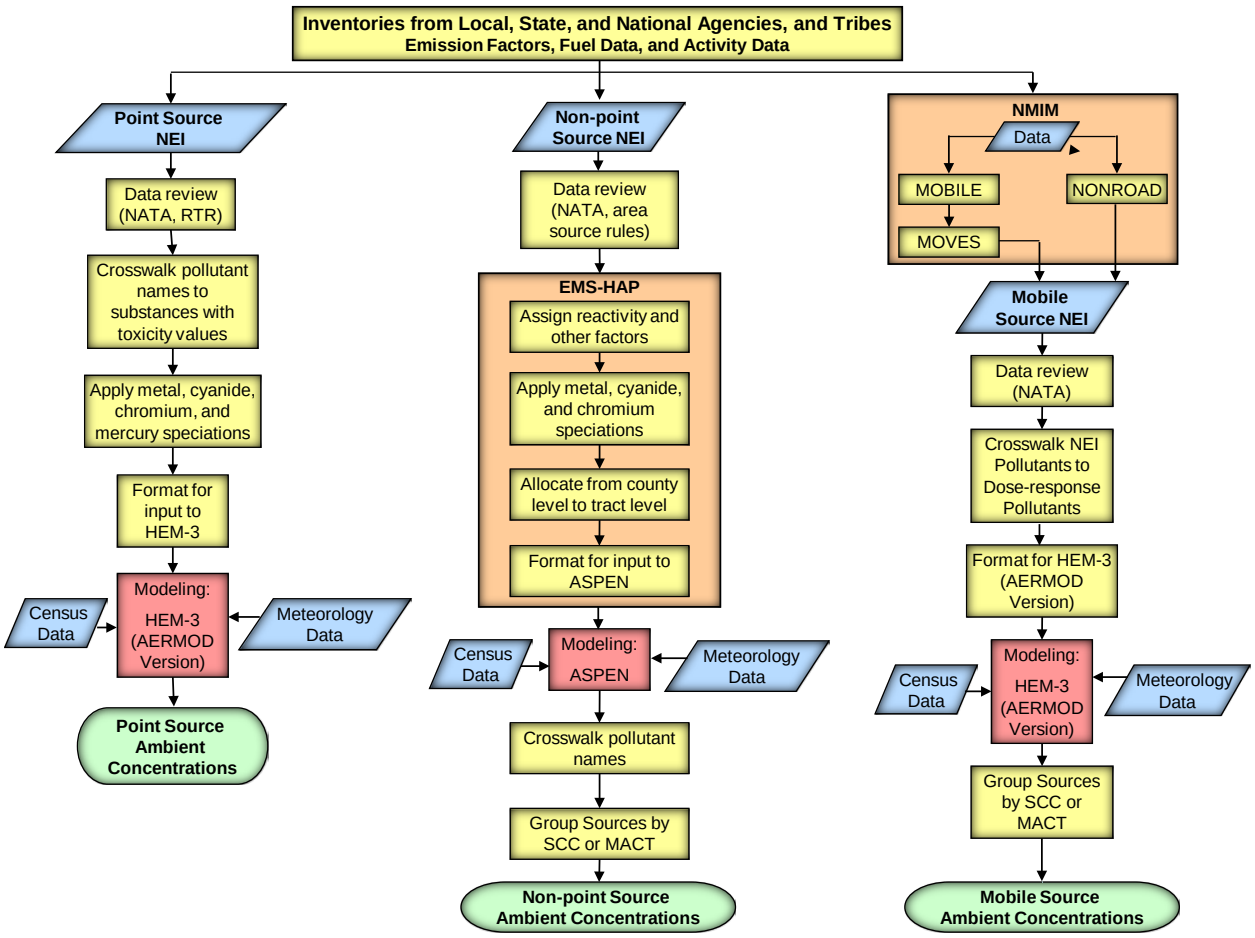
Other differences reflect the specific role and function of the resulting inventory within the context of the NATA risk assessment process and are more accurately described as post-processing procedures rather than substantive changes. Examples of these types of changes include:

- Air toxic name conversions, placing individual air toxics into groups, and similar transcription and phraseology conversions (e.g., for the purpose of crosswalking the identity of an emitted air toxic to a substance with a quantitative dose-response value);
- Adjustments to emission rates of metal compounds based on the toxic metal proportion of the compound's molecular weight (e.g., only the mass fraction of arsenic trioxide that consists of arsenic); and
- Speciation of some metal compounds into individual air toxics based on toxicity associated with a certain valence, particle size, or chemical reactivity.

In addition, background concentrations for some air toxics are estimated for NATA based on monitoring and other data (there is no national inventory for emissions from background sources), and the secondary formation of a few air toxics is addressed in NATA but is not included in NEI.

The culmination of the data processing procedures associated with NATA is the most complete emissions inventory possible at the time of the NATA analysis, and it is an inventory specifically formatted for NATA modeling procedures. This NATA inventory is used to estimate the cumulative health impacts of air toxics. Exhibit 2-2 summarizes the main steps in the process of developing the inventories used in NATA for point, non-point, and mobile sources and subsequent modeling to estimate ambient air concentrations. Background sources (for which NEI is not the starting point for the NATA inventory) and secondary formation of air toxics (which constitutes a relatively minor component of the entire NATA inventory) are not included in Exhibit 2-2.

Exhibit 2-2. The NATA Emissions Inventory and Ambient Concentration Development Processes for Point Sources, Non-point Sources, and Mobile Sources



Note: Background sources and secondary compound formation are not shown.
Acronyms: NEI = National Emissions Inventory; RTR = Risk and Technology Review; HEM = Human Exposure Model; HAP = hazardous air pollutant; ASPEN = Assessment System for Population Exposure Nationwide; **EMS-HAP** = Emissions Modeling System for Hazardous Air Pollutants; SCC = Source Classification Code; MACT = Maximum Achievable Control Technology; NMIM = National Mobile Inventory Model; MOBILE = Mobile Source Emission Factor Model NONROAD, together with MOBILE, comprise the MOVES model; MOVES = Motor Vehicle Emission Simulator

2.2 How Is the Point-source Emissions Inventory Prepared for NATA Modeling?

The NEI is the underlying basis and starting point for developing the inventory of point-source emissions used in NATA.[3] To develop the point-source NEI, when facility information is available from more than one data source (see the bulleted list of sources in Section 2.1), EPA uses a standardized process to match facilities among data bases, selects the highest-confidence emissions data from among the various data bases, and quality assures the data (see the documentation on the development of the final version of the 2002 point-source NEI (EPA 2006c), and documentation on the 2002 quality assurance procedures (EPA 2006b); these documents on the point-source NEI are the most current ones available at the time of the 2005 NATA).

From a NATA modeling perspective, the most important parameters evaluated as part of the NEI quality assurance process include:

- point-source coordinates;
- unit and process identifiers (which help identify individual emission points);
- stack parameters (such as stack height and exit gas temperature);
- air toxic information; and
- emissions amounts.

To develop the point-source inventory that is used for NATA modeling, EPA conducts additional review and processing of the point-source NEI. Some emission rates, location coordinates, and other parameters are modified to reflect more recent information or corrections that result from reviews of these data being conducted by EPA. For example, as a part of EPA's residual risk assessment process, updated information is acquired for certain source categories that are the current focus of EPA's RTR program through engineering reviews and public comment. Some corrected or updated facility data are provided by states and other organizations following their review of draft NATA results. These changes typically comprise focused, facility-specific modifications and adjustments (rather than broad corrections resulting in a fundamentally different inventory for NATA relative to NEI). In addition to these "spot checks" and reviews, several more general processes are conducted on the inventory in preparation for modeling of ambient air concentrations and, eventually, the characterization of health risks.

Point-source emissions are modeled using the AERMOD version of the Human Exposure Model-3 (HEM-3), described in more detail in Section 3.1. HEM-3 models emissions from individual sources to estimate ambient air concentrations used in human health risk assessments, including NATA.

[3] In the discussions of inventories and results presented online for the 1996, 1999, and 2002 NATA, EPA refers to "major" and "area" (or "area and other") sources when discussing stationary sources of air toxics. In the context of those previous assessments, major sources are point sources of emissions that meet the 1990 Clean Air Act definition of "major" sources – that is, sources that have the potential to emit 10 tons per year of a HAP or at least 25 tons per year of any combination of HAPs. The "area and other" category refers to emissions and results associated with stationary point sources with inventoried locations that do *not* meet the 1990 Clean Air Act definition of "major" (referred to as "area" sources in the 1990 Clean Air Act); stationary sources that are not inventoried at the facility or source level (such as dry cleaners, residential wood stoves, and agricultural tilling); and a few other categories of sources. Beginning with the 2005 NATA, inventories and results for stationary sources were grouped into either the "point" or "non-point" category, *based solely on how the emissions are inventoried by EPA*. Thus, the point source category in the 2005 NATA included all stationary sources that were inventoried at the facility level (regardless of their status as major or area per 1990 Clean Air Act definitions), and the non-point category included all stationary sources that were not incorporated into the point source category.

In this assessment, ambient air refers to the air surrounding a person through which air toxics can be carried. Because NEI does not include a single field that can be used to uniquely identify each emissions source, the first important task in preparing point-source data for NATA modeling is to establish a unique source identifier. This is accomplished by using the following combination of NEI data fields: NEI facility identification code, state facility identification code, process identification code, emission unit identification code, emission release point identification code, and emission release point type. After the unique source identifiers have been defined, a screen is conducted to identify reporting errors, and any identified errors are addressed (see the adjacent text box). Then, several standardized routines are performed to translate NEI data into the appropriate inputs for HEM-3 (AERMOD version). These routines include various formatting changes, unit translations, source identifications, and emissions modifications. General descriptions about some of the important routines are described in the subsections that follow. More specific details about how the point-source NEI was used to create the point-source inventory used in the 2005 NATA (including how the NEI data are transformed specifically for the models used in NATA) are provided in Section E.1 of Appendix E to this document.

Addressing NEI Reporting Errors in Preparing the NATA Inventory

For NEI, EPA conducts comprehensive quality assurance to check for missing or erroneous values, such as stack parameters with values outside a reasonable, expected range. Sometimes, however, reporting errors are identified in NEI when it is processed for NATA modeling. These errors might result from the addition of new data that occurs during review of NEI. A reporting error can create a situation where a single, unique emissions source is assigned multiple values for a given parameter, such as spatial coordinates, stack parameters, or fugitive source dimensions. For example, one source might have two disparate values for stack height that were originally associated with separate air toxics emitted from that same stack. In preparing the NATA inventory, the disparate values would be set to one single value (typically the first value that appears in the data base).

2.2.1 Air Toxics Crosswalk

To derive quantitative risk estimates in the NATA risk assessment, individual air toxics reported in the point-source NEI must be matched to the air toxics for which dose-response values and reference concentration values are currently defined for use in NATA. This is accomplished by creating a crosswalk between the two lists of air toxics. The crosswalk is then used when model input files are generated for estimating ambient concentrations of emissions from point sources. Although generating the crosswalk is straightforward when there is a one-to-one match between air toxics listed in NEI and substances included in the dose-response tables (such as for acetamide), the cross-walking process is more complicated for some air toxics, such as groups of emitted air toxics that correspond to a single substance on the dose-response table (e.g., some metals) or air toxics that correspond to multiple substances on the dose-response table (e.g., mercury and chromium, see Section 2.2.2 below). The air toxic crosswalk used for the 2005 NATA is included in Appendix C of this document.

2.2.2 Mercury and Chromium

Mercury and chromium differ from many other air toxics in that they occur in emissions and in the ambient atmosphere in more than one valence state, and the health impacts and toxicities associated with the different chemical species vary. Consequently, EPA differentiates among the important individual chemical species of mercury and chromium when conducting NATA. For example, hexavalent chromium is treated as a carcinogen, and cancer risks are calculated using the **unit risk estimate** for this species, while trivalent chromium is not evaluated for cancer risk (EPA considers the data available for trivalent chromium inadequate to classify its human carcinogenicity).

Thus, within the crosswalk of air toxic names for NEI and the NATA dose-response library, emissions of air toxics reported in NEI as "mercury compounds" and "mercury" are speciated into divalent mercury and elemental mercury. Similarly, "chromium compounds" and "chromium" are speciated into hexavalent chromium and trivalent chromium.[4] Note that emissions that are already reported in NEI as one of these species are not adjusted. For example, any emissions reported as "chromium (VI) compounds" are not modified and are assessed using the dose-response values for hexavalent chromium.

The adjustment factors applied to mercury and chromium emissions are assigned based on characteristics of the emitting source, which are obtained from other fields included in NEI. Specifically, speciation factors for mercury and chromium are based on Maximum Achievable Control Technology (MACT) codes, Source Classification Codes (SCCs), and Standard Industrial Classifications (SICs) assigned to fields associated with the emission point of interest, applying the hierarchy described in the text box below. These associations were developed based on input from EPA engineers and the public, states, and industries. The NEI Mercury Speciation Table provides factors for speciating mercury emissions into divalent and elemental mercury. The NEI Chromium Speciation Table provides similar factors for speciating chromium emissions into hexavalent and trivalent chromium. For the versions of these tables used in the 2005 NATA, refer to Exhibits D-1 and D-2 in Appendix D to this document.

Hierarchy Used to Apply Mercury and Chromium Speciation Factors for NATA

For a source reporting mercury or chromium emissions but not reporting the mercury or chromium species, the Maximum Achievable Control Technology (MACT) code, Source Classification Code (SCC), and Standard Industrial Classification (SIC) are identified based on the fields associated with that unique release point.

- If a speciation factor for chromium or mercury is associated with that MACT code, that factor is used.
- If the source's MACT code is not included in the speciation table, the source's speciation factor is based on the source's SCC.
- If the MACT code and SCC are not included the speciation table, the source's speciation factor is based on the source's SIC code.
- If the source's MACT code, SCC, and SIC code are not included in the speciation table, the national default speciation factor is used. The national default for mercury is 50% divalent mercury and 50% elemental mercury, and the national default for chromium is 34% hexavalent chromium and 66% trivalent chromium. The national default for divalent mercury was chosen by the EPA Office of Research and Development for the 2005 Clean Air Mercury Rule (EPA 2010d). The national default for hexavalent chromium was chosen because it was the upper-bound value from tests at coal- and oil-fired electric utility boilers (EPA 1998).

In addition, in a few cases (e.g., some pulp and paper records, and some boiler records), the chromium speciation assignment is based on a record's ***combination*** of MACT code and SCC. Except for these cases, the MACT-SCC pairs should not be used.

[4] Emissions reported in NEI as chromium (VI) trioxide (chromic acid mist) are treated differently because a reference concentration was derived specifically for evaluating inhalation exposures to this chemical. This value is used in NATA (see Appendix H to this document).

2.2.3 Metals and Cyanide

Example: Adjusting Emissions for Metal Compounds

Arsenic trioxide (As_2O_3) has a molecular weight of about 197.8. Arsenic, with an atomic mass of 74.92, is the toxic element of interest in this metal compound. Emissions reported in NEI are therefore multiplied by 0.7574 (i.e., (74.92 × 2) / 197.8), and the resulting emission rate is used in NATA modeling.

After grouping or renaming the air toxics, emissions reported in NEI for each metal compound of known composition are adjusted so that the emissions rate used for NATA modeling corresponds to the mass of the elemental metal only, and not the entire mass of the metal compound (see the adjacent text box for an example calculation). This approach also is applied for cyanide compounds by adjusting the total mass emissions to account for the mass of cyanide ion. These metal and cyanide adjustments are performed because the dose-response values used for risk assessment correspond to the toxic portion of an air toxic, which for metal compounds is the metal only and for cyanide compounds is the cyanide ion only. Metal compounds that are reported as unspecified mixtures, such as "cadmium compounds," are treated as if the emission rate in NEI corresponds to the metal portion only. This is a conservative assumption with regard to health risks because it assumes the entire mass of the emission rate reported in NEI corresponds to the toxic fraction of the metal or cyanide compound. This metal and cyanide speciation procedure is also used for the RTR inhalation analysis process. The metal and cyanide speciations used for the 2005 NATA are provided in the air toxic names crosswalk in Exhibit C-1 in Appendix C to this document.

2.2.4 Coke Oven Facilities

In the 2002 NATA, emissions from coke oven facilities produced modeled human health risks that were among the greatest in the assessment. In a subsequent, more refined analysis of a coke oven in Indiana (IDEM 2006), however, the modeling and monitoring data suggested that the risk in the census tract containing that facility was overestimated in the 2002 NATA by about 70 percent. NATA is a screening study that uses general information about sources to develop estimates of risks that are more likely to overestimate impacts than underestimate them; as such, it does not necessarily incorporate refined information about emission sources. Coke ovens were modeled as non-point sources in the 2002 NATA and emissions from non-point sources are estimated in NATA at the county level, not the higher resolution point level. This approach does not explicitly consider some site-specific information, such as the enhanced buoyancy around the hot banks of coke ovens, when developing estimates of the health impacts of the emissions. The enhanced buoyancy effect from coke ovens can increase the height that the emission plume reaches before it laterally disperses, resulting in lower exposures and diminished health impacts relative to those that the 2002 NATA estimated.

For the 2005 NATA, EPA reevaluated how coke ovens are represented in NATA and took a more site-specific approach to modeling their emissions. Specifically, emissions from coke ovens were moved to the point-source inventory, where site-specific characteristics are represented more realistically using the parameter fields in the point-source inventory (e.g., exact stack coordinates and stack heights, exit gas temperatures, and exit gas velocities). Enhanced buoyancy around hot banks causes the associated emission plume to travel a significant vertical distance before it disperses laterally. This buoyancy was accounted for in the 2005 NATA modeling by increasing the modeled release height of certain emission stacks. Any coke oven stacks associated with charge lids, doors, and charging, pushing, or off-take processes, and with stacks shorter than 126 feet, were set to 126 feet. This height was chosen because most (160 of 165) of the coke-oven stacks modeled in previous NATAs had stacks shorter than 126 feet (heights overall ranged from 10 feet to 315 feet).

2.2.5 Airport Facilities

Airport facilities are a special part of the point source emissions inventory. Airport-related emissions are allocated to a single point at each airport with one exception – emissions from ground-support equipment are inventoried in the 2005 non-road mobile source NEI, not the 2005 point source NEI.

For the 2002 NATA, airport-related emissions were estimated for about 4,000 airports. These emissions were included in the 2005 NEI point source inventory, but they were not used in the 2005 NATA. There are far more than 4,000 airports in the country, and although many of them are small, they can be located near populated areas and pose health risks to nearby residents. So, for the 2005 NATA, a new dataset of estimated airport-related emissions, representative of 2008, was developed for about 20,000 airports. These 2008 airport emissions included ground-support equipment. For the 2005 NATA, the non-road mobile inventory also included ground-support equipment. These non-road mobile ground-support equipment emissions were relatively small and were not removed from NATA, leading to small overestimations in these emissions. More details on the development of the 2008 airport emissions dataset can be found in the Documentation for Aircraft Component of the National Emissions Inventory Methodology (Eastern Research Group, 2010).

As stated above, airport emissions are assigned to a single point at each airport. For NATA, the point-source airport-wide emissions are assigned to one or multiple fugitive areas that represent runways at the airports, and these runway emissions are modeled in HEM-AERMOD along with the rest of the point sources. See Appendix E for more information on how the emissions were assigned to runways. For the 2002 NATA, the airport results were presented in the point-source section of results. For the 2005 NATA, the airport results are presented in the mobile non-road section of results.

2.3 How Is the Non-point-source Emissions Inventory Prepared for NATA Modeling?

NEI is the underlying basis and starting point for developing the inventory of non-point-source emissions used in NATA. A detailed description of the development of the non-point inventory for 2002 is presented in EPA's documentation on the development of the final 2002 non-point NEI (EPA 2006a) the most current documentation available for this inventory at the time of the 2005 NATA.

Ambient concentrations resulting from non-point-source emissions are modeled for NATA using the Assessment System for Population Exposure Nationwide (ASPEN), which is described in Section 3.2. To prepare the non-point NEI for modeling with ASPEN, the EPA Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP; EPA 2009l) is used to process NEI data. EMS-HAP is a data processing package that generates model-ready, tract-level emissions for input into ASPEN from county-level NEI non-point data. Within EMS-HAP, HAPs are speciated where appropriate, source groupings are made, and spatial and temporal allocations are applied. Below are brief descriptions of the important data-processing steps as they are carried out for NATA using EMS-HAP.

2.3.1 Source Groupings

For the purpose of assessing potential health risks from certain industries and activities, non-point sources are grouped into the categories shown in Exhibit D-4 in Appendix D to this document. These categories are based on MACT and SCC codes. See Exhibit D-3 in Appendix D to this document for descriptions of each MACT code.

2.3.2 Metals and Cyanide

Similar to the point-source methodology, the emissions amount of each metal compound of known composition is reduced by the proportion of the molecular weight of the metal to the molecular weight of the HAP molecule. This approach also is applied for the cyanide component of cyanide compounds. These metal and cyanide speciations are performed because the dose-response values used for risk assessment correspond to the toxic portion of a HAP (i.e., the metal portion of a metal compound, the cyanide portion of a cyanide compound). The final, comprehensive metal or cyanide speciations are part of the "General HAP" table in EMS-HAP (see Appendix C of the EMS-HAP version 3 documentation [EPA 2004d] for the General HAP table).

2.3.3 HAP Crosswalk, Particulate Sizes, and Reactivity Classes

The General HAP table in EMS-HAP contains a crosswalk of NEI HAPs and the HAP categories that ASPEN is set up to recognize and model. HAP categories are then further partitioned based on their particulate sizes or their chemical reactivity, or both. ASPEN uses particle size to determine appropriate deposition rates and chemical reactivity to determine appropriate decay rates. For example, individual lead compounds (lead carbonate, lead titanate, lead sulfate) are grouped into "lead compounds, fine particulate" and "lead compounds, coarse particulate" for ASPEN modeling. The ratios used to speciate the HAP category emissions into reactivity classes or fine and coarse particulates also are provided in the "General HAP" table in EMS-HAP. These ratios were developed during the Cumulative Exposure Project and are described in Appendix D of the EMS-HAP version 2 documentation (EPA 2002f). See the adjacent text box for an example of how emissions of a HAP in the non-point source NEI are speciated by its metal component, the HAP's chemical identity is crosswalked to a HAP category, and the emissions are partitioned into particulate sizes.

An Example of How Metal and Particulate Speciations Are Applied

To illustrate the speciation approach with lead carbonate ($PbCO_3$), the atomic weight of lead is 207.2 and the molecular weight of the molecule is 267.2092. The emission of lead carbonate is reduced by 0.7754 (i.e., 207.2 / 267.2092). Then, "lead carbonate" is crosswalked to the "lead compounds" HAP category, and its emissions are then speciated into its fine and coarse parts using a 74:26 fine:coarse ratio.

2.3.4 Chromium

One especially noteworthy HAP crosswalk included in the "Specific HAP" table in EMS-HAP pertains to chromium (for the Specific HAP table, see Appendix C of the EMS-HAP version 3 documentation; EPA 2004d). In the table, "chromium compounds" and "chromium" are first speciated into hexavalent and trivalent chromium and then into their fine and coarse parts. The factors used to speciate emissions into the hexavalent and trivalent parts were developed on a source category basis with input from the EPA engineers involved in those source categories. The same hierarchy used with point sources to speciate mercury and chromium compounds is used with non-point sources to speciate chromium compounds (see complete description in Section 2.2.2).

2.3.5 County-to-Tract Spatial Allocation

The non-point NEI reports emissions at the county level. Because ASPEN models non-point sources at the census-tract level, EMS-HAP spatially allocates the county-level emissions reported in NEI to the census tracts within the county. Census tracts are land areas defined by the U.S. Census Bureau that vary in size and typically contain about 4,000 residents each. Census tracts are typically smaller than

2 square miles in cities, but are much larger in **rural** areas. To make the county-to-tract emissions assignments, EMS-HAP uses spatial allocation factors derived from the distributions of various "spatial surrogates" that have geographic patterns expected to be similar to the geographic patterns of the source of the emissions. In the example provided on the next page (from the 2002 NEI), the source of the emissions is the cultivation of orchards and vineyards, and the primary surrogate for assigning county-level emissions to census tracts is the area of land classified as "orchards/vineyards." The primary spatial surrogates are those that best correspond to the emission category of interest; this surrogate is the first choice for allocating county-level emissions to the tracts within a county. Secondary, tertiary, or quaternary surrogates are used when the surrogate of higher priority is not found in a particular county.

To develop the spatial surrogates, EPA categorizes all non-point-source types into groups that can be defined using SCCs. For each source group, spatial surrogates are developed for every county in the United States. Thus, surrogates are developed that can be used in every county, even if no emissions were reported from that source type in a county, so that the surrogate list covers all possible scenarios. The surrogate files in EMS-HAP also contain urban/rural flags that ASPEN then uses to assign the dispersion characteristics of a source. The urban/rural flag is assigned based on population density or land-use.

Using Surrogates to Spatially Allocate Non-point Emissions – Orchards and Vineyards

Emissions associated with the cultivation of orchards and vineyards can be identified in the non-point 2002 NEI by Source Classification Code (SCC) and – like all emissions in the non-point NEI – are reported at the county level. To allocate the reported emissions to the census tracts within these counties, spatial surrogates for the presence of orchards and vineyards were developed using information from the 1992 National Land Cover Database (NLCD) and the 2000 U.S. Census. These surrogates were developed for each of the 3,149 counties in the United States, even though they were applied only for the subset of counties reporting orchard/vineyard emissions in the non-point NEI. Four levels of surrogates were developed as follows (listed in level of decreasing preference):

- Primary surrogate: Land area classified as "orchards/vineyards" in the 1992 NLCD. This surrogate was identified for tracts within 135 counties.
- Secondary surrogate: Land area classified as "agricultural" (a category that includes orchards/vineyards and other subcategories) in the 1992 NLCD (identified for tracts within 2,886 of the remaining 3,014 counties).
- Tertiary surrogate: Land area not designated as urbanized or urban cluster by the U.S. Census (identified for 121 of the remaining 128 counties).
- Quaternary surrogate: Land area classified as non-water in the 1992 NLCD (used if necessary for the remaining 7 counties).

The surrogate for a given emissions source type and for a given county is then used to apportion that source's emissions to the census tracts in that county. In this example, if the primary surrogate is chosen for a particular county, the land area classified as orchards/vineyards in each tract compared to the county as a whole is used to apportion the county's orchards and vineyards emissions to the census tracts. Only one surrogate per county was used. For each surrogate, if more than one census tract within a county met the listed criteria, county-level emissions were apportioned among these tracts based on land area of tracts.

2.3.6 Temporal Allocation

ASPEN requires emissions for eight 3-hour periods within an annually averaged day. The uniform allocation of annual emissions to days results in each day of the year containing the same emissions. For each non-point-source SCC, EMS-HAP has a surrogate emission cycle for the eight 3-hour periods of an average day of the year (i.e., 5 percent of the daily emissions are released in the hours from midnight through 2 a.m. hours, 9 percent in the hours from 3 a.m. through 5 a.m., and so on, until the percentage totals 100 for the day). These temporal surrogates are used to allocate daily emissions into the eight 3-hour periods.

2.4 How Is the Mobile-source Emissions Inventory Prepared for NATA Modeling?

Mobile-source emissions data for NATA are largely based directly on the NEI. Highway vehicle emissions of several air toxics – diesel PM, benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and naphthalene – however, are based on EPA's Motor Vehicle Emission Simulator (MOVES; EPA 2009h). The detailed documentation on the development of the second version of the 2005 mobile-source NEI (EPA 2008b) is the most current mobile-source documentation available at the time of the 2005 NATA.

The mobile-source NEI is developed using the National Mobile Inventory Model (NMIM; EPA 2009i) for all sources except commercial marine vessels, locomotives, and aircraft. NMIM produces, in a consistent and automated way, county-level mobile-source emissions inventories nationwide for NEI and for EPA rulemaking. NMIM is a consolidation of two EPA models: the Mobile Source Emission Factor model (MOBILE; EPA 2009g) and the NONROAD (EPA 2009j) model. NMIM enables users to input geographic, vehicular, and air toxics information, which are converted to the necessary MOBILE or NONROAD inputs. NMIM then runs MOBILE or NONROAD and processes their outputs in various ways for the user. NMIM also estimates toxic emissions for non-road sources using toxic-to-VOC ratios for gaseous air toxics, toxic-to-PM ratios for **polycyclic aromatic hydrocarbons**, and mass-per-mile emission factors for metals (EPA, 2005b).

MOBILE and NONROAD use combined specific vehicle, activity, and fuel data from states and government agencies along with vehicle emissions data to estimate inventories. Activity data for vehicles and non-road equipment are typically available at the national, state, or metropolitan statistical area (MSA) level, and thus must be allocated to counties using surrogates such as population and land use. This allocation introduces significant uncertainty to county-level emission estimates. Exhibit 2-3 shows the types of processes, vehicles, and roads for which MOBILE estimates emissions, and Exhibit 2-4 shows the types of processes and groups of uses for which NONROAD estimates emissions. Motor vehicle emissions are estimated separately for each process, vehicle class, and roadway type listed.

As stated above, data for some motor vehicle air toxics (e.g., diesel PM, benzene) in the NEI were replaced with data from MOVES. A similar replacement has been done for the EPA 2005 Modeling Platform version 4 (EPA 2009f). An EPA modeling platform includes emissions data and tools that are in development for future EPA analyses to support criteria air pollutants, mercury, and other HAPs to prepare emission for air quality models.

MOVES-based toxic emissions estimates were initially developed using an internal draft version of the model, and the estimates then were adjusted to be consistent with the publicly released MOVES 2010. Replacement of inventory estimates from the second version of the 2005 NEI with MOVES-based estimates resulted in higher toxic emission estimates.

Mobile sources are grouped into the categories shown in Exhibit D-5 (in Appendix D to this document) to facilitate the assessment of potential health risks as part of NATA. These categories are based on SCC codes. For example, category c28 corresponds to on-road gasoline vehicles and is defined by all SCC codes having "22010" as the first five digits. See Exhibit D-3 of Appendix D to this document for descriptions of each MACT code.

For the 2005 NATA, ambient concentrations resulting from mobile-source emissions were derived using HEM-3. Prior to modeling, the county-level emissions for mobile sources compiled in the

Exhibit 2-3. Elements for Which MOBILE Estimates Emissions[a]

Processes	Vehicle Classes	Roadway Types
Exhaust Evaporation Refueling Brake wear Tire wear	Light-duty gasoline vehicles and two kinds of trucks Heavy-duty gasoline vehicles and buses Motorcycles Light-duty diesel vehicles and trucks Class 2b, light-, medium-, and heavy-duty diesel vehicles Diesel buses	Rural and urban interstates Rural major and minor collectors Urban collectors Rural and urban minor arterials Rural and urban other principal arterials Rural and urban locals Urban other freeways and expressways

[a] Items listed in this exhibit are included in MOBILE version 6.2; applies to the on-road mobile sources of the 2005 NATA.

Exhibit 2-4. Elements for Which NONROAD Estimates Emissions[a]

Processes	Use Groups	
Exhaust	Recreational	Logging
Evaporation	Construction	Airport support [b]
Refueling	Industrial	Underground mining
	Lawn and garden	Oil fields
	Agriculture	Pleasure craft
	Commercial	Railroads

[a] Applies to the non-road mobile sources of the 2005 NATA.

[b] The NONROAD estimates of emissions from airport ground-support equipment are currently included in the non-road mobile source NEI. The 2008 airport-related emissions used in the 2005 NATA, however, also include emissions from ground-support equipment. The ground-support equipment emissions were relatively small and they were not removed from the non-road mobile source inventor, leading to small overestimations in emissions from ground-support equipment.

inventory were allocated to census tracts within each county in the same manner as for non-point-source emissions. The allocation process relies on analyses conducted for the 2002 NATA by applying the county- and air-toxic-specific spatial surrogates for mobile-source types generated by EMS-HAP. The 2002 allocation factors were used because the 2005 inventory of mobile sources does not contain the SCCs required for the EMS-HAP spatial surrogate methodology. Section 2.3.5 of this document provides additional information on this process.

To derive quantitative risk estimates for NATA, the individual air toxics contained in the mobile-source inventory are matched to the air toxics having currently defined toxicity values for use in NATA. This air toxics matching process is the same as that used for point sources. Additional detail on how the mobile-source NEI was used and processed for the 2005 NATA is provided in Section E.3 of Appendix E to this document.

Diurnal variations in on-road and non-road mobile-source emissions are modeled in HEM-3 on an hourly basis. Emissions are allocated to hourly values using temporal allocation profiles developed by EPA for urban and regional-scale modeling of ozone and particulate matter. In this temporal allocation step, the seasonal profiles used in ozone and PM modeling are combined to produce aggregate diurnal profiles for an average day. Separate diurnal profiles are developed for on-road and non-road sources.

2.5 How Are Emissions from Background Sources Accounted for in NATA?

For NATA, one of three methods is used to estimate county-level ambient concentrations of selected air toxics from background sources. These concentrations are then added to the concentrations of air toxics from the various sources. Methods for estimating background concentrations involve the use of monitoring data, emissions data, or known air toxics dispersion properties. A complete inventory of

emissions from background sources is not compiled. Section 3.3 provides details on how background source concentrations are estimated.

2.6 How Are the Secondary Formation and Decay of Air Toxics Addressed for NATA Modeling?

Some air toxics that point-, non-point-, and mobile-source types emit can be transformed into other compounds in the atmosphere. Gaseous hydrocarbons (e.g., methane, hexanes, propane) and gaseous nitrogen oxides (e.g., nitric oxide, nitrogen dioxide) can undergo a series of photochemical reactions (initiated by ultraviolet rays on sunny days) that result in other air toxics such as aldehydes. Some air toxics can decay to produce other hazardous or nonhazardous chemicals.

In the 2005 NATA, secondary ambient concentrations of formaldehyde, acetaldehyde, and acrolein were estimated using the EPA Community Multiscale Air Quality (CMAQ) modeling system and NEI data. The CMAQ model was also used to estimate the concentration of 1,3 butadiene and the concentration of acrolein resulting from the decay of 1,3-butadiene. Simpler secondary formation calculations for some air toxics also were performed for non-point-source data in ASPEN. Concentrations of the four air toxics estimated using CMAQ were also estimated by ASPEN and for simplicity were not removed from the 2005 NATA, leading to small double-counting for formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene.

Section 3.4 provides details on the CMAQ modeling system. Using the 2005 NATA as an example, more specific details about how the NEI is used in NATA to estimate air toxics concentrations as a result of secondary formation and decay are provided in Section E.4 of Appendix E to this document.

2.7 Summary

- NATA addresses most of the 187 HAPs currently defined in the Clean Air Act, plus diesel PM.
- The emissions inventory used in NATA is divided by source type: stationary point sources (including source related to airports), non-point sources, on-road and non-road mobile sources (excluding airport-related sources for the purposes of NATA), and background sources. The secondary formation and decay of some air toxics is also considered.
- The emissions inventory used in NATA is primarily derived from the NEI. Background sources are an exception: Ambient concentrations resulting from background sources are derived from monitoring data, emissions data, and some data derived by other methods.
- A defined methodology is used to transform the original inventory data into data suited for the air quality models used in NATA. This methodology includes speciating metals, cyanide, chromium, and mercury where necessary, and crosswalking air toxics contained in the NEI with air toxics contained in the NATA dose-response/reference concentration library.

3 ESTIMATING AMBIENT CONCENTRATIONS OF AIR TOXICS

The NATA emission estimates described in Section 2 are used as input to EPA air quality models to estimate ambient concentrations of emitted air toxics. An air quality model is a set of mathematical equations that uses emissions, meteorological, and other information to simulate the behavior and movement of air toxics in the atmosphere. Air quality models estimate outdoor concentrations of air toxics at specified locations. For the 2005 NATA, three air quality models were used:

- Human Exposure Model-3 (HEM-3), AERMOD version;
- Assessment System for Population Exposure Nationwide (ASPEN); and
- Community Multiscale Air Quality (CMAQ) model.

Exhibit 3-1 shows which model is used to estimate ambient concentrations for each emission source type included in NATA and at what spatial resolution. These model assignments are specific to the 2005 NATA and could change for future assessments.

Exhibit 3-1. Models Used to Estimate Ambient Concentrations for the 2005 NATA

Emission Source Type	Model	Spatial Resolution of Modeled Ambient Concentrations
Point	HEM-3	Census block
On-road mobile	HEM-3	Census block
Non-road mobile	HEM-3	Census block
Non-point	ASPEN	Census tracts (interpolated from gridded model outputs)
Secondary formation and decay	CMAQ	Census tract (computed from gridded model outputs)
Background	Derived, not modeled	County

HEM-3 is currently configured to run using one of two dispersion models: AERMOD 09170 which is EPA's preferred and recommended plume dispersion model (EPA 2009k), or ISCST3 (the Industrial Source Complex-Short Term, version 3 model). In the 2005 NATA application of HEM-3, the AERMOD version was applied. All references in this document regarding the use of HEM-3 are to the AERMOD version of the model.

For NATA, HEM-3 is configured to use the latest decennial U.S. Census data to determine the locations of model receptors (i.e., people). For the 2005 NATA, point-source and mobile-source concentrations were modeled at representative points in each census block within 50 kilometers of each source. ASPEN is configured to model concentrations at a polar grid of receptors surrounding sources; for the 2005 NATA, these results were used to interpolate concentrations to census-tract centroids (a spatial reference point the U.S. Census uses for the tract – see Section 3.1). The CMAQ modeling system estimates ambient concentrations of air toxics resulting from secondary formation (i.e., atmospheric transformation of precursor compounds into air toxics) within grid cells, and grid-cell concentration estimates are interpolated to census tracts in post-processing.

Each air quality model used for NATA requires meteorological inputs. Due to the nationwide scope of the assessment and the extremely large number of sources modeled in NATA, acquiring current, site-specific meteorological data for every modeled source is not feasible. Therefore, the following meteorology data are used for NATA:

- HEM-3 requires hourly meteorological data. For the 2005 NATA, EPA developed a set of annual meteorological data input files to use with HEM-3 for about 150 surface observation sites nationwide for 1991. Newer data were not used because the surface stations began to be modified in 1992, and the collection of important ceiling height data was discontinued. The meteorological station closest to each emissions source was chosen to represent meteorological conditions at that source. In addition to the meteorological data that are contained in the HEM-3 library, several states provided supplemental meteorological data to better characterize local impacts.

- ASPEN requires a set of meteorological inputs known as a STability ARray, or STAR, which is a joint frequency distribution of Pasquill stability category (e.g., A represents very unstable, B is unstable, etc.), wind speed, and wind direction. A set of model-ready STARs based on data from numerous hourly surface observation sites nationwide is provided with ASPEN. For NATA, the default STAR data from the site nearest each emissions source is chosen to represent meteorological conditions at that source.

- The CMAQ model requires meteorological data in a gridded, high-resolution format, so it relies on outputs from a meteorological model to develop meteorological parameters for the modeling domain rather than recorded meteorology data. The gridded meteorological input data for the entire year of 2005 are derived from simulations of the Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model. This model, commonly referred to as MM5, is a limited-area, nonhydrostatic, terrain-following system that solves for the full set of physical and thermodynamic equations that govern atmospheric motions (Grell et al. 1994). Details on the meteorological modeling and evaluation of the MM5 data are described in EPA 2010i. For NATA, a set of national-scale modeled meteorological inputs is used.

For all three models, each source location and the release parameters must be specified. Release parameters include emission rate, stack height and diameter, exit velocity, and exit temperature. Using these and other parameters, HEM-3 and ASPEN estimate the magnitude and distribution of ambient air concentrations in the vicinity (usually within 50 kilometers) of each source. The CMAQ model estimates ambient air concentrations within grid cells covering the continental United States and also incorporates the long-range transport of air toxics.

County-level background concentrations are estimated using available ambient monitoring data and NEI emissions data. The ambient air toxic concentrations that are the outputs of HEM-3, ASPEN, and the CMAQ model are then combined with these estimated background concentrations to develop a total annual average ambient concentration of each air toxic for each census tract in the United States. These values are used in NATA as representative, long-term ambient outdoor concentrations, which are then used as inputs for exposure modeling. The application of HEM-3 for NATA is provided in Section 3.1 and for ASPEN in Section 3.2. The derivation of background concentrations is discussed in Section 3.3, and the use of the CMAQ model for NATA is discussed in Section 3.4.

3.1 How Is HEM-3 Used to Estimate Air Toxics Concentrations in NATA?

For the 2005 NATA, HEM-3 was used to estimate ambient air toxics concentrations attributable to **point**, **on-road mobile**, and **non-road mobile sources**. Point sources are modeled as discrete points, while mobile sources are modeled as tract-level (polygonal) non-point sources. EPA developed HEM-3 to streamline the modeling of the dispersion, human exposure, and human health risks that result from the air emissions of air toxics from sources or clusters of sources. When run using AERMOD as the dispersion model, as was done for NATA, HEM-3 can model air toxic dispersion from a range of source types. AERMOD is a steady-state plume model developed by the American Meteorological Society and EPA to model dispersion using planetary boundary-layer turbulence and various source and terrain characteristics. See the HEM-3 user's guide for detailed documentation on HEM-3 (EPA 2007e).

HEM-3 modeling for major stationary sources took into account the available emission parameters for each emissions source, including stack height and diameter, exit gas temperature and velocity. Where dimensions were available in the emissions inventory, fugitive sources were modeled as area or volume sources. The effects of terrain elevation were also taken into account.

EPA modeled on-road and non-road emission sources as large non-point sources using the "polygon" option of HEM-3 and AERMOD. Under this option, emissions are distributed evenly over an irregular polygon defined for each tract. Tract boundaries were determined using geographic information systems (GIS). To reduce computational requirements for AERMOD, each tract shape was smoothed until the resulting polygon had 20 or fewer vertices.

Vertical emission dispersion characteristics for modeling emissions from mobile sources are difficult to characterize and subject to numerous uncertainties. The turbulent wake generated by the emitting vehicle and turbulence generated by nearby vehicles and other roughness elements, such as sound barriers, median barriers, trees, and buildings, influence the emission plumes from mobile sources. Thermally induced turbulence generated by sunlight on dark pavement can also enhance the initial vertical dispersion (Brode, Roger, 2009, pers. comm.). For the 2005 NATA, EPA used vertical emission parameters for mobile sources derived from a previous mobile-source modeling study. In that analysis, EPA estimated average emission heights and initial vertical dispersion coefficients for light-duty vehicles and heavy-duty vehicles. The emission height and dispersion coefficients were designed to represent an emission plume extending from ground level to about 1.7 times the vehicle height, based on previous field measurements of dust generated on an unpaved road (Gilles et al., 2005). For the NATA analysis, vertical dispersion parameters for on-road emission sources were based on an average of the parameters for light-duty and heavy-duty vehicles, weighted by the average distribution of air toxics emissions from these vehicle classes. This calculation gave an initial vertical release height for on-road mobile sources of 1.44 meters and with an initial vertical dispersion of 1.33 meters. EPA modeled non-road mobile emissions sources at an initial vertical release height of 2 meters and an initial vertical dispersion of 1 meter.

Aircraft takeoff and landing emissions were modeled as rectangular non-point sources, with horizontal dimensions based on the reported numbers and lengths of runways. The initial vertical release height was 5 meters and the initial vertical dispersion was 4.6 meters. EPA selected these parameters to reflect a plume extending from ground level to about 10 meters, based on an average of aircraft and various diesel ground support equipment (Brode, Roger, 2009, pers. comm.).

Although HEM-3 can estimate ambient outdoor concentrations, population exposure, and potential cancer and non-cancer health risks, exposure and risk calculations are performed outside of the model for NATA (see Section 4 for a discussion on **exposure assessment** and Section 5 for a discussion on estimating cancer and non-cancer risk).

As noted above, the HEM-3 meteorology data base used for the 2005 NATA included meteorology data from reporting year 1991 at more than 120 hourly surface stations and more than 60 twice-daily upper-air stations. The census library includes data from the latest decennial U.S. Census (for the 2005 NATA, the 2000 U.S. Census was used). The census data are used to locate model receptors at census-block centroids. Census blocks are the smallest spatial population groupings the U.S. Census develops. The centroid of a census tract or census block (also referred to as an "internal point") is a point identified by the U.S. Census that is located inside the tract or block and used as a spatial reference point for that tract or block. The centroid is usually (but not always) located at the approximate geographic center of the census tract or block.

HEM-3 also contains elevation data from the U.S. Geological Survey's 1:250,000 Digital Elevation Model (USGS 2009), which are used to determine the elevation of the terrain at which census-block model receptors are located. In general, for other inputs and settings that HEM-3 requires, the EPA-recommended default values are used for NATA dispersion modeling. HEM-3 can account for plume depletion and reactivity/degradation, which are two processes that can reduce ambient concentrations of emitted air toxics. For NATA 2005, however, the source- and air-toxic-specific data HEM-3 requires to model these processes were not available in the emissions inventory, and therefore these processes were not considered. This approach is generally health-protective – that is, it likely results in overestimates of the ambient concentration for air toxics that are subject to deposition or decay.

To ensure that HEM-3 outputs are compatible with the risk characterization calculations that use the model results, air toxics in the emissions inventories are matched to those air toxics for which dose-response data are available. For example, emissions of chromium are speciated into their hexavalent and trivalent forms because only the hexavalent form is considered carcinogenic and has dose-response data. Similarly, mercury emissions are speciated into divalent and elementary mercury forms. The individual emissions sources in the point-source inventory are identified for source-level modeling, while the county-level emissions from mobile sources are distributed among census tracts. The processing of emissions data for HEM-3 modeling is discussed in more detail in Section 2 of this document.

3.2 How Is ASPEN Used to Estimate Air Toxics Concentrations in NATA?

ASPEN is a computer simulation model used to estimate ambient air toxics concentrations attributable to non-point sources for the 2005 NATA. ASPEN is a steady-state Gaussian model that takes into account important determinants of air toxics concentrations, including rate of release, location of release, the height from which the air toxics are released, wind speeds and directions (using data from the meteorological station nearest to the modeled source); breakdown of the air toxics in the atmosphere after being released (i.e., reactive decay); and settling of air toxics out of the atmosphere (i.e., deposition). The model can be used to estimate air toxics concentrations for every census tract in the United States, Puerto Rico, and the U.S. Virgin Islands, based on the U.S. Census. The dispersion model included in ASPEN is similar to the Industrial Source Complex-Long Term Model, version 2 (ISCLT2), one of EPA's accepted alternative air quality models. Refer to the ASPEN User's Guide (EPA 2000a) for comprehensive ASPEN documentation.

Non-point sources modeled in NATA are associated with a census tract, but they are not situated at specific locations. To model dispersion of non-point-source emissions, ASPEN treats each source as a "pseudo-point" source located at the centroid of the census tract in which it is located (i.e., the "resident tract"). ASPEN estimates ambient concentrations for a pre-set polar receptor grid, and then interpolates ambient concentrations from the grid receptors to each census-tract centroid outside of the source's resident tract.

This interpolation approach cannot be implemented within the resident census tract, however, because the concentration cannot be estimated at the emission point (i.e., at the tract centroid) with the ASPEN Gaussian formulation. To estimate the average concentration for a resident tract, ASPEN represents the non-point source for a tract as multiple pseudo-point sources geographically dispersed throughout the tract, rather than as a single source. Ambient concentrations in the resident census tract are estimated by spatial averaging of the ambient concentrations at all grid receptors that fall within the bounds of the tract. When these resident tract and non-resident-tract concentrations are calculated for all sources, the concentrations are summed for each tract.

To reduce the requirements for computational resources, ASPEN approaches meteorological conditions from a climatological perspective with a STAR joint frequency distribution of wind speed, wind direction, and atmospheric stability categories. The ASPEN STAR data base is derived from nationwide National Weather Service station data. To create the STARs, meteorological data are stratified by time of day into eight 3-hour time blocks to preserve any characteristic diurnal patterns that might be important in subsequent estimation of population exposure. Thus, eight STARs are created for each meteorological site. Long-term ambient concentrations are calculated by simulating the concentrations for each combination of factors, finding the frequency-weighted average for each time block, and finally averaging across time blocks.

The processing of emissions data for ASPEN modeling is discussed in more detail in Section 2 of this document. In summary, air toxics in the emissions inventories are crosswalked to HAP categories, speciated based on particle size, or categorized according to chemical reactivity. Some air toxics are also speciated based on chemical structure or valence to reflect differences in toxicity. County-level emissions from non-point sources are allocated to census tracts based on spatial surrogates, and among 3-hour daily time blocks based on diurnal temporal profiles.

3.3 How Are Background Source Concentrations Derived for NATA?

Ambient background concentrations are included in NATA for a subset of the air toxics included in the emission inventory. For NATA, EPA uses background concentrations to represent the contributions to ambient concentrations of air toxics resulting from three sources: (1) natural sources, (2) emissions of persistent air toxics that occurred in previous years, and (3) long-range transport from distant sources. These background concentrations are intended to represent levels of air toxics found in a particular year even if there had been no local anthropogenic emissions of those air toxics during that year. Accurately estimating outdoor concentrations requires accounting for the background component of total ambient concentrations. Average background concentrations were developed for the 2002 and 2005 NATAs at the county level and on an annual average timescale (see Appendix F).

The number of air toxics with background concentration estimates included in NATA increased between the first 1996 assessment and the 2002 assessment. In 1990, the Cumulative Exposure Project identified background concentrations for 12 air toxics in a literature review (Rosenbaum et al. 1999, Woodruff et al. 1998). The concentration data for these 12 air toxics were used for the 1996 NATA. For the 1999 NATA, ambient monitoring data were used to derive background concentrations for air toxics where available ambient monitoring data were of sufficient density and quality (Bortnick et al. 2003). For other air toxics, the concentrations identified from the Cumulative Exposure Project were retained. In total, the 1999 NATA accounted for background sources for 28 of the air toxics in its inventory, 11 of which also were included in the 1996 NATA. For the 2002 NATA, the background source methodology was revised to derive background concentrations for 34 air toxics. Fifteen of those 34 air toxics also had background concentrations in the 1999 NATA, and 9 in the 1996 NATA. The background concentration estimates from the 2002 NATA were used for the 2005 NATA.

Three methods were used to estimate background concentrations for the 2002 and 2005 NATAs. The ambient method uses available monitoring data, the emissions method uses NEI emissions data, and the uniform method assumes a uniform nationwide concentration for the air toxic. The method used for each air toxic in the 2002 and 2005 NATAs is shown in Exhibit 3-2. A brief summary of the methodology as implemented for these two assessments is presented below. A more detailed description of the background source estimation methodology implemented for the 2002 and 2005 NATAs is provided in Appendix F to this document.

The **ambient method** for estimating background concentration relies on air toxics monitoring data with adequate spatial resolution and sufficient measurements above minimum detection levels. For the ambient method, data from the 2002 through 2005 EPA Air Quality System (EPA 2007b) are used, supplemented with data from the Interagency Monitoring of Protected Visual Environments (IMPROVE 2010) and the Southeastern Aerosol Research Characterization Study experiment (SEARCH 2010). The distribution of measurements collected for each county are analyzed, and the county background concentrations are estimated based on the lower **percentile** values and the fraction of measurements

Exhibit 3-2. Background Air Toxics and Estimation Methods Included the 2002 and 2005 NATAs

Ambient Method	Emissions Method	Uniform Method
1,3-Butadiene	1,1,2,2-Tetrachloroethane	Carbon tetrachloride
1,4-Dichlorobenzene	1,2-Dibromo-3-chloropropane	Methyl bromide
Acetaldehyde[a]	Acrylonitrile	Methyl chloride
Arsenic	Benzidine	Methyl chloroform
Benzene	Beryllium	
Chloroform	Cis(2-ethylhexyl)phthalate	
Chromium (total)[b]	Cadmium	
Dichloromethane	Chromium (VI)[b]	
Formaldehyde[a]	Ethylene dibromide	
Lead	Ethylene dichloride	
Manganese	Ethylene oxide	
Nickel	Hydrazine	
Tetrachloroethylene	Naphthalene	
Toluene	Propylene dichloride	
	Quinoline	
	Trichloroethylene	

[a] For the 2005 NATA, the background sources of acetaldehyde and formaldehyde were removed and modeled within the CMAQ model as secondary formation.

[b] Measured concentrations of chromium (which are available only as total unspeciated chromium) are more reliable than concentrations estimated using the emissions method. Therefore, if measured concentrations of chromium were available, EPA used these data for NATA and applied a factor of 0.34 to total chromium to obtain values for hexavalent chromium (with the balance being trivalent chromium). If no ambient data were available for a specific location, EPA used the emissions method to estimate a background concentration for hexavalent chromium (no background for trivalent chromium was estimated).

exceeding the minimum detection level. Fourteen air toxic background concentration estimates were derived using the ambient method for the 2002 and 2005 NATAs. Representative percentiles of these background concentration estimates are then assigned to counties that do not have ambient monitors based on the county populations. If no monitors are located in a county, EPA considers the population density of that county and assigns a representative background concentration selected from the national data set for counties with similar population densities. For a county with only one monitor, that monitor's concentrations are used to estimate background. For a county with multiple monitors, the lowest annual monitored concentrations from among the multiple monitors are assigned to that county.

When reliable ambient measurements are not available for an air toxic, the **emissions method** is used to estimate concentrations for air toxics that are predominantly emitted by point sources, do not have

secondary components, and have residence times less than one year. This method was applied for 16 air toxics in the 2002 and 2005 NATAs, using emissions data from NEI aggregated to the county level. Air toxic residence time, which is estimated based on air toxic removal rates by deposition or chemical decay, is used to estimate "buffer distances" up to 500 kilometers. A buffer distance is the radius of influence of each air toxic in each county. Concentration gradients are estimated based on the buffer distance, remote concentration measurements (taken as minimum background concentrations), and maximum background concentration estimates derived from previous ASPEN simulations. For each county and air toxic combination, the buffer distance and concentration gradient are used to calculate the concentration of the air toxic resulting from emissions in surrounding counties.

For four air toxics in the 2002 and 2005 NATAs, the **uniform method** was used to estimate background concentrations. These air toxics have long lifetimes and well-characterized concentrations and are routinely measured at remote sites. For these air toxics, the same uniform background concentration is assumed for each county across the United States.

For NATA, each tract within a county receives the same county-level background concentration for a given air toxic. The county-level background concentrations included in the 2002 and 2005 NATA are posted online (EPA 2002b).

3.4 How Is the CMAQ Model Used to Estimate Air Toxics Concentrations in NATA?

EPA used the outputs from the 2005-based CMAQ (EPA 2009a) modeling platform that was used in support of the final revisions to the National Renewable Fuel Standard rule (commonly known as RFS2) (EPA 2010i) as part of the 2005 NATA to consider the secondary formation of formaldehyde, acetaldehyde, and acrolein from other volatile organic compounds. This 2005 multi-pollutant modeling platform used CMAQ version 4.7. "Secondary formation" occurs when an emitted substance chemically transforms in the atmosphere to become another (i.e., secondary) substance. CMAQ also was used to consider the decay of 1,3-butadiene to acrolein, both of which are HAPs. For the 2005 NATA, simple secondary formation calculations also were performed in ASPEN for some HAPs emitted by non-point sources. These ASPEN-generated secondary formation concentrations were not removed, leading to a few double-counting anomalies for formaldehyde, acetaldehyde, and acrolein. These double-counting anomalies are not likely to be a major influence on the NATA risk results.

CMAQ is a multi-chemical, multi-scale air quality modeling system that simulates the atmospheric and land processes affecting the transport, transformation, and deposition of air toxics and their precursors on both regional and urban scales. It is intended to holistically consider major air toxic issues, such as photochemical oxidants, particulate matter, acidic deposition, and nutrient deposition. CMAQ is a three-dimensional Eulerian photochemical grid model with algorithms that fundamentally differ from the Gaussian dispersion algorithms used within HEM-3 and ASPEN. CMAQ calculates ambient concentrations within model grid cells, with detailed treatment of atmospheric chemistry and physics. For NATA, these grid-cell concentrations are interpolated to census-tract centroids.

The CMAQ model includes modules that simulate the emission, production, decay, deposition, and transport of organic and inorganic gas-phase and particle-phase air toxics in the atmosphere. The key inputs to the CMAQ model include emissions from anthropogenic and biogenic sources, meteorological data, and initial and boundary conditions. A 2005 emissions inventory based on the 2005 version 4 platform was developed for the CMAQ modeling platform. A detailed discussion of the emissions inventory development can be found at EPA 2010j. The meteorological input files were derived from a simulation of the Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model (MM5; UCAR 2008) for the entire year of 2005. The MM5 outputs are then processed through

the Meteorology Chemistry Interface Processor (MCIP) model to provide gridded, model-ready inputs for CMAQ. On meteorological outputs that have high vertical resolution (such as outputs from MM5), MCIP uses mass-weighted averaging. For details on the 2005-based CMAQ platform and evaluation see EPA 2010i.

The lateral boundary and initial species concentrations for CMAQ version 4.7 are provided by a three-dimensional global atmospheric chemistry model, the Goddard Earth Observing System-Chem (Harvard University 2010). This model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the National Aeronautics and Space Administration's Goddard Earth Observing System.

CMAQ estimates air toxics concentrations for 12-kilometer by 12-kilometer grids in the eastern United States and 36-kilometer by 36-kilometer grids in the western United States. The concentrations within these grids are assumed to be the same for all tracts in the grid. In the 2005 NATA results, the CMAQ concentration estimates of formaldehyde, acetaldehyde, and acrolein due to secondary formation are presented separately from the concentrations of these air toxics from the other source types (point sources, non-point sources, etc.).

For 1,3-butadiene, CMAQ results were assumed to reflect the total concentration of the air toxic, taking into account its decay. Results from HEM-3 and ASPEN were then used to compute the fraction of this total concentration attributable to major point sources, non-point sources, on-road mobile sources, and non-road mobile sources. Because the secondary concentrations for 1,3,-butadiene were also estimated in ASPEN for non-point sources, the CMAQ secondary concentrations for 1,3-butadiene might have been somewhat over-allocated to non-point sources compared to the other source types.

3.5 Summary

- For the 2005 NATA, HEM-3 (AERMOD version) was used to model the ambient concentrations of emissions from point sources and mobile sources at the census-block level, and ASPEN was used to model ambient concentration from non-point sources at the census-tract level.
- CMAQ results of the secondary formation and decay of some air toxics in grid cells were used for the 2005 NATA. For NATA, these grid cell concentrations are assumed to be the same for all tracts in the grid.
- Background ambient concentrations were derived at the county level from monitoring data and emissions data.
- HEM-3 and ASPEN are steady-state dispersion models. CMAQ fundamentally differs from these two models in that it uses Eulerian photochemical grid-based algorithms to model ambient concentrations.
- HEM-3 and ASPEN use a collection of representative meteorological and climate data. CMAQ uses more sophisticated modeled meteorological data.

4 ESTIMATING EXPOSURES FOR POPULATIONS

Estimating inhalation exposure concentrations is a critical step in determining potential health risks because ambient concentrations do not take into account movements of individuals among geographic locations and microenvironments where pollutant concentrations can differ. Individuals differ in their daily activities, the amount of time spent engaged in the activities, and the locations where the activities occur. Most activities occur in indoor environments (e.g., the home, workplace, school, vehicle), where pollutant concentrations can differ from those in the outdoor environment. Therefore, the average concentration of a pollutant that people breathe can differ significantly from the ambient concentration at a fixed outdoor location.

This section describes how exposure concentrations are estimated for NATA. It begins with an overview of the two approaches used for NATA: (1) application of an EPA exposure model for the 1996 and 1999 NATAs that uses ambient concentrations, empirical activity data, and other information to model exposures; and (2) use of exposure-to-ambient concentration ratios, which were used for the 2002 and 2005 NATAs. This introduction is followed by more detailed descriptions of each approach as they have been applied for NATA, a summary of the user inputs and other data required for each approach, and an overview of the quality assurance measures included in estimating exposures.

4.1 How Are Exposure Concentrations Estimated for NATA?

EPA has used two approaches to estimate inhalation exposure concentrations for NATA, referred to in this document as the direct modeling approach and the exposure ratio approach. Both approaches use ambient concentrations estimated with dispersion models, as described in Section 3. In addition, both approaches yield census-tract-level exposure concentration estimates that are used to determine potential health risks for NATA.

The **direct modeling approach** involves exposure modeling using the EPA Hazardous Air Pollutant Exposure Model (HAPEM). HAPEM, described in greater detail in Section 4.2, is a screening-level exposure model that estimates inhalation exposure concentrations corresponding to estimated ambient pollutant concentrations. EPA used versions 4 and 5 of HAPEM (i.e., HAPEM4 and HAPEM5) for the 1996 and 1999 NATAs, respectively, as described in Section 4.3.

The second method, the **exposure ratio approach**, was used for the 2002 and 2005 NATAs. This approach does not involve conducting HAPEM modeling but rather relies on exposure ratios calculated from the results of the 1999 HAPEM modeling efforts conducted for NATA. Ambient to exposure concentration ratios were approximated for each combination of source type, census tract, and air toxic. The exposure ratio approach is described in Section 4.4.

4.2 What Is HAPEM?

Nearly two decades ago, EPA developed the Hazardous Air Pollutant Exposure Model for Mobile Sources (HAPEM-MS) to assess inhalation exposure to air toxics from highway mobile sources. This initial version of HAPEM used carbon monoxide as a tracer for highway mobile-source air toxic emissions. EPA has since updated and improved HAPEM to enable the prediction of inhalation exposure

concentrations for a wide range of air toxics using either modeled ambient concentrations or measured data (without regard to source type), and the model no longer uses carbon monoxide as a tracer. Recent versions of HAPEM incorporate a range of enhancements, and, as a result, HAPEM version 4 and later versions can be used to predict annual average human exposure levels on a nationwide basis at a spatial resolution as fine as the census-tract level (EPA 2002e, EPA 2005c, EPA 2007d). The enhancements incorporated into recent versions of HAPEM facilitate its use for large-scale inhalation risk assessments such as NATA. Inhalation exposure concentrations for the 1996 and 1999 NATAs were estimated using HAPEM4 and HAPEM5, respectively. Exhibit 4-1 outlines the key differences between these two versions. A complete history of HAPEM can be found in the User's Guide for HAPEM6 (EPA 2007d), the latest version of HAPEM available at the time this document was prepared.

Exhibit 4-1. Key Differences Between HAPEM4 and HAPEM5

Characteristic	HAPEM4	HAPEM5
Data source for population demographics	1990 U.S. Census	2000 U.S. Census
Characterization of microenvironmental factors	Point estimates	Probability distributions
Method for creation of annual average activity patterns from daily activity pattern data	Resampling of daily diaries for each of 365 days without accounting for autocorrelation	Sampling a limited number of daily diaries to represent an individual's range of activities, accounting for autocorrelation
Interpretation of exposure concentration range for a given cohort/tract combination	Uncertainty for the average annual exposure concentration for the cohort/tract combination	Variability of annual exposure concentrations across cohort/tract members

HAPEM uses a general approach of tracking representative individuals of specified demographic groups as they move among indoor and outdoor microenvironments and between geographic locations. As described in the following section, personal activity and commuting data specific to a hypothetical individual's demographic groups are used to determine the census tracts containing residential and work locations and the microenvironments within each tract. Empirically based factors reflecting the relationship between exposure concentrations within each microenvironment and the outdoor (ambient) air concentrations at that location are selected by the model through a stochastic sampling process to estimate exposure concentrations.

To estimate long-term exposure concentration for a hypothetical individual, the pollutant concentrations in each microenvironment visited are first combined into a daily average concentration. The daily averages are then combined with proper weighting for season and day type to calculate a long-term average. Finally, the long-term averages are stratified by demographic group and census tract to create a distribution of exposure concentrations for each stratum. The **median** of each distribution represents the best estimate of exposure for a "typical" person of that demographic group in that census tract. In this case, "typical" does not refer to a specific individual in the population or even the average over a group of individuals. Rather, this person is a hypothetical individual residing at the centroid of a census tract and engaging in a range of activities (both indoor and outdoor) that are representative of those in which individuals of that demographic group in that census tract might engage. Additional technical information on HAPEM can be found in the HAPEM6 User's Guide (EPA 2007d).

4.3 What Are the Important Inputs to HAPEM, and How Was the Model Applied for the 1996 and 1999 NATAs?

HAPEM requires four primary types of information to estimate exposure concentrations: (1) ambient concentrations of air toxics, (2) population data from the U.S. Census Bureau, (3) population

activity data, and (4) microenvironmental data. These inputs are discussed in more detail below, accompanied by descriptions of the data used for NATA and related information on how the model was configured and applied for the 1996 and 1999 assessments to conduct direct exposure modeling.

4.3.1 Ambient Air Concentration Data

HAPEM is typically applied using annual average, diurnally distributed ambient air concentrations. Input concentrations can be monitoring data or concentrations estimated using a dispersion model or other air quality model. For the 1996 and 1999 NATAs, annual average ambient concentrations for each census tract were estimated using ASPEN combined with background concentrations estimated from measurement data. To preserve characteristic diurnal patterns in ambient concentrations that might be important in estimating population exposure, ASPEN annual average concentration estimates were stratified by time of day, with an annual average computed for each of eight 3-hour time blocks (e.g., midnight to 3 a.m., 3 a.m. to 6 a.m.). In addition, ASPEN air quality files containing census-tract-level ambient concentration estimates were developed separately for each of four principal source sectors: point, non-point, mobile on-road, and mobile non-road. Thus, exposure model results generated for NATA can be summarized for each source sector or any combination of sectors.

4.3.2 Population Demographic Data

HAPEM divides the exposed population into cohorts such that each person in the population is assigned to one and only one cohort, and all the cohorts combined encompass the entire population. A cohort is defined as a group of people whose exposure is expected to differ from exposures of other cohorts due to certain characteristics shared by the people within that cohort. For NATA, cohorts are defined using residential census tract, gender, and age. The population in each census tract was divided into 10 demographic groups based on all possible combinations of:

- both genders (i.e., males and females), and
- five age groups (i.e., 0–4, 5–11, 12–17, 18–64, and ≥65 years of age).

For the 1996 NATA, these groups were developed using demographic data derived from the 1990 U.S. Census. For the 1999 NATA, the demographic groups were updated with 2000 U.S. Census data. Predicted inhalation exposure concentrations were aggregated across cohorts to estimate general population exposure concentrations.

4.3.3 Population Activity Data

HAPEM draws on two types of data to define activities for the modeled population: activity pattern data and commuting pattern data. **Human activity pattern data** are used to determine the frequency and duration of exposure within various microenvironments, for example, indoors at home, in-vehicle, and outdoors. Activity pattern data are taken from demographic surveys of individuals' daily activities that specify the sequence, duration, and locations of those activities. Commuting data specify the number of residents in each tract that work in that tract and every other census tract (i.e., the population associated with each home tract/work tract pair) and the distance between the centroids of the two tracts. HAPEM uses these data in coordination with the activity pattern data to place a hypothetical individual who commutes to work either in the home tract or the work tract at each 3-hour time step, and in a specific microenvironment. The microenvironment assignments and locations derived from these data are then used to calculate exposure concentrations, as explained in the next section.

The default source of activity pattern data used by HAPEM and for NATA is EPA's Consolidated Human Activity Database (CHAD; EPA 2009e). To develop CHAD, data from 12 individual U.S.

studies of human activities were combined into one comprehensive data system that contains 22,968 person-days of activity pattern records. Because of limitations of the study designs of the surveys from which it is derived, CHAD might not be representative of all demographic groups, particularly ethnic minorities and low-income populations. Another limitation of the activity pattern data in CHAD is that most are for individuals over a one- or two-day period only. Extrapolation of these short-term records to annual activity patterns required for air toxic exposure assessment introduces some uncertainty into the analysis. As described below, the algorithms in HAPEM5 (used for the 1999 NATA) address this by implementing a stochastic process to create simulated long-term (multi-day) activity patterns from daily activity pattern data that account for day-to-day autocorrelation.

These algorithms were not included in HAPEM4. In applying HAPEM4 for the 1996 NATA, for each demographic group, 365 daily activity diaries were selected randomly (with replacement) and combined to find the average fraction of time spent in each of 37 microenvironments, for each of eight 3-hour time blocks. One hundred such annual activity patterns were constructed for each demographic group. Then, for each census tract, 30 of the 100 annual patterns were randomly selected (with replacement) to represent typical annual time allocations for group members in that tract. The result is a set of 30 annual exposure concentrations estimates for each demographic group in each tract. Because this approach to constructing an annual sequence of diaries does not take into account day-to-day autocorrelation of activities for an individual, each of the 100 annual patterns is an estimate of an average activity pattern for that cohort (i.e., an estimate of the average amount of time that members of the cohort spend in each microenvironment). Thus, the range of the exposure concentrations for each cohort-tract combination represents the uncertainty of the average annual concentration for that cohort-tract combination.

In developing HAPEM5 (the model used for the 1999 NATA), new algorithms were added for creating annual average activity patterns from daily activity pattern data to better represent the variability among individuals within a cohort-tract combination. For each day type and demographic group, daily activity diaries were divided into three groups based on similarity using a cluster analysis. To simulate the activities of an individual, one diary was selected from each group for each day type, resulting in nine diaries in total. Then, for each day type, the sequence of the selected diaries was determined according to the probability of transition from one cluster group to another, as determined by analysis of the CHAD data. Again, the simulation was repeated 30 times, resulting in a set of 30 annual exposure concentrations estimates for each demographic group in each census tract. Use of a limited number of diaries and the transition probabilities is a way to account for day-to-day autocorrelation of activities for an individual, so each exposure concentration estimate represents an estimate for an individual rather than an average for the group. Therefore, with this approach the range represents the variability of exposure concentrations across the group.

Commuting pattern data, the second type of population activity data used in HAPEM, are derived for each cohort from a special U.S. Census data base containing information on tract-to-tract commuting patterns. An important limitation is that the commuting pattern data included in HAPEM do not account for the movement of school-age children who travel (or commute) to a school located outside of their home tract.

4.3.4 Microenvironmental Data

A microenvironment is a three-dimensional space in which human contact with an environmental pollutant occurs. In HAPEM, this space is treated as a well-characterized, relatively homogenous location with respect to pollutant concentrations for a specified time period. The inhalation exposure estimate is determined by the sequence of microenvironments visited by the individual. The

concentration in each microenvironment is estimated by adjusting the ambient concentration estimate for the census tract where it is located by three microenvironmental factors:

- a penetration factor that is an estimate of the ratio of the microenvironmental concentration to the concurrent outdoor concentration in the immediate vicinity of the microenvironment; penetration factors are pollutant-specific estimates that are derived from reported measurement studies;
- a proximity factor that is an estimate of the ratio of the outdoor concentration in the immediate vicinity of the microenvironment to the outdoor concentration represented by the ambient air concentration input to the model; and
- an **additive factor** that accounts for emission sources within or near a particular microenvironment, such as indoor emission sources.

The relationship between the estimated exposure concentrations, the input ambient concentration, and these three factors is demonstrated by the equation below.

$$C_{(i,k,t)} = CONC_{(i,t)} \times PEN_k \times PROX_k + ADD_k$$

Where:

$C_{(i,k,t)}$ = exposure concentration predicted within census tract *i* and microenvironment *k* for time step *t*, in units of $\mu g/m^3$

$CONC_{(i,t)}$ = ambient concentration for census tract *i* for time step *t*, in units of $\mu g/m^3$

PEN_k = penetration factor for microenvironment *k*

$PROX_k$ = proximity factor for microenvironment *k*

ADD_k = additive factor accounting for sources within microenvironment *k*, in units of $\mu g/m^3$

In HAPEM5 and HAPEM6, stochastic processes can be used to select work tracts, ambient air concentrations, and microenvironmental factors. This important feature allows exposures to be characterized with probability distributions rather than point estimates, which more accurately reflect the variability of these components and simulate some of the variability found in measurement studies.

In HAPEM, the characteristics of each microenvironment are used to assign each microenvironment to one of three groups: indoors, outdoors, and in-vehicle. For the 2005 NATA, 37 microenvironments were used. The microenvironments in the indoor group were further classified as associated with either residence or other buildings, while those in the outdoor group were categorized as either near-road or away-from-road. Each group consists of microenvironments expected to have similar penetration factors, thus allowing microenvironmental factors developed for one microenvironment to be applied to other microenvironments in the same group. These 37 microenvironments are listed in Exhibit 4-2, categorized according to group and subgroup. An important consideration is that data to support quantitative microenvironmental factors are not well developed for many of the air toxic compounds and for most of the 37 microenvironments, which introduces uncertainty into the analysis of exposures. Section 7 discusses uncertainty and variability with regard to this and other issues for NATA. The additive factor (ADD_k) in the expression for exposure concentration, above, was set to zero for NATA because indoor source data are currently incomplete (recall that NATA covers only pollutants derived from outdoor sources).

Exhibit 4-2. Categorized HAPEM Microenvironments Used in NATA[a]

Indoors	Outdoors	In Vehicle
Residence Residential garage Residence – no gas stove Residence – gas stove Residence – attached garage Residence – stove and garage *Other Building* Public garage Service station Other repair shop Office Store Restaurant Manufacturing facility School Church Shopping mall Auditorium Healthcare facility Other public building Other location Not specified	*Near-road* Parking lot/Garage Near-road Motorcycle Service station Other location[a] Not specified[a] *Away-from-road* Construction site Residential grounds School grounds Sports arena Park/golf course Other location[a] Not specified[a]	Car Bus Truck Other Train/Subway Airplane

[a] Uses average of factors estimated for outdoors, near-road and outdoors, away-from-road.

4.4 How Were Exposure Factors Used for the 2002 and 2005 NATA?

HAPEM exposure modeling for NATA requires substantial time and resources for data collection and processing, computing, and model processing. Due to these requirements, new HAPEM modeling was not performed for the 2002 and 2005 NATAs. Instead, the 2002 and 2005 exposure estimates were developed using exposure factors derived from the 1999 NATA HAPEM simulations. In particular, the exposure estimates for the 1999 NATA were obtained by multiplying modeled (i.e., ASPEN) census-tract-level ambient concentrations by exposure factors that were calculated for each combination of air toxic, tract, and source type by dividing exposure concentration (estimated using HAPEM5 for the 1999 NATA) by ambient concentration (estimated by ASPEN for the 1999 NATA). The 2002 and 2005 assessments used the same 2000 U.S. Census data as the 1999 NATA to determine demographic distributions.

Exhibit G-1 in Appendix G to this document shows the overall average exposure-to-ambient concentration ratios (i.e., exposure factors) calculated from HAPEM and ASPEN outputs for each pollutant. This ratio is presented for total levels and for each of the five source sectors considered in the assessment (i.e., point, non-point, on-road mobile, non-road mobile, and background). Overall, the HAPEM exposure predictions are lower than the corresponding predicted air quality values. This reduction likely results from the inability of many pollutants to penetrate efficiently into an indoor environment. (Recall that indoor sources of air toxics have not been included in any versions of NATA completed to date). Note that because tract-level exposure factors were used for the 2002 and 2005 NATAs, estimated exposure concentrations also vary by tract, even where the estimated ambient concentration is constant across a census tract (such as for non-point sources) or across the nation (as is the case for assumed background concentrations of a small number of pollutants).

4.5 How Does NATA Incorporate Quality Assurance into the Exposure Modeling?

A model performance evaluation can provide valuable information regarding model uncertainty when using computer simulation models of human exposures to pollutants, and a well-conducted evaluation can substantially increase confidence in model results for a given application or use. One type of performance evaluation is the use of measurements and environmental data as a benchmark for comparison of modeling estimates. EPA has worked with the Mickey Leland Center (NUATRC 2009) on past assessments to help identify new and independent sources of personal monitoring data for use in comparison with the NATA results.

Extensive peer review involving independent scientific and technical advice from scientists, engineers, and economists can be another valuable component of a model evaluation. In July 2000, HAPEM4 underwent external peer review by technical experts for both the microenvironmental factors used in the model and the overall application of the model for NATA. A discussion of several of the issues addressed by these reviews is included in Appendix A of the report for the 1996 NATA presented to EPA's Science Advisory Board for review (EPA 2001b). In 2001, EPA's Scientific Advisory Board reviewed the application of HAPEM4 as part of the 1996 NATA review (EPA 2001a). Although several limitations were identified in the current methodology, HAPEM4 was acknowledged as an appropriate tool to help better understand the relationship of human exposures to ambient concentration levels.

4.6 Summary

- Estimating inhalation exposure concentrations is a critical step in determining potential health risks, because ambient concentrations do not account for movements of individuals among geographic locations and microenvironments where pollutant concentrations can differ.
- Inhalation exposure concentrations for the 1996 and 1999 NATAs were estimated using HAPEM4 and HAPEM5, respectively.
- For the 2002 and 2005 NATAs, exposure estimates were derived by multiplying ambient concentrations for each source by a tract-level exposure factor derived from the results of previous HAPEM5 modeling.
- Both methods for estimating exposures for populations yield tract-level exposure concentrations that can be used to determine potential health risks.

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5 CHARACTERIZING EFFECTS OF AIR TOXICS

Exposure to air toxics is associated with increased incidence of cancer and a variety of adverse non-cancer health effects. The type and severity of effects depends on several factors, including the identity and nature of the chemical to which an individual is exposed, the magnitude and duration of exposure, and the unique behaviors and sensitivities of exposed individuals. The process of identifying and quantifying the adverse health effects associated with exposure to a chemical is accomplished with EPA risk assessment methods by way of a **toxicity assessment**. As indicated in Exhibit 1-2 of this document and described in more detail in Volume 1 of EPA's Air Toxics Risk Assessment Reference Library (EPA 2004a), two processes comprise toxicity assessment: **hazard identification**, during which the specific adverse effects are identified that can be causally linked with exposure to a given chemical; and **dose-response assessment**, which characterizes the quantitative relationship between chemical dose (or concentration) and adverse effects (i.e., the hazard(s) identified in the first step).[5] Ultimately, the results of the toxicity assessment, referred to in this document as "toxicity values," are used in conjunction with exposure estimates to characterize the health risks for exposed populations as described in Section 6. Although the toxicity assessment is an integral and important part of the overall air toxics risk assessment, it is usually accomplished prior to the risk assessment. EPA has completed this toxicity assessment for many air toxics and has made available the resulting toxicity information and dose-response values, which have undergone extensive peer review.

This section explains how toxicity assessment is conducted as part of the NATA risk assessment process. Specifically, the sections that follow provide an overview of the cancer and non-cancer toxicity values used in NATA and the primary sources of these values. Several adjustments and assumptions to toxicity values that are specific to the NATA risk assessment process are also described.

5.1 What Are Toxicity Values and How Does NATA Use Them?

The toxicity values used for NATA are quantitative expressions used to estimate the likelihood of adverse health effects given an estimated level and duration of exposure. These toxicity values are based on the results of dose-response assessments, which estimate the relationship between the dose and the frequency or prevalence of a response in a population or the probability of a response in any individual. Because NATA is focused on long-term exposures, the toxicity values used in NATA are based on the results of chronic dose-response studies when such data are available. Chronic dose-response assessments can be used to help evaluate the specific 70-year average (i.e., "lifetime") exposure concentrations associated with cancer prevalence rates, or, for non-cancer effects, the concentrations at

[5] The phrase "dose-response" is used generally here and elsewhere in this document to refer to the relationship between a level of a chemical and a physical response. The values EPA uses for inhalation, however, are derived for exposure concentration, although with consideration of dose. Consideration of the relationship between exposure concentration, dose, and dosimetry (how the body handles a chemical once it is inhaled) is inherent in the derivation of values. The term "toxicity values" is used here to refer to the reference concentrations and unit risk estimates used in inhalation risk assessment.

which non-cancer adverse health effects might occur given exposure over an extended period of time (possibly a lifetime, but the time frame also can be shorter).

The toxicity values that are combined with exposure concentrations to conduct the risk characterization in NATA are based on the results of quantitative dose-response assessments. The actual values used, however, are not strictly considered dose-response or concentration-response values. To estimate cancer risks in NATA, the results of cancer dose-response assessments for a given chemical are converted to a value (i.e., a unit risk estimate or URE) that incorporates certain exposure assumptions. This value can be multiplied by the 70-year average exposure concentration to obtain a lifetime cancer risk estimate for each individual. To evaluate the potential for non-cancer adverse health effects, chronic dose-response data are used to estimate a threshold that is the exposure concentration in air at which adverse health effects are assumed to be unlikely (i.e., the reference concentration or RfC). These two types of values are described in more detail in the following section.

The toxicity values used in NATA are consistent with those that the EPA Office of Air Quality Planning and Standards (OAQPS) has compiled for chronic oral and inhalation exposures to air toxics and for acute exposures to air toxics, including those used in residual risk assessments (EPA 2007c). Sources of chronic dose-response assessments used for the 2005 NATA were prioritized according to OAQPS risk assessment guidelines and level of peer review. The full set of toxicity values used for the 2005 NATA is presented in Exhibit H-1 in Appendix H to this document. More information about the dose-response assessments used to develop this set of toxicity values can be found in the Health Effects Information summary developed for the 2002 NATA (EPA 2002d) and in Appendix H to this document.

5.2 What Types of Toxicity Values Are Used in NATA?

Each toxicity value used in NATA is best described as an estimate within a range of possible values appropriate for screening-level risk assessments. EPA has updated the values in subsequent versions of NATA as better data have become available. It is important to note that the uncertainty in the dose-response assessments and toxicity values that NATA relies on is to some extent one-sided, providing a conservative (health-protective) estimate of risk. The "true" cancer risk and potential for adverse non-cancer impacts are believed to be lower than estimated in this assessment, although the possibility remains that they could be greater. Uncertainty in the derivation of the dose-response values and in other aspects of the NATA process is discussed in Section 7.

5.2.1 Cancer Unit Risk Estimate

A cancer dose-response curve is used to demonstrate the quantitative relationship between dose and the likelihood of contracting cancer. If the dose-response relationship is linear, the cancer response is assumed to increase proportionally with the dose (which might be expressed as an exposure concentration, an absorbed internal dose, a dose to a specific organ or tissue, or other measure). EPA has proposed that linear extrapolation of carcinogenic risk in the low-dose region of the curve is a reasonable approach for estimating risk at relatively low exposures, such as those typically experienced by the general population for air toxics (i.e., the true value of the risk is unknown, and could be as low as zero). An upper-bound lifetime cancer risk represents a plausible upper limit to the true probability that an individual will contract cancer as a result of exposure over a 70-year lifetime to a given hazard (e.g., exposure to an air toxic).

> The **unit risk estimate (URE)** is the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 microgram per cubic meter ($\mu g/m^3$) in air. UREs are considered upper bound estimates, meaning they represent a plausible upper limit to the true value. The true risk is likely to be less, but could be greater.

For an inhalation risk assessment (and for NATA), a URE can be used to calculate the estimated cancer risk from inhalation exposure

concentrations. A URE is calculated by using dose-response information for a chemical and developing a factor in the appropriate units that can be combined directly with exposure concentrations in air to estimate individual cancer risks, given certain assumptions regarding the exposure conditions. Specifically, the URE represents the upper-bound of the excess cancer risk estimated to result from continuous exposure to a concentration of 1 **microgram** of a substance per cubic meter of air, over a 70-year lifetime and assuming a daily inhalation rate of about 20 m^3/day. The risk value is derived from the slope of the dose-response curve as estimated using a linearized multistage statistical model in the low-dose portion of the curve. The interpretation of the URE is as follows: if the URE is 1.5×10^{-6} µg/m^3, no more than 1.5 excess tumors would develop per 1,000,000 people if they were exposed daily for a lifetime to a concentration of 1 µg/m^3. To the extent that true dose-response relationships for some air toxics compounds are not strictly linear, this assumption could result in overestimates of cancer risk. The upper bound is not a true statistical confidence limit because the URE reflects unquantifiable assumptions about effects at low doses. Thus, although the actual carcinogenic risk is likely to be lower than what is reflected in the URE, it also might be higher.

The URE provides an estimate of toxic potency of a chemical. EPA's **weight of evidence (WOE)** descriptors provide estimates of the *level of certainty* regarding a chemical's carcinogenic potential. EPA evaluates three broad categories of toxicological data to make a WOE determination: (1) human data (primarily epidemiological); (2) animal data (results of long-term experimental animal bioassays); and (3) supporting data, including a variety of short-term tests for genotoxicity and other relevant properties, pharmacokinetic and metabolic studies, and structure-activity relationships. These data are evaluated in combination to characterize the extent to which they support the hypothesis that an agent or chemical causes cancer in humans. The approach outlined in EPA's Guidelines for Carcinogen Risk Assessment (EPA 2005a) considers available scientific information regarding carcinogenicity and provides a narrative approach to characterizing carcinogenicity rather than assigning chemicals to specific categories (as was done previously by EPA according to the 1986 guidelines). To provide some measure of clarity and consistency in an otherwise free-form, narrative characterization, standard descriptors are used as part of the hazard narrative to express the conclusion regarding the WOE for carcinogenic hazard potential. There are five recommended standard hazard descriptors, described below.

EPA's Weight of Evidence (WOE) Descriptors (EPA 2005a)

- Carcinogenic to humans
- Likely to be carcinogenic to humans
- Suggestive evidence of carcinogenic potential
- Inadequate information to assess carcinogenic potential
- Not likely to be carcinogenic to humans

Carcinogenic to Humans: This descriptor indicates strong evidence of human carcinogenicity. This descriptor is appropriate when there is convincing epidemiologic evidence of a causal association between human exposure and cancer. Alternatively, this descriptor might be equally appropriate with a lesser weight of epidemiologic evidence that is strengthened by other lines of evidence. It can be used when all of the following conditions are met: (1) there is strong evidence of an association between human exposure and either cancer or the key precursor events of the agent's mode of action but not enough for a causal association; (2) there is extensive evidence of carcinogenicity in animals; (3) the mode(s) of carcinogenic action and associated key precursor events have been identified in animals; and (4) there is strong evidence that the key precursor events that precede the cancer response in animals are anticipated to occur in humans and progress to tumors, based on available biological information.

Likely to Be Carcinogenic to Humans: This descriptor is appropriate when the WOE is adequate to demonstrate carcinogenic potential to humans but does not reach the WOE for the descriptor "Carcinogenic to Humans." Adequate evidence consistent with this descriptor covers a broad spectrum. At one end of the spectrum is evidence for an association between human exposure to the agent and cancer and strong experimental evidence of carcinogenicity in animals. At the other end, with no human

data, the weight of experimental evidence shows animal carcinogenicity by a mode or modes of action that are relevant or assumed to be relevant to humans. The use of the term "likely" as a WOE descriptor does not correspond to a quantifiable probability. Moreover, additional data, such as information on the mode of action, might change the choice of descriptor for the illustrated examples.

Suggestive Evidence of Carcinogenic Potential: This descriptor is appropriate when the WOE is suggestive of carcinogenicity; that is, a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion. This descriptor covers a spectrum of evidence associated with varying levels of concern for carcinogenicity, ranging from a positive cancer result in the only study on an agent to a single positive cancer result in an extensive data base that includes negative studies in other species. Depending on the extent of the data base, additional studies might or might not provide further insights.

Inadequate Information to Assess Carcinogenic Potential: This descriptor is appropriate when available data are judged inadequate for applying one of the other descriptors. Additional studies generally would be expected to provide further insights.

Not Likely to Be Carcinogenic to Humans: This descriptor is appropriate when the available data are considered robust for deciding that there is no basis for human hazard concern. In some instances, there can be positive results in experimental animals when there is strong, consistent evidence that each mode of action in experimental animals does not operate in humans. In other cases, there can be convincing evidence in both humans and animals that the agent is not carcinogenic. A descriptor of "not likely" applies only to the circumstances supported by the data. For example, an agent might be "Not Likely to Be Carcinogenic" by one route but not necessarily by another. In those cases that have positive animal experiment(s) but the results are judged to be not relevant to humans, the narrative discusses why the results are not relevant.

Important to note is that these WOE categories express only a *relative* level of certainty that these substances might cause cancer in humans. The categories do not specifically connote relative levels of hazard or the degree of conservatism applied in developing a dose-response assessment. For example, a substance with suggestive evidence of carcinogenic potential might impart a greater cancer risk to more people than another substance that is carcinogenic to humans.

The process of developing UREs includes several important sources of uncertainty. Many of the air toxic compounds in NATA are classified as "likely" carcinogens. The term likely, as used in this instance, means that data are not sufficient to prove these substances definitively cause cancer in humans. That some are not human carcinogens at environmentally relevant exposure concentrations is possible, and the true cancer risk associated with these air toxics might be zero. UREs for most of the air toxics were developed from animal data using health protective methods to extrapolate to humans. Actual human responses might differ from those predicted. For more information, see the 2005 Guidelines for Carcinogen Risk Assessment (EPA 2005a).

5.2.2 Non-cancer Chronic Reference Concentration

The RfC is an estimate of a continuous inhalation exposure that is thought to be without an appreciable risk of deleterious health effects over a lifetime. The population considered in the derivation of RfCs includes sensitive subgroups (i.e., children, asthmatics,

The **reference concentration (RfC)** is 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 deleterious effects during a lifetime.

and the elderly). The RfC is derived from the review of a health effects data base for a chemical, and identification of the most sensitive and relevant endpoint, along with the principal study or studies demonstrating that endpoint. The value is calculated by dividing the no-observed-adverse-effect level, or an analogous exposure level obtained with an alternate approach (e.g., a lowest-observed-adverse-effect level or a benchmark dose), by uncertainty factors reflecting the limitations of the data used.

As with UREs for cancer risk assessment, the process of developing RfCs includes several important sources of uncertainty that span perhaps an order of magnitude. Uncertainty factors are intended to account for the (1) variation in sensitivity among the individuals in the population, (2) uncertainty in extrapolating laboratory animal data to humans, (3) uncertainty in extrapolating from data obtained in a study involving a less-than-lifetime exposure, (4) uncertainty in using lowest-observed-adverse-effect-level or other data rather than no-observed-adverse-effect-level data, and (5) inability of any single study to adequately address all possible adverse outcomes in humans. Additionally, an adjustment factor is sometimes applied to account for scientific uncertainties in the data or study design not explicitly captured in the uncertainty factors (e.g., a statistically inadequate sample size or poor exposure characterization). For more information, refer to EPA's Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (EPA 1994).

Unlike linear dose-response assessments for cancer, non-cancer risks generally are not expressed as a probability that an individual will experience an adverse effect. Instead, in an air toxics risk assessment, the potential for non-cancer effects in humans typically is quantified by calculating the ratio of the inhalation exposure concentration to the RfC. This ratio is referred to as the hazard quotient (HQ). For a given air toxic, exposures at or below the reference concentration (i.e., HQs are 1 or less) are not likely to be associated with adverse health effects. As exposures increase above the reference concentration (i.e., HQs are greater than 1), the potential for adverse effects also increases. The HQ, however, should not be interpreted as a probability of adverse effects. Additional information is provided in the description of risk characterization for NATA in Section 6 of this document.

5.3 What Data Sources for Toxicity Values Are Used for NATA?

Dose-response assessment information for evaluating chronic exposures for NATA is obtained from multiple sources and prioritized according to OAQPS risk assessment guidelines and level of peer review. The sources are listed below in order of highest (most preferred) to lowest priority. Exhibit H-1 in Appendix H to this document lists the toxicity values and supporting information for both cancer and non-cancer chronic effects used in the 2005 NATA. Cancer effects are characterized according to the extent to which available data support the hypothesis that a pollutant causes cancer in humans. Information on individual substances is included in the footnotes of Exhibit H-1.

5.3.1 U.S. EPA Integrated Risk Information System

EPA disseminates dose-response assessment information in several forms, depending on the level of internal review. The Integrated Risk Information System (IRIS) is an electronic database prepared and maintained by EPA that contains information on human health effects, which could result from exposure to various substances in the environment. These assessments have undergone external peer review and subsequent revision, compliant with requirements EPA instituted in 1996 for the IRIS review process.

Externally peer-reviewed assessments under development for IRIS were given first priority for NATA. These assessments reflect the most recent available toxicity information and data analysis and were used in some cases to supersede existing values on IRIS. Current IRIS values are used for NATA when peer-reviewed IRIS values under development are not available.

5.3.2 U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry

The Agency for Toxic Substances and Disease Registry (ATSDR) publishes minimal risk levels (MRLs) for many substances based on health effects other than cancer. The MRL is defined as an estimate of human exposure to a substance that is likely to be without an appreciable risk of adverse effects (other than cancer) over a specified duration of exposure. For non-cancer values in the 2005 NATA, inhalation MRLs were used when IRIS RfC values were not available, because their concept, definition, and derivation are analogous. ATSDR does not develop assessments based on carcinogenicity. After internal and external review, MRLs are published in pollutant-specific toxicological profile documents. They are also available in the table of "comparison values" (Minimal Risk Levels [MRLs] for Hazardous Substances) that ATSDR regularly updates and which is available at (ATSDR 2009).

5.3.3 California Environmental Protection Agency Office of Environmental Health Hazard Assessment

California's Office of Environmental Health Hazard Assessment (OEHHA) develops reference exposure levels based on health effects other than cancer and UREs based on carcinogenicity. The reference exposure level is defined as a concentration level at or below which no adverse health effects are anticipated. For non-cancer values in the 2005 NATA, inhalation reference exposure levels were used when no IRIS or ATSDR values were available, because the concept, definition, and derivation are analogous for all three sources. For cancer values in the assessment, UREs from OEHHA were used when no IRIS values existed. OEHHA dose-response information is available at Air Toxicology and Epidemiology (OEHHA 2007). Technical support documents for assessing hotspots are available on the OEHHA Web site at Hotspots Guidelines.

5.3.4 U.S. EPA Health Effects Assessment Summary Tables

The Health Effects Assessment Summary Tables (EPA 2008c) are a comprehensive listing consisting almost entirely of provisional UREs, RfCs, and other risk assessment information of interest that various EPA offices have developed. The assessments have never been submitted for EPA consensus and were last updated in 1997. NATA uses information from these tables only when no values from the sources discussed in Sections 5.3.1 through 5.3.3 are available.

5.3.5 World Health Organization International Agency for Research on Cancer

The International Agency for Research on Cancer of the World Health Organization (WHO) coordinates and conducts research on cancer and provides information on related cancer research and epidemiology. Although the agency does not develop quantitative dose-response values, it has published a series of monographs on the carcinogenicity of a wide range of substances (WHO 2009). The following "degrees of evidence" the International Agency for Research on Cancer has published are included in Exhibit H-1 in Appendix H to this document as supporting information when EPA WOE determinations are not available for a substance or are out of date:

- Group 1: Carcinogenic to humans;
- Group 2A: Probably carcinogenic to humans;
- Group 2B: Possibly carcinogenic to humans;
- Group 3: Not classifiable as to human carcinogenicity; and
- Group 4: Probably not carcinogenic to humans.

5.4 What Additional Decisions Are Made for Some Chemicals with Respect to Toxicity Values?

After the dose-response information is prioritized, OAQPS makes additional changes are to some of the chronic inhalation exposure values to address data gaps, increase accuracy, and avoid underestimating risk for NATA. Important changes made for the 2005 NATA are outlined below and are reflected in Exhibit H-1 in Appendix H to this document.

5.4.1 Carcinogens with Oral Assessments but Lacking Inhalation Assessments

For some substances, a quantitative dose-response relationship has been estimated for **oral exposure** (e.g., via consumption of contaminated food or water), but not for inhalation exposure. Instead, a health-protective approach to inhalation risk assessment is used that estimates an inhalation cancer toxicity value from the existing oral value. For the 2005 NATA, inhalation UREs were derived from oral carcinogenic potency estimates for 10 carcinogenic substances that lack inhalation assessments:

- benzotrichloride
- captan
- dichlorodiphenyldichloroethylene (DDE)
- dichlorvos
- 3,3'-dimethoxybenzidine
- 3,3'-dimethylbenzidine
- isophorone
- pentachloronitrobenzene
- propylene dichloride
- trifluralin

The conversion from oral risk (unit risk per milligram/kilogram/day [mg/kg-day]$^{-1}$ oral intake) to inhalation risk (unit risk per microgram/cubic meter [µg/m^3]$^{-1}$ exposure concentration) uses EPA's standard assumptions of a 70-kilogram (154-pound) body mass and a 20-m^3/day inhalation rate. These values are considered to approximately represent the typical adult population in the United States. To extrapolate to inhalation risk, the oral potency slope is normalized to body weight by dividing by 70 kilograms and then multiplying by the daily inhalation rate. A unit conversion factor for mass (from milligrams to micrograms) also is included. This approach assumes that the chemical mass absorbed by the body is the same for a given mass of pollutant, whether it is ingested or inhaled. The relationship is described by the following equation.

$$URE_x = CPS_x \times \frac{1}{BW} \times Inh \times \left(\frac{1\,mg}{1000\,\mu g} \right)$$

Where:

URE_x	=	unit risk estimate for inhalation for chemical *x*, in units of $(\mu g/m^3)^{-1}$
CPS_x	=	carcinogenic potency slope for ingestion (oral slope factor) for chemical *x*, in units of $(mg/kg\text{-}day)^{-1}$
BW	=	assumed adult body weight (70 kilograms)
Inh	=	assumed daily inhalation rate (20 m^3/day)

Although conversion of an oral slope factor to an inhalation URE is not optimal risk assessment practice, the alternative would be to omit these substances from any quantitative inhalation risk estimates, thereby making a *de facto* assumption of zero carcinogenic risk by inhalation. For the purposes of NATA, EPA prefers to use the approach described above to screen these substances for their potential contributions to cancer risk. If the NATA process indicates that such a substance is a potentially important contributor to risk, the substance will be prioritized for further evaluation through EPA's IRIS process.

5.4.2 Polycyclic Organic Matter

A substantial proportion of POM reported in the 2005 NEI was not speciated into individual compounds. For example, some emissions of POM were reported in NEI as "7-PAH" or "16-PAH," representing subsets of certain POM, or simply as "total PAH" or "polycyclic organic matter." In other cases, individual POM compounds are reported for which no quantitative cancer dose-response value has been published in the sources used for NATA. As a result, simplifying assumptions that characterize emissions reported as POM are applied so that cancer risk can be quantitatively evaluated for these chemicals without substantially under- or overestimating risk (which can occur if all reported emissions of POM are assigned the same URE). To accomplish this, POM emissions as reported in NEI are grouped into categories. EPA assigns dose-response values based on the known or estimated toxicity for POM within each group and on information for the POM speciation of emission sources, such as wood fires and industrial processes involving combustion.

For the 1996 NATA, unspeciated POM emissions were divided into two overlapping groups and assigned a URE equal to either 5 or 18 percent of the URE for pure benzo[a]pyrene. These values were derived from information developed in the 1996 NEI regarding mass fractions of POM compounds for common emission sources and the relative toxicity of those compounds. A more detailed description of how these UREs were assigned is provided in Appendix H of EPA's report on the 1996 NATA provided to the Science Advisory Board (EPA 2001b). For the subsequent assessments in 1999, 2002, and 2005, the approach was further refined, and POM emissions were divided into eight POM groups. The first two groups included unspeciated POM (including "total PAH") and individual POM species with no URE assigned. Both groups were assigned a URE equal to 5 percent of that for pure benzo[a]pyrene, using logic similar to that applied for the 1996 NATA (i.e., taking into account toxicity and the estimated emission profile of POM compounds). Groups 3 through 7 comprised POM compounds whose emissions were reported as individual compounds and for which UREs have been estimated. Compounds in these groups were categorized based on toxicity, and an appropriate URE was assigned to each category based on toxicity of the compounds included in the group. Category 8 was composed of unspeciated polynuclear aromatic hydrocarbons reported as 7-PAH and was assigned a URE equal to 18 percent of that for pure benzo[a]pyrene. Exhibit I-1 in Appendix I to this document shows the eight POM groups and the associated URE assignments used for the 2005 NEI.

5.4.3 Glycol Ethers

Much of the emission inventory information for the glycol ether category reports only the total mass for the entire group without distinguishing among individual glycol ether compounds. In other cases, emissions of individual glycol ether compounds that have not been assigned dose-response values are reported. Individual glycol ether compounds vary substantially in toxicity. To avoid underestimating the health hazard associated with glycol ethers, EPA has protectively applied the RfC for ethylene glycol methyl ether (the most toxic glycol ether for which an assessment exists) to glycol ether emissions of unspecified composition.

5.4.4 Metals

Several decisions made for the 2005 NATA regarding the toxicity values used for metal compounds are discussed in this section.

Hexavalent chromium compounds. The IRIS RfC for particulate hexavalent chromium was used instead of the RfC for chromic acid mists and dissolved aerosols to avoid underestimating the health hazard associated with these compounds. The RfC for particulate hexavalent chromium is less than those RfCs for chromic acid mists and dissolved aerosols.

Lead. EPA has concluded that toxicological data to develop a cancer inhalation URE for lead are insufficient at this time. The EPA National Ambient Air Quality Standard (NAAQS), developed using the EPA Integrated Exposure, Uptake, Biokinetic Model, was used in preference to the RfC for non-cancer adverse effects because the NAAQS for lead was developed using more recent toxicity and dose-response information on the non-cancer adverse impacts of lead. The lead NAAQS, a rolling 3-month average level of lead in total suspended particles, is used as a long-term value in NATA.

Nickel compounds. The cancer inhalation URE for most of the emissions of nickel compounds included in NATA (including unspecified nickel emissions reported as "nickel compounds") was derived from the IRIS URE for insoluble nickel compounds in crystalline form. Soluble nickel species, and insoluble species in amorphous form, do not appear to produce genotoxic effects by the same toxic mode of action as insoluble crystalline nickel. Nickel speciation information for some of the largest nickel-emitting sources, including oil and coal combustion, suggests that at least 35 percent of total nickel emissions could be soluble compounds. The remaining insoluble nickel emissions, however, are not well characterized. Consistent with this limited information, EPA conservatively assumes for NATA that 65 percent of emitted nickel is insoluble and that all insoluble nickel is crystalline. Because the nickel URE listed in IRIS is based on nickel subsulfide and represents pure insoluble crystalline nickel, it is adjusted to reflect an assumption that 65 percent of the total mass of emitted nickel might be carcinogenic. In cases where a chemical-specific URE is identified for a reported nickel compound, it is used without adjustment. Furthermore, the MRL in Table 2 of the ATSDR is not adjusted because the non-cancer effects of nickel are not thought to be limited to the crystalline, insoluble form.

5.4.5 Adjustment of Mutagen UREs to Account for Exposure During Childhood

For carcinogenic chemicals acting via a mutagenic mode of action (i.e., chemicals that cause cancer by damaging genes), EPA recommends that estimated risks reflect the increased carcinogenicity of such chemicals during childhood. This approach is explained in detail in the Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005c). Where available data do not support a chemical-specific evaluation of differences between adults and children, the Supplemental Guidance recommends using the following default adjustment factors for early-life exposures: increase the carcinogenic potency by 10-fold for children up to 2 years old and by 3-fold for children 2 to 15 years old. These adjustments have the aggregate effects of increasing by about 60 percent the estimated risk (a 1.6-fold increase) for a lifetime constant inhalation exposure. EPA recommends that these default adjustments be made only for carcinogens known to be mutagenic for which data to evaluate adult and juvenile differences in toxicity are not available.

For NATA 2005, the UREs for acrylamide, benzidine, ethyl carbamate, and PAHs were adjusted upward, by multiplying by a factor of 1.6, to account for the increased risk during childhood exposures. These air toxics are the only ones that met the criteria described in the previous paragraph at the time of this assessment. The overall lifetime adjustment was applied because a single, lifetime average exposure concentration was estimated for NATA rather than age group-specific exposures. The URE for vinyl chloride includes exposure from birth, although the IRIS assessment contains UREs for both exposure from birth and exposure during adulthood. This value already accounts for childhood exposure; thus, no additional factor was applied.

5.4.6 Diesel Particulate Matter

EPA has concluded that insufficient toxicological data are available to develop a URE for diesel PM. Evidence exists, however, that the general population is exposed to levels close to or overlapping with apparent levels that have been linked to increased cancer risk in epidemiological studies. Furthermore, EPA has concluded that national average lifetime cancer risk from exposure to diesel

exhaust (which contains both gases and particulate matter) could exceed 1 in 100,000 and could be as high as 1 in 1,000, although the lower end of the risk range includes zero. More information on health effects associated with diesel exhaust can be found in the Health Assessment Document for Diesel Engine Exhaust (EPA 2002c). EPA uses an IRIS RfC for adverse non-cancer effects of diesel PM.

5.4.7 Other Notes

Benzene. The URE for benzene represents the upper bound of a range of IRIS **maximum likelihood estimate (MLE)** UREs. MLEs are central tendency estimates of risk. NATA identifies benzene as a relatively large "driver" for air-toxic cancer risk, and a large proportion of the emissions come from mobile sources.

2-Nitropropane. The URE for 2-nitropropane derived by the Health Council of the Netherlands in 1999 was used in preference to the value in Health Effects Assessment Summary Tables, which does not reflect the most recent studies and analysis methods.

Formaldehyde. The URE for formaldehyde in IRIS was used for the 2005 NATA in preference to the URE in previous assessments derived by CIIT (now called the Hamner Institutes for Health Sciences). In addition, the 2005 NATA used outputs from the CMAQ model to estimate the additional ambient concentration of formaldehyde due to its secondary formation in the atmosphere.

5.5 Summary

- To evaluate the potential of a given air toxic to cause cancer and other adverse health effects, EPA identifies potential adverse effects that a particular substance causes and evaluates the specific exposure concentrations at which these effects might occur.
- The unit risk estimate (URE) represents the upper-bound excess cancer risk estimated to result from continuous exposure to a concentration of 1 microgram of a substance per cubic meter of air over a 70-year lifetime.
- The reference concentration (RfC) is an estimate of a continuous inhalation exposure concentration over a 70-year lifetime that is thought to be without an appreciable risk of deleterious effects. The population considered in the derivation of RfCs includes sensitive subgroups (i.e., children, asthmatics, and the elderly).
- Dose-response assessment information for chronic exposure is obtained from multiple sources and prioritized according to conceptual consistency with OAQPS risk assessment guidelines and level of peer review.
- After prioritizing dose-response information, EPA adjusts some chronic toxicity values to increase accuracy and to avoid underestimating risk.

6 CHARACTERIZING RISKS AND HAZARDS IN NATA

Risk characterization, the final step in EPA's risk assessment process for air toxics, combines the information from modeled exposure estimates and the dose-response assessment to provide a quantitative estimate of potential cancer risk and non-cancer hazard associated with real-world exposure to air toxics. The term "risk" implies a statistical probability of developing cancer over a lifetime. Non-cancer "risks," however, are not expressed as a statistical probability of developing a disease. Rather, non-cancer "hazards" are expressed as a ratio of the exposure concentration to an RfC associated with observable adverse health effects.

This section provides information on the risk characterization conducted for NATA. After a brief overview of the risk-related questions that NATA is intended to address, the methods used to conduct characterization of cancer risk and non-cancer hazards for NATA are described. A discussion of the quantitative results included in NATA follows this description.

6.1 What Risk Characterization Questions does NATA Address?

The NATA risk characterization considers both cancer risk and the potential for non-cancer effects from inhalation of air toxics nationwide, in both urban and rural areas. The purpose of NATA is to understand cancer risks and non-cancer hazards to help EPA and others identify air toxics and source categories of greatest potential concern, and to set priorities for collecting additional information to improve future assessments. The assessment represents a "snapshot" in time for characterizing risks from exposure to air pollutants; it is not designed to characterize risks sufficiently for regulatory action. The risk characterization for the 2005 NATA, which was limited to inhalation risk from outdoor sources, was designed to answer the following questions:

- Which air toxics pose the greatest potential risk of cancer or adverse non-cancer effects across the entire United States?
- Which air toxics pose the greatest potential risk of cancer or adverse non-cancer effects in some areas of the United States?
- Which air toxics pose lesser, but still significant, potential risk of cancer or adverse non-cancer effects across the entire United States?
- When risks from all air toxics are combined, how many people have the potential for an upper-bound lifetime cancer risk greater than 1 in a million?
- When potential adverse effects from all air toxics are combined, how many people are likely exposed to concentrations that exceed reference levels intended to protect against adverse effects (e.g., a hazard index greater than 1.0)?

6.2 How Is Cancer Risk Estimated?

To estimate cancer risks in NATA, the results of cancer dose-response assessments for a given chemical are converted to a URE that is then multiplied by the estimated inhalation exposure

concentration to obtain an individual lifetime cancer risk estimate. The approach for cancer risk characterization used in NATA is consistent with EPA's 2005 final Guidelines for Carcinogen Risk Assessment (EPA 2005a). When used in conjunction with the cancer UREs described in Section 5, the approach is also consistent with EPA's associated documentation on Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005c).

6.2.1 Individual Pollutant Risk

Individual lifetime cancer risk associated with exposure to a single air pollutant is estimated by multiplying an average estimated long-term exposure concentration (EC) by the corresponding URE for that pollutant. Thus, the following equation estimates the probability of an individual's developing cancer over a lifetime due to a given inhalation exposure.

$$\text{Risk} = \text{EC} \times \text{URE}$$

Where:

Risk	=	estimated incremental lifetime cancer risk for an individual as a result of exposure to a specific air toxic, unitless (expressed as a probability)
EC	=	estimate of long-term inhalation exposure concentration for a specific air toxic, in units of $\mu g/m^3$
URE	=	the corresponding inhalation unit risk estimate for that air toxic, in units of $(\mu g/m^3)^{-1}$

It is important to note that UREs are typically upper-bound estimates, so actual risks might be lower than predicted. Also, the true value of the risk is unknown.

6.2.2 Multiple Pollutant Risk

The individual lifetime cancer risk resulting from exposure to multiple air toxics is estimated by summing the chronic cancer risk for each air toxic that can be quantified. This estimate of risk focuses on the additional lifetime risk of cancer predicted from the exposure being analyzed, over and above that due to any other factors. The following equation estimates the predicted cumulative individual cancer risk from inhalation of multiple substances:

$$\text{Risk}_{tot} = \text{Risk}_1 + \text{Risk}_2 + \ldots + \text{Risk}_i$$

Where:

Risk_{tot}	=	total cumulative individual lifetime cancer risk, across *i* substances
Risk_i	=	individual risk estimate for the i^{th} substance

For NATA, the estimated exposure concentrations are not considered to be upper bound. Rather, they represent central tendency estimates of exposure concentrations for each demographic group at the geographic unit of analysis (e.g., the census-tract level). Because cancer slope factors are not "most probable estimates," however, but instead are 95-percent upper confidence intervals, summing traditional risk levels can cause the resulting sum to overestimate a 95-percent upper confidence level risk for a mixture.

The NATA approach assumes an additive effect from simultaneous exposures to several carcinogens. Summing cancer risk estimates is not appropriate when effects from multiple chemicals are synergistic (greater than additive) or antagonistic (less than additive). Notwithstanding the statistical

limitations of summing traditional risk estimates and the implicit assumption that the toxicities will be additive (i.e., no interactions such as synergism or antagonism occur), the numerical ease for combining risk in this way makes this method the most popular for approximating cumulative risks in the short term, at least for a screening level of assessment. Information on non-additive interactions is not readily available in a form that can be used for NATA. In the absence of specific information, therefore, cancer risk from various chemicals is conservatively assumed to be additive. Thus, the cancer risks from all air toxic compounds listed as carcinogenic or likely carcinogenic to humans are summed to determine cumulative cancer risks for NATA. More information on EPA's methods for conducting risk assessment of mixtures can be found in the 2003 Framework for Cumulative Risk Assessment (EPA 2003).

Neurotoxicity (EPA 1999b)

Reproductive Toxicity (EPA 1996b)

6.3 How Is Non-cancer Hazard Estimated?

To evaluate the potential for non-cancer adverse health effects, chronic dose-response data are used to estimate a threshold that is the exposure concentration at which adverse health effects are assumed to be unlikely (i.e., the RfC). (See Section 5 for more information on non-cancer RfCs.) Due to the wide variety of endpoints, hazard identification procedures for non-cancer effects have not been described as completely in EPA guidance as procedures for the identification of carcinogens. EPA has published guidelines, however, for assessing several specific types of chronic non-cancer effects: mutagenicity, developmental toxicity, neurotoxicity, and reproductive toxicity. EPA has also published a framework for using studies of these and other effects in inhalation risk assessment (EPA 1994).

EPA's Chronic Non-cancer Guidelines

- Mutagenicity (EPA 1986a)
- Developmental Toxicity (EPA 1991)

6.3.1 Individual Pollutant Hazard

Chronic non-cancer hazards are estimated for NATA by dividing a chemical's estimated long-term EC by the RfC for that chemical to yield an HQ. The following equation estimates the non-cancer hazard due to a given inhalation exposure:

$$HQ = EC / RfC$$

Where:

HQ = the hazard quotient for an individual air toxic, unitless
EC = estimate of long-term inhalation exposure concentration for a specific air toxic, in units of mg/m^3
RfC = the corresponding reference concentration for that air toxic, in units of mg/m^3

An HQ value less than or equal to 1.0 indicates that the exposure is not likely to result in adverse non-cancer effects. An HQ value greater than 1.0, however, does not necessarily suggest a likelihood of adverse health effects and cannot be interpreted to mean that adverse health effects are statistically likely to occur. It is simply a statement of whether, and by how much, an exposure concentration exceeds the RfC, indicating that a potential exists for adverse health effects.

6.3.2 Multiple Pollutant Hazard

Chronic non-cancer hazards for multiple air toxics are estimated by summing chronic non-cancer hazards for individual air toxics that cause similar adverse health effects to yield a hazard index (HI). Aggregation in this way produces a target-organ-specific HI, defined as a sum of HQs for individual air toxics that affect the same organ or organ system. More information on chemical mixtures risk assessment methods can be found in the EPA supplementary guidance for risk assessment of mixtures (EPA 2000b).

The following equation estimates the cumulative non-cancer hazard from inhalation of multiple substances:

$$HI = HQ_1 + HQ_2 + \ldots + HQ_i$$

Where:

HI = the hazard index for chronic exposure to air toxics 1 through *i*, unitless
HQ_i = the hazard quotient for the i^{th} air toxic, where all *i* air toxics are assumed to affect the same target organ or organ system, unitless

As with the HQ, an HI value less than or equal to 1.0 indicates that the exposure is not likely to result in adverse non-cancer effects. An HI value greater than 1.0, however, does not necessarily suggest a likelihood of adverse health effects and cannot be interpreted as a statistical probability of adverse effects occurring.

This equation assumes an additive effect from simultaneous exposures to several chemicals. Summing of HQs is inappropriate when effects from multiple chemicals are synergistic (greater than additive) or antagonistic (less than additive). As is the case with cancer risk, quantitative information on non-additive interactions resulting in non-cancer hazards is not readily available; consequently, the non-cancer HQs are assumed to be additive for chemicals with the same target organ or organ system. For the 1996 and 1999 NATAs, non-cancer hazards were combined for six target organs or systems: respiratory, cardiovascular, blood, liver/kidney, nervous, and immune. Results from these assessments indicated that the primary non-cancer hazards for inhalation exposures to the modeled chemicals were respiratory and neurological (i.e., central nervous system) hazards. As a result, combined non-cancer hazards associated with only these two endpoints were calculated for the 2002 assessment. The 2005 assessment presents non-cancer results for all endpoints in the form of HQs; HIs are reported only for neurological and respiratory endpoints.

6.4 How Are Risk Estimates and Hazard Quotients Calculated for NATA at Tract, County, and State Levels?

The cancer risk and HQs for each toxic air pollutant modeled are estimated from exposure concentrations (not ambient concentrations) by combining them with UREs and inhalation RfCs (or their equivalents). As described previously, the modeling conducted for NATA results in ambient concentrations for each air toxic emitted by modeled sources, with the level of spatial resolution varying by source type and the corresponding modeling approach (see Section 3, Exhibit 3-1). For the 2005 NATA, point sources were modeled at the census-block level in HEM-3. Non-road mobile sources also were modeled using HEM-3, but input emissions for these categories were allocated only to the census-tract level. Non-point sources were modeled at the census tract level using ASPEN. Secondary formation and pollutant decay were estimated at the grid level using CMAQ.

Ambient concentrations from all source types modeled in NATA must be harmonized to a common level of resolution so that ambient and exposure concentrations and risks can be combined across (and compared between) source types. For the 2005 NATA, estimated concentrations were adjusted as necessary to obtain a set of results at the census-tract level. These estimates were then used to estimate inhalation exposure concentrations and cancer risks and non-cancer hazards. The ambient and exposure concentrations and risk results were also aggregated to broader spatial scales, including county, state, regional, and national levels. Although ASPEN results—the ambient concentration estimates generated for non-point sources—were output at the census-tract level, the other model results and estimated ambient concentrations required some adjustment, as described below.

6.4.1 Model Results for Point Sources: Aggregation to Tract-level Results

For the 2005 NATA, HEM-3 was used to estimate ambient concentrations for point-source emissions, and model results were generated at the block level. For risk and exposure calculations, EPA aggregated concentration results to the tract level by taking a population-weighted average of all of the block-level concentrations within a given tract, as follows:

$$Conc_{tract\ i} = \frac{\sum Pop_{block\ j} * Conc_{block\ j}}{\sum Pop_{block\ j}}$$

Where:

$Conc_{tract\ i}$ = ambient concentration for census tract *i*
$Conc_{block\ j}$ = ambient concentration for census block *j* (contained within tract *i*), estimated by HEM-3
$Pop_{block\ j}$ = population of blocks contained in tract *i*

Unweighted average concentrations also were calculated at the tract level as follows:

$$Conc_{tract\ i} = \frac{\sum Conc_{block\ j}}{n}$$

Where:

$Conc_{tract\ i}$ = ambient concentration for census tract *i*
$Conc_{block\ j}$ = ambient concentration for census block *j* (contained within tract *i*), estimated by HEM-3
n = number of census blocks contained in tract *i*

6.4.2 Background Concentrations and Secondary Pollutants: Interpolation to Tract-level Results

For NATA 2005, both background concentrations and estimated concentrations of secondary pollutants generated by the CMAQ model were estimated for levels other than census tract and thus require interpolation "down" to the tract level. Background concentrations were estimated at the county level. To obtain tract-level concentrations, the county-level estimate was assigned to all census tracts within that county. For secondary pollutants, concentrations were estimated using CMAQ. The results for each grid were then applied evenly to all tracts located within the grid.

6.4.3 Aggregation of Tract-level Results to Larger Spatial Units

For the 2005 NATA, tract-level ambient concentrations were aggregated up to the county, state, regional, and national level using a method that weights concentration according to the population within a region. For a county, for example, a population-weighted ambient concentration was estimated by multiplying the tract-level concentrations by the population of each tract, summing these population-weighted concentrations, and dividing by the total county population encompassing all tracts to obtain a final population-weighted, county-level concentration. The process for aggregating from the tract to the county level can be expressed using the following equation:

$$Conc_{county\ k} = \frac{\sum (Conc_{tract\ i} \times Pop_{tract\ i})}{Pop_{county\ k}}$$

Where:

$Conc_{county\ k}$ = population-weighted concentration for county *k*
$Conc_{tract\ i}$ = ambient concentration in tract *i* (contained within county *k*)
$Pop_{tract\ i}$ = population in tract *i* (contained within county *k*)
$Pop_{county\ k}$ = population in county *k*

This same method was applied when aggregating up to the state, regional, or national level, using the appropriate concentration and population values. The 2005 NATA includes ambient and exposure concentrations and cancer risk and non-cancer HQs at the tract, county, state, regional, and national levels.

The ambient concentrations derived at the block level also were used to estimate exposure concentrations using the exposure factors (i.e., ratios of exposure concentration to estimated ambient concentration). Because the exposure factors used in the 2005 NATA were applied at the tract level, each census block is assigned the tract-level factor and the census-block-level exposure concentrations are estimated. As is done with the ambient-level concentrations, the block-level exposure concentrations are used to estimate cancer and non-cancer effects and to aggregate these concentrations up to larger spatial scales. To aggregate tract-level concentrations up to the county-, state-, regional-, or national-level concentrations, the tract-level concentrations are population-weighted.

6.5 What Risk Characterization Results Does NATA Report?

Each NATA provides a snapshot of the outdoor air quality and the risks to human health that would result if air toxic emission levels remain unchanged. The assessment is based on an inventory of air toxics emissions from that year. Individuals are assumed to spend their entire lifetimes exposed to these air toxics. Therefore, the reductions in emissions that have occurred since the year of the assessment or those that might happen in the future due to regulations for mobile and industrial sources are not accounted for. Each NATA represents an update and enhancement to the previous NATA. Because with each successive assessment, improvements in methodology are made, comparing assessment results from year to year is not meaningful. Any change in emissions, ambient concentrations, or risks might be due to either improvement of methodology or to real changes in emissions or source characterization.

The evaluation of national-scale results and comparison of risks among chemicals make it possible to estimate which air toxics pose the greatest potential risk to human health in the United States. A summary of these findings is reported in each assessment. Cancer risks are presented as lifetime risks,

meaning the risk of developing cancer as a result of inhalation exposure to each air toxic compound over a normal lifetime of 70 years. Non-cancer hazards are presented in terms of the ratio between the exposure and an RfC for inhalation exposures (i.e., the HQ). As described previously in this section, HQs are combined across chemicals where a common target organ or system is expected to estimate HI.

Using these quantitative results, NATA classifies certain pollutants as **drivers** or **contributors** at the national or regional scale based on certain criteria. Exhibit 6-2 presents the criteria for classifying the air toxics included in NATA at the regional and national level. In general, drivers and contributors are defined as air toxics showing a particular level of risk or hazard for some number of people exposed. They are also presented in Exhibit 6-2 in order of their cancer weight-of-evidence classification. For

Exhibit 6-2. NATA Health Effects Drivers and Contributors for Risk Characterization

Risk Characterization Category	Criterion (Criteria in both columns must be met)	
	Individual Health Risk or Hazard Index Exceeds	**Minimum Number of People Exposed (in millions)**
Cancer Risk *(Value in first column represents individual lifetime cancer risk, in a million)*[a]		
National cancer driver	10	25
Regional cancer driver (either set of criteria can be used)	10	1
	100	0.01
National cancer contributor	1	25
Regional cancer contributor	1	1
Hazard Index *(Value in first column represents chronic hazard index for any organ/organ system)*[b]		
National non-cancer driver	1.0	25
Regional non-cancer driver	1.0	0.01

[a] Cancer risks are upper-bound lifetime cancer risks, that is, a plausible upper limit to the true probability that an individual will contract cancer over a 70-year lifetime as a result of a given hazard (such as exposure to a toxic chemical). This risk can be measured or estimated in numerical terms (e.g., one chance in a hundred).

[b] Hazard Index is the sum of the hazard quotients for substances that affect the same target organ or organ system. Because different pollutants can cause similar adverse health effects, combining hazard quotients associated with different substances is often appropriate to understand the potential health risks associated with aggregate exposures to multiple pollutants.

example, for a pollutant to be categorized in NATA as a cancer contributor at the national level, the individual lifetime cancer risk for that pollutant must have shown by the assessment to be 1 in a million *and* the number of people exposed to that pollutant must have been shown to be at least 25 million. For a pollutant to be categorized in NATA as a regional driver of non-cancer health effects, the chronic hazard index for that pollutant must have been shown to exceed 1.0 *and* the number of people exposed to that pollutant must have been shown to be at least 0.01 million.

The NATA results for 2005 indicated that most individuals' estimated risk was between 1 in a million and 100 in a million, although a small number of localized areas showed risks of higher than 100 in a million. Although individuals and communities might be concerned about these results, it is important to recall that NATA was not designed to assess specific risk values at local levels. The results are best used as a tool to prioritize pollutants, emissions sources, and locations of interest for further investigation. Furthermore, readers are reminded that the risks estimated by the assessment do not consider indoor sources of air toxics or ingestion exposure to any pollutants. Also, although NATA estimates cancer and non-cancer risks for numerous pollutants, additional chemicals might exist that are not identified or for which toxicity information is unavailable. Therefore, these risk estimates represent only a subset of the total potential cancer and non-cancer risk associated with air toxics.

Analytical results, including modeled ambient concentrations, exposure, and risks, for each NATA are also provided at the census-tract, county, and state level for those who wish to do their own technical analyses and comparisons using the most refined output available. These results are available at 1996 Assessment Results (EPA 1996a), 1999 Assessment Results (EPA 1999a), and 2002 Assessment Results (EPA 2002a). The results from the most recent assessment can be found online at 2005 Assessment Results Website In performing such analyses, users must be extremely mindful of the purposes for which NATA was developed. NATA was developed as a tool to inform both national and more localized efforts to collect air toxics information and characterize emissions (e.g., prioritize pollutants or geographic areas of interest for more refined data collection such as monitoring). The results are most meaningful when viewed at the state or national level. Nevertheless, reported spatial patterns within a county likely represent actual variations in *overall average* population risks. Less likely, however, is that the assessment pinpoints the exact locations where higher risks exist or that the assessment captures the highest risks in a county. Using these results alone to draw conclusions about local concentrations and risk is inappropriate.

This assessment has not focused on the identification of geographic areas or populations that have significantly higher risks than others. Rather, it has focused on characterizing geographic patterns and ranges of risk across the country. In general, however, spending time in larger urban areas tends to pose greater risks than spending time in smaller urban and rural areas because the emissions of air toxics tend to be higher and more concentrated in areas with more people. This trend is not, however, universal and can vary from pollutant to pollutant according to its sources and can also be affected by exposures and risk from non-inhalation and indoor sources of exposure.

Based on the NATA results, millions of people live in areas where air toxics pose potential health concerns. Although air quality continues to improve, more needs to be done to meet the Clean Air Act's requirements to reduce the potential exposure and risk from these chemicals. EPA will continue to develop air toxic regulations and cost-effective pollution prevention and other control options to address indoor and urban pollutant sources that significantly contribute to risk.

6.6 Summary

- The purpose of NATA is to understand cancer risk and non-cancer health effects to help EPA and others identify pollutants and source categories of greatest potential concern, and to set priorities for collecting additional information to improve future assessments.
- Cancer risk is expressed as a statistical probability that an individual will develop cancer. Cancer risks are assumed to be additive across chemicals for NATA.
- Non-cancer hazard is expressed as an HQ, which is the ratio of the exposure concentration to an RfC associated with observable adverse effects.
- NATA estimates most individuals' risk to be between 1 in a million and 100 in a million, although a small number of localized areas show risk higher than 100 in a million.
- Air toxics data for each NATA are presented at the national, regional, state, county, and census-tract levels. The results are most meaningful when viewed at the state or national level. Using these results in the absence of additional information to draw conclusions about local concentrations and risk is inappropriate.

7 VARIABILITY AND UNCERTAINTY ASSOCIATED WITH NATA

7.1 Introduction

This section presents discussions on variability and uncertainty associated with the NATA process. Clearly understanding these two fundamental concepts − which are inherent in all broad-scale assessments that rely on models and data − will enable the users of the NATA results to understand which questions can be answered appropriately and which cannot.

Key Definitions for this Section

Variability represents the ***diversity or heterogeneity in a population or parameter*** (e.g., variation in heights of people). Variability cannot be reduced by taking more (or better) measurements; however, it can be accounted for by a more detailed modeling approach (e.g., modeling peoples' heights in terms of age will reduce the unexplained variability due to variation in heights).

Uncertainty refers to the ***lack of knowledge*** regarding the actual values of model input variables (parameter uncertainty) and of physical systems (model uncertainty). Uncertainty can be reduced through improved measurements and improved model formulation.

As stated in Section 1, NATA results should not be used for limited-scale or site-focused applications. NATA results are intended to characterize broad-scale risk to help identify those air toxics and source sectors associated with the highest exposures and posing the greatest potential health risks. The results are intended to identify geographic patterns and ranges of risks across the country. To avoid over-interpretation and misapplication of the results, users must first understand the concepts of variability and uncertainty and then must recognize the role that these elements play in the NATA results.

Air toxic emissions, air concentrations, and exposures are not the same throughout the United States, and the risks associated with air toxics are not the same for all people. Some geographic areas have higher concentrations than others. At certain times, the concentration is higher at a given location than at other times. The risks for some individuals are below the national average, while for others the risks are above the national average. For these reasons, understanding how the ambient (outdoor) air concentration, exposure, and risk from air toxics varies throughout the United States is essential for understanding NATA. This information comes from a process called variability analysis.

EPA seeks to protect health with reasonable confidence based on the best data available. Estimates of air concentrations, exposures, and risks, however, necessarily always involve assumptions. Assumptions are necessary to simplify the problem at hand, while also making assessment possible given available information and resources. Assumptions introduce uncertainties into the results because confidence that the assumptions are entirely correct is not possible. Understanding the magnitude of these uncertainties, the level of confidence that can be placed in statements related to the assessment, and how this confidence affects the ability to make reasoned decisions is essential. This information comes from a process called uncertainty analysis.

7.2 How Does NATA Address Variability?

The NATA process focuses on the variation in ambient air concentrations, exposures, and risks in geographic areas of the United States, Puerto Rico, and the U.S. Virgin Islands. Included, for example, are variations in the locations of various sources and the amounts of pollutants that these sources emit,

variations in meteorological conditions in various parts of the country, and variations in the daily activities of people. This section presents information on the key components that drive variability in risks associated with air toxics and the variability components that NATA addresses. A brief explanation is also provided on how NATA results should be interpreted in light of variability.

7.2.1 What Are the Components of Variability?

The NATA results show how air concentrations, exposures, and risks vary across broad geographic regions of the country. They do not fully characterize how concentration, exposure, and risk vary among individuals, except to the extent these individuals live in different geographic regions and are affected by the values typical of a census tract in that region. NATA results also do not fully characterize how ambient air concentrations might vary temporally and they do not characterize how concentrations vary spatially within a census tract. Following is an explanation of some of the components of variability that determine differences in ambient air concentrations and individual risks. Key components driving variability in risk associated with air toxics include temporal variation, geographic variation, and variations in where people live, their levels of activities, and their degrees of **susceptibility** or sensitivity, as described below.

Temporal. Sources do not emit air toxics at constant rates. Similarly, the meteorological conditions that affect dispersion in the atmosphere vary over time. Thus, the ambient air concentration at a given location can vary over time.

Geographic. The influence of pollutant emissions on ambient concentrations at a particular location depends on the degree of atmospheric dispersion of the emissions as they travel from the source to the receptor. Dispersion depends on both meteorological conditions, which vary from place to place, and the travel distance from source to receptor. As a result, the ambient air concentration can vary greatly among different locations. The NATA analysis accounts for some geographic variation by using available meteorology data representative of the location, and by modeling ambient concentrations for census blocks and tracts, but the spatial resolution of model predictions is limited.

Individual location. Two individuals might live at different locations within the same census tract. The ambient concentration estimated for the tract is only an approximation of conditions at all locations in the tract. Different locations within that tract might have different average ambient concentrations. Therefore, exposures and risks also can vary.

Individual activity patterns. Two individuals might live at the same location but engage in different activities (called an "activity pattern") during each day. Concentrations of substances indoors often differ from concentrations outdoors. If one person spends more time indoors than the other person, the average air concentration to which the two are exposed will differ, even though the ambient air concentration is the same. Similarly, one person might spend more time in a car than the other person, exposed to an air concentration that is typical near roads. The net effect would be that the concentration of each air toxic in the air actually inhaled by these two individuals will differ. In other words, the exposure differs for these two individuals.

In addition, buildings and vehicles vary with respect to the amount of outdoor pollution that penetrates into the indoor and in-vehicle microenvironments due to differences in ventilation and building and vehicle integrity. Thus, two people who live in the same location and spend the same amount of time indoors can still be exposed to different pollutant concentrations.

Susceptibility. Two individuals might live at the same location and engage in the same activities, but one person might be more susceptible than another. Susceptibility refers to the extent to which an individual:

- Takes an air toxic into the body,
- transports it into an organ or tissue that might be adversely affected by it, or
- develops an adverse effect.

An individual who is more susceptible might develop a higher concentration of an air toxic in his or her organs or tissues, or have a higher chance of developing an adverse health effect, than another individual even though the exposures for both individuals are the same. For example, people breathe at different rates; two individuals placed into exactly the same air might bring different amounts of an air toxic into their bodies. The amount of an air toxic reaching an organ or tissue also might vary from individual to individual, even if both bring the same amount into their lungs. The amount of time the air toxic remains in the body also might differ. Finally, the innate sensitivity to the effect might vary even at equal doses in the tissues. The net effect of these factors is that either the dose of the air toxic delivered to the organs or tissues of the body or the level of response, or both, can differ substantially between these two individuals, even though the individuals are exposed to exactly the same pollutant concentrations.

The extent to which each factor described above influences variation in individual risk can depend on the age, gender, or ethnic group to which an individual belongs, as well as on that individual's lifestyle. These groups comprise different receptor populations, or cohorts, and the exposures and risks can differ among them.

7.2.2 How Does NATA Quantify Variability?

EPA conducts NATA to understand how ambient air concentration, exposure, and risk vary geographically and ***not*** among specific individuals. EPA calculates the ambient air concentrations for each specific, discrete location (i.e., census-block centroid or census-tract centroid; see discussion below) based on the emission sources and meteorological conditions affecting those specific tracts. Some temporal variation is accounted for in NATA calculations. For example, meteorology data used for modeling point and mobile sources using HEM-3 is temporally dynamic. This model therefore captures important variation in ambient conditions on an hourly basis before the resulting ambient air concentrations are time-averaged. Furthermore, the ambient concentration inputs to HAPEM are stratified into eight 3-hour time blocks; HAPEM then calculates exposure concentrations for each 3-hour time block before calculating an overall, long-term average exposure concentration. Although his approach to dispersion and exposure modeling takes into account some important temporal variation, these time-stratified model outputs are averaged prior to the risk characterization step and are not included in the NATA results reported by EPA.

The NATA concentrations and risks do, however, reflect a degree of geographic variation. The smallest geographic area for which NATA results are reported is the census tract. Although results are reported at the census-tract level, average risk estimates are far more uncertain at this level of spatial resolution than at the county or state level. Census tracts are small, relatively permanent statistical subdivisions of a county, typically having between 2,500 and 8,000 residents. Census tracts do not cross county boundaries. Their areas vary widely depending on the density of settlement. Census tracts tend to be small in densely populated areas but can be very large in sparsely populated areas. Within census tracts are census blocks, which are areas bounded by visible or virtual features, such as streets, streams, city, or town boundaries. Census blocks are typically small in area; for example, in an urban area, a census block might correspond to a block bounded by city streets. In remote areas, however, census blocks might be large and irregular, comprising many square miles.

Air concentrations are estimated in NATA at either the census-block or census-tract level, depending on the source type modeled and the model used to estimate ambient concentration (see Section 3 of this document for detailed information on modeling resolution). For a given source type and modeling approach, variation in ambient air concentrations within a census tract or block is not explicitly modeled. Instead, a representative ambient air concentration is estimated for a single location near the center of the tract or block (i.e., the centroid, which is typically, but not always, the geographic center of the tract or block chosen by the U.S. Census Bureau as a reference point). Ambient concentrations estimated at the block level are then averaged for the encompassing census tract, with concentration and risk results reported at the tract level. Assessment results do not reflect variations in the susceptibility of people within a census tract because the focus is to compare typical exposures and risks in different tracts. As a result, individual exposures or risks might differ by as much as a factor of 10 in either direction. Exposure or risk determined in NATA should be considered as representative of the geographic area where an individual lives, but not necessarily be considered as that individual's personal risk.

Thus, the results of the NATA analysis do not allow for a comparison of ambient air concentrations, exposures, or risks between two individuals. They do, however, enable the user to understand the variation in typical values for these quantities among counties or states and to a lesser degree among census tracts. For an individual, however, the values might differ from the typical value for the county or state if that individual:

- lives in a part of the geographic area that has a higher or lower than typical value;
- has an activity pattern that causes a higher or lower exposure than is typical; or
- is more (or less) susceptible than a "typical" person used in this assessment.

For the purposes of estimating and reporting risk, individuals are assumed to be located at the centroid of the census tract in which they live. This assumption allows the variation in geographic location of individuals *among* census tracts to be examined, but it does not allow variation in geographic location of individuals *within* a census tract to be evaluated. Activity patterns are included for each of ten cohorts defined by age and gender (racial/ethnic groups also were initially considered, but the activity patterns were not significantly different and so these groups were averaged). Even within a receptor population, some variability in activity patterns among individuals is considered. Differences in susceptibility, however, are not included in NATA. EPA took this approach for the 2005 NATA for two primary reasons:

- An overall purpose of NATA is to examine broad differences driven by geography. NATA considers only geographic differences in air toxic concentration, exposure, and risk. The goal is to understand how these three factors differ among people living in different geographic areas. These differences are assessed, as mentioned above, by tracking differences in air concentration in different census tracts, producing differences in the typical air toxic concentrations, exposures, and risks in different tracts. Differences in susceptibility, however, can produce differences in risk between two individuals in the same census tract, and reporting on these differences is not a purpose of NATA.
- **The variability in susceptibility is difficult to model at the national scale.** Very limited information is available on differences in susceptibility among individuals. Even if EPA were to choose to calculate and report differences among individuals in a census tract, scientifically reliable information necessary to produce these calculations is not available for many of the air toxics. Given current information, estimating variability in the rates at which people breathe air might be possible, but this variability is only a small component of the overall variation in susceptibility. EPA therefore has chosen not to incorporate this source of variation between individuals.

Taking into consideration these limitations, EPA elected to incorporate differences in emissions and meteorology (resulting in differences in ambient air concentration) and differences in location of typical individuals (resulting in differences in exposure) among census tracts. Variation in activity patterns for different age groups is reflected in the assessments to the degree than the age of residents varies by location. Variability in susceptibility is not included for the reasons given above. Temporal variation in inputs is addressed in the development of time-weighted averages of emissions characteristics, meteorological conditions, and exposure concentrations. Temporal variation in the estimated ambient air concentrations, however, is not reflected in the results (only time-weighted annual averages are presented).

7.2.3 How Does Variability Affect Interpretation of NATA Results?

The NATA analysis illustrates how ambient air concentration, exposure, and risk vary throughout the United States. The assessment does not focus on the variation in exposure and risk among individuals. It focuses on variation among well-defined geographic areas, such as counties or states, based on calculations of ambient air concentration, exposure, and risk in various census tracts. To a lesser degree, variation among demographic groups is also addressed by NATA, in that differences in activity patterns are taken into account in modeling exposure concentrations using HAPEM. Risk results, however, are not presented separately for individual demographic groups.

The information contained in the maps, charts, and tables produced in NATA display predictions of cancer risk and non-cancer hazard. Cancer risk results include statements such as:

> "X percent of the census tracts in a given area are characterized by a typical lifetime excess cancer risk of less than R."

For this statement, if X is 25 percent and R is 1 in a million, the result would be:

> "25 percent of the census tracts are characterized by a typical risk of less than 1 in a million."

This statement does not necessarily mean that 25 percent of individuals in the specified area have a cancer risk of less than 1 in a million. Some people in these census tracts would be expected to have a risk above 1 in a million. Although an individual might live in a census tract where the typical or average risk is less than 1 in a million, that individual might live nearer the source than the average person in the census tract, or might have an activity pattern that leads to greater exposure, or might be more susceptible. All these factors could cause that individual to experience a risk above the typical value for that census tract. Conversely, the individual also could have a lower risk by living farther from the source, or having an activity pattern that produces lower exposures, or being less susceptible.

The important point to remember when interpreting the maps and charts of the NATA analysis is that they show variation among values of ambient air concentration, exposure, or risk in census tracts or larger areas such as counties. This presentation allows for the identification of geographic regions (counties or states) where these values are higher or lower than the aggregated national average for all census tracts. It does not allow for the identification of individuals who have higher or lower values of ambient air concentration, exposure, or risk, nor does it allow for identification of specific census tracts that are higher or lower than average. Nevertheless, individuals with a high risk are more likely to be located in geographic regions characterized by a high risk than in those geographic regions characterized by a low risk. The same can be said for exposure (i.e., individuals with a high exposure are more likely to be found in geographic regions characterized by high exposure than in those regions characterized by low exposure).

7.3 How Does NATA Address Uncertainty?

No scientific statement (in risk assessment or other areas of science) can be made with complete confidence. Risk estimates are always uncertain to some degree due to issues such as those discussed below. To maintain transparency and openness in the presentation of risk results, the party conducting a risk assessment must explain these uncertainties and how these uncertainties increase or decrease confidence. The NATA analysis produces statements about variability in ambient air concentrations, exposures, and risks across geographic regions for typical individuals, as described in Section 7.2. In this section, the discussion of uncertainty is intended to address the confidence with which these statements regarding variability can be made. It is important to note that uncertainty does not prevent EPA from making a statement of risk, nor does it prevent EPA from taking reasonable actions. Uncertainty does, however, require that the nature of the uncertainty, and the implications for decisions, be understood so the degree of support for the statement can be correctly and properly interpreted.

7.3.1 What Are the Components of Uncertainty?

Uncertainty arises from a variety of sources. To understand the sources of uncertainty affecting a risk assessment, considering the process by which a study such as NATA is performed is instructive, as described in the following sections.

Problem Formulation. The problem to be addressed must first be defined. For example, a question that might help define the problem could include, "Is the occurrence of adverse human health effects correlated with emissions from industrial facilities?" What the study is intended to address and how the results will be used should be clear at the outset. This initial step in the analysis introduces problem formulation uncertainty. The purpose of NATA is described in Section 1 of this document, where the question addressed in the assessment is defined as precisely as possible (e.g., that the study is limited to estimates of health effects in human populations), along with information about the limitations of the assessment. The issue of problem formulation uncertainty is not considered further in this document.

Defining the Analysis Components. This step describes what can influence the answer to the problem. In NATA, the multiple influences include emissions from a variety of sources (e.g., mobile, area, stationary); atmospheric dispersion; activity patterns for different cohorts; UREs and RfCs; and other considerations. Where the science is poorly developed, the factors that must be included might not be clear. Resources also might be limited, making the inclusion of all factors in the study infeasible. This step in the analysis, which results in the conceptual model for the assessment, introduces conceptual uncertainty. This issue is also addressed in the discussion of the limitations of NATA in Section 1, where the aspects of the problem that are (and are not) included in the study are addressed (e.g., that the study addresses inhalation of air toxics only). The issue of conceptual uncertainty is not considered further here.

Selecting Models. All risk assessments use models. The NATA analysis uses a series of mathematical models. Models are used in NATA to produce the emissions inventory; to calculate ambient air concentration (ASPEN, HEM-3, and CMAQ); to calculate exposure (HAPEM); and to calculate risk (for cancer and non-cancer effects). All scientific models involve uncertainties because a model reduces a (potentially very complex) set of chemical, biological, physical, social, or other processes to manageable algorithms that can be used to perform calculations and make forecasts. The simplifications that are inherent in the development of a model introduce uncertainties.

Typically, more than one model is available for application to a problem and those models can produce different results. Thus, uncertainty is introduced as to which model, and which model results,

should be used. As a simple example, NATA uses a linear statistical model to relate exposure concentration and cancer risk: Cancer risk equals the exposure (air concentration) times a URE. Uncertainty analysis involves asking a series of questions: Are we certain this linear relationship is correct? Could the relationship be quadratic (i.e., risk equals exposure times the square of the dose) rather than linear? Could the relationship have a threshold (i.e., no risk is apparent until the exposure becomes sufficiently large)? What are the implications for estimates of risk if these different models are used? What are the implications for decisions if a clear choice among the models cannot be made?

This step in the analysis introduces model uncertainty. Judging model uncertainty can be both quantitative and qualitative. Qualitative issues involve the scientific plausibility of the model. Does the model include all important processes? Does it explain the phenomenon (e.g., atmospheric dispersion) well? Is the model well accepted in the scientific community – has it passed critical tests and been subject to rigorous peer review?

Quantitative issues involve comparing model results against sets of data (although this also involves issues of parameter uncertainty discussed in the next bullet). Does the model generally predict these data accurately? Are the predictions accurate to within a factor of 2; a factor of 4? What is the effect of any approximation methods used in the model?

Applying Models. The models used in the NATA analysis require parameter inputs such as emission rates, stack heights, fractions of time spent indoors, and UREs. Although models describe general relationships among properties of the real world (e.g., the linear relationship between exposure and cancer risk), parameters quantify these properties for specific cases (e.g., the numerical value of the URE for benzene). Parameters provide the numbers needed in the models. Various data bases are available from which these parameters can be estimated, and the methods used to collect the data and to compile the data bases introduce uncertainties. All of these factors introduce parameter uncertainty.

Although parameter uncertainty has both quantitative and qualitative aspects, common practice is to characterize this source of uncertainty quantitatively, with some qualitative caveats. For example, parameter uncertainty might be characterized by a confidence interval, which states that the true value of the parameter (such as the stack height for a facility) probably lies somewhere between 40 and 60 meters, or that the stack height is "known to be within" a factor of 1.2, or that the stack height is "accurate to within" 20 percent. Attached to this quantitative characterization of uncertainty will be a qualitative caveat such as "the estimate of this uncertainty is based on measurements made in 1990 at facilities similar to the one considered in this study, but a change in the design of stacks might have been made since 1990." This qualitative statement provides some idea of the confidence with which the quantitative assessment of uncertainty can be applied.

7.3.2 What Components of Uncertainty Does NATA Include?

NATA Components that Include Uncertainty

- Ambient concentrations
- Exposure estimates
- Risk estimates

For this discussion, the uncertainties in NATA have been divided into three sources, based on the three steps leading from the estimate of emissions to the calculations of risk. There is uncertainty in ambient air concentrations, which is due to uncertainty in the emissions estimates and in ASPEN, HEM-3, and the CMAQ model. There is uncertainty in exposure, which is due to uncertainty in the activity patterns, the locations of individuals within a census tract, and the microenvironmental concentrations as reflected in the HAPEM model. Finally there is uncertainty in risk, which is due to uncertainty in the shape of the relationship between exposure and effects, the URE, and the RfC. These three sources of uncertainty are discussed below.

Ambient Air Concentration. Considering first the predictions of ambient air concentration, the specific sources of uncertainty derive from the parameters for the following: emissions, the stack, particle sizes and reactivity, chemical speciation, terrain, background concentration, meteorology, dispersion model equations, and chemical transformation. These sources of uncertainty are discussed briefly in this section.

Emissions parameters, including emission rates and locations of sources, are taken from the NEI data base, which is a composite of estimates produced by state and local regulatory agencies, industry, and EPA. The quality of specific emissions rates and locations contained in this data base (e.g., industrial emissions from a specific census tract) has not been fully assessed, although reviews have been conducted. Some of the parameter values could be out of date, errors might have been introduced in transcribing raw data to a computer file, and other data quality issues might be present. This data base is updated continuously. In some cases, the locations of point sources are unknown and the source is assumed to be in the centroid of a census tract. Overall, about 1 percent of the individual point sources (excluding airports) have been assigned to county centroids, and another 5 percent have been assigned to locations based on facility zip codes.

Uncertainty also is inherent in the emission models used to develop inventory estimates. For example, county-level air toxic emissions from non-road equipment are estimated by applying fractions of toxic total hydrocarbons to county-level hydrocarbon estimates for gaseous air toxics and fractions of toxic particulate matter to county-level particulate matter estimates for PAHs; emission factors based on milligrams per mile are used for metals. The toxic fractions are derived from speciation data, based on limited testing of a few equipment types. The county-level total organic gas and particulate estimates used are derived from the EPA NONROAD model. In the NONROAD model, uncertainties are associated with emission factors, activity, and spatial allocation surrogates. National-level emissions in NONROAD are allocated to the county level using surrogates, such as construction costs (to allocate emissions of construction equipment) and employees in manufacturing (to allocate industrial equipment). Availability of more specific local data on equipment populations and usage will result in more accurate inventory estimates. For mobile and non-point sources, population is used to allocate vehicle miles traveled from state or metropolitan statistical area to county, which is a source of considerable uncertainty.

For mobile and non-point sources, the emissions rates are typically allocated from the county level to census-tract levels through a surrogate such as population or land use. This allocation introduces additional uncertainty because the data on the surrogates also have uncertainty, and the correlations between the surrogates and the emissions are imperfect.

ASPEN, HEM-3, and the CMAQ model require information on **stack parameters** for atmospheric estimates, including stack height and diameter and exit gas temperature and velocity. The NEI data base provides most of these values. Default values are used when the required data are not available or they are judged unreliable (e.g., physically unrealistic values). If data on stack parameters are missing, they are estimated from similar facilities. About two-thirds of the unique vertical stacks in the NEI include at least one stack parameter that is a default value.

ASPEN requires information on the physical properties of the pollutant, including **particle size** and **reactivity parameters**. The proportion of the pollutant that is gaseous fine particulate or coarse particulate affects the extent to which the pollutant is removed from the air by deposition. The chemical reactivity of the pollutant determines whether it will undergo atmospheric transformations to other compounds. These parameters are not available in the NEI data base, so representative values are assigned. Representative values of the deposition velocities for particles (the speed at which they settle to

the ground) also are used. Any specific source, however, might actually have values that differ from the ones that are assumed.

The health effects of an air toxic depend on its chemical form when inhaled. For many sources, the NEI data base does not include information on **chemical speciation of the pollutants** of interest, but instead contains the total rate of air toxic emitted in all its forms. Assumptions about chemical speciation are made based on values estimated to be representative at such sources, taking into account information on source type, typical feedstock materials, knowledge of the process involved, or other relevant factors. Any one source, however, might actually have different values than the ones assumed.

The dispersion, or movement, of air toxics in the atmosphere is influenced by the topography of the area surrounding a source, which is characterized by **terrain parameters**. Although CMAQ model estimates include consideration of topography, ASPEN and HEM-3 estimates do not. Not accounting for terrain introduces uncertainty into predictions of ambient air concentrations, particularly in areas with hills or mountains.

Another source of uncertainty in the modeling of ambient air toxics concentrations is the values used for the **background concentration estimates** that are added at each location to reflect sources other than the ones modeled in NATA. These sources might, for example, include contributions from long-range transport of compounds from other counties and states. Although the rigor of the background estimates has been improved for each successive NATA, uncertainties remain, given the complexity of estimating such values. For more details on background concentrations, refer to the discussion in Section 2.

The representation of **meteorological parameters** in the CMAQ model is advanced, as the parameters are derived using MM5. ASPEN and HEM-3 require less complex representation of meteorological parameters, primarily the direction and speed of airflow and the stability of the atmosphere (which affects how high gases rise once they are emitted). For ASPEN and HEM-3, NATA uses meteorological data from the nearest available monitoring station. Uncertainties arise from the fact that the data typically are not measured at the precise location of a given source, and sometimes are not for the same year, and therefore might not represent the meteorological conditions accurately.

The **dispersion model equations** used in ASPEN, HEM-3, and the CMAQ model represent another source of uncertainty. ASPEN uses a Gaussian dispersion equation to calculate ambient air concentration, taken from the ISCLT2 computer model; the uncertainty in the ISCLT2 model has been studied extensively. The version of HEM-3 used for NATA uses the Gaussian equations implemented in the AERMOD computer model and has many of the same uncertainties as ASPEN. The CMAQ model is more complex in its treatment of pollutant dispersion and atmospheric dynamics. Nevertheless, many assumptions underlie the Eulerian approach to dispersion, which are outlined further in the science documentation for the CMAQ model.

The **chemical transformation equations** used in ASPEN and HEM-3 give rise to some uncertainty for NATA. Although atmospheric chemistry of some air toxics is complex and nonlinear, ASPEN and HEM-3 represent these processes with simple exponential decay. For predicting the secondary formation of formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein (which is a decay product of 1,3-butadiene) the more complex CMAQ model was used, which includes more detailed algorithms for these processes.

To help characterize the aggregate uncertainty of the dispersion model predictions, as part of the 2005 NATA, EPA compared modeled concentrations to available ambient air quality monitoring data. For each monitor-pollutant combination, EPA compared the predicted annual average concentrations at

the ambient monitor location to the annual average monitored value. These comparisons showed reasonably good agreement for gaseous pollutants, but a tendency for models to underestimate particulate concentrations. Measured concentrations were taken from EPA's National Air Toxics Trends Stations and Air Quality System. The model-to-monitor comparison approach used for the 2005 analysis was similar to that used for the 1996, 1999, and 2002 NATAs; however, for the earlier analyses, ambient concentrations were estimated for the census tract where the ambient monitor was located, rather than the exact location. For the 2005 NATA, the exact locations of the monitors were used for the model-to-monitor comparison, an approach that increases accuracy over previous assessments. For more details about the model-to-monitor analyses for previous assessments, see Comparison of 1996 ASPEN Modeling System Results to Monitored Concentrations (EPA 2009d), Comparison of 1999 Model-Predicted Concentrations to Monitored Data (EPA 2009b), and Comparison of 2002 Model-Predicted Concentrations to Monitored Data (EPA 2009c).

Results of the comparison for the 2005 NATA include the number of monitoring sites and the median ratio of model-to-monitor annual average concentrations by pollutant, on a point-to-point basis. The number of sites is the number of monitors with valid data. A median ratio close to 1 implies that the model overestimates the ambient concentrations about as often as it underestimates them. Discrepancies between model predictions and concentration measurements can be attributed to five sources of uncertainty:

- emission characterization uncertainty (e.g., specification of source location, emission rates, and release characterization);
- meteorological characterization uncertainty (e.g., representativeness);
- model formulation and methodology uncertainty (e.g., characterization of dispersion, plume rise, deposition, chemical reactivity);
- monitoring uncertainty; and
- uncertainty in background concentrations.

Underestimates for some pollutants could be a result of the following reasons:

- The NEI might be missing specific emission sources (some of the emissions parameters are missing for many of the sources in the NEI).
- The emission rates could be underestimated.
- There is uncertainty in the accuracy of the monitor averages; the monitors, in turn, have their own sources of uncertainty. Sampling and analytical uncertainty, measurement bias, and temporal variation all can cause the ambient concentrations to be inaccurate or imprecise representations of the true atmospheric averages.
- Model-to-model spatial comparisons are imprecise. The results suggest that the model estimates are uncertain on a local scale (i.e., at the census-tract level). EPA believes that the model estimates are more reliably interpreted as being a value likely to be found within 30 km of the census-tract location.
- Background concentrations are poorly characterized. Most of the pollutants for which the model underestimated ambient concentrations were those for which background concentrations were not estimated. If background concentrations are a large fraction of ambient concentrations, the result would be large underestimation in model predictions.

Despite such uncertainty, EPA believes that the 2005 predictions are an improvement over those developed in the 1996, 1999, and 2002 assessments.

Exposure. Sources of uncertainty in the relationship between ambient air concentrations and exposure concentrations include those associated with microenvironmental factors and activity patterns. HAPEM calculates the exposure concentration in various microenvironments (e.g., indoors at home, in a car) based on the ambient air concentration predicted by ASPEN, HEM-3, or the CMAQ model and **microenvironmental factors**. HAPEM4 characterizes these microenvironmental factors as point estimates. In HAPEM5, the factors are characterized as probability distributions to better reflect the variability found in air toxic measurements. For many air toxics, the measurement studies needed to estimate microenvironmental factors are not available, so the values used are based on measurement studies of similar compounds in similar situations. This practice introduces uncertainty into the estimation of exposure concentrations for such compounds. In addition, even for air toxics with measurement studies, the estimated microenvironmental factors have some uncertainty because the number of such studies is limited. Furthermore, the uniform application of the microenvironmental factors to all census tracts introduces uncertainty by not accounting for possible geographic differences among tracts (e.g., different window opening behavior, different levels of building integrity).

The **activity pattern sequences for individuals** used in HAPEM are based on CHAD. HAPEM4 and HAPEM5 take different approaches to creating annual average activity patterns based on these data, as explained in Section 4.3.3. The algorithms in HAPEM5 are expected to be an improvement and likely better represent the variability among individuals within a cohort-tract combination, largely by addressing correlation between subsequent activity patterns assumed to occur for each cohort-tract combination. With the approaches in both versions of HAPEM, there is uncertainty as to the representativeness of the daily diaries in CHAD, which is a compilation of several studies, including some that are not recent and some for which the data are based on non-random sampling. With respect to the HAPEM5 approach, there is uncertainty about how well the procedure represents actual daily autocorrelation between types of activity. This latter issue, however, pertains only to the variability of the exposure concentrations across the demographic group and not the median exposure concentration, which is the concentration reported by NATA.

The **commuting data** used in HAPEM are based on an EPA analysis of information from a special study by the U.S. Census. HAPEM4 and HAPEM5, used for the 1996 and 1999 NATAs, use this information in coordination with the activity pattern data to place an individual either in the home tract or the work tract at each time step. For these versions of HAPEM, data collected as part of the 1990 U.S. Census were used to develop the commuting data. These data introduce some uncertainty because they simplify commuting patterns to a pair of home and work census tracts and might not reflect certain details of some commutes (e.g., the additional census tracts encountered by commuters who travel to non-adjacent tracts; more complex commuting patterns that are not point to point). An additional important consideration is that the commuting pattern data included in HAPEM do not account for the movement of school-age children who travel (or commute) to a school located outside the tracts n which they reside.

Risk. Concerning the predictions of risk, the specific sources of uncertainty in dose-response relationships (in addition to those considered for ambient air concentration and exposure) are hazard identification, dose-response models for carcinogens, UREs, and RfCs.

One component of predicting risk is **hazard identification**. Cancer risk estimates are based on the assumption that a compound is either a carcinogen or produces a non-cancer effect. This judgment is based on the results of a hazard identification stage in which the evidence that an air toxic produces either cancer or a non-cancer effect is assessed. Because the evidence for either judgment is never unequivocal, a compound labeled as a carcinogen, or one deemed to produce non-cancer effects, might in fact produce

no such effect in humans. This possibility introduces uncertainty into the calculation of risk because the risk could, in fact, be zero. As the evidence for the original conclusion (i.e., that the compound produces the effect) increases, this uncertainty decreases.

Cancer risk estimates are based on the assumption that the relationship between exposure and probability of cancer is linear. In other words, the probability of developing cancer is assumed to be proportional to the exposure (equal to the exposure times a URE). This type of **dose-response model** is used routinely in regulatory risk assessment because it is believed to be conservative; that is, if the model is incorrect, it is more likely to lead to an overestimate of the risk than to an underestimate. Other scientifically valid, biologically based models are available, which produce estimates of cancer risk that differ from those obtained from the linear model. Uncertainty in risk estimates is, therefore, introduced by the inability to completely justify use of one model or the other (because each model has some scientific support). An essential consideration is that this uncertainty is, to some extent, one-sided. In other words, conservatism when uncertainty exists allows more confidence in the conclusion that the true risk is *less than that predicted* than in the conclusion that the risk is *greater than that predicted*.

URE parameters have associated uncertainty. In some cases, the UREs are based on maximum likelihood estimates of the slope of the dose-response relationship derived from reliable data. In other cases, the UREs are based on "upper bound" estimates (i.e., the slope is not the best estimate, but is a conservative value that is likely to lead to overestimates of risk) derived from less reliable data. For some compounds, the UREs are derived from human exposure studies, but for others they are from animal exposures. These considerations introduce uncertainty into the URE values, and the amount of uncertainty varies among air toxics.

Another source of uncertainty in estimating risk derives from the values chosen for the **RfC parameters** used to calculate an HQ for non-cancer health risk. The RfC, which (like the URE) is based on limited information, is uncertain, and as a result the value of HQ also is uncertain. As is the case for UREs, the uncertainty in the RfC is generally one-sided and the risk is unlikely to be greater than predicted.

7.4 Summary of Limitations in NATA

EPA developed this assessment tool to inform both national and more localized efforts to collect information and characterize or reduce air toxics emissions (e.g., to prioritize pollutants or geographic areas of interest for monitoring and community assessments). As described above, many of the elements in the assessment process for NATA, as in other assessments that derive results from environmental data and modeling of environmental data, are characterized by uncertainty and variability. Because of this, EPA suggests exercising caution when using the results of these assessments, as the overall quality and uncertainty of each assessment vary from location to location and from pollutant to pollutant. In many cases more *localized* assessments, incorporating appropriately scaled local monitoring and modeling, could be necessary to better characterize local-level risk.

Recognizing the specific limitations in NATA results is critical to their proper interpretation and utility, including that the results:

- apply to geographic areas, not specific locations.
- do not include impacts from sources in Canada or Mexico.
- are restricted to year to which the assessment pertains (because the assessment uses emissions data from that year).
- do not reflect exposures and risk from all compounds.
- do not reflect all pathways of exposure.

- reflect only compounds released into the outdoor air.
- do not fully capture variation in background ambient air concentrations.
- might systematically underestimate ambient air concentration for some compounds.
- are based on default, or simplifying, assumptions where data are missing or of poor quality.
- might not accurately capture sources that have episodic emissions.
- contain uncertainty.

The results apply to geographic areas, not specific locations. The assessment focuses on variations in air concentration, exposure, and risk among geographic areas such as census tracts, counties, and states. All questions asked, therefore, must *focus on the variations among areas*. They cannot be used to identify "hot spots" where the air concentration, exposure, or risk might be significantly higher than other locations within a census tract or county. Furthermore, this type of modeling assessment cannot address the kinds of questions an epidemiology study might, such as the relationship between asthma or cancer risk or proximity of residences to point sources, roadways, and other sources of air toxics emissions.

The results do not include impacts from sources in Canada or Mexico. Because the assessments do not include the emissions of sources in Canada and Mexico, the results for states that border these countries do not reflect these potentially significant sources of transported emissions.

The results apply to groups, not to specific individuals. Within a census tract, all individuals are assigned the same ambient air concentration, which is chosen to represent a typical ambient air concentration. Similarly, the exposure assessment uses activity patterns that do not fully reflect variations among individuals. As a result, the exposures and risks in a census tract should be interpreted as *typical values* rather than as means, medians, or some other statistical average. The values are likely to be in the midrange of values for all individuals in the census tract.

The results for the 2005 NATA are restricted to 2005 because the assessment used emissions data from 2005. The 2005 emissions are the most up-to-date data set on emissions. The assumption regarding emissions in the assessment is that the levels remain constant throughout one's lifetime (the emissions are not today's levels nor are they projected levels). Emissions continue to decrease, however, as (1) mobile-source regulations are phased in over time, (2) EPA-issued air toxics regulations for major industrial sources reach compliance due dates, (3) state and industry initiatives to reduce air pollutants continue, and (4) some facilities are retired or close.

The results do not reflect exposures and risk from all compounds. Only 140 of the 179 air toxics modeled in NATA have dose-response values. The remaining 39 air toxics that do not therefore are not considered in the aggregate cancer risk or target organ-specific hazard indices. Of particular significance is that the assessment does not quantify cancer risk from diesel PM, although EPA has concluded that the general population is exposed to levels close to or overlapping with apparent levels that have been linked to increase cancer risk in epidemiology studies. Currently, there is no unit risk estimate for diesel PM.

The results do not reflect all pathways of exposure. The assessment includes only risks from direct inhalation of the emitted air toxics compounds. It does not consider air toxics compounds that might then deposit onto soil and into water and food, and therefore enter the body through ingestion or skin contact. Consideration of these routes of exposure could increase estimates of exposure and risk.

The assessment results reflect only compounds released into the outdoor air. The assessment does not include exposure to air toxic compounds produced indoors, such as from stoves or out-gassing from building materials, or evaporative benzene emissions from cars in attached garages. For some compounds such as formaldehyde, these indoor sources can contribute significantly to the total exposure for an individual, even if only inhalation exposures are considered. In addition, the assessment does not

consider toxics released directly to water and soil. It does take into account transformation of one pollutant into another (i.e., secondary formation) in the atmosphere.

The assessment does not fully reflect variation in background ambient air concentrations. The assessment uses background ambient air concentrations that are average values over broad geographic regions. Much more research is needed before an accurate estimate of background concentrations at the level of census tracts, or even at the higher geographic scales (e.g., counties and states), can be made. Because background levels contribute to the overall exposure in this assessment, the lack of detailed information on variations in background exposures likely causes the amount of variation in total exposure and risk from one census tract to another to be smaller than otherwise would be the case.

The assessment might systematically underestimate ambient air concentration for some compounds. ASPEN and HEM-AERMOD are used to estimate ambient air concentrations. ASPEN has been shown to underestimate measured concentrations in many cases. No such bias has been found for the AERMOD model. This would tend to result in an overall underestimation of the exposure and risk. The actual effect of this issue is unknown at present, but an indication of ASPEN's performance can be gauged by comparing the modeled results to monitoring results.

The assessment uses default, or simplifying, assumptions where data are missing or of poor quality. Data for some variables used in the modeling for emissions and dispersion of air toxics compounds (such as stack height and facility location) are not always available or are flawed. In such instances, these values are replaced by default assumptions. For example, a stack height for a facility might be set equal to stack heights at comparable facilities or the location of the facility might be placed at the center of a census tract. These substitutions introduce uncertainty into the final predictions of ambient concentration, exposure, and risk.

The assessment might not accurately capture sources that have episodic emissions. Some facilities might experience short-term (for a few days or weeks) deviations from their typical emissions patterns, such as during startups, shutdowns, malfunctions, and upsets. ASPEN and HEM-AERMOD assume that emission rates are uniform throughout the year.

Estimates of risk are uncertain. Data for some air toxics known to be carcinogenic to animals are lacking for humans. Such air toxics are assumed to be human carcinogens. Additionally, the relationships between exposure and the probability of cancer for all air toxics addressed in this assessment are assumed to be linear (i.e., the effects at low exposures are extrapolated from higher, measurable exposures with a straight line). Finally, some estimates of cancer risk are considered to be best estimates of cancer risk (those based on human data), while others are "upper-bound" estimates (usually based on animal data but sometimes based on human data). Using animal data, the estimate of risk is equally likely to overestimate risk as underestimate risk. Using human data, the estimate is more likely to overestimate risk. Most, but not all, of the cancer risk estimates that EPA develops are "upper-bound" estimates. EPA cancer risk estimates for several important air toxics such as hexavalent chromium and benzene, however, are "best estimates."

Sources of uncertainty in the development of RfCs generally are intraspecies extrapolation (animal to human) and interspecies extrapolation (average human to sensitive human). Additional sources of uncertainty are the use of a lowest-observed-adverse-effect level instead of a no-observed-adverse-effect level (the latter is preferred). These uncertainties are taken into account in the derivation of the RfCs. Because the RfCs used in the assessment in estimating an HQ are conservative, meaning they represent exposures at which no appreciable risk is expected to occur within an order of magnitude uncertainty, an HQ greater than 1 should not necessarily be taken to indicate that a health effect is expected.

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Appendix A

Glossary

1 in a million cancer risk:

A risk level of 1 in a million implies a likelihood that up to one person, out of one million equally exposed people, would contract cancer if exposed continuously (24 hours per day) to the specific concentration over 70 years (an assumed lifetime). This would be in addition to those cancer cases that would normally occur in an unexposed population of one million people. Note that this assessment looks at *lifetime* cancer risks, which should not be confused with or compared to *annual* cancer risk estimates. If you would like to compare an annual cancer risk estimate with the results in this assessment, you would need to multiply that annual estimate by a factor of 70 or alternatively divide the lifetime risk by a factor of 70.

"N" in a million cancer risk:

A risk level of "N" in a million implies a likelihood that up to "N" people, out of one million equally exposed people would contract cancer if exposed continuously (24 hours per day) to the specific concentration over 70 years (an assumed lifetime). This would be in addition to those cancer cases that would normally occur in an unexposed population of one million people. Note that this assessment looks at *lifetime* cancer risks, which should not be confused with or compared to *annual* cancer risk estimates. If you would like to compare an annual cancer risk estimate with the results in this assessment, you would need to multiply that annual estimate by a factor of 70 or alternatively divide the lifetime risk by a factor of 70.

Activity pattern data:

In an inhalation exposure assessment, activity pattern data depict both the actual physical activity (including an associated inhalation exertion level); the physical location; and the time of day the activity takes place (e.g., at midnight, while sleeping at home, jogging in the park at 8 a.m., or driving in a car at 6 p.m.). The Hazardous Air Pollution Model (HAPEM) model extracts activity pattern data from EPA's Comprehensive Human Activity Database (CHAD).

Air toxics:

Also known as toxic air pollutants or hazardous air pollutants; those pollutants known to cause or suspected of causing cancer or other serious health problems. Health concerns could 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 or sensitive populations such as children. Five important air pollutants are not included in the list of air toxics because the Clean Air Act addresses them separately as "criteria pollutants." These are particulate matter (PM), nitrogen oxides (NO_x), sulfur oxides (SO_x), ozone, and carbon monoxide. Lead is both a criteria pollutant and an air toxic. These pollutants are not addressed in NATA.

Ambient:

Surrounding, as in the surrounding environment. In NATA assessments, ambient air refers to the outdoor air surrounding a person through which pollutants can be carried. Therefore, the ambient concentrations estimated by NATA are those concentrations estimated in the outdoor environment. NATA also estimates exposure concentrations that result from an individual's movement through various microenvironments, including the indoor environment.

Area and other sources:

Include sources that generally have lower emissions on an individual basis than "major sources" and are often too small or ubiquitous to be inventoried as individual sources. "Area sources" include facilities that have air toxics emissions below the major source threshold as defined in the air toxics sections of the Clean Air Act and thus emit less than 10 tons of a single toxic air pollutant or less than 25 tons of multiple toxic air pollutants in any one year. Area sources include smaller facilities, such as dry cleaners.

ASPEN (Assessment System for Population Exposure Nationwide) model:

A computer simulation model used to estimate toxic air pollutant concentrations. The ASPEN model takes into account important determinants of pollutant concentrations, such as: rate of release, location of release, the height

from which the pollutants are released, wind speeds and directions from the meteorological stations nearest the release, breakdown of the pollutants in the atmosphere after being released (i.e., reactive decay), settling of pollutants out of the atmosphere (i.e., deposition), and transformation of one pollutant into another (i.e., secondary formation or decay). The model estimates toxic air pollutant concentrations for every census tract in the United States, Puerto Rico, and the Virgin Islands. For more detailed information, see ASPEN Model.

Atmospheric transformation (Secondary Formation):

The process by which hazardous air pollutants (HAP) are transformed in the air into other chemicals. When a HAP is transformed, the original HAP no longer exists; it is replaced by one or more chemicals. Compared to the original HAP, the newer reaction products can have more, less, or the same toxicity. Transformations and removal processes affect both the fate of the HAP and its atmospheric persistence. Persistence is important because human exposure to HAPS is influenced by the length of time the HAP remains in the atmosphere. Note that in NATA the terms atmospheric transformation and secondary formation are used interchangeably.

Background concentrations:

For NATA, the contributions to outdoor air toxics concentrations resulting from natural sources, persistence in the environment of past years' emissions and long-range transport from distant sources. Background concentrations could be levels of pollutants that would be found in a particular year such as 1996 or 1999, even if there had been no recent manmade emissions. Background concentrations must be added to the modeled concentrations. See more information on background concentrations in Section 2 of this document.

Cancer risk:

The probability of contracting cancer over the course of a lifetime (assumed to be 70 years for the purposes of NATA risk characterization).

Carcinogen:

A chemical or physical agent that can cause cancer.

Chemical Abstracts Service (CAS) Number:

A unique number assigned to a chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called "Chemical Abstracts." The purpose is to make database searches more convenient, as chemicals often have many names.

Census tracts:

Land areas defined by the U.S. Census Bureau. Tracts can vary in size but each typically contains about 4,000 residents. Census tracts are usually smaller than 2 square miles in cities, but are much larger in rural areas.

Chromium:

Chromium sources of emissions include the combustion of coal and oil, electroplating, vehicles, iron and steel plants, and metal smelters. The emissions reflected in NATA assessments are based on state and local agency reporting of chromium as "chromium and compounds," individual chromium compounds, and chromium ions. In the 1996 NATA, because of inconsistent reporting, all chromium emissions reported were lumped for dispersion modeling as "Chromium VI" using the assumption that 34 percent of the reported chromium is hexavalent chromium (which is the most toxic form) based on information from past inventorying efforts. For 1999, a more refined approach was used to estimate emissions of hexavalent chromium that did not rely on an across-the-board assumption about the percentage of chromium that was hexavalent. Individual compounds of chromium reported in the inventory were identified as either hexavalent or trivalent based on their chemical formulas. Any compounds reported as either "chromium" or "chromium and compounds" were then speciated using source category-specific speciation data. The particular speciation data used are documented in Appendix C of the Emissions Modeling System for Hazardous Air Pollutants User's Guide. For source categories where speciation data were not available, the U.S. Environmental Protection Agency (EPA) also assumed that 34 percent of the chromium is hexavalent.

Cohort:

Generally defined as a group of people within a population who are assumed to have identical exposures during a specified exposure period. The use of cohorts is a necessary simplifying assumption for modeling exposures of a

large population. For the exposure assessment, the population is divided into a set of cohorts such that (1) each person is assigned to one and only one cohort, and (2) all the cohorts combined encompass the entire population.

Critical effect:

The first adverse effect, or its known precursor, that occurs on the most sensitive species as the dose rate of an agent increases.

Diesel particulate matter:

A mixture of particles that is a component of diesel exhaust. EPA lists diesel exhaust as a mobile source air toxic due to the cancer and non-cancer health effects associated with exposure to whole diesel exhaust. EPA believes that exposure to whole diesel exhaust is best described, as many researchers have done over the years, by diesel particulate concentrations.

Dispersion model:

A computerized set of mathematical equations that uses emissions and meteorological information to simulate the behavior and movement of air pollutants in the atmosphere. The results of a dispersion model are estimated outdoor concentrations of individual air pollutants at specified locations.

Emission density:

Represents tons of emitted air toxics per year within a given area on a per-square-mile basis. In NATA, total county emissions are divided by the area (in total square miles) of the county. Emission density is often used to show emissions information graphically because it provides a more consistent basis for comparison than emissions totals alone.

Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP):

A modeling system that processes the National Emissions Inventory to provide model-ready emissions for input into dispersion models. These inputs consist of tract-level emissions and point-source emissions for each toxic air pollutant, temporalized into eight 3-hour time blocks for an annually averaged year. For purposes of NATA, the EMS-HAP temporalized emission outputs are summed into annual emissions.

Exposure assessment:

Identifying the ways in which chemicals might reach individuals (e.g., by breathing); estimating how much of a chemical an individual is likely to be exposed to; and estimating the number of individuals likely to be exposed.

Hazard index:

The sum of hazard quotients for substances that affect the same target organ or organ system. Because different pollutants (air toxics) can cause similar adverse health effects, combining hazard quotients associated with different substances is often appropriate. EPA has drafted revisions to the national guidelines on mixtures that support combining the effects of different substances in specific and limited ways. Ideally, hazard quotients should be combined for pollutants that cause adverse effects by the same toxic mechanism. Because detailed information on toxic mechanisms is not available for most of the substances in NATA, however, EPA aggregates the effects when they affect the same target organ regardless of the mechanism. The hazard index (HI) is only an approximation of the aggregate effect on the target organ (e.g., the lungs) because some of the substances might cause irritation by different (i.e., non-additive) mechanisms. As with the hazard quotient, aggregate exposures below an HI of 1.0 derived using target organ specific hazard quotients likely will not result in adverse non-cancer health effects over a lifetime of exposure and would ordinarily be considered acceptable. An HI equal to or greater than 1.0, however, does not necessarily suggest a likelihood of adverse effects. Because of the inherent conservatism of the reference concentration (RfC) methodology, the acceptability of exceedances must be evaluated on a case-by-case basis, considering such factors as the confidence level of the assessment, the size of the uncertainty factors used, the slope of the dose-response curve, the magnitude of the exceedance, and the number or types of people exposed at various levels above the RfC. Furthermore, the HI cannot be translated to a probability that adverse effects will occur, and it is not likely to be proportional to risk.

Hazard quotient:

The ratio of the potential exposure to the substance and the level at which no adverse effects are expected. If the hazard quotient (HQ) is calculated to be less than 1, then no adverse health effects are expected as a result of

exposure. If the HQ is equal to or greater than 1, then adverse health effects are possible. The HQ cannot be translated to a probability that adverse health effects will occur, and it is unlikely to be proportional to risk. Especially important to note is that an HQ equal to or exceeding 1 does not necessarily mean that adverse effects will occur.

Hazardous Air Pollutant Exposure Model (HAPEM):

A computer model that has been designed to estimate inhalation exposure for specified population groups and air toxics. Through a series of calculation routines, the model makes use of census data, human activity patterns, ambient air quality levels, climate data, and indoor/outdoor concentration relationships to estimate an expected range of inhalation exposure concentrations for groups of individuals. For more detailed information, see HAPEM Model.

High end:

Describing a person living at the centroid (defined as a reference point that is usually but not always located at the geographic center of a census tract) of a census tract and engaging in a range of activities (indoors and outdoors) that tend to produce higher exposures and risks than are typical. These activities were chosen to represent the 90^{th} percentile of individuals, meaning 90 percent of individuals are expected to engage in activities that put them at lower risk. Important to bear in mind, however, is that the full variation in exposures among individuals is not reflected in the current assessment because all individuals are placed at the centroid of a census tract.

Inhalation:

Breathing. Once inhaled, contaminants can be deposited in the lungs, taken into the blood, or both.

Lifetime cancer risk:

The probability of contracting cancer over the course of a lifetime (assumed to be 70 years for the purposes of NATA risk characterization).

Major sources:

Defined by the Clean Air Act as those stationary facilities that emit or have the potential to emit 10 tons of any one toxic air pollutant or 25 tons of more than one toxic air pollutant per year.

Maximum likelihood estimate (MLE):

The most accurate maximum likelihood estimate is, by definition, the mode of a data set (i.e., the most frequent observation). When data are too limited to identify a clear mode, the average or the median of the data is usually substituted. For some air toxics for which adequate human data exist, EPA has based the unit risk estimate on the MLE for response data or for fitted curves.

Median:

The middle value of a set of ordered values (i.e., half the numbers are less than or equal to the median value). A median is the 50^{th} percentile of the data.

Microenvironment:

A small space in which human contact with a pollutant takes place. A microenvironment can be treated as a well-characterized, relatively homogenous location with respect to pollutant concentrations for a specified time period. For NATA, the Hazardous Air Pollutant Exposure Model considers cohort activities in 37 microenvironment locations that include: (1) indoor locations (e.g., residence, office, store, school, restaurant, church, manufacturing facility, auditorium, healthcare facility, service station, other public building, garage); (2) outdoor locations (e.g., parking lot/garage, near road, motorcycle, service station, construction site, residential grounds, school, sports arena, park/golf course); and (3) in-vehicle locations (e.g., car, bus, truck, other, train/subway, airplane).

Microgram:

One-millionth of a gram. One gram is about one twenty-eighth of an ounce.

National-Scale Air Toxics Assessment (NATA):

EPA's ongoing comprehensive evaluation of air toxics in the United States. These activities include the expansion of air toxics monitoring, improvement and periodic updating of emission inventories, improvement of national- and local-scale modeling, continued research on health effects and exposures to both ambient and indoor air, and improvement of assessment tools.

National Emissions Inventory:

EPA prepares a national database of air emissions information with input from numerous state and local air agencies, from tribes, and from industry. This database contains information on stationary and mobile sources that emit criteria air pollutants and their precursors, as well as hazardous air pollutants. The database includes estimates of annual emissions, by source, of air pollutants in each area of the country, on an annual basis. The National Emissions Inventory includes emission estimates for all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. Emission estimates for individual point or major sources (facilities), as well as county-level estimates for area, mobile, and other sources, are available for 1985 through 1999 for criteria pollutants, and for all years beginning in 1996 for hazardous air pollutants.

National Toxics Inventory:

EPA's compilation of quantitative information concerning the mass of air toxics emitted into the atmosphere (through smokestacks, tailpipes, vents, etc.). Starting in 1996, EPA included the National Toxics Inventory in the National Emissions Inventory, which also includes information on criteria air pollutants and their precursors.

Non-cancer risk:

The risk associated with effects other than cancer, based on the reference concentration, which is an estimate, with uncertainty spanning perhaps an order of magnitude, of an inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risks of deleterious effects during a lifetime.

Non-road mobile sources:

Mobile sources not found on roads and highways (e.g., airplanes, trains, lawn mowers, construction vehicles, farm machinery).

On-road mobile sources:

Vehicles found on roads and highways (e.g., cars, trucks, buses).

Overall confidence:

EPA has assigned an overall confidence level for each pollutant based on consideration of the combined uncertainties from emissions estimation, ambient concentration modeling, and exposure modeling. These judgments refer to the relative confidence between two air toxics compounds. A judgment of "higher" means the confidence is higher for this compound than for compounds assigned a "medium" or "lower." The confidence also depends on the geographic scale considered. As larger geographic areas are considered, and the exposure is averaged over census tracts in that region, the confidence in estimates of these averages generally will increase. The confidence ratings apply to the nationwide estimates and not to smaller scales (e.g., state or county-level).

Oral exposure:

Eating food and drinking water (and pollutants), and their entry into the digestive tract**.**

Percentile:

Any one of the points dividing a distribution of values into parts that each contain 1/100 of the values. For example, the 75^{th} percentile is a value such that 75 percent of the values are less than or equal to it. In this assessment, the distribution of values represented (national, state, or county percentiles) depends on the presentation format of the results (map, bar chart, or data table).

Polycyclic organic matter (POM):

Defines a broad class of compounds that includes the polycyclic aromatic hydrocarbons. Polycyclic organic matter compounds are formed primarily from combustion and are present in the atmosphere in particulate form. Sources of air emissions are diverse and include vehicle exhausts, forest fires and wildfires, asphalt roads, coal, coal tar,

coke ovens, agricultural burning, residential wood burning, and hazardous waste sites. Not all POM reported to EPA's National Emission Inventory is speciated. As a result, EPA applied some simplifying assumptions to model and assess the risk from the individual pollutants that comprise polycyclic organic matter. See Appendix I to this document for more information.

7-PAH (Polycyclic aromatic hydrocarbons):

The 7-PAH group includes 7 chemical species: benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene. The 7-PAHs are a subset of 16-PAH (16-PAH is referred to as polycyclic organic matter or "POM" in the presentation of results for the assessment). The 7 species that make up 7-PAH are in the cancer weight-of-evidence group "suggestive of evidence of human carcinogencity."

Reference concentration (RfC):

The reference concentration is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups that include children, asthmatics, and the elderly) that is likely to be without an appreciable risk of deleterious 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.

Risk:

The probability that damage to life, health, or the environment will occur as a result of a given hazard (such as exposure to a toxic chemical). Some risks can be measured or estimated in numerical terms (e.g., one chance in a hundred).

Rural:

Consistent with the definition EPA used in the analyses to support the Integrated Urban Air Toxics Strategy, a county is considered "rural" if it does not contain a metropolitan statistical area with a population greater than 250,000 and the U.S. Census Bureau does not designate more than 50 percent of the population as "urban." The 1999, 2002, and 2005 NATAs used the 2000 Census data, and the 1996 NATA relied on 1990 Census data to make this determination. Note that this definition does not necessarily apply for any regulatory or implementation purpose.

Science Advisory Board (SAB):

A panel of scientists, engineers, and economists who provide EPA with independent scientific and technical advice.

Stationary Sources:

The National Emissions Inventory typically identifies emissions as being emitted from "major" sources or "area" sources based on the 10-ton or 25-ton definitions contained in the Clean Air Act. For presentation purposes, the NATA results are identified as "point" and "non-point" sources rather than "major" and "area" sources. The point and non-point designations reflect the way each source of emissions is modeled. Some smaller sources that are area sources in the inventory (based on the amount of their emissions) are modeled as point sources rather than fugitive sources because the location of their emissions was identified with latitude and longitude coordinates.

Susceptibility:

An increased likelihood of an adverse effect, often discussed in terms of relationship to a factor (e.g., lifestage, demographic feature, or genetic characteristic) that can be used to describe a human subpopulation.

Toxicity weighting:

A relative risk evaluation tool that normalizes the emissions rates of each HAP to a hypothetical substance with an inhalation unit risk value of 1 per $\mu g/m^3$ (for carcinogenic effects) or a reference concentration (RfC) of 1 mg/m^3 (for non-cancer effects). It is entirely emissions-based and toxicity-based, and does not consider dispersion, fate, receptor locations, and other exposure parameters. It may be calculated based on the emissions data for all HAPs released from a facility or source being assessed. It is particularly useful if there are a large number of HAPs and there is a desire to focus the risk analysis on a smaller subset of HAPs that contribute the most to risk.

Typical:

Describes a hypothetical person living at the census tract centroid (defined as a reference point that is usually but not always located at the geographic center of a census tract) and engaging in a range of activities (indoors and outdoors) that are representative of those in which individuals residing in that tract might engage. To characterize the risk that this person might experience, NATA divides the population as a whole into cohorts (groups who are assumed to have identical exposures during a specified exposure period) based on where they live, how old they are, whether they are male or female, and what their daily activity patterns might be. For each combination of residential census tract, age, and gender, various age- and gender-appropriate daily activity patterns are selected to represent the range of exposure conditions for residents of the tract. A population-weighted typical exposure estimate is calculated for each cohort, and this value is used to estimate representative risks for a "typical" individual residing in that tract.

Upper bound:

A plausible upper limit to the true value of a quantity; usually not a true statistical confidence limit.

Upper-bound lifetime cancer risk:

A plausible upper limit to the true probability that an individual will contract cancer over a 70-year lifetime as a result of a given hazard (such as exposure to a toxic chemical). This risk can be measured or estimated in numerical terms (e.g., one chance in a hundred).

Unit risk estimate (URE):

The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 microgram per cubic meter ($\mu g/m^3$) in air. The interpretation of the unit risk estimate would be as follows: if the unit risk estimate = 1.5×10^{-6} per $\mu g/m^3$, 1.5 excess tumors are expected to develop per 1,000,000 people if they were exposed daily for a lifetime to 1 microgram of the chemical in 1 cubic meter of air. Unit risk estimates are considered upper-bound estimates, meaning they represent a plausible upper limit to the true value. (Note that this is usually not a true statistical confidence limit.) The true risk is likely to be less, but could be greater.

Upper confidence limit (UCL):

The upper confidence limit is the upper bound of a confidence interval around any calculated statistic, typically an average. For example, the 95-percent confidence interval for an average is the range of values that will contain the true average (i.e., the average of the full statistical population of all possible data) 95 percent of the time. In other words, one could say with 95-percent certainty that the "true" average will exceed the upper confidence limit only 2.5 percent of the time. EPA has based most unit risk estimates on the upper confidence limit of response data or of fitted curves, to avoid underestimating the true unit risk estimate in light of the uncertainty.

Urban:

Consistent with the definition EPA used in the analyses to support the Integrated Urban Air Toxics Strategy, a county is considered "urban" if it either includes a metropolitan statistical area with a population greater than 250,000 or the U.S. Census Bureau designates more than 50 percent of the population as "urban." The 1999, 2002, and 2005 national-scale assessment s used 2000 census data and the 1996 national-scale assessment relied on 1990 census data to make this determination. Note that this definition does not necessarily apply for any regulatory or implementation purpose.

Weight-of-evidence (WOE) for carcinogenicity:

The weight-of-evidence narrative for carcinogenicity is a summary that explains what is known about an agent's human carcinogenic potential and the conditions that characterize its expression. The narrative should be sufficiently complete to stand alone, highlighting the key issues and decisions that were the basis for the evaluation of the agent's potential hazard. The weight of evidence characterizes the extent to which the available data support the hypothesis that an agent causes cancer in humans. Under EPA's 1986 risk assessment guidelines, the weight of evidence is described by categories "A through E," with Group A for known human carcinogens through Group E for agents with evidence of non-carcinogenicity. The approach outlined in EPA's guidelines for carcinogen risk assessment (2005) considers all scientific information in determining if and under what conditions an agent can cause cancer in humans, and provides a narrative approach to characterize carcinogenicity rather than categories. To provide clarity and consistency in an otherwise free-form, narrative characterization, standard descriptors are used as part of the hazard narrative to express the conclusion regarding the weight of evidence for carcinogenic hazard potential. Five standard hazard descriptors are recommended: (1) carcinogenic to humans, (2) likely to be

carcinogenic to humans, (3) suggestive evidence of carcinogenic potential, (4) inadequate information to assess carcinogenic potential, and (5) not likely to be carcinogenic to humans.

Carcinogenic to humans: This descriptor indicates strong evidence of human carcinogenicity. It covers different combinations of evidence. This descriptor is appropriate when the epidemiologic evidence of a causal association between human exposure and cancer is convincing. An exception is that this descriptor might also be equally appropriate with a lesser weight of epidemiologic evidence that is strengthened by other lines of evidence. This descriptor can be used when all of the following conditions are met: (a) there is strong evidence of an association between human exposure and either cancer or the key precursor events of the agent's mode of action but not enough for a causal association; (b) there is extensive evidence of carcinogenicity in animals; (c) the mode(s) of carcinogenic action and associated key precursor events have been identified in animals, (d) there is strong evidence that the key precursor events that precede the cancer response in animals are anticipated to occur in humans and progress to tumors, based on available biological information.

Likely to be carcinogenic to humans: This descriptor is appropriate when the weight of the evidence is adequate to demonstrate carcinogenic potential to humans but does not reach the weight of evidence for the descriptor "carcinogenic to humans." Adequate evidence consistent with this descriptor covers a broad spectrum. At one end of the spectrum is evidence for an association between human exposure to the agent and cancer and strong experimental evidence of carcinogenicity in animals; at the other, with no human data, the weight of experimental evidence shows animal carcinogenicity by a mode or modes of action that are relevant or assumed to be relevant to humans. The use of the term "likely" as a weight-of-evidence descriptor does not correspond to a quantifiable probability. Moreover, additional information, for example, on mode of action, might change the choice of descriptor for the illustrated examples.

Suggestive evidence of carcinogenic potential: This descriptor is appropriate when the weight of evidence suggests carcinogenicity; a concern for potential carcinogenic effects in humans is raised, but the data are judged insufficient for a stronger conclusion. This descriptor covers a spectrum of evidence associated with varying levels of concern for carcinogenicity, ranging from a positive cancer result in the only study on an agent to a single positive cancer result in an extensive data base that includes negative studies in other species. Depending on the extent of the data base, additional studies might or might not provide further insights.

Inadequate information to assess carcinogenic potential: This descriptor is appropriate when available data are judged inadequate for applying one of the other descriptors. Additional studies generally would be expected to provide further insights.

Not likely to be carcinogenic to humans: This descriptor is appropriate when the available data are considered robust for deciding that there is no basis for human hazard concern. In some instances, there can be positive results in experimental animals when the evidence is strong and consistent that each mode of action in experimental animals does not operate in humans. In other cases, the evidence in both humans and animals that the agent is not carcinogenic can be convincing. "Not likely" applies only to the circumstances supported by the data. For example, an agent might be "not likely to be carcinogenic" by one route but not necessarily by another. In cases having positive animal experiment(s) but the results are judged not to be relevant to humans, the narrative discusses why the results are not relevant.

Appendix B

Air Toxics Included in Modeling for the 2005 NATA

This appendix contains two tables. The first (Exhibit B-1) lists the air toxics included in the 2005 NATA emissions inventory and indicates the inventory types(s) reporting each air toxic. The names shown in this table match the terminology used in the 1990 Clean Air Act; for example, Table B-1 lists "chromium compounds" but does not indicate which individual compounds containing chromium were modeled (see Appendix C to this document for the names of the actual substances included in the 2005 NATA).

Exhibit B-1 also indicates whether or not the air toxic was modeled for air concentrations. Two air toxics (radionuclides and asbestos) were not modeled because suitable emissions data have not been compiled for them on a national scale and because suitable health risk indicators have not been developed. Exhibit B-1 also indicates if cancer risks and chronic non-cancer hazard quotients were estimated for each air toxic. The decision to quantify risks or hazard quotients for an air toxic was based on whether a suitable toxicity value could be identified, as explained in more detail in Chapter 4 of this document. Note that, although diesel particulate matter also was modeled and is included in this table, it is not categorized as a hazardous air pollutant in the Clean Air Act. The second table (Exhibit B-2) lists the seven air toxics that were not modeled for the 2005 NATA emissions inventory and why.

Exhibit B-1. Air Toxics Included in the 2005 NATA Emissions Inventory, and Which Ones were Modeled for Air Concentrations, Cancer Risk, and Non-Cancer Risk[a]

Air Toxic	CAS Number[b]	Inventory Types Reporting Emissions					Included as Background	Modeled for		
		Point		Non-Point	On-Road Mobile	Non-Road Mobile		Air Concentrations?	Cancer Risk?	Non-Cancer Risk?
		Excl. Airports	Airports Only[c]							
1,1,2,2-Tetrachloroethane	79345	Y		Y			Y[d]	Y	Y	
1,1,2-Trichloroethane	79005	Y		Y				Y	Y	Y
1,1-Dimethyl hydrazine	57147	Y						Y		
1,2,4-Trichlorobenzene	120821	Y		Y				Y		Y
1,2-Dibromo-3-chloropropane	96128	Y					Y[d]	Y	Y	Y
1,2-Epoxybutane	106887	Y						Y		Y
1,2-Propylenimine (2-methyl aziridine)	75558							Y		
1,3-Butadiene	106990	Y	Y	Y	Y	Y	Y[e]	Y	Y	Y
1,3-Dichloropropene	542756	Y		Y				Y	Y	Y
1,3-Propane sultone	1120714	Y						Y	Y	
1,4-Dichlorobenzene(p)	106467			Y			Y[e]	Y	Y	Y
1,4-Dioxane	123911	Y		Y				Y	Y	Y
2,2,4-Trimethylpentane	540841	Y	Y	Y	Y	Y		Y		
2,4,5-Trichlorophenol	95954	Y						Y		
2,4,6-Trichlorophenol	88062	Y		Y				Y	Y	
2,4-D, salts and esters	94757	Y		Y				Y		
2,4-Dinitrophenol	51285	Y		Y				Y		
2,4-Dinitrotoluene	121142	Y		Y				Y	Y	
2,4-Toluene diamine	95807	Y						Y	Y	

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Air Toxic	CAS Number[b]	Inventory Types Reporting Emissions					Included as Background	Modeled for		
		Point		Non-Point	On-Road Mobile	Non-Road Mobile		Air Concentrations?	Cancer Risk?	Non-Cancer Risk?
		Excl. Airports	Airports Only[c]							
2,4-Toluene diisocyanate	584849	Y		Y				Y	Y	Y
2- Acetylaminofluorene	53963	Y						Y		
2-Chloroacetophenone	532274	Y		Y				Y		Y
2-Nitropropane	79469	Y		Y				Y	Y	Y
3,3'-Dichlorobenzidine	91941	Y						Y	Y	
3,3'-Dimethoxybenzidine	119904	Y						Y	Y	
3,3'-Dimethylbenzidine	119937	Y						Y	Y	
4,4'-Methylene bis(2-chloroaniline)	101144	Y						Y	Y	
4,4'-Methylenedianiline	101779	Y						Y	Y	Y
4,6-Dinitro-o-cresol, and salts	534521	Y						Y		
4-Aminobiphenyl	92671	Y						Y		
4-Nitrobiphenyl	92933	Y						Y		
4-Nitrophenol	100027	Y		Y				Y		
Acetaldehyde	75070	Y	Y	Y	Y	Y	Y[e]	Y	Y	Y
Acetamide	60355	Y		Y				Y	Y	
Acetonitrile	75058	Y		Y				Y		Y
Acetophenone	98862	Y		Y				Y		
Acrolein	107028	Y	Y	Y	Y	Y		Y		Y
Acrylamide	79061	Y		Y				Y	Y	Y
Acrylic acid	79107	Y		Y				Y		Y
Acrylonitrile	107131	Y		Y			Y[e]	Y	Y	Y
Allyl chloride	107051	Y		Y				Y	Y	Y
Aniline	62533	Y		Y				Y	Y	Y
Antimony Compounds	–	Y		Y		Y		Y		Y
Arsenic Compounds (inorganic including arsine)	–	Y		Y	Y	Y	Y[e]	Y	Y	Y
Asbestos	1332214	Y								
Benzene (including benzene from gasoline)	71432	Y	Y	Y	Y	Y	Y[e]	Y	Y	Y
Benzidine	92875	Y					Y[d]	Y	Y	Y
Benzotrichloride	98077	Y						Y	Y	
Benzyl chloride	100447	Y		Y				Y	Y	
Beryllium Compounds	–	Y		Y		Y	Y[d]	Y	Y	Y
Biphenyl	92524	Y		Y				Y		
Bis(2-ethylhexyl)phthalate (DEHP)	117817	Y		Y			Y[d]	Y	Y	Y
Bis(chloromethyl)ether	542881	Y						Y	Y	
Bromoform	75252	Y		Y				Y	Y	
Cadmium Compounds	–	Y		Y		Y	Y[d]	Y	Y	Y
Calcium cyanamide	156627	Y						Y		Y
Captan	133062	Y		Y				Y	Y	
Carbaryl	63252	Y		Y				Y		

Exhibit B-1. Air Toxics Included in the 2005 NATA Emissions Inventory, and Which Ones were Modeled for Air Concentrations, Cancer Risk, and Non-Cancer Risk[a]

Air Toxic	CAS Number[b]	Inventory Types Reporting Emissions					Included as Background	Modeled for		
		Point		Non-Point	On-Road Mobile	Non-Road Mobile		Air Concentrations?	Cancer Risk?	Non-Cancer Risk?
		Excl. Airports	Airports Only[c]							
Carbon disulfide	75150	Y		Y				Y		Y
Carbon tetrachloride	56235	Y		Y			Y[d]	Y	Y	Y
Carbonyl sulfide	463581	Y		Y				Y		
Catechol	120809	Y						Y		
Chlordane	57749	Y						Y	Y	Y
Chlorine	7782505	Y		Y		Y		Y		Y
Chloroacetic acid	79118	Y		Y				Y		
Chlorobenzene	108907	Y		Y				Y		Y
Chlorobenzilate	510156	Y						Y	Y	
Chloroform	67663	Y		Y			Y[e]	Y		Y
Chloromethyl methyl ether	107302	Y		Y				Y		
Chloroprene	126998	Y		Y				Y		Y
Chromium Compounds	–	Y		Y	Y	Y	Y[f]	Y	Y[g]	Y[g]
Cobalt Compounds	–	Y		Y		Y		Y		Y
Coke Oven Emissions	–	Y						Y	Y	
Cresols/Cresylic acid (isomers and mixture)	1319773	Y		Y				Y		Y
Cumene	98828	Y	Y	Y		Y		Y		Y
Cyanide Compounds	–	Y		Y				Y		Y
DDE	3547044	Y						Y	Y	
Diazomethane	334883	Y		Y				Y		
Dibenzofurans	132649	Y		Y				Y		
Dibutylphthalate	84742	Y		Y				Y		
Dichloroethyl ether (Bis(2-chloroethyl)ether)	111444	Y		Y				Y	Y	
Dichlorvos	62737	Y						Y	Y	Y
Diethanolamine	111422	Y		Y				Y		Y
Diethyl sulfate	64675	Y		Y				Y		
Dimethyl aminoazobenzene	0117	Y						Y	Y	
Dimethyl carbamoyl chloride	79447	Y						Y		
Dimethyl formamide	68122	Y		Y				Y		Y
Dimethyl phthalate	131113	Y		Y				Y		
Dimethyl sulfate	77781	Y		Y				Y		
Epichlorohydrin (l-Chloro-2,3-epoxypropane)	106898	Y		Y				Y	Y	Y
Ethyl acrylate	140885	Y		Y				Y		
Ethyl benzene	100414	Y	Y	Y	Y	Y		Y	Y	Y
Ethyl carbamate (Urethane)	51796	Y						Y	Y	
Ethyl chloride (Chloroethane)	75003	Y		Y				Y		Y
Ethylene dibromide (Dibromoethane)	106934	Y		Y			Y[d]	Y	Y	Y
Ethylene dichloride (1,2-Dichloroethane)	107062	Y		Y			Y[d]	Y	Y	Y
Ethylene glycol	107211	Y		Y				Y		Y

Exhibit B-1. Air Toxics Included in the 2005 NATA Emissions Inventory, and Which Ones were Modeled for Air Concentrations, Cancer Risk, and Non-Cancer Risk[a]

Air Toxic	CAS Number[b]	Inventory Types Reporting Emissions					Included as Background	Modeled for		
		Point		Non-Point	On-Road Mobile	Non-Road Mobile		Air Concentrations?	Cancer Risk?	Non-Cancer Risk?
		Excl. Airports	Airports Only[c]							
Ethylene imine (Aziridine)	151564	Y		Y				Y		
Ethylene oxide	75218	Y		Y			Y[d]	Y	Y	Y
Ethylene thiourea	96457	Y		Y				Y	Y	Y
Ethylidene dichloride (1,1-Dichloroethane)	75343	Y		Y				Y	Y	Y
Fine Mineral Fibers	–	Y						Y		
Formaldehyde	50000	Y	Y	Y	Y	Y	Y[e]	Y	Y	Y
Glycol ethers	–	Y		Y				Y		Y
Heptachlor	76448	Y						Y	Y	
Hexachlorobenzene	118741	Y		Y				Y	Y	Y
Hexachlorobutadiene	87683	Y		Y				Y	Y	Y
Hexachlorocyclopentadiene	77474	Y		Y				Y		Y
Hexachloroethane	67721	Y						Y	Y	Y
Hexamethylene-1,6-diisocyanate	822060	Y		Y				Y		Y
Hexane	110543	Y	Y	Y	Y	Y		Y		Y
Hydrazine	302012	Y		Y			Y[d]	Y	Y	Y
Hydrochloric acid	7647010	Y		Y				Y		Y
Hydrogen fluoride (Hydrofluoric acid)	7664393	Y		Y				Y		Y
Hydroquinone	123319	Y		Y				Y		
Isophorone	78591	Y		Y				Y	Y	Y
Lead Compounds	–	Y	Y	Y		Y	Y[e]	Y		Y
Lindane (all isomers)	58899	Y		Y				Y	Y	Y
Maleic anhydride	108316	Y		Y				Y		Y
Manganese Compounds	–	Y		Y	Y	Y	Y[e]	Y		Y
m-Cresol	108394			Y				Y		Y
Mercury Compounds	–	Y		Y	Y	Y		Y		Y
Methanol	67561	Y	Y	Y		Y		Y		Y
Methoxychlor	72435	Y						Y		
Methyl bromide (Bromomethane)	74839	Y		Y			Y[h]	Y		Y
Methyl chloride (Chloromethane)	74873	Y		Y			Y[h]	Y		Y
Methyl chloroform (1,1,1-Trichloroethane)	71556	Y		Y			Y[h]	Y		Y
Methyl hydrazine	60344	Y		Y				Y		
Methyl iodide (Iodomethane)	74884	Y		Y				Y		
Methyl isobutyl ketone (Hexone)	108101	Y		Y				Y		Y
Methyl isocyanate	624839	Y						Y		Y
Methyl methacrylate	80626	Y		Y				Y		Y
Methyl tert butyl ether	1634044	Y		Y	Y	Y		Y	Y	Y
Methylene chloride (Dichloromethane)	75092	Y		Y			Y[d]	Y	Y	Y

Exhibit B-1. Air Toxics Included in the 2005 NATA Emissions Inventory, and Which Ones were Modeled for Air Concentrations, Cancer Risk, and Non-Cancer Risk[a]

Air Toxic	CAS Number[b]	Inventory Types Reporting Emissions					Included as Background	Modeled for		
		Point		Non-Point	On-Road Mobile	Non-Road Mobile		Air Concentrations?	Cancer Risk?	Non-Cancer Risk?
		Excl. Airports	Airports Only[c]							
Methylene diphenyl diisocyanate (MDI)	101688	Y		Y				Y		Y
m-Xylenes	108383	Y	Y	Y	Y	Y		Y		Y
N,N-Dimethylaniline	121697	Y		Y				Y		
Naphthalene	91203	Y	Y	Y	Y	Y	Y[d]	Y	Y	Y
Nickel Compounds	–	Y		Y	Y	Y	Y[e]	Y	Y	Y
Nitrobenzene	98953	Y		Y				Y	Y	Y
N-Nitrosodimethylamine	62759	Y						Y	Y	
N-Nitrosomorpholine	59892	Y						Y	Y	
o-Anisidine	90040	Y						Y		
o-Cresol	95487			Y				Y		Y
o-Toluidine	95534	Y		Y				Y	Y	
o-Xylenes	95476		Y	Y	Y	Y		Y		Y
p-Cresol	106445			Y				Y		Y
Pentachloronitrobenzene (Quintobenzene)	82688	Y						Y	Y	
Pentachlorophenol	87865	Y		Y				Y	Y	Y
Phenol	108952	Y	Y	Y				Y		Y
Phosgene	75445	Y		Y				Y		Y
Phosphine	7803512	Y		Y				Y		Y
Phosphorus	7723140	Y		Y				Y		
Phthalic anhydride	85449	Y		Y				Y		Y
Polychlorinated biphenyls (Aroclors)	1336363	Y		Y				Y	Y	
Polycylic Organic Matter	–	Y	Y	Y	Y	Y		Y	Y	
p-Phenylenediamine	106503	Y						Y		
Propionaldehyde	123386	Y	Y	Y	Y	Y		Y		Y
Propoxur (Baygon)	114261	Y						Y		
Propylene dichloride (1,2-Dichloropropane)	78875	Y		Y			Y[d]	Y	Y	Y
Propylene oxide	75569	Y		Y				Y	Y	Y
p-Xylenes	106423			Y	Y	Y		Y		Y
Quinoline	91225	Y					Y[d]	Y		
Quinone	106514	Y						Y		
Radionuclides (including radon)	–	Y								
Selenium Compounds	–	Y		Y		Y		Y		Y
Styrene	100425	Y	Y	Y	Y	Y		Y		Y
Styrene oxide	96093	Y						Y		Y
Tetrachloroethylene (Perchloroethylene)	127184	Y		Y			Y[e]	Y	Y	Y
Titanium tetrachloride	7550450	Y		Y				Y		Y
Toluene	108883	Y	Y	Y	Y	Y	Y[e]	Y		Y
Toxaphene (chlorinated camphene)	8001352	Y						Y	Y	

Exhibit B-1. Air Toxics Included in the 2005 NATA Emissions Inventory, and Which Ones were Modeled for Air Concentrations, Cancer Risk, and Non-Cancer Risk[a]

Air Toxic	CAS Number[b]	Inventory Types Reporting Emissions					Included as Background	Modeled for		
		Point		Non-Point	On-Road Mobile	Non-Road Mobile		Air Concentrations?	Cancer Risk?	Non-Cancer Risk?
		Excl. Airports	Airports Only[c]							
Trichloroethylene	79016	Y		Y			Y[d]	Y	Y	Y
Triethylamine	121448	Y		Y				Y		Y
Trifluralin	1582098	Y		Y				Y	Y	
Vinyl acetate	108054	Y		Y				Y		Y
Vinyl bromide	593602	Y						Y	Y	Y
Vinyl chloride	75014	Y		Y				Y	Y	Y
Vinylidene chloride (1,1-Dichloroethylene)	75354	Y		Y				Y		Y
Xylenes (isomers and mixture)	1330207		Y	Y		Y		Y		Y
Diesel particulate matter (not a hazardous air pollutant, but included in the 2005 NATA)	–				Y	Y		Y		Y

[a] Applicable to the 2005 NATA; might differ for previous or future versions of the assessment. Diesel particulate matter, which is not a hazardous air pollutant, was also modeled.

[b] The CAS (Chemical Abstracts Service) Number is a unique number assigned to a chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called "Chemical Abstracts." The purpose is to make database searches more convenient, as chemicals often have many names. A dash (–) in this column indicates no CAS number has been defined for the air toxic.

[c] Although airport-related emissions are inventoried and modeled as point sources, their results in the 2005 NATA are presented with the non-road mobile source type. In previous versions of NATA, results for airport-related emissions were presented with the point source type.

[d] Ambient concentrations of this pollutant resulting from background sources were calculated using the "emissions method" in the background source methodology.

[e] Ambient concentrations of this pollutant resulting from background sources were calculated using the "ambient method" in the background source methodology.

[f] Ambient concentrations of the National Emissions Inventory pollutants "Chromium" and "Chromium (VI)" resulting from background sources were calculated using the ambient method and emissions method, respectively, from the background source methodology. The 1990 Clean Air Act air toxics list does not distinguish between these two pollutants.

[g] Only hexavalent chromium were evaluated for cancer and non-cancer human health risk. Trivalent chromium was not evaluated for risk.

[h] Ambient concentrations of this pollutant resulting from background sources were calculated using the "uniform method" in the background source methodology.

Exhibit B-2. Air Toxics Not Included in 2005 NATA Emissions Inventory

Hazardous Air Pollutant [a]	Reason for Exclusion from 2005 NATA
1,2-Diphenylhydrazine	Not reported to the National Emissions Inventory (NEI)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	Not well-represented in NEI
Beta-propiolactone	Not reported to NEI
Chloramben	Not reported to NEI
Hexamethylphosphoramide	Not reported to NEI; current uses not well-known but believed to be very small in frequency and quantity
N-nitroso-N-methylurea	Not reported to NEI; current uses not well-known but believed to be very small in frequency and quantity
Parathion	Not reported to NEI

Appendix C

Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act; and the NATA Toxicity Table and Metal and Cyanide Speciation Factors

Exhibit C-1 provides the air toxic name crosswalk used to conduct the modeling of emissions from point, non-point, and mobile sources for the 2005 NATA. This crosswalk provides a critical link between lists of air toxic names in two data bases used for NATA:

- the NATA emission inventory of point, non-point, and mobile sources, which is derived from the National Emissions Inventory (NEI) and uses NEI air toxic names; and
- the set of toxicity values used by EPA to conduct risk characterization for NATA (see Appendix H of this document).

This crosswalk is required to bridge differences in the air toxic names and identities included in NEI and the set of toxicity values used for NATA. In some cases, nomenclature or syntax differences occur in the names used for the same chemical. Such differences can include spaces, dashes, numbers between parts of an air toxic name, alternate names for an air toxic, and other syntactical differences. An exact match must be specified for the modeling to proceed correctly.

In other cases, EPA has not identified suitable toxicity values for some air toxics in NEI. These air toxics include those for which toxicity data are insufficient or absent, and emissions reported in NEI as a group or non-specific substance, such as total polyaromatic hydrocarbons (PAHs) or beryllium compounds. In addition, for polycyclic organic matter (POM), emissions of individual POM species are grouped into one of several POM groups. These assignments are also reflected in this crosswalk table (see Appendix H to this document for more information on POM grouping).

This table also indicates the corresponding 1990 Clean Air Act Amendment names for each air toxic, as well as the air toxic name used in the NATA risk result. In addition, Exhibit C-1 shows how metal and cyanide chemicals are speciated based on their metal or cyanide mass fractions. This value is used to adjust modeled mass emissions prior to modeling and conducting risk calculations, because metal and cyanide toxicity is usually evaluated relative to the amount of metal or cyanide ion present, not the total mass of the metal or cyanide compound. For example, for calcium chromate ($CaCrH_2O_4$), the chromium ion is the toxic substance, and therefore the relevant amount in assessing risk is the mass of chromium to which an individual is exposed, not the mass of calcium chromate or mass of chromate ions. Consequently, prior to modeling, the reported emissions of calcium chromate are multiplied by the fraction of the compound's mass that is chromium, or 158.09 (the molecular weight of the compound) divided by 51.996 (the atomic weight of chromium). This value (i.e., 0.3332) is the "metal speciation factor" for emissions of calcium chromate. Metals reported as unspecified mixtures or compounds (e.g., "chromium compounds") are assumed to be reported as the mass of the metal only. This is a health-protective assumption (i.e., the emission amounts for these entities are not adjusted downward).

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
79345	79345	1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	–	1
79005	79005	1,1,2-Trichloroethane	1,1,2-Trichloroethane	1,1,2-Trichloroethane	1,1,2-Trichloroethane	–	1
57147	57147	1,1-Dimethyl Hydrazine	1,1-Dimethyl hydrazine	1,1-Dimethylhydrazine	1,1-Dimethylhydrazine	–	1
58899	58899	1,2,3,4,5,6-Hexachlorocyclyhexane	Lindane (all isomers)	Lindane (gamma-HCH)	1,2,3,4,5,6-Hexachlorocyclyhexane (all stereo isomers)	–	1
120821	120821	1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene	–	1
96128	96128	1,2-Dibromo-3-Chloropropane	1,2-Dibromo-3-chloropropane	1,2-Dibromo-3-chloropropane	1,2-Dibromo-3-chloropropane	–	1
106887	106887	1,2-Epoxybutane	1,2-Epoxybutane	1,2-Epoxybutane	1,2-Epoxybutane	–	1
75558	75558	1,2-Propylenimine	1,2-Propylenimine (2-methyl aziridine)	1,2-Propyleneimine	1,2-Propyleneimine	–	1
106990	106990	1,3-Butadiene	1,3-Butadiene	1,3-Butadiene	1,3-Butadiene	–	1
542756	542756	1,3-Dichloropropene	1,3-Dichloropropene	1,3-Dichloropropene	1,3-Dichloropropene	–	1
1120714	1120714	1,3-Propanesultone	1,3-Propane sultone	1,3-Propane sultone	1,3-Propane sultone	–	1
106467	106467	1,4-Dichlorobenzene	1,4-Dichlorobenzene(p)	p-Dichlorobenzene	1,4-Dichlorobenzene	–	1
540841	540841	2,2,4-Trimethylpentane	2,2,4-Trimethylpentane	2,2,4-Trimethylpentane	2,2,4-Trimethylpentane	–	1
95954	95954	2,4,5-Trichlorophenol	2,4,5-Trichlorophenol	2,4,5-Trichlorophenol	2,4,5-Trichlorophenol	–	1
88062	88062	2,4,6-Trichlorophenol	2,4,6-Trichlorophenol	2,4,6-Trichlorophenol	2,4,6-Trichlorophenol	–	1
94757	94757	2,4-Dichlorophenoxy Acetic Acid	2,4-D, salts and esters	2,4-D, salts and esters	2,4-D, salts and esters	–	1
51285	51285	2,4-Dinitrophenol	2,4-Dinitrophenol	2,4-Dinitrophenol	2,4-Dinitrophenol	–	1
121142	121142	2,4-Dinitrotoluene	2,4-Dinitrotoluene	2,4-Dinitrotoluene	2,4-Dinitrotoluene	–	1
584849	584849	2,4-Toluene Diisocyanate	2,4-Toluene diisocyanate	2,4-Toluene diisocyanate	2,4-Toluene diisocyanate	–	1
53963	53963	2-Acetylaminofluorene	2- Acetylaminofluorene	2-Acetylaminofluorene	2-Acetylaminofluorene	–	1
532274	532274	2-Chloroacetophenone	2-Chloroacetophenone	2-Chloroacetophenone	2-Ahloroacetophenone	–	1
79469	79469	2-Nitropropane	2-Nitropropane	2-Nitropropane	2-Nitropropane	–	1
91941	91941	3,3'-Dichlorobenzidene	3,3'-Dichlorobenzidine	3,3'-Dichlorobenzidine	3,3'-Dichlorobenzidine	–	1
119904	119904	3,3'-Dimethoxybenzidine	3,3'-Dimethoxybenzidine	3,3'-Dimethoxybenzidine	3,3'-Dimethoxybenzidine	–	1
119937	119937	3,3'-Dimethylbenzidine	3,3'-Dimethylbenzidine	3,3'-Dimethylbenzidine	3,3'-Dimethylbenzidine	–	1
101144	101144	4,4'-Methylenebis(2-Chloraniline)	4,4'-Methylene bis(2-chloroaniline)	4,4'-Methylene bis(2-chloroaniline)	4,4'-Methylene bis(2-chloroaniline)	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
101779	101779	4,4'-Methylenedianiline	4,4'-Methylenedianiline	4,4'-Methylenedianiline	4,4'-Methylenedianiline	–	1
101688	101688	4,4'-Methylenediphenyl Diisocyanate	Methylene diphenyl diisocyanate (MDI)	Methylene diphenyl diisocyanate	4,4'-Methylenediphenyl diisocyanate (mdi)	–	1
534521	534521	4,6-Dinitro-o-Cresol	4,6-Dinitro-o-cresol, and salts	4,6-Dinitro-o-cresol	4,6-Dinitro-o-cresol (including salts)	–	1
92671	92671	4-Aminobiphenyl	4-Aminobiphenyl	4-Aminobiphenyl	4-Aminobiphenyl	–	1
60117	60117	4-Dimethylaminoazobenzene	Dimethyl aminoazobenzene	p-Dimethylaminoazobenzene	4-Dimethylaminoazobenzene	–	1
92933	92933	4-Nitrobiphenyl	4-Nitrobiphenyl	4-Nitrobiphenyl	4-Nitrobiphenyl	–	1
100027	100027	4-Nitrophenol	4-Nitrophenol	4-Nitrophenol	4-Nitrophenol	–	1
75070	75070	Acetaldehyde	Acetaldehyde	Acetaldehyde	Acetaldehyde	–	1
60355	60355	Acetamide	Acetamide	Acetamide	Acetamide	–	1
75058	75058	Acetonitrile	Acetonitrile	Acetonitrile	Acetonitrile	–	1
98862	98862	Acetophenone	Acetophenone	Acetophenone	Acetophenone	–	1
107028	107028	Acrolein	Acrolein	Acrolein	Acrolein	–	1
79061	79061	Acrylamide	Acrylamide	Acrylamide	Acrylamide	–	1
79107	79107	Acrylic Acid	Acrylic acid	Acrylic acid	Acrylic acid	–	1
107131	107131	Acrylonitrile	Acrylonitrile	Acrylonitrile	Acrylonitrile	–	1
107051	107051	Allyl Chloride	Allyl chloride	Allyl chloride	Allyl chloride	–	1
62533	62533	Aniline	Aniline	Aniline	Aniline	–	1
7440360	7440360	Antimony	Antimony Compounds	Antimony compounds	Antimony Compounds	–	1
1309644	1309644	Antimony Trioxide	Antimony Compounds	Antimony trioxide	Antimony Compounds	Antimony	0.8353
1327339	1327339	Antimony Oxide	Antimony Compounds	Antimony oxide	Antimony Compounds	Antimony	0.7933
92	None	Antimony & Compounds	Antimony Compounds	Antimony compounds	Antimony Compounds	–	1
93	None	Arsenic & Compounds (Inorganic Including Arsine)	Arsenic Compounds (inorganic including arsine)	Arsenic compounds	Arsenic Compounds(inorganic including arsine)	–	1
7440382	7440382	Arsenic	Arsenic Compounds (inorganic including arsine)	Arsenic compounds	Arsenic Compounds(inorganic including arsine)	–	1
1303282	1303282	Arsenic Pentoxide	Arsenic Compounds (inorganic including arsine)	Arsenic pentoxide	Arsenic Compounds(inorganic including arsine)	Arsenic	0.6519
1327533	1327533	Arsenic Trioxide	Arsenic Compounds (inorganic including arsine)	Arsenic trioxide	Arsenic Compounds(inorganic including arsine)	Arsenic	0.7574

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
7778394	7778394	Arsenic Acid	Arsenic Compounds (inorganic including arsine)	Arsenic acid	Arsenic Compounds(inorganic including arsine)	Arsenic	0.5278
7784421	7784421	Arsine	Arsenic Compounds (inorganic including arsine)	Arsine	Arsenic Compounds(inorganic including arsine)	–	1
1332214	1332214	Asbestos	Asbestos	Asbestos	Asbestos	–	1
71432	71432	Benzene	Benzene (including benzene from gasoline)	Benzene	Benzene (including benzene from gasoline)	–	1
92875	92875	Benzidine	Benzidine	Benzidine	Benzidine	–	1
98077	98077	Benzotrichloride	Benzotrichloride	Benzotrichloride	Benzotrichloride	–	1
100447	100447	Benzyl Chloride	Benzyl chloride	Benzyl chloride	Benzyl chloride	–	1
7440417	7440417	Beryllium	Beryllium Compounds	Beryllium compounds	Beryllium Compounds	–	1
1304569	1304569	Beryllium Oxide	Beryllium Compounds	Beryllium Oxide	Beryllium Compounds	Beryllium	0.3603
109	None	Beryllium & Compounds	Beryllium Compounds	Beryllium compounds	Beryllium Compounds	–	1
92524	92524	Biphenyl	Biphenyl	Biphenyl	Biphenyl	–	1
117817	117817	Bis(2-Ethylhexyl)Phthalate	Bis(2-ethylhexyl)phthalate (DEHP)	Bis(2-ethylhexyl)phthalate	Bis(2-ethylhexyl)phthalate (DEHP)	–	1
542881	542881	Bis(Chloromethyl)Ether	Bis(chloromethyl)ether	Bis(chloromethyl)ether	Bis(chloromethyl) ether	–	1
75252	75252	Bromoform	Bromoform	Bromoform	Bromoform	–	1
1306190	1306190	Cadmium Oxide	Cadmium Compounds	Cadmium Oxide	Cadmium Compounds	Cadmium	0.8753
543908		Cadmium acetate	Cadmium Compounds	Cadmium acetate	Cadmium Compounds	Cadmium	0.4834
10325947	10325947	Cadmium Nitrate	Cadmium Compounds	Cadmium nitrate	Cadmium Compounds	Cadmium	0.4714
7440439	7440439	Cadmium	Cadmium Compounds	Cadmium compounds	Cadmium Compounds	–	1
125	None	Cadmium & Compounds	Cadmium Compounds	Cadmium compounds	Cadmium Compounds	–	1
156627	156627	Calcium Cyanamide	Calcium cyanamide	Calcium cyanamide	Calcium cyanamide	–	1
133062	133062	Captan	Captan	Captan	Captan	–	1
63252	63252	Carbaryl	Carbaryl	Carbaryl	Carbaryl	–	1
75150	75150	Carbon Disulfide	Carbon disulfide	Carbon disulfide	Carbon disulfide	–	1
56235	56235	Carbon Tetrachloride	Carbon tetrachloride	Carbon tetrachloride	Carbon tetrachloride	–	1
463581	463581	Carbonyl Sulfide	Carbonyl sulfide	Carbonyl sulfide	Carbonyl sulfide	–	1
120809	120809	Catechol	Catechol	Catechol	Catechol	–	1
57749	57749	Chlordane	Chlordane	Chlordane	Chlordane	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
7782505	7782505	Chlorine	Chlorine	Chlorine	Chlorine	–	1
79118	79118	Chloroacetic Acid	Chloroacetic acid	Chloroacetic acid	Chloroacetic acid	–	1
108907	108907	Chlorobenzene	Chlorobenzene	Chlorobenzene	Chlorobenzene	–	1
510156	510156	Chlorobenzilate	Chlorobenzilate	Chlorobenzilate	Chlorobenzilate	–	1
67663	67663	Chloroform	Chloroform	Chloroform	Chloroform	–	1
107302	107302	Chloromethyl Methyl Ether	Chloromethyl methyl ether	Chloromethyl methyl ether	Chloromethyl methyl ether	–	1
126998	126998	Chloroprene	Chloroprene	Chloroprene	chloroprene	–	1
16065831	16065831	Chromium III	Chromium Compounds	Chromium (III) compounds	Chromium Compounds	–	1
7440473	7440473	Chromium [c]	Chromium Compounds	Chromium (VI) compounds	Chromium Compounds	–	1
13765190	13765190	Calcium Chromate	Chromium Compounds	Calcium Chromate	Chromium Compounds	Chromium VI	0.3332
13530659	13530659	Zinc Chromate	Chromium Compounds	Zinc Chromate	Chromium Compounds	Chromium VI	0.2867
7788989		Ammonium chromate	Chromium Compounds	Ammonium chromate	Chromium Compounds	Chromium	0.342
7778509	7778509	Potassium Dichromate	Chromium Compounds	Potassium Dichromate	Chromium Compounds	Chromium	0.3535
7775113	7775113	Sodium Chromate	Chromium Compounds	Sodium Chromate	Chromium Compounds	Chromium VI	0.4406
11103869	11103869	Zinc Potassium Chromate	Chromium Compounds	Zinc Potassium Chromate	Chromium Compounds	Chromium VI	0.218
7789062	7789062	Strontium Chromate	Chromium Compounds	Strontium Chromate	Chromium Compounds	Chromium VI	0.2554
7440473	7440473	Chromium[d]	Chromium Compounds	Chromium (III) compounds	Chromium Compounds	–	1
14307336		Chromic acid (H2Cr2O7), calcium salt (1:1)	Chromium Compounds	Chromium (VI) compounds	Chromium Compounds	Chromium	0.403
10101538	10101538	Chromic Sulfate	Chromium Compounds	Chromic Sulfate	Chromium Compounds	Chromium	0.2611
7789006	7789006	Potassium Chromate	Chromium Compounds	Potassium Chromate	Chromium Compounds	Chromium	0.2677
10294403	10294403	Barium Chromate	Chromium Compounds	Barium Chromate	Chromium Compounds	Chromium VI	0.2053
50922297	50922297	Zinc Chromite	Chromium Compounds	Zinc Chromite	Chromium Compounds	Chromium	0.2803
12018198	12018198	Chromium Zinc Oxide	Chromium Compounds	Chromium Zinc Oxide	Chromium Compounds	Chromium	0.3899
136	None	Chromium & Compounds[d]	Chromium Compounds	Chromium (III) compounds	Chromium Compounds	–	1
10060125	10060125	Chromium Chloride, Hexahydrate	Chromium Compounds	Chromium (III) compounds	Chromium Compounds	Chromium	0.3283

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
136	None	Chromium & Compounds[d]	Chromium Compounds	Chromium (VI) compounds	Chromium Compounds	–	1
18540299	18540299	Chromium (VI)	Chromium Compounds	Chromium (VI) compounds	Chromium Compounds	–	1
7738945	7738945	Chromic Acid (VI)	Chromium Compounds	Chromic Acid (VI)	Chromium Compounds	Chromium VI	0.4406
1333820	1333820	Chromium Trioxide	Chromium Compounds	Chromium (VI) trioxide, chromic acid mist	Chromium Compounds	Chromium	0.52
10025737		Chromium (III) Chloride	Chromium Compounds	Chromium Chloride	Chromium Compounds	Chromium	0.3284
10588019	10588019	Sodium Dichromate	Chromium Compounds	Sodium Dichromate	Chromium Compounds	Chromium VI	0.397
1308141	1308141	Chromium Hydroxide	Chromium Compounds	Chromium (III) compounds	Chromium Compounds	Chromium	0.5048
1308389	1308389	Chromic Oxide	Chromium Compounds	Chromic Oxide	Chromium Compounds	Chromium	0.6842
13530682	None	Chromic Sulfuric Acid	Chromium Compounds	Chromic sulfuric acid	Chromium Compounds	Chromium	0.477
139	None	Cobalt & Compounds	Cobalt Compounds	Cobalt compounds	Cobalt Compounds	–	1
136527	136527	Hexanoic acid, 2-ethyl-, cobalt(2+) salt	Cobalt Compounds	Hexanoic acid, 2-ethyl-, cobalt(2+) salt	Cobalt Compounds	Cobalt	0.2056
1308061	1308061	Cobalt Oxide (II,III)	Cobalt Compounds	Cobalt Oxide (II,III)	Cobalt Compounds	Cobalt	0.2447
1345160	1345160	Cobalt Aluminate	Cobalt Compounds	Cobalt Aluminate	Cobalt Compounds	Cobalt	0.3332
7440484	7440484	Cobalt	Cobalt Compounds	Cobalt compounds	Cobalt Compounds	–	1
1307966	1307966	Cobalt Oxide	Cobalt Compounds	Cobalt Oxide	Cobalt Compounds	Cobalt	0.7865
61789513	61789513	Cobalt Naphtha	Cobalt Compounds	Cobalt compounds	Cobalt Compounds	Cobalt	0.1448
16842038	16842038	Cobalt Hydrocarbonyl	Cobalt Compounds	Cobalt Hydrocarbonyl	Cobalt Compounds	Cobalt	0.3471
140	None	Coke Oven Emissions	Coke Oven Emissions	Coke Oven Emissions	Coke oven emissions	–	1
141	None	Benzene Soluble Organics (BSO)	Coke Oven Emissions	Benzene Soluble Organics (BSO)	Coke oven emissions	–	1
142		Methylene Chloride Soluble Organics (MCSO)	Coke Oven Emissions	Methylene Chloride Soluble Organics (MCSO)	Coke oven emissions	–	1
1319773	1319773	Cresol	Cresols/Cresylic acid (isomers and mixture)	Cresols (mixed)	Cresol_cresylic acid (mixed isomers)	–	1
106445	106445	p-Cresol	p-cresol	p-Cresol (4-methy phenol)	Cresol_cresylic acid (mixed isomers)	–	1
108394	108394	m-Cresol	m-cresol	m-Cresol (3-methylphenol)	Cresol_cresylic acid (mixed isomers)	–	1
95487	95487	o-Cresol	o-cresol	o-Cresol	Cresol_cresylic acid (mixed isomers)	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
98828	98828	Cumene	Cumene	Cumene	Cumene	–	1
143339	143339	Sodium Cyanide	Cyanide Compounds	Sodium Cyanide	Cyanide Compounds	Cyanide	0.5516
151508	151508	Potassium Cyanide	Cyanide Compounds	Potassium cyanide	Cyanide Compounds	Cyanide	0.415
74908	74908	Hydrogen Cyanide	Cyanide Compounds	Hydrogen cyanide	Cyanide Compounds	–	1
13943583	13943583	Potassium Ferrocyanide	Cyanide Compounds	Cyanide compounds	Cyanide Compounds	Cyanide	0.4402
78820	78820	2-Methyl-Propanenitrile	Cyanide Compounds	2-Methyl-Propanenitrile	Cyanide Compounds	Cyanide	0.3911
557211	557211	Zinc Cyanide	Cyanide Compounds	Zinc cyanide	Cyanide Compounds	Cyanide	0.4601
544923	544923	Copper Cyanide	Cyanide Compounds	Copper cyanide	Cyanide Compounds	Cyanide	0.3021
57125	57125	Cyanide	Cyanide Compounds	Hydrogen cyanide	Cyanide Compounds	–	1
144	None	Cyanide & Compounds	Cyanide Compounds	Cyanide compounds	Cyanide Compounds	–	1
72559	72559	DDE (1,1-Dichloro-2,2-Bis(p-Chlorophenyl) Ethylene)	DDE	DDE (1,1-Dichloro-2,2-Bis(p-Chlorophenyl) Ethylene	DDE (1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene)	–	1
334883	334883	Diazomethane	Diazomethane	Diazomethane	Diazomethane	–	1
132649	132649	Dibenzofuran	Dibenzofurans	Dibenzofuran	Dibenzofuran	–	1
84742	84742	Dibutyl Phthalate	Dibutylphthalate	Dibutylphthalate	Dibutylphthalate	–	1
111444	111444	Dichloroethyl Ether	Dichloroethyl ether (Bis(2-chloroethyl)ether)	Dichloroethyl ether	Dichloroethyl ether (bis[2-chloroethyl]ether)	–	1
62737	62737	Dichlorvos	Dichlorvos	Dichlorvos	Dichlorvos	–	1
111422	111422	Diethanolamine	Diethanolamine	Diethanolamine	Diethanolamine	–	1
64675	64675	Diethyl Sulfate	Diethyl sulfate	Diethyl Sulfate	Diethyl sulfate	–	1
131113	131113	Dimethyl Phthalate	Dimethyl phthalate	Dimethyl phthalate	Dimethyl phthalate	–	1
77781	77781	Dimethyl Sulfate	Dimethyl sulfate	Dimethyl sulfate	Dimethyl sulfate	–	1
79447	79447	Dimethylcarbamoyl Chloride	Dimethyl carbamoyl chloride	Dimethylcarbamoyl Chloride	Dimethylcarbamoyl chloride	–	1
106898	106898	1-Chloro-2,3-Epoxypropane	Epichlorohydrin (l-Chloro-2,3-epoxypropane)	Epichlorohydrin	Epichlorohydrin	–	1
140885	140885	Ethyl Acrylate	Ethyl acrylate	Ethyl acrylate	Ethyl acrylate	–	1
51796	51796	Ethyl Carbamate Chloride	Ethyl carbamate (Urethane)	Ethyl carbamate	Ethyl carbamate (urethane) chloride (chloroethane)	–	1
75003	75003	Ethyl Chloride	Ethyl chloride (Chloroethane)	Ethyl chloride	Ethyl chloride	–	1
100414	100414	Ethyl Benzene	Ethyl benzene	Ethyl benzene	Ethylbenzene	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
106934	106934	Ethylene Dibromide	Ethylene dibromide (Dibromoethane)	Ethylene dibromide	Ethylene dibromide (dibromoethane)	–	1
107062	107062	Ethylene Dichloride	Ethylene dichloride (1,2-Dichloroethane)	Ethylene dichloride	Ethylene dichloride (1,2-dichloroethane)	–	1
107211	107211	Ethylene Glycol	Ethylene glycol	Ethylene glycol	Ethylene glycol	–	1
75218	75218	Ethylene Oxide	Ethylene oxide	Ethylene oxide	Ethylene oxide	–	1
96457	96457	Ethylene Thiourea	Ethylene thiourea	Ethylene thiourea	Ethylene thiourea	–	1
151564	151564	Ethyleneimine	Ethylene imine (Aziridine)	Ethylene imine (aziridine)	Ethyleneimine (aziridine)	–	1
75343	75343	Ethylidene Dichloride (1,1-Dichloroethane)	Ethylidene dichloride (1,1-Dichloroethane)	Ethylidene dichloride	Ethylidene dichloride (1,1-dichloroethane)	–	1
383	None	Fine Mineral Fibers	Fine Mineral Fibers	Fine Mineral Fibers	Fine mineral fibers	–	1
50000	50000	Formaldehyde	Formaldehyde	Formaldehyde	Formaldehyde	–	1
171	None	Glycol Ethers	Glycol ethers	Glycol Ethers	Glycol ethers	–	1
7795917	7795917	Ethylene Glycol Mono-Sec-Butyl Ether	Glycol ethers	Ethylene Glycol Mono-Sec-Butyl Ether	Glycol ethers	–	1
112072	112072	2-Butoxyethyl Acetate	Glycol ethers	2-Butoxyethyl Acetate	Glycol ethers	–	1
122996	122996	Phenyl Cellosolve	Glycol ethers	Phenyl Cellosolve	Glycol ethers	–	1
143226	143226	Triglycol Monobutyl Ether	Glycol ethers	Triglycol Monobutyl Ether	Glycol ethers	–	1
1002671		Diethylene Glycol Ethyl Methyl Ether	Glycol ethers	Diethylene Glycol Ethyl Methyl Ether	Glycol ethers	–	1
629141	629141	Ethylene Glycol Diethyl Ether	Glycol ethers	Ethylene glycol Diethyl Ether	Glycol ethers	–	1
120558	120558	Diethylene Glycol Dibenzoate	Glycol ethers	Diethylene Glycol Dibenzoate	Glycol ethers	–	1
112367	112367	Diethylene Glycol Diethyl Ether	Glycol ethers	Diethylene Glycol Diethyl Ether	Glycol ethers	–	1
112594	112594	N-Hexyl Carbitol	Glycol ethers	N-Hexyl Carbitol	Glycol ethers	–	1
112152	112152	Carbitol Acetate	Glycol ethers	Carbitol Acetate	Glycol ethers	–	1
112505	112505	Ethoxytriglycol	Glycol ethers	Ethoxytriglycol	Glycol ethers	–	1
112356	112356	Methoxytriglycol	Glycol ethers	Methoxytriglycol	Glycol ethers	–	1
112345	112345	Diethylene Glycol Monobutyl Ether	Glycol ethers	Diethylene glycol monobutyl ether	Glycol ethers	–	1
124174	124174	Butyl Carbitol Acetate	Glycol ethers	Butyl Carbitol Acetate	Glycol ethers	–	1
112254	112254	2-(Hexyloxy)Ethanol	Glycol ethers	2-(Hexyloxy)Ethanol	Glycol ethers	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
111966	111966	Diethylene Glycol Dimethyl Ether	Glycol ethers	Diethylene Glycol Dimethyl Ether	Glycol ethers	–	1
109864	109864	Ethylene Glycol Methyl Ether	Glycol ethers	Ethylene glycol methyl ether	Glycol ethers	–	1
16672392	16672392	Di(Ethylene Glycol Monobutyl Ether) Phthalate	Glycol ethers	Di(Ethylene Glycol Monobutyl Ether) Phthalate	Glycol ethers	–	1
2807309	2807309	Propyl Cellosolve	Glycol ethers	Ethylene glycol methyl ether	Glycol ethers	–	1
1589497	1589497	3-Methoxy-1-Propanol	Glycol ethers	3-Methoxy-1-Propanol	Glycol ethers	–	1
764487	764487	Ethylene Glycol Monovinyl Ether	Glycol ethers	Ethylene Glycol Monovinyl Ether	Glycol ethers	–	1
112276	112276	Triethylene glycol	Glycol ethers	Triethylene glycol	Glycol ethers	–	1
67425	67425	(Ethylenebis(Oxyethylenenitrilo)) Tetraacetic Acid	Glycol ethers	(Ethylenebis(Oxyethylenenitrilo)) Tetraacetic Acid	Glycol ethers	–	1
111900	111900	Diethylene Glycol Monoethyl Ether	Glycol ethers	Diethylene glycol monoethyl ether	Glycol ethers	–	1
110496	110496	Ethylene Glycol Monomethyl Ether Acetate	Glycol ethers	Ethylene glycol methyl ether acetate	Glycol ethers	–	1
110714	110714	1,2-Dimethoxyethane	Glycol ethers	1,2-Dimethoxyethane	Glycol ethers	–	1
110805	110805	Cellosolve Solvent	Glycol ethers	Ethylene glycol ethyl ether	Glycol ethers	–	1
111159	111159	Cellosolve Acetate	Glycol ethers	Ethylene glycol ethyl ether acetate	Glycol ethers	–	1
111773	111773	Diethylene Glycol Monomethyl Ether	Glycol ethers	Diethylene Glycol Monomethyl Ether	Glycol ethers	–	1
76448	76448	Heptachlor	Heptachlor	Heptachlor	Heptachlor	–	1
118741	118741	Hexachlorobenzene	Hexachlorobenzene	Hexachlorobenzene	Hexachlorobenzene	–	1
87683	87683	Hexachlorobutadiene	Hexachlorobutadiene	Hexachlorobutadiene	Hexachlorobutadiene	–	1
77474	77474	Hexachlorocyclopentadiene	Hexachlorocyclopentadiene	Hexachlorocyclopentadiene	Hexachlorocyclopentadiene	–	1
67721	67721	Hexachloroethane	Hexachloroethane	Hexachloroethane	Hexachloroethane	–	1
822060	822060	Hexamethylene Diisocyanate	Hexamethylene-1,6-diisocyanate	Hexamethylene-1,6-diisocyanate	Hexamethylene diisocyanate	–	1
110543	110543	Hexane	Hexane	n-Hexane	Hexane	–	1
302012	302012	Hydrazine	Hydrazine	Hydrazine	Hydrazine	–	1
7647010	7647010	Hydrochloric Acid	Hydrochloric acid	Hydrochloric acid	Hydrochloric acid (hydrogen chloride [gas only])	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
7664393	7664393	Hydrogen Fluoride	Hydrogen fluoride (Hydrofluoric acid)	Hydrofluoric acid	Hydrogen fluoride (hydrofluoric acid)	–	1
123319	123319	Hydroquinone	Hydroquinone	Hydroquinone	Hydroquinone	–	1
78591	78591	Isophorone	Isophorone	Isophorone	Isophorone	–	1
7784409	7784409	Lead Arsenate	Lead Compounds	Lead as Lead Arsenate	Lead Compounds	Lead	0.5935
7446142	7446142	Lead Sulfate	Lead Compounds	Lead Sulfate	Lead Compounds	Lead	0.6788
7758976	7758976	Lead Chromate	Chromium Compounds	Chromium (VI) as Lead Chromate	Chromium Compounds	Chromium	0.1609
7758976	7758976	Lead Chromate	Lead Compounds	Lead as Lead Chromate	Lead Compounds	Pb	0.6411
7784409	7784409	Lead Arsenate	Arsenic Compounds (inorganic including arsine)	Arsenic as Lead Arsenate	Arsenic Compounds(inorganic including arsine)	Arsenic	0.2146
1309600	1309600	Lead Dioxide	Lead Compounds	Lead Dioxide	Lead Compounds	Lead	0.8662
7439921	7439921	Lead	Lead Compounds	Lead compounds	Lead Compounds	–	1
1335326	1335326	Lead Subacetate	Lead Compounds	Lead Subacetate	Lead Compounds	Lead	0.7696
195	None	Lead & Compounds	Lead Compounds	Lead compounds	Lead Compounds	–	1
18454121	18454121	Lead Chromate Oxide	Lead Compounds	Lead as Lead Chromate Oxide	Lead Compounds	Pb	0.7584
18454121	18454121	Lead Chromate Oxide	Chromium Compounds	Chromium (VI) as Lead Chromate Oxide	Chromium Compounds	Chromium	0.0952
602	None	Lead Compounds (Inorganic)	Lead Compounds	Lead compounds	Lead Compounds	–	1
78002	78002	Tetraethyl Lead	Lead Compounds	Lead compounds	Lead Compounds	Lead	0.6407
1317368	1317368	Lead (II) Oxide	Lead Compounds	Lead (II) Oxide	Lead Compounds	Lead	0.9283
108316	108316	Maleic Anhydride	Maleic anhydride	Maleic anhydride	Maleic Anhydride	–	1
7439965	7439965	Manganese	Manganese Compounds	Manganese compounds	Manganese Compounds	–	1
1317357	1317357	Manganese Tetroxide	Manganese Compounds	Manganese Tetroxide	Manganese Compounds	Manganese	0.7203
198	None	Manganese & Compounds	Manganese Compounds	Manganese compounds	Manganese Compounds	–	1
1317346	1317346	Manganese Trioxide	Manganese Compounds	Manganese Trioxide	Manganese Compounds	Manganese	0.6955
1313139	1313139	Manganese Dioxide	Manganese Compounds	Manganese Dioxide	Manganese Compounds	Manganese	0.6319
7785877	7785877	Manganese Sulfate	Manganese Compounds	Manganese Sulfate	Manganese Compounds	Manganese	0.3638
10377669	10377669	Manganese Nitrate	Manganese Compounds	Manganese Nitrate	Manganese Compounds	Manganese	0.3036
199	None	Mercury & Compounds[d]	Mercury Compounds	Mercury (elemental)	Mercury Compounds	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
200	7439976	Elemental Gaseous Mercury	Mercury Compounds	Mercury (elemental)	Mercury Compounds	–	1
7487947	7487947	Mercuric Chloride	Mercury Compounds	Mercuric chloride	Mercury Compounds	Mercury	0.7388
22967926	22967926	Mercury (Organic)	Mercury Compounds	Mercury (Organic)	Mercury Compounds	–	1
201	14302875	Gaseous Divalent Mercury	Mercury Compounds	Mercuric chloride	Mercury Compounds	–	1
7439976	7439976	Mercury[d]	Mercury Compounds	Mercury (elemental)	Mercury Compounds	–	1
7439976	7439976	Mercury[d]	Mercury Compounds	Mercuric chloride	Mercury Compounds	–	1
199	None	Mercury & Compounds[d]	Mercury Compounds	Mercuric chloride	Mercury Compounds	–	1
202	14302875	Particulate Divalent Mercury	Mercury Compounds	Mercuric chloride	Mercury Compounds	–	1
67561	67561	Methanol	Methanol	Methanol	Methanol	–	1
72435	72435	Methoxychlor	Methoxychlor	Methoxychlor	Methoxychlor	–	1
74839	74839	Methyl Bromide	Methyl bromide (Bromomethane)	Methyl bromide	Methyl bromide (bromomethane)	–	1
74873	74873	Methyl Chloride	Methyl chloride (Chloromethane)	Methyl chloride	Methyl chloride (chloromethane)	–	1
71556	71556	Methyl Chloroform	Methyl chloroform (1,1,1-Trichloroethane)	1,1,1-Trichloroethane	1,1,1-Trichloroethane	–	1
74884	74884	Methyl Iodide	Methyl iodide (Iodomethane)	Methyl iodide	Methyl iodide (iodomethane)	–	1
108101	108101	Methyl Isobutyl Ketone	Methyl isobutyl ketone (Hexone)	Methyl isobutyl ketone	Methyl isobutyl ketone (hexone)	–	1
624839	624839	Methyl Isocyanate	Methyl isocyanate	Methyl isocyanate	Methyl isocyanate	–	1
80626	80626	Methyl Methacrylate	Methyl methacrylate	Methyl methacrylate	Methyl methacrylate	–	1
1634044	1634044	Methyl Tert-Butyl Ether	Methyl tert butyl ether	Methyl tert-butyl ether	Methyl tert-butyl ether	–	1
75092	75092	Methylene Chloride	Methylene chloride (Dichloromethane)	Methylene chloride	Methylene chloride (dichloromethane)	–	1
60344	60344	Methylhydrazine	Methyl hydrazine	Methyl hydrazine	Methylhydrazine	–	1
121697	121697	N,N-Dimethylaniline	N,N-Dimethylaniline	N,N-dimethylaniline	n,n-Dimethylaniline	–	1
68122	68122	N,N-Dimethylformamide	Dimethyl formamide	Dimethyl formamide	Dimethyl formamide	–	1
91203	91203	Naphthalene	Naphthalene	Naphthalene	Naphthalene	–	1
10101970	10101970	Nickel (II) Sulfate Hexahydrate	Nickel Compounds	Nickel (II) Sulfate Hexahydrate	Nickel Compounds	Nickel	0.2234
1313991	1313991	Nickel Oxide	Nickel Compounds	Nickel oxide	Nickel Compounds	Nickel	0.7412
13138459	13138459	Nickel Nitrate	Nickel Compounds	Nickel nitrate	Nickel Compounds	Nickel	0.3213

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
7718549	7718549	Nickel Chloride	Nickel Compounds	Nickel chloride	Nickel Compounds	Nickel	0.453
226	None	Nickel & Compounds	Nickel Compounds	Nickel compounds	Nickel Compounds	–	1
7786814	7786814	Nickel Sulfate	Nickel Compounds	Nickel Sulfate	Nickel Compounds	Nickel	0.3794
373024	373024	Nickel Acetate	Nickel Compounds	Nickel Acetate	Nickel Compounds	Nickel	0.3321
7440020	7440020	Nickel	Nickel Compounds	Nickel compounds	Nickel Compounds	–	1
13770893	13770893	Nickel Sulfamate	Nickel Compounds	Nickel Sulfamate	Nickel Compounds	Nickel	0.234
98953	98953	Nitrobenzene	Nitrobenzene	Nitrobenzene	Nitrobenzene	–	1
62759	62759	N-Nitrosodimethylamine	N-Nitrosodimethylamine	Nitrosodimethylamine	n-Nitrosodimethylamine	–	1
59892	59892	N-Nitrosomorpholine	N-Nitrosomorpholine	N-Nitrosomorpholine	n-Nitrosomorpholine	–	1
90040	90040	o-Anisidine	o-Anisidine	Anisidine	Anisidine	–	1
95534	95534	o-Toluidine	o-Toluidine	o-Toluidine	o-Toluidine	–	1
123911	123911	p-Dioxane	1,4-Dioxane	1,4-Dioxane	1,4-Dioxane	–	1
82688	82688	Pentachloronitrobenzene	Pentachloronitrobenzene (Quintobenzene)	Pentachloronitrobenzene	Pentachloronitrobenzene (quintobenzene)	–	1
87865	87865	Pentachlorophenol	Pentachlorophenol	Pentachlorophenol	Pentachlorophenol	–	1
108952	108952	Phenol	Phenol	Phenol	Phenol	–	1
75445	75445	Phosgene	Phosgene	Phosgene	Phosgene	–	1
7803512	7803512	Phosphine	Phosphine	Phosphine	Phosphine	–	1
7723140	7723140	Phosphorus	Phosphorus	Phosphorus, white	Phosphorus	–	1
85449	85449	Phthalic Anhydride	Phthalic anhydride	Phthalic anhydride	Phthalic anhydride	–	1
1336363	1336363	Polychlorinated Biphenyls	Polychlorinated biphenyls (Aroclors)	Polychlorinated biphenyls	Polychlorinated biphenyls (aroclors)	–	1
249		15-PAH	Polycylic Organic Matter	POM 71002	PAHPOM	–	1
85018	85018	Phenanthrene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
86737	86737	Fluorene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
206440	206440	Fluoranthene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
129000	129000	Pyrene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
120127	120127	Anthracene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
83329	83329	Acenaphthene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
208968	208968	Acenaphthylene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
191242	191242	Benzo[g,h,i,]Perylene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
218019	218019	Chrysene	Polycylic Organic Matter	POM 77002	PAHPOM	–	1
193395	193395	Indeno[1,2,3-c,d]Pyrene	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
205992	205992	Benzo[b]Fluoranthene	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
207089	207089	Benzo[k]Fluoranthene	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
246	None	Polycyclic Organic Matter	Polycylic Organic Matter	POM 71002	PAHPOM	–	1
75	None	7-PAH	Polycylic Organic Matter	POM 78002	PAHPOM	–	1
102	None	Benzo[b+k]Fluoranthene	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
50328	50328	Benzo[a]Pyrene	Polycylic Organic Matter	POM 75002	PAHPOM	–	1
130498292	130498292	PAH, total	Polycylic Organic Matter	POM 71002	PAHPOM	–	1
53703	53703	Dibenzo[a,h]Anthracene	Polycylic Organic Matter	POM 75002	PAHPOM	–	1
130498292		PAH, Total	Polycylic Organic Matter	POM 71002	PAHPOM	–	1
56553	56553	Benz[a]Anthracene	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
56832736	56832736	Benzofluoranthenes	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
203338	203338	Benzo(a)Fluoranthene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
191300	191300	Dibenzo[a,l]Pyrene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
189640	189640	Dibenzo[a,h]Pyrene	Polycylic Organic Matter	POM 74002	PAHPOM	–	1
198550	198550	Perylene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
195197	195197	Benzo(c)phenanthrene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
189559	189559	Dibenzo[a,i]Pyrene	Polycylic Organic Matter	POM 74002	PAHPOM	–	1
192972	192972	Benzo[e]Pyrene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
91576	91576	2-Methylnaphthalene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
205823	205823	B[j]Fluoranthen	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
26914181	26914181	Methylanthracene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
3697243	3697243	5-Methylchrysene	Polycylic Organic Matter	POM 75002	PAHPOM	–	1
56495	56495	3-Methylcholanthrene	Polycylic Organic Matter	POM 75002	PAHPOM	–	1
57976	57976	7,12-Dimethylbenz[a]Anthracene	Polycylic Organic Matter	POM 73002	PAHPOM	–	1
40	None	16-PAH	Polycylic Organic Matter	POM 71002	PAHPOM	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
90120	90120	1-Methylnaphthalene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
5522430	5522430	1-Nitropyrene	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
8007452	8007452	Coal Tar	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
192654	192654	Dibenzo[a,e]Pyrene	Polycylic Organic Matter	POM 75002	PAHPOM	–	1
91587	91587	2-Chloronaphthalene	Polycylic Organic Matter	POM 72002	PAHPOM	–	1
224420	224420	Dibenzo[a,j]Acridine	Polycylic Organic Matter	POM 76002	PAHPOM	–	1
106503	106503	p-Phenylenediamine	p-Phenylenediamine	p-Phenylenediamine	p-Phenylenediamine	–	1
123386	123386	Propionaldehyde	Propionaldehyde	Propionaldehyde	Propionaldehyde	–	1
114261	114261	Propoxur	Propoxur (Baygon)	Propoxur	propoxur (baygon)	–	1
78875	78875	Propylene Dichloride	Propylene dichloride (1,2-Dichloropropane)	Propylene dichloride	Propylene dichloride (1,2-dichloropropane)	–	1
75569	75569	Propylene Oxide	Propylene oxide	Propylene oxide	Propylene oxide	–	1
91225	91225	Quinoline	Quinoline	Quinoline	Quinoline	–	1
106514	106514	Quinone	Quinone	Quinone	Quinone (p-benzoquinone)	–	1
606		Radon and Its Decay Products	Radionuclides (including radon)	Radon and its decay products	Not In Results	–	0
400	None	Radionuclides (Including Radon)	Radionuclides (including radon)	Radionuclides	Not In Results	–	0
605	None	Radionuclides	Radionuclides (including radon)	Radionuclides	Not In Results	–	0
7440611	7440611	Uranium	Radionuclides (including radon)	Uranium	Not In Results	–	0
7783791	7783791	Selenium Hexafluoride	Selenium Compounds	Selenium Hexafluoride	Selenium Compounds	Selenium	0.4092
7446084	7446084	Selenium Dioxide	Selenium Compounds	Selenium Dioxide	Selenium Compounds	Selenium	0.7116
253	None	Selenium & Compounds	Selenium Compounds	Selenium compounds	Selenium Compounds	–	1
7782492	7782492	Selenium	Selenium Compounds	Selenium compounds	Selenium Compounds	–	1
12640890	12640890	Selenium Oxide	Selenium Compounds	Selenium Oxide	Selenium Compounds	Selenium	0.8315
100425	100425	Styrene	Styrene	Styrene	Styrene	–	1
96093	96093	Styrene Oxide	Styrene oxide	Styrene oxide	Styrene oxide	–	1
127184	127184	Tetrachloroethylene	Tetrachloroethylene (Perchloroethylene)	Tetrachloroethene	Tetrachloroethylene (perchloroethylene)	–	1
7550450	7550450	Titanium Tetrachloride	Titanium tetrachloride	Titanium tetrachloride	Titanium tetrachloride	–	1

Exhibit C-1. Crosswalk for Air Toxics Names in NEI, the NATA Toxicity Table, NATA Results, and the Clean Air Act, and Metal and Cyanide Speciation Factors[a]

NEI Air Toxics Code	CAS Number	Air Toxic Name				Metal for Speciation	Metal/Cyanide Speciation Factor [c]
		In NEI and NATA Inventories	In Exhibit B-1[b] (1990 Clean Air Act Names)	In Exhibit H-1[b] (NATA Toxicity Table Names)	In NATA Results		
108883	108883	Toluene	Toluene	Toluene	Toluene	–	1
95807	95807	Toluene-2,4-Diamine	2,4-Toluene diamine	2,4-Toluene diamine	2,4-Toluene diamine	–	1
8001352	8001352	Toxaphene	Toxaphene (chlorinated camphene)	Toxaphene	Toxaphene (chlorinated camphene)	–	1
79016	79016	Trichloroethylene	Trichloroethylene	Trichloroethylene	Trichloroethylene	–	1
121448	121448	Triethylamine	Triethylamine	Triethylamine	Triethylamine	–	1
1582098	1582098	Trifluralin	Trifluralin	Trifluralin	Trifluralin	–	1
108054	108054	Vinyl Acetate	Vinyl acetate	Vinyl acetate	Vinyl acetate	–	1
593602	593602	Vinyl Bromide	Vinyl bromide	Vinyl bromide	Vinyl bromide	–	1
75014	75014	Vinyl Chloride	Vinyl chloride	Vinyl chloride	Vinyl chloride	–	1
75354	75354	Vinylidene Chloride	Vinylidene chloride (1,1-Dichloroethylene)	Vinylidene chloride	Vinylidene chloride (1,1-dichloroethylene)	–	1
1330207	1330207	Xylenes (Mixture of o, m, and p Isomers)	Xylenes (isomers and mixture)	Xylenes (mixed)	Xylenes (mixed isomers)	–	1
106423	106423	p-Xylene	p-xylenes	p-Xylene	Xylenes (mixed isomers)	–	1
108383	108383	m-Xylene	m-xylenes	m-Xylene	Xylenes (mixed isomers)	–	1
95476	95476	o-Xylene	o-xylenes	o-Xylene	Xylenes (mixed isomers)	–	1

[a] Applies to the 2005 NATA; can differ for previous or future versions of the assessment; NEI = National Emissions Inventory.

[b] Exhibit B-1 and Exhibit H-1 are contained in Appendix B and Appendix H, respectively, to this document.

[c] Some NEI HAPs are speciated into more than one metal or into a metal and cyanide (CN).

[d] Separate chromium (Appendix D to this document, Exhibit D-1) and mercury (Appendix D to this document, Exhibit D-2) speciation tables are used to speciate source category emissions into hexavalent and trivalent chromium emissions and into divalent and elemental mercury emissions.

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Appendix D

Additional Information Used to Process the 2005 NATA Inventory: Chromium and Mercury Speciation Tables, MACT Code Descriptions, and Non-point and Mobile Source SCC Groupings

As described in Section 2 of this document, emissions reported in the National Emissions Inventory (NEI) as "chromium compounds" and "chromium" are both partitioned to amounts of hexavalent chromium (Cr(VI)) and trivalent chromium (Cr(III)). Similarly, "mercury compounds" and "mercury" are both partitioned to amounts of divalent mercury (Hg2) and elemental mercury (Hg0). Factors used in the 2005 National-scale Air Toxics Assessment (NATA) for speciating chromium emissions into hexavalent and trivalent chromium are presented in Exhibit D-1, and factors for speciating mercury emissions into divalent and elemental mercury are presented in Exhibit D-2. The relative emissions of each species are estimated according to characteristics of the emitting sources, which are represented in NEI by Maximum Achievable Control Technology (MACT) codes, Source Classification Codes (SCCs), and Standard Industrial Classifications (SICs) assigned in NEI to each source. Descriptions of each MACT code included in these two tables are presented in Exhibit D-3 for reference. The speciation factors used to apportion unspecified chromium and mercury emissions were developed for the 2005 NATA using information from EPA engineers and input from the public, states, and industries.

Exhibits D-1 and D-2 list the chromium and mercury speciation factors used in the 2005 NATA for various MACT codes, SCCs, and SICs. For each source reporting unspeciated chromium or mercury, the associated MACT code, SCC, or SIC was used to apportion the emissions to the appropriate species. MACT code was used as the first priority when available and SCC as the second priority (e.g., SCC was used to apportion chromium emissions if the MACT code for the emitting source was not included in Exhibit D-1). If none of these three codes are listed in the speciation table for a given source, a national default speciation factor was used for that source. The national default applied for chromium for the 2005 NATA was 34 percent hexavalent chromium and 66 percent trivalent chromium. For mercury, the national default was to divide the emissions evenly between divalent and elemental mercury (i.e., a 50/50 split). In a few cases (e.g., some pulp and paper records and some boiler records), the chromium speciation assignment was based both on a record's MACT code and its SCC.

Also included in this appendix (not related to the chromium/mercury speciation factors) are two sets of categories used to group results for the 2005 NATA. For the purpose of assessing potential health risks from certain industries and activities, non-point sources and mobile sources were grouped into the categories shown in Exhibits D-4 and D-5. These categories are based on MACT and SCC codes.

Exhibit D-1. Chromium Speciation Table Used for the 2005 NATA

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
0105			18	82
0105-1			4	96
0105-2	20300101		12	88
0105-2	20300101		12	88
0105-2			18	82
0107	10200401		10	90
0107	10200401		10	90
0107			56	44
0107-1	10200201		56	44
0107-1	10200201		56	44
0107-1	10200202		56	44
0107-1	10200202		56	44
0107-1	10200203		56	44
0107-1	10200203		56	44
0107-1	10200204		56	44
0107-1	10200204		56	44
0107-1	10200205		56	44
0107-1	10200205		56	44
0107-1	10200212		56	44
0107-1	10200212		56	44
0107-1	10200218		56	44
0107-1	10200218		56	44
0107-1	10200222		56	44
0107-1	10200222		56	44
0107-1	10200802		56	44
0107-1	10200802		56	44
0107-1	10300206		56	44
0107-1	10300206		56	44
0107-1			12	88
0107-2	10200601		19	81
0107-2	10200601		19	81
0107-2	10200602		19	81
0107-2	10200602		19	81
0107-2	10200603		19	81
0107-2	10200603		19	81
0107-2	10200604		19	81
0107-2	10200604		19	81
0107-2	10200799		19	81
0107-2	10200799		19	81
0107-2	10300601		19	81
0107-2	10300601		19	81
0107-2	10300602		19	81
0107-2	10300602		19	81
0107-2	10300603		19	81
0107-2	10300603		19	81
0107-2	10500106		19	81
0107-2	10500106		19	81
0107-2	30790003		19	81
0107-2	30790003		19	81
0107-2	39000699		19	81
0107-2	39000699		19	81
0107-2			4	96
0107-3	10200401		56	44
0107-3	10200401		56	44
0107-3	10200402		56	44
0107-3	10200402		56	44
0107-3	10200405		56	44
0107-3	10200405		56	44
0107-3	10200501		56	44
0107-3	10200501		56	44
0107-3	10200502		56	44
0107-3	10200502		56	44
0107-3	10201302		56	44
0107-3	10201302		56	44
0107-3	10300401		56	44
0107-3	10300401		56	44
0107-3	10300501		56	44
0107-3	10300501		56	44
0107-3	10500206		56	44
0107-3	10500206		56	44
0107-3			18	82
0107-4	10200901		0	100
0107-4	10200901		0	100
0107-4	10200902		0	100
0107-4	10200902		0	100
0107-4	10200903		0	100
0107-4	10200903		0	100
0107-4	10200905		0	100
0107-4	10200905		0	100
0107-4	10200907		0	100
0107-4	10200907		0	100
0107-4	10200908		0	100
0107-4	10200908		0	100
0107-4	10200911		0	100
0107-4	10200911		0	100
0107-4	10200912		0	100
0107-4	10200912		0	100
0107-4	10201201		0	100
0107-4	10201201		0	100
0107-4	10300902		0	100
0107-4	10300902		0	100
0107-4			56	44
0108-1			4	96
0108-2			18	82
0201			3	97
0202			100	0
0202-1			100	0
0202-2			100	0
0203			3	97
0204			3	97
0205			1	99
0207			3	97
0260			3	97
0262			3	97
0266			3	97
0267			3	97
0302			3	97
0304			3	97
0305			3	97
0308			3	97
0361			3	97
0362			3	97
0363			3	97
0364			12	88
0410			8	92
0412			100	0
0414			43	57
0418			5	95
0502			10	90
0503			10	90
0560			10	90
0601			10	90
0701			25	75
0716			0	100
0801			19	81
0801-1			19	81
0801-2			19	81
0801-3			8	92
0801-4			19	81

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
0801-5			19	81
0801-6			19	81
0801-7			19	81
1460			25	75
1461			25	75
1607			98	2
1610			98	2
1615			98	2
1624	30700799		18	82
1624	30700799		18	82
1624			28	72
1626-1	10200602		4	96
1626-1	10200709		34	66
1626-1	10200799		4	96
1626-1	30700121		19	81
1626-1	30700121		19	81
1626-1	30700122		25	75
1626-1	30700122		25	75
1626-1	30700199		25	75
1626-1	30700199		25	75
1626-1	30700405		25	75
1626-1	30700405		25	75
1626-1	30701399		3	97
1626-1	30701399		3	97
1626-1	30799998		100	0
1626-1	30799999		98	2
1626-1	30799999		98	2
1626-1	39000699		4	96
1626-1	39999992		3	97
1626-1	39999992		3	97
1626-1	39999999		25	75
1626-1	39999999		25	75
1626-1	null		100	0
1626-2	10100202		12	88
1626-2	10100204		12	88
1626-2	10100212		12	88
1626-2	10200204		12	88
1626-2	30700104		25	75
1626-2	30700104		25	75
1626-2	30700105		1.6	98.4
1626-2	30700105		1.6	98.4
1626-2	30700106		1.6	98.4
1626-2	30700106		1.6	98.4
1626-2	30700110		19	81
1626-2	30700110		19	81

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
1626-2	30700199		100	0
1626-2	30700221		34	66
1626-2	30700222		0	100
1626-2	30700222		0	100
1626-2	30700223		34	66
1626-2	30700303		0	100
1626-2	30700303		0	100
1626-2	30700399		0	100
1626-2	30700399		0	100
1626-2	30790001		18	82
1626-2	30790002		18	82
1626-2	30790003		3	97
1626-2	30790003		3	97
1626-2	30790011		18	82
1626-2	30790012		18	82
1626-2	30790013		4	96
1626-2	30790014		4	96
1626-2	30790021		18	82
1626-2	39000403		3	97
1626-2	39000403		3	97
1626-2	39000503		18	82
1626-2	39000602		0	100
1626-2	39000602		0	100
1626-2	39000603		3	97
1626-2	39000603		3	97
1626-2	39000699		4	96
1626-2	39000699		4	96
1626-2	39999999		18	82
1626-2	39999999		18	82
1626-2	50300506		19	81
1626-2	null		100	0
1626-3	10200602		4	96
1626-3	39000699		0	100
1626-3	39000699		0	100
1626-3	50300101		0	100
1626-3	50300101		0	100
1626-3	50300107		19	81
1626-3	50300107		19	81
1626-3	50300506		4	96
1626-3	50300506		4	96
1626-3	null		100	0
1666			1.6	98.4
1669			1.6	98.4
1801			19	81
1802			19	81

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
1802-1			19	81
1802-2			19	81
1807-1			19	81
1807-2			19	81
1808-1			12	88
1808-2	10100601		3	97
1808-2	10100601		3	97
1808-2			4	96
1808-3			18	82
1808-4			56	44
1860			19	81
	204001		18	82
	402010		4	96
	501001		19	81
	10100101		12	88
	10100201		12	88
	10100202		12	88
	10100203		12	88
	10100204		12	88
	10100205		12	88
	10100211		12	88
	10100212		12	88
	10100215		12	88
	10100217		12	88
	10100218		12	88
	10100221		12	88
	10100222		12	88
	10100223		12	88
	10100224		12	88
	10100226		12	88
	10100238		12	88
	10100301		12	88
	10100302		12	88
	10100303		12	88
	10100318		12	88
	10100401		18	82
	10100404		18	82
	10100501		18	82
	10100601		4	96
	10100602		4	96
	10100604		4	96
	10100701		4	96
	10100702		4	96
	10100703		4	96
	10100801		4	96

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	10100901		56	44
	10100902		56	44
	10100903		56	44
	10100911		56	44
	10101002		4	96
	10101201		56	44
	10101202		56	44
	10101208		56	44
	10101301		56	44
	10101302		56	44
	10101901		12	88
	10102001		12	88
	10102018		12	88
	10200101		12	88
	10200104		12	88
	10200201		12	88
	10200202		12	88
	10200203		12	88
	10200204		12	88
	10200205		12	88
	10200206		12	88
	10200212		12	88
	10200217		12	88
	10200218		12	88
	10200219		12	88
	10200222		12	88
	10200224		12	88
	10200225		12	88
	10200226		12	88
	10200301		12	88
	10200302		12	88
	10200303		12	88
	10200306		12	88
	10200307		12	88
	10200401		18	82
	10200402		18	82
	10200403		18	82
	10200404		18	82
	10200405		18	82
	10200501		18	82
	10200502		18	82
	10200503		18	82
	10200504		18	82
	10200505		18	82
	10200601		4	96

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	10200602		4	96
	10200603		4	96
	10200604		4	96
	10200701		4	96
	10200704		4	96
	10200707		4	96
	10200710		4	96
	10200799		4	96
	10200802		12	88
	10200804		12	88
	10200901		56	44
	10200902		56	44
	10200903		56	44
	10200904		56	44
	10200905		56	44
	10200906		56	44
	10200907		56	44
	10200908		56	44
	10200910		56	44
	10200911		56	44
	10200912		56	44
	10201001		4	96
	10201002		4	96
	10201201		56	44
	10201202		56	44
	10201301		56	44
	10201302		18	82
	10201401		4	96
	10201403		18	82
	10201404		18	82
	10300102		12	88
	10300205		12	88
	10300206		12	88
	10300207		12	88
	10300208		12	88
	10300209		12	88
	10300216		12	88
	10300217		12	88
	10300218		12	88
	10300222		12	88
	10300223		12	88
	10300224		12	88
	10300401		18	82
	10300402		18	82
	10300403		18	82

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	10300404		18	82
	10300501		18	82
	10300502		18	82
	10300503		18	82
	10300504		18	82
	10300601		4	96
	10300602		4	96
	10300603		4	96
	10300799		4	96
	10300811		4	96
	10300901		56	44
	10300902		56	44
	10300903		56	44
	10300908		56	44
	10301002		4	96
	10301201		56	44
	10301202		56	44
	10301301		18	82
	10301302		18	82
	10500102		12	88
	10500105		18	82
	10500106		4	96
	10500110		4	96
	10500113		18	82
	10500114		18	82
	10500205		18	82
	10500206		4	96
	10500214		18	82
	20100101		18	82
	20100102		18	82
	20100105		18	82
	20100107		18	82
	20100201		4	96
	20100202		4	96
	20100901		18	82
	20101001		18	82
	20101010		18	82
	20101020		18	82
	20101021		18	82
	20101031		18	82
	20200101		18	82
	20200102		18	82
	20200103		18	82
	20200107		18	82
	20200201		4	96

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	20200202		4	96
	20200203		4	96
	20200204		4	96
	20200252		4	96
	20200253		4	96
	20200254		4	96
	20200301		18	82
	20200401		18	82
	20200402		18	82
	20200701		4	96
	20200901		18	82
	20200902		18	82
	20201607		18	82
	20201609		18	82
	20300101		18	82
	20300102		18	82
	20300201		4	96
	20300202		4	96
	20300301		18	82
	20400101		18	82
	20400102		18	82
	20400110		18	82
	20400111		18	82
	20400112		18	82
	20400199		18	82
	20400202		4	96
	20400299		4	96
	20400302		18	82
	20400303		18	82
	20400305		18	82
	20400401		18	82
	20400402		18	82
	20400404		18	82
	27300320		4	96
	27602011		18	82
	28888801		18	82
	30101699		25	75
	30101704		25	75
	30102127		25	75
	30102308		25	75
	30103099		25	75
	30103554		19	81
	30103599		25	75
	30103601		25	75
	30103602		25	75

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30103603		25	75
	30103604		25	75
	30103605		25	75
	30103606		25	75
	30103607		25	75
	30103608		25	75
	30103609		25	75
	30103699		25	75
	30103801		25	75
	30107001		25	75
	30107002		25	75
	30111201		25	75
	30112599		25	75
	30187097		25	75
	30187098		25	75
	30190001		18	82
	30190003		4	96
	30190004		4	96
	30190011		18	82
	30190013		4	96
	30190014		4	96
	30201601		12	88
	30290001		18	82
	30290003		4	96
	30300101		3	97
	30300105		3	97
	30300106		3	97
	30300108		3	97
	30300199		3	97
	30300302		3	97
	30300303		3	97
	30300304		3	97
	30300399		3	97
	30300603		3	97
	30300604		3	97
	30300621		3	97
	30300623		3	97
	30300625		3	97
	30300701		3	97
	30300702		3	97
	30300808		3	97
	30300809		3	97
	30300819		3	97
	30300820		3	97
	30300821		3	97

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30300825		3	97
	30300826		3	97
	30300833		3	97
	30300834		3	97
	30300899		3	97
	30300904		3	97
	30300906		3	97
	30300907		3	97
	30300908		3	97
	30300910		3	97
	30300911		3	97
	30300912		3	97
	30300913		3	97
	30300914		3	97
	30300915		3	97
	30300916		3	97
	30300917		3	97
	30300920		3	97
	30300921		3	97
	30300922		3	97
	30300924		3	97
	30300928		3	97
	30300931		3	97
	30300932		3	97
	30300933		3	97
	30300936		3	97
	30300998		3	97
	30300999		3	97
	30301299		3	97
	30301512		3	97
	30301518		3	97
	30301521		3	97
	30301523		3	97
	30302312		4	96
	30302313		18	82
	30302314		12	88
	30303015		3	97
	30388801		3	97
	30390001		18	82
	30390003		4	96
	30390004		4	96
	30390024		4	96
	30399999		3	97
	30400101		100	0
	30400102		100	0

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30400103		100	0
	30400107		100	0
	30400108		100	0
	30400109		100	0
	30400120		100	0
	30400121		100	0
	30400199		100	0
	30400207		3	97
	30400214		3	97
	30400219		3	97
	30400220		3	97
	30400224		3	97
	30400239		3	97
	30400299		3	97
	30400301		3	97
	30400303		3	97
	30400304		3	97
	30400315		3	97
	30400318		3	97
	30400320		3	97
	30400322		3	97
	30400325		3	97
	30400331		3	97
	30400333		3	97
	30400340		3	97
	30400350		3	97
	30400360		3	97
	30400398		3	97
	30400399		3	97
	30400401		1	99
	30400402		1	99
	30400403		1	99
	30400407		1	99
	30400410		1	99
	30400413		1	99
	30400414		1	99
	30400415		1	99
	30400416		1	99
	30400418		1	99
	30400419		1	99
	30400421		1	99
	30400422		1	99
	30400423		1	99
	30400426		1	99
	30400499		1	99

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30400701		12	88
	30400704		3	97
	30400705		12	88
	30400706		3	97
	30400708		3	97
	30400709		3	97
	30400711		3	97
	30400712		3	97
	30400713		3	97
	30400714		3	97
	30400715		3	97
	30400724		3	97
	30400732		12	88
	30400733		12	88
	30400744		3	97
	30400745		3	97
	30400768		3	97
	30400799		3	97
	30400899		3	97
	30400999		3	97
	30401002		3	97
	30401099		3	97
	30402004		3	97
	30402201		3	97
	30405001		3	97
	30405099		3	97
	30488801		3	97
	30490001		18	82
	30490002		18	82
	30490003		4	96
	30490013		4	96
	30490023		4	96
	30490031		18	82
	30490033		4	96
	30490034		4	96
	30499999		3	97
	30500102		5	95
	30500108		5	95
	30500151		5	95
	30500199		5	95
	30500201		5	95
	30500202		5	95
	30500203		5	95
	30500204		5	95
	30500205		5	95

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30500206		5	95
	30500208		5	95
	30500209		5	95
	30500211		5	95
	30500213		5	95
	30500215		5	95
	30500240		5	95
	30500241		5	95
	30500242		5	95
	30500245		5	95
	30500246		5	95
	30500247		5	95
	30500251		5	95
	30500252		5	95
	30500255		5	95
	30500258		5	95
	30500261		5	95
	30500290		5	95
	30500298		5	95
	30500299		5	95
	30500310		43	57
	30500311		43	57
	30500312		43	57
	30500313		43	57
	30500314		43	57
	30500316		43	57
	30500335		43	57
	30500397		43	57
	30500606		8	92
	30500607		8	92
	30500608		8	92
	30500609		8	92
	30500610		8	92
	30500611		8	92
	30500612		8	92
	30500613		8	92
	30500614		8	92
	30500615		8	92
	30500616		8	92
	30500617		8	92
	30500618		8	92
	30500619		8	92
	30500620		8	92
	30500621		8	92
	30500622		8	92

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30500623		8	92
	30500629		8	92
	30500699		8	92
	30500706		8	92
	30500714		8	92
	30500717		8	92
	30500799		8	92
	30500801		43	57
	30500806		43	57
	30500812		43	57
	30500899		43	57
	30501101		0.5	99.5
	30501106		0.5	99.5
	30501107		0.5	99.5
	30501108		0.5	99.5
	30501109		0.5	99.5
	30501110		0.5	99.5
	30501111		0.5	99.5
	30501112		0.5	99.5
	30501113		0.5	99.5
	30501114		0.5	99.5
	30501115		0.5	99.5
	30501120		0.5	99.5
	30501199		0.5	99.5
	30501201		100	0
	30501202		100	0
	30501203		100	0
	30501205		100	0
	30501207		100	0
	30501222		100	0
	30501223		100	0
	30501299		100	0
	30501999		25	75
	30505001		5	95
	30590001		18	82
	30590002		18	82
	30590003		4	96
	30600101		18	82
	30600103		18	82
	30600104		4	96
	30600105		4	96
	30600106		4	96
	30600111		18	82
	30600201		10	90
	30600202		10	90

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30600301		10	90
	30600401		10	90
	30600602		10	90
	30600701		10	90
	30600702		10	90
	30600801		10	90
	30600816		10	90
	30600822		10	90
	30600904		4	96
	30601101		10	90
	30601401		10	90
	30601402		10	90
	30609904		10	90
	30688801		10	90
	30699998		10	90
	30699999		10	90
	30700104		25	75
	30700105		100	0
	30700106		10	90
	30700110		75	25
	30700121		0	100
	30700122		0	100
	30700199		100	0
	30700221		34	66
	30700222		34	66
	30700223		34	66
	30700303		34	66
	30700399		100	0
	30700405		4	96
	30700610		28	72
	30700701		28	72
	30700703		28	72
	30700709		28	72
	30700720		28	72
	30700740		28	72
	30701001		28	72
	30701010		28	72
	30702098		0	100
	30702099		0	100
	30790001		18	82
	30790002		18	82
	30790003		4	96
	30790011		18	82
	30790012		18	82
	30790013		4	96

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	30790014		4	96
	30790021		18	82
	30799998		100	0
	30799999		100	0
	30890003		4	96
	30890013		4	96
	30890023		4	96
	30901001		98	2
	30901002		98	2
	30901003		98	2
	30901005		98	2
	30901006		98	2
	30901014		98	2
	30901015		98	2
	30901018		98	2
	30901028		98	2
	30901038		98	2
	30901097		98	2
	30901098		98	2
	30901099		98	2
	30904001		1.6	98.4
	30904010		1.6	98.4
	30904020		1.6	98.4
	30990001		18	82
	30990003		4	96
	30990013		4	96
	30990023		4	96
	31000203		4	96
	31000205		4	96
	31000401		18	82
	31000402		18	82
	31000403		18	82
	31000404		4	96
	31000405		4	96
	31000411		18	82
	31000412		18	82
	31000413		18	82
	31390003		4	96
	31502088		19	81
	31502101		19	81
	31502102		19	81
	31615001		99	1
	31616003		99	1
	39000201		12	88
	39000289		12	88

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	39000299		12	88
	39000403		18	82
	39000499		18	82
	39000501		18	82
	39000503		18	82
	39000599		18	82
	39000602		4	96
	39000603		4	96
	39000605		4	96
	39000689		4	96
	39000699		4	96
	39000701		4	96
	39000788		4	96
	39000797		4	96
	39000798		4	96
	39000889		12	88
	39000899		12	88
	39000989		56	44
	39000999		56	44
	39001099		4	96
	39001299		56	44
	39001399		56	44
	39900601		4	96
	39990003		4	96
	39990013		4	96
	39990024		4	96
	40200803		4	96
	40200840		4	96
	40201001		4	96
	40201901		0	100
	40201999		0	100
	40202401		25	75
	40202402		25	75
	40202406		25	75
	40202499		25	75
	40290013		4	96
	49090013		4	96
	50100101		19	81
	50100102		19	81
	50100103		19	81
	50100104		19	81
	50100105		19	81
	50100106		19	81
	50100421		4	96
	50100505		19	81

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	50100506		19	81
	50100515		19	81
	50100516		19	81
	50100518		19	81
	50100601		18	82
	50100602		18	82
	50100701		19	81
	50100799		19	81
	50190005		19	81
	50190006		19	81
	50200101		19	81
	50200102		19	81
	50200103		19	81
	50200501		19	81
	50200502		19	81
	50200503		19	81
	50200504		19	81
	50200505		19	81
	50200506		19	81
	50200518		19	81
	50290006		4	96
	50300101		19	81
	50300102		19	81
	50300104		19	81
	50300107		19	81
	50300111		19	81
	50300112		19	81
	50300113		19	81
	50300114		19	81
	50300204		12	88
	50300501		19	81
	50300504		19	81
	50300506		19	81
	50300599		19	81
	50390006		4	96
	50410535		19	81
	2101001000		12	88
	2101002000		12	88
	2101004000		18	82
	2101005000		18	82
	2101006000		4	96
	2102001000		12	88
	2102002000		12	88
	2102004000		18	82
	2102005000		18	82

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	2102006000		4	96
	2102006002		4	96
	2102007000		4	96
	2102008000		56	44
	2102011000		18	82
	2102012000		18	82
	2103001000		12	88
	2103002000		12	88
	2103004000		18	82
	2103005000		18	82
	2103006000		4	96
	2103007000		4	96
	2103008000		56	44
	2103011000		18	82
	2103011005		18	82
	2104001000		12	88
	2104002000		12	88
	2104004000		18	82
	2104006000		4	96
	2104006010		4	96
	2104007000		4	96
	2104008000		56	44
	2104008001		56	44
	2104008010		56	44
	2104008030		56	44
	2104008050		56	44
	2104008051		56	44
	2104008070		56	44
	2104011000		18	82
	2199001000		12	88
	2199004000		18	82
	2199004001		18	82
	2199004002		18	82
	2199005000		18	82
	2199006001		4	96
	2199011000		18	82
	220*		18	82
	223*		18	82
	226*		18	82
	227*		18	82
	228*		18	82
	2301000000		25	75
	2301020000		25	75
	2303000000		3	97
	2306000000		10	90

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
	2309000000		98	2
	2309100010		98	2
	2309100030		98	2
	2309100050		98	2
	2312000000		1.6	98.4
	2601020000		19	81
	2801520000		18	82
	2801520004		18	82
	2805000000		19	81
	2810060100		19	81
	2810060200		19	81
		28	25	75
		213	19	81
		241	19	81
		251	19	81
		252	19	81
		253	19	81
		279	19	81
		333	3	97
		742	19	81
		752	19	81
		971	19	81
		2421	28	72
		2431	28	72
		2435	28	72
		2436	28	72
		2439	28	72
		2449	28	72
		2493	28	72
		2499	28	72
		2511	0	100
		2512	0	100
		2517	0	100
		2519	0	100
		2521	0	100
		2531	0	100
		2541	0	100
		2591	0	100
		2599	0	100
		2611	100	0
		2621	100	0
		2631	100	0
		2800	25	75

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
		2812	25	75
		2813	25	75
		2816	25	75
		2819	25	75
		2873	25	75
		2874	25	75
		2875	25	75
		2879	25	75
		2892	25	75
		2899	25	75
		2911	10	90
		2951	3	97
		2952	5	95
		2992	10	90
		2999	10	90
		3241	8	92
		3251	43	57
		3253	43	57
		3255	43	57
		3259	43	57
		3261	43	57
		3264	43	57
		3269	43	57
		3273	0.5	99.5
		3312	3	97
		3313	3	97
		3315	3	97
		3316	3	97
		3317	3	97
		3321	3	97
		3322	3	97
		3324	3	97
		3325	3	97
		3331	3	97
		3334	3	97
		3339	3	97
		3341	3	97
		3351	3	97
		3353	3	97
		3354	3	97
		3355	3	97
		3356	3	97
		3357	3	97

MACT Code	SCC	SIC	% Cr(VI)	% Cr(III)
		3363	3	97
		3364	3	97
		3365	3	97
		3366	3	97
		3369	3	97
		3398	3	97
		3399	3	97
		3469	98	2
		3471	98	2
		3479	1.6	98.4
		3511	4	96
		3569	1.6	98.4
		3720	25	75
		3721	25	75
		3724	25	75
		3728	25	75
		3761	25	75
		3764	25	75
		3769	25	75
		3820	14	86
		3821	14	86
		3822	14	86
		3823	14	86
		3824	14	86
		3825	14	86
		3826	14	86
		3827	14	86
		3829	14	86
		3861	99	1
		4911	18	82
		4931	18	82
		4939	18	82
		4952	19	81
		4953	19	81
		4959	19	81
		6553	19	81
		7261	19	81

Exhibit D-2. Mercury Speciation Table Used in the 2005 NATA

MACT Code	SCC	SIC	% Hg2	% Hg0
0101-1			50	50
0101-2			50	50
0105			50	50
0105-1			50	50
0105-2			50	50
0107			50	50
0107-1			50	50
0107-2			50	50
0107-3			50	50
0107-4			50	50
0108-2			50	50
0201			20	80
0202			20	80
0202-1			20	80
0202-2			20	80
0203			20	80
0205			20	80
0207			20	80
0260			20	80
0262			20	80
0263			20	80
0266			20	80
0267			20	80
0304			20	80
0305			20	80
0308			20	80
0310			20	80
0363			20	80
0364			20	80
0406			20	80
0408			20	80
0409			20	80
0410			25	75
0411			20	80
0412			20	80
0414			20	80
0418			20	80
0460			20	80
0502			20	80
0503			20	80
0560			20	80
0601			20	80
0701			20	80
0710			20	80
0712			20	80
0715			20	80
0801			78	22
0801-1			78	22
0801-2			78	22
0801-3			78	22
0801-4			78	22
0801-5			78	22
0801-6			78	22
0801-7			78	22
0802			20	80
0803			20	80
0805			78	22
0960			20	80
1103			20	80
1160			20	80
1201			20	80
1337			20	80
1347			20	80
1403			5	95
1405			20	80
1407			20	80
1410			20	80
1411			20	80
1415			20	80
1460			20	80
1461			20	80
1501			20	80
1560			20	80
1626-2			50	50
1626-3			50	50
1641			20	80
1642			20	80
1660			20	80
1664			20	80
1666			20	80
1667			20	80
1669			20	80
1801			95	5
1802-1			78	22
1802-2			78	22
1807-1			78	22
1807-2			78	22
1808-1			0	0
1808-3			50	50
1808-4			50	50
1860			78	22
MLTPH			20	80
	10100101		50	50
	20101020		50	50
	28000212		50	50
	28000217		50	50
	30102923		20	80
	30200410		20	80
	30200499		20	80
	30200513		20	80
	30200601		20	80
	30200602		20	80
	30200603		20	80
	30200604		20	80
	30200605		20	80
	30200606		20	80
	30200607		20	80
	30200608		20	80
	30200609		20	80
	30200611		20	80
	30200771		20	80
	30200772		20	80
	30200773		20	80
	30200774		20	80
	30200799		20	80
	30200899		20	80
	30288801		20	80
	30288802		20	80
	30400401		20	80
	30400414		20	80
	30500610		25	75
	30500612		25	75
	30500613		25	75
	30500618		25	75
	30500621		25	75
	30500706		25	75

MACT Code	SCC	SIC	% Hg2	% Hg0
	30501001		50	50
	30501010		50	50
	30501011		50	50
	30501015		50	50
	30501031		50	50
	30501101		25	75
	30501106		25	75
	30501107		25	75
	30501108		25	75
	30501109		25	75
	30501110		25	75
	30501111		25	75
	30501112		25	75
	30501113		25	75
	30501199		25	75
	30501403		20	80
	30501499		20	80
	30501504		20	80
	30501507		20	80
	30501513		20	80
	30501599		20	80
	30502001		50	50
	30502002		50	50
	30502004		50	50
	30502006		50	50
	30502007		50	50
	30502011		50	50
	30502015		50	50
	30502032		50	50
	30502099		50	50
	30502501		20	80
	30502503		20	80
	30502504		20	80
	30502505		20	80
	30502506		20	80
	30502507		20	80
	30502510		20	80
	30502511		20	80
	30502699		20	80
	30502709		20	80
	30502910		78	22
	30504033		20	80
	30504034		20	80
	30504099		20	80
	30508909		50	50

MACT Code	SCC	SIC	% Hg2	% Hg0
	30508921		50	50
	30510103		20	80
	30510199		20	80
	30510298		20	80
	30510299		20	80
	30510399		20	80
	30510498		20	80
	30510502		25	75
	30510599		20	80
	30510809		20	80
	30588801		50	50
	30599999		50	50
	30600816		20	80
	30600904		20	80
	30601401		20	80
	30609903		20	80
	30900201		20	80
	30900205		20	80
	31000205		20	80
	31401101		50	50
	31499999		50	50
	31502101		78	22
	31502102		78	22
	39000602		25	75
	39000689		50	50
	39000699		50	50
	39001399		50	50
	39999997		50	50
	39999999		50	50
	40188898		50	50
	40299998		50	50
	40500201		50	50
	49099999		50	50
	50100101		78	22
	50100102		78	22
	50100103		78	22
	50100505		78	22
	50100799		78	22
	50200101		78	22
	50200102		78	22
	50200504		78	22
	50200505		78	22
	50200601		20	80
	50200602		20	80
	50290006		78	22

MACT Code	SCC	SIC	% Hg2	% Hg0
	50300101		78	22
	50300601		20	80
	50300810		50	50
	50300899		50	50
	210400200		50	50
	210400400		50	50
	220100100		9	91
	220100111		9	91
	220100113		9	91
	220100115		9	91
	220100117		9	91
	220100119		9	91
	220100121		9	91
	220100123		9	91
	220100125		9	91
	220100127		9	91
	220100129		9	91
	220100131		9	91
	220100133		9	91
	220102000		9	91
	220102011		9	91
	220102013		9	91
	220102015		9	91
	220102017		9	91
	220102019		9	91
	220102021		9	91
	220102023		9	91
	220102025		9	91
	220102027		9	91
	220102029		9	91
	220102031		9	91
	220102033		9	91
	220104000		9	91
	220104011		9	91
	220104013		9	91
	220104015		9	91
	220104017		9	91
	220104019		9	91
	220104021		9	91
	220104023		9	91
	220104025		9	91
	220104027		9	91
	220104029		9	91
	220104031		9	91
	220104033		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	220107000		9	91
	220107011		9	91
	220107013		9	91
	220107015		9	91
	220107017		9	91
	220107019		9	91
	220107021		9	91
	220107023		9	91
	220107025		9	91
	220107027		9	91
	220107029		9	91
	220107031		9	91
	220107033		9	91
	220108000		9	91
	220108011		9	91
	220108013		9	91
	220108015		9	91
	220108017		9	91
	220108019		9	91
	220108021		9	91
	220108023		9	91
	220108025		9	91
	220108027		9	91
	220108029		9	91
	220108031		9	91
	220108033		9	91
	223000100		44	56
	223000111		44	56
	223000113		44	56
	223000115		44	56
	223000117		44	56
	223000119		44	56
	223000121		44	56
	223000123		44	56
	223000125		44	56
	223000127		44	56
	223000129		44	56
	223000131		44	56
	223000133		44	56
	223006000		44	56
	223006011		44	56
	223006013		44	56
	223006015		44	56
	223006017		44	56
	223006019		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223006021		44	56
	223006023		44	56
	223006025		44	56
	223006027		44	56
	223006029		44	56
	223006031		44	56
	223006033		44	56
	223007000		44	56
	223007011		44	56
	223007013		44	56
	223007015		44	56
	223007017		44	56
	223007019		44	56
	223007021		44	56
	223007023		44	56
	223007025		44	56
	223007027		44	56
	223007029		44	56
	223007031		44	56
	223007033		44	56
	223007111		44	56
	223007113		44	56
	223007115		44	56
	223007117		44	56
	223007119		44	56
	223007121		44	56
	223007123		44	56
	223007125		44	56
	223007127		44	56
	223007129		44	56
	223007131		44	56
	223007133		44	56
	223007211		44	56
	223007213		44	56
	223007215		44	56
	223007217		44	56
	223007219		44	56
	223007221		44	56
	223007223		44	56
	223007225		44	56
	223007227		44	56
	223007229		44	56
	223007231		44	56
	223007233		44	56
	223007311		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223007313		44	56
	223007315		44	56
	223007317		44	56
	223007319		44	56
	223007321		44	56
	223007323		44	56
	223007325		44	56
	223007327		44	56
	223007329		44	56
	223007331		44	56
	223007333		44	56
	223007411		44	56
	223007413		44	56
	223007415		44	56
	223007417		44	56
	223007419		44	56
	223007421		44	56
	223007423		44	56
	223007425		44	56
	223007427		44	56
	223007429		44	56
	223007431		44	56
	223007433		44	56
	223007511		44	56
	223007513		44	56
	223007515		44	56
	223007517		44	56
	223007519		44	56
	223007521		44	56
	223007523		44	56
	223007525		44	56
	223007527		44	56
	223007529		44	56
	223007531		44	56
	223007533		44	56
	226000000		9	91
	226000100		9	91
	226000101		9	91
	226000102		9	91
	226000103		9	91
	226000104		9	91
	226000105		9	91
	226000106		9	91
	226000200		9	91
	226000200		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	226000200		9	91
	226000200		9	91
	226000201		9	91
	226000201		9	91
	226000201		9	91
	226000202		9	91
	226000202		9	91
	226000202		9	91
	226000203		9	91
	226000203		9	91
	226000203		9	91
	226000203		9	91
	226000204		9	91
	226000204		9	91
	226000204		9	91
	226000205		9	91
	226000205		9	91
	226000205		9	91
	226000206		9	91
	226000206		9	91
	226000206		9	91
	226000206		9	91
	226000207		9	91
	226000207		9	91
	226000207		9	91
	226000208		9	91
	226000300		9	91
	226000301		9	91
	226000302		9	91
	226000303		9	91
	226000304		9	91
	226000305		9	91
	226000306		9	91
	226000307		9	91
	226000400		9	91
	226000401		9	91
	226000401		9	91
	226000401		9	91
	226000401		9	91
	226000402		9	91
	226000402		9	91
	226000402		9	91
	226000402		9	91
	226000403		9	91
	226000403		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	226000403		9	91
	226000403		9	91
	226000404		9	91
	226000404		9	91
	226000404		9	91
	226000404		9	91
	226000405		9	91
	226000405		9	91
	226000405		9	91
	226000405		9	91
	226000406		9	91
	226000406		9	91
	226000406		9	91
	226000406		9	91
	226000407		9	91
	226000407		9	91
	226000407		9	91
	226000407		9	91
	226000500		9	91
	226000501		9	91
	226000501		9	91
	226000502		9	91
	226000502		9	91
	226000503		9	91
	226000503		9	91
	226000504		9	91
	226000504		9	91
	226000505		9	91
	226000505		9	91
	226000506		9	91
	226000600		9	91
	226000600		9	91
	226000601		9	91
	226000601		9	91
	226000602		9	91
	226000602		9	91
	226000603		9	91
	226000700		9	91
	226000700		9	91
	226000701		9	91
	226000701		9	91
	226000702		9	91
	226000800		9	91
	226000800		9	91
	226000801		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	226000900		9	91
	226000901		9	91
	226001000		9	91
	226001001		9	91
	226500000		9	91
	226500100		9	91
	226500101		9	91
	226500102		9	91
	226500103		9	91
	226500104		9	91
	226500105		9	91
	226500106		9	91
	226500200		9	91
	226500200		9	91
	226500200		9	91
	226500200		9	91
	226500201		9	91
	226500201		9	91
	226500201		9	91
	226500202		9	91
	226500202		9	91
	226500202		9	91
	226500203		9	91
	226500203		9	91
	226500203		9	91
	226500203		9	91
	226500204		9	91
	226500204		9	91
	226500204		9	91
	226500205		9	91
	226500205		9	91
	226500205		9	91
	226500206		9	91
	226500206		9	91
	226500206		9	91
	226500206		9	91
	226500207		9	91
	226500207		9	91
	226500207		9	91
	226500208		9	91
	226500300		9	91
	226500301		9	91
	226500302		9	91
	226500303		9	91
	226500304		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	226500305		9	91
	226500306		9	91
	226500307		9	91
	226500400		9	91
	226500401		9	91
	226500401		9	91
	226500401		9	91
	226500401		9	91
	226500402		9	91
	226500402		9	91
	226500402		9	91
	226500402		9	91
	226500403		9	91
	226500403		9	91
	226500403		9	91
	226500403		9	91
	226500404		9	91
	226500404		9	91
	226500404		9	91
	226500404		9	91
	226500405		9	91
	226500405		9	91
	226500405		9	91
	226500405		9	91
	226500406		9	91
	226500406		9	91
	226500406		9	91
	226500406		9	91
	226500407		9	91
	226500407		9	91
	226500407		9	91
	226500407		9	91
	226500500		9	91
	226500501		9	91
	226500501		9	91
	226500502		9	91
	226500502		9	91
	226500503		9	91
	226500503		9	91
	226500504		9	91
	226500504		9	91
	226500505		9	91
	226500505		9	91
	226500506		9	91
	226500600		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	226500600		9	91
	226500601		9	91
	226500601		9	91
	226500602		9	91
	226500602		9	91
	226500603		9	91
	226500700		9	91
	226500700		9	91
	226500701		9	91
	226500701		9	91
	226500702		9	91
	226500800		9	91
	226500800		9	91
	226500801		9	91
	226500900		9	91
	226500901		9	91
	226501000		9	91
	226501001		9	91
	227000000		44	56
	227000100		44	56
	227000101		44	56
	227000102		44	56
	227000103		44	56
	227000104		44	56
	227000105		44	56
	227000106		44	56
	227000200		44	56
	227000200		44	56
	227000200		44	56
	227000200		44	56
	227000201		44	56
	227000201		44	56
	227000201		44	56
	227000202		44	56
	227000202		44	56
	227000202		44	56
	227000203		44	56
	227000203		44	56
	227000203		44	56
	227000203		44	56
	227000204		44	56
	227000204		44	56
	227000204		44	56
	227000205		44	56
	227000205		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	227000205		44	56
	227000206		44	56
	227000206		44	56
	227000206		44	56
	227000206		44	56
	227000207		44	56
	227000207		44	56
	227000207		44	56
	227000208		44	56
	227000300		44	56
	227000301		44	56
	227000302		44	56
	227000303		44	56
	227000304		44	56
	227000305		44	56
	227000306		44	56
	227000307		44	56
	227000400		44	56
	227000401		44	56
	227000401		44	56
	227000401		44	56
	227000401		44	56
	227000402		44	56
	227000402		44	56
	227000402		44	56
	227000402		44	56
	227000403		44	56
	227000403		44	56
	227000403		44	56
	227000403		44	56
	227000404		44	56
	227000404		44	56
	227000404		44	56
	227000404		44	56
	227000405		44	56
	227000405		44	56
	227000405		44	56
	227000405		44	56
	227000406		44	56
	227000406		44	56
	227000406		44	56
	227000406		44	56
	227000407		44	56
	227000407		44	56
	227000407		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	227000407		44	56
	227000500		44	56
	227000501		44	56
	227000501		44	56
	227000502		44	56
	227000502		44	56
	227000503		44	56
	227000503		44	56
	227000504		44	56
	227000504		44	56
	227000505		44	56
	227000505		44	56
	227000506		44	56
	227000600		44	56
	227000600		44	56
	227000601		44	56
	227000601		44	56
	227000602		44	56
	227000602		44	56
	227000603		44	56
	227000700		44	56
	227000700		44	56
	227000701		44	56
	227000701		44	56
	227000702		44	56
	227000800		44	56
	227000800		44	56
	227000801		44	56
	227000900		44	56
	227000901		44	56
	227001000		44	56
	227001001		44	56
	227500000		44	56
	227500100		44	56
	227500100		44	56
	227502000		44	56
	227502000		44	56
	227502002		44	56
	227505000		44	56
	227505000		44	56
	227506000		44	56
	227507000		44	56
	227508500		44	56
	227590000		44	56
	228000100		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	228000210		44	56
	228000220		44	56
	228000310		44	56
	228000320		44	56
	228000400		9	91
	228200000		44	56
	228200500		9	91
	228200500		9	91
	228200501		9	91
	228200501		9	91
	228200502		9	91
	228200502		9	91
	228201000		9	91
	228201000		9	91
	228201001		9	91
	228201001		9	91
	228201002		9	91
	228201002		9	91
	228202000		44	56
	228202000		44	56
	228202001		44	56
	228202001		44	56
	228202002		44	56
	228202002		44	56
	228300000		44	56
	228300201		44	56
	228300202		44	56
	228300300		44	56
	228300301		44	56
	228300302		44	56
	228300400		9	91
	228300401		9	91
	228300402		9	91
	228500200		44	56
	228500200		44	56
	228500200		44	56
	228500200		44	56
	228500201		44	56
	228500201		44	56
	228500301		9	91
	228500401		9	91
	260102000		78	22
	262000000		20	80
	262003000		20	80
	265000000		20	80

MACT Code	SCC	SIC	% Hg2	% Hg0
	280152000		50	50
	280500000		78	22
	281005000		78	22
	281006010		78	22
	281006020		78	22
	285000100		0	100
	285100100		0	100
	286100000		0	100
	286100001		0	100
	220100111		9	91
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	220100125		9	91
	220100127		9	91
	220100127		9	91
	220100127		9	91
	220100127		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	220100129		9	91
	220100129		9	91
	220100129		9	91
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	220100133		9	91
	220100133		9	91
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	220102013		9	91
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	220102015		9	91
	220102017		9	91
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	220102017		9	91
	220102019		9	91
	220102019		9	91
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	220102021		9	91
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	220102023		9	91
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	220102023		9	91
	220102025		9	91
	220102025		9	91
	220102025		9	91
	220102025		9	91
	220102027		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	220102027		9	91
	220102027		9	91
	220102027		9	91
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	220102031		9	91
	220102033		9	91
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	220104013		9	91
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	220104013		9	91
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	220104015		9	91
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	220104023		9	91
	220104023		9	91
	220104023		9	91
	220104023		9	91
	220104025		9	91
	220104025		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
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	220104025		9	91
	220104027		9	91
	220104027		9	91
	220104027		9	91
	220104027		9	91
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	220104031		9	91
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	220104031		9	91
	220104033		9	91
	220104033		9	91
	220104033		9	91
	220104033		9	91
	220107011		9	91
	220107011		9	91
	220107011		9	91
	220107011		9	91
	220107013		9	91
	220107013		9	91
	220107013		9	91
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	220107015		9	91
	220107015		9	91
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	220107015		9	91
	220107017		9	91
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	220107021		9	91
	220107021		9	91
	220107021		9	91
	220107023		9	91
	220107023		9	91
	220107023		9	91

MACT Code	SCC	SIC	% Hg2	% Hg0
	220107023		9	91
	220107025		9	91
	220107025		9	91
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	220107025		9	91
	220107027		9	91
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	220107031		9	91
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	220108019		9	91
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MACT Code	SCC	SIC	% Hg2	% Hg0
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	220108023		9	91
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	220108025		9	91
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	223000121		44	56
	223000121		44	56
	223000123		44	56
	223000123		44	56
	223000123		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
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	223000125		44	56
	223000125		44	56
	223000127		44	56
	223000127		44	56
	223000127		44	56
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	223006027		44	56
	223006027		44	56
	223006027		44	56
	223006029		44	56
	223006029		44	56
	223006029		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223006031		44	56
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	223006031		44	56
	223006033		44	56
	223006033		44	56
	223006033		44	56
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	223007133		44	56
	223007133		44	56
	223007133		44	56
	223007211		44	56
	223007211		44	56
	223007211		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223007213		44	56
	223007213		44	56
	223007213		44	56
	223007215		44	56
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	223007315		44	56
	223007315		44	56
	223007315		44	56
	223007317		44	56
	223007317		44	56
	223007317		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223007319		44	56
	223007319		44	56
	223007319		44	56
	223007321		44	56
	223007321		44	56
	223007321		44	56
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	223007421		44	56
	223007421		44	56
	223007421		44	56
	223007423		44	56
	223007423		44	56
	223007423		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223007425		44	56
	223007425		44	56
	223007425		44	56
	223007427		44	56
	223007427		44	56
	223007427		44	56
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	223007513		44	56
	223007515		44	56
	223007515		44	56
	223007515		44	56
	223007517		44	56
	223007517		44	56

MACT Code	SCC	SIC	% Hg2	% Hg0
	223007517		44	56
	223007519		44	56
	223007519		44	56
	223007519		44	56
	223007521		44	56
	223007521		44	56
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	223007525		44	56
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	223007525		44	56
	223007527		44	56
	223007527		44	56
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	223007529		44	56
	223007529		44	56
	223007531		44	56
	223007531		44	56
	223007531		44	56
	223007533		44	56
	223007533		44	56
	223007533		44	56
		1021	20	80

MACT Code	SCC	SIC	% Hg2	% Hg0
		1031	20	80
		1041	0	100
		1044	20	80
		1099	50	50
		1221	50	50
		1222	50	50
		1241	50	50
		2621	50	50
		2911	50	50
		2992	50	50
		3241	25	75
		3251	20	80
		3273	50	50
		3275	50	50
		3295	20	80
		3613	50	50
		3629	50	50
		3641	20	80
		3823	50	50
		3829	50	50
		4491	50	50
		4953	78	22
		5169	20	80
		7261	78	22

Exhibit D-3. Maximum Achievable Control Technology (MACT) Codes and the Source Categories They Represent

MACT Code	MACT Source Category
0101-1	Engine Test Facilities
0101-2	Rocket Engine Test Firing
0105	Stationary Reciprocating Internal Combustion Engines
0105-1	Stationary Reciprocating Internal Combustion Engines – Natural Gas
0105-2	Stationary Reciprocating Internal Combustion Engines – Oil
0107	Industrial/Commercial/Institutional Boilers & Process Heaters
0107-1	Industrial/Commercial/Institutional Boilers & Process Heaters – Coal
0107-2	Industrial/Commercial/Institutional Boilers & Process Heaters – Gas
0107-3	Industrial/Commercial/Institutional Boilers & Process Heaters – Oil
0107-4	Industrial/Commercial/Institutional Boilers & Process Heaters – Wood or Waste
0108	Stationary Combustion Turbines
0108-1	Stationary Combustion Turbines – Natural Gas
0108-2	Stationary Combustion Turbines – Oil
0201	Primary Aluminum Production
0202	Secondary Aluminum Production
0203	Primary Copper Smelting
0204	Primary Lead Smelting
0205	Secondary Lead Smelting
0207	Primary Magnesium Refining
0260	Secondary Nonferrous Metals
0262	Primary Nonferrous Metals – Zinc, Cadmium, and Beryllium
0263	Lead Acid Battery Manufacturing
0264	Wood Preserving
0265	Chemical Manufacturing: Chromium Compounds
0266	Primary Metal Products Manufacturing
0267	Secondary Copper Smelting
0302	Coke Ovens: Charging, Top Side, and Door Leaks
0303	Coke Ovens: Pushing, Quenching, and Battery Stacks
0304	Ferroalloys Production
0305	Integrated Iron & Steel Manufacturing
0308	Iron and Steel Foundries
0310	Steel Pickling – HCL Process
0360	Ferroalloys Production: Ferromanganese and Silicomanganese
0361	Copper Foundries
0362	Iron and Steel Forging
0363	Nonferrous Foundries, Not Elsewhere Classified
0364	Stainless and Nonstainless Steel Manufacturing: Electric Arc Furnaces (EAF)
0402	Asphalt/Coal Tar Application – Metal Pipes
0406	Refractory Products Manufacturing

Exhibit D-3. Maximum Achievable Control Technology (MACT) Codes and the Source Categories They Represent

MACT Code	MACT Source Category
0408	Lime Manufacturing
0409	Mineral Wool Production
0410	Portland Cement Manufacturing
0411	Taconite Iron Ore Processing
0412	Wool Fiberglass Manufacturing
0413	Wet-Formed Fiberglass Mat Production
0414	Brick and Structural Clay Products Manufacturing
0415	Clay Ceramics Manufacturing
0418	Asphalt Processing and Asphalt Roofing Manufacturing
0460	Pressed and Blown Glass and Glassware Manufacturing
0501	Oil & Natural Gas Production
0502	Petroleum Refineries – Catalytic Cracking, Catalytic Reforming, and Sulfur Plant Units
0503	Petroleum Refineries – Other Sources Not Distinctly Listed
0504	Natural Gas Transmission and Storage
0560	Cyclic Crude and Intermediate Production
0601	Gasoline Distribution (Stage I)
0602	Organic Liquids Distribution (Non-Gasoline)
0603	Marine Vessel Loading Operations
0701	Aerospace Industries
0702	Auto & Light Duty Truck (Surface Coating)
0703	Wood Building Products (Surface Coating)
0704	Large Appliance (Surface Coating)
0705	Magnetic Tapes (Surface Coating)
0707	Metal Can (Surface Coating)
0708	Metal Coil (Surface Coating)
0709	Metal Furniture (Surface Coating)
0710	Miscellaneous Metal Parts and Products (Surface Coating)
0711	Paper and Other Webs (Surface Coating)
0712	Plastic Parts and Products (Surface Coating)
0713	Printing, Coating, and Dyeing Of Fabrics
0714	Printing/Publishing (Surface Coating)
0715	Shipbuilding & Ship Repair (Surface Coating)
0716	Wood Furniture (Surface Coating)
0760	Autobody Refinishing Paint Shops
0801	Hazardous Waste Incineration
0801-1	Hazardous Waste Incineration: Commercial
0801-2	Hazardous Waste Incineration: On-Site
0801-3	Hazardous Waste Incineration: Cement Kilns
0801-4	Hazardous Waste Incineration: Lightweight Aggregate Kilns
0801-5	Hazardous Waste Incineration: Solid Fuel Boilers

Exhibit D-3. Maximum Achievable Control Technology (MACT) Codes and the Source Categories They Represent

MACT Code	MACT Source Category
0801-6	Hazardous Waste Incineration: Liquid Fuel Boilers
0801-7	Hazardous Waste Incineration: HCl Production Furnaces
0802	Municipal Landfills
0803	Publicly Owned Treatment Works (POTWs)
0805	Site Remediation
0806	Off-Site Waste and Recovery Operations
0911	Pesticide Active Ingredient Production
0960	Agricultural Chemicals and Pesticides Manufacturing
1001	Acrylic/Modacrylic Fibers Production
1003	Spandex Production
1101	Manufacture of Nutritional Yeast
1103	Solvent Extraction for Vegetable Oil Production
1160	Prepared Feeds Manufacturing
1201	Pharmaceutical Production
1301	Acetal Resins Production
1302	Acrylonitrile-Butadiene-Styrene Production
1305	Boat Manufacturing
1307	Butyl Rubber Production
1311	Epichlorohydrin Elastomers Production
1312	Epoxy Resins Production
1313	Ethylene-Propylene Rubber Production
1314	Flexible Polyurethane Foam Production
1315	Hypalon™ Production
1317	Methyl Methacrylate-Acrylonitrile-Butadiene-Styrene Production
1318	Methyl Methacrylate-Butadiene-Styrene Terpolymers Production
1320	Neoprene Production
1321	Nitrile Butadiene Rubber Production
1322	Non-Nylon Polyamides Production
1325	Polybutadiene Rubber Production
1326	Polycarbonates Production
1328	Polyethylene Terephthalate Production
1331	Polystyrene Production
1332	Polysulfide Rubber Production
1336	Polyvinyl Chloride and Copolymers Production
1337	Reinforced Plastic Composites Production
1338	Styrene Acrylonitrile Production
1339	Styrene-Butadiene Rubber and Latex Production
1341	Flexible Polyurethane Foam Fabrication Operations
1342	Nitrile Resins Production
1347	Amino/Phenolic Resins Production

Exhibit D-3. Maximum Achievable Control Technology (MACT) Codes and the Source Categories They Represent

MACT Code	MACT Source Category
1348	Viscose Process Manufacturing
1349	Cellulose Products Manufacturing
1360	Plastic Materials and Resins Manufacturing
1361	Synthetic Rubber Manufacturing
1401	Ammonium Sulfate – Caprolactam By-Product Plants
1403	Mercury Cell Chlor-Alkali Plants
1405	Cyanide Chemicals Manufacturing
1407	Hydrochloric Acid Production
1409	Hydrogen Fluoride Production
1410	Phosphate Fertilizers Production
1411	Phosphoric Acid Manufacturing
1414	Uranium Hexafluoride Production
1415	Carbon Black Production
1460	Inorganic Pigments Manufacturing
1461	Industrial Inorganic Chemical Manufacturing
1501	Synthetic Organic Chemical Manufacturing (HON)
1560	Industrial Organic Chemical Manufacturing
1604	Carbonyl Sulfide (COS) Production
1607	Chromic Acid Anodizing
1609	Commercial Sterilization Facilities
1610	Decorative Chromium Electroplating
1614	Halogenated Solvent Cleaners
1615	Hard Chromium Electroplating
1619	Industrial Cooling Towers
1621	Paint Stripping Operations
1624	Plywood and Composite Wood Products
1625	Polyether Polyols Production
1626	Pulp and Paper Production – Not Otherwise Sub-Classified
1626-1	Pulp & Paper Production – Pulping and Bleaching Systems at Kraft, Soda, Sulfite, and Semichemical Pulping Mills (Subpart S)
1626-2	Pulp & Paper Production – Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite, and Stand-alone Semichemical Pulping Mills (Subpart MM)
1626-3	Pulp and Paper Production – NonMACT Facilities
1629	Semiconductor Manufacturing
1631	Rubber Tire Production
1634	Leather Tanning and Finishing Operations
1635	Ethylene Processes
1636	Friction Materials Manufacturing
1641	Miscellaneous Organic Chemical Manufacturing
1642	Miscellaneous Coating Manufacturing

Exhibit D-3. Maximum Achievable Control Technology (MACT) Codes and the Source Categories They Represent

MACT Code	MACT Source Category
1643	Dry Cleaning Facilities: Perchloroethylene
1644	Hospital Sterilizers
1660	Valves and Pipe Fittings Manufacturing
1661	Heating Equipment Manufacturing, Except Electric
1662	Fabricated Structural Metal Manufacturing
1663	Fabricated Plate Work
1664	Fabricated Metal Products Manufacturing, Not Elsewhere Classified
1665	Electrical and Electronics Equipment: Finishing Operations
1666	Industrial Machinery and Equipment: Finishing Operations
1667	Chemical Preparations
1668	Paints and Allied Products Manufacturing
1669	Plating and Polishing
1801	Medical Waste Incinerators
1802	Municipal Waste Combustors
1802-1	Municipal Waste Combustors: Small
1802-2	Municipal Waste Combustors: Large
1807-1	Commercial and Industrial Solid Waste Incineration
1807-2	Other Solid Waste Incineration
1808-1	Utility Boilers: Coal
1808-2	Utility Boilers: Natural Gas
1808-3	Utility Boilers: Oil
1808-4	Utility Boilers: Wood or Waste
1860	Sewage Sludge Incineration
None	Not a MACT process

Exhibit D-4. Categories for Grouping Results for Non-point Sources

Category ID	Description	Basis for Assigning Categories
c1	Industrial/Commercial/Institutional Boilers & Process Heaters, all fuels	Maximum Achievable Control Technology (MACT) codes: 0107 (Industrial/Commercial/ Institutional Boilers & Process Heaters), 0107-1 (Coal), 0107-2 (Gas), 0107-3 (Oil), and 0107-4 (Wood/Waste) and Source Classification Codes (SCC) = 2101002000, 2101004000, 2101005000, 2101006000, 2102001000, 2102002000, 2102004000, 2102005000, 2102006000, 2102006001, 2102007000, 2102008000, 2102011000, 2102012000, 2103001000, 2103002000, 2103004000, 2103005000, 2103006000, 2103007000, 2103007005, 2103008000, 2103010000, 2103011000, 2103011005, 2199001000, 2199004000, 2199004001, 2199005000, 2199006000, 2199006001, 2199007000, 2199008000, 2199011000
c2	Stationary Reciprocating Internal Combustion Engines	MACT codes: 0105 (Stationary Reciprocal Internal Combustion Engines), 0105-1 (Natural Gas) and 0105-2 (Oil)
c3	Residential Heating – all fuels except for wood	SCC = 2104001000, 2104002000, 2104004000, 2104006000, 2104006010, 2104007000, 2104011000
c4	Residential Heating – wood and wood residue *Includes woodstoves, fireplaces fireplace inserts and outdoor wood burning equipment.*	SCC = 2104008000, 2104008001, 2104008002, 2104008003, 2104008004, 2104008010, 2104008030, 2104008050, 2104008051, 2104008052, 2104008053, 2104008070
c5	Commercial Cooking Includes charbroiling and frying (commercial only).	SCC = 2302002000, 2302002100, 2302002200, 2302003100
c6	Asphalt Paving and Roofing	SCC = 2306010000, 2461020000, 2461021000, 2461022000, 2461023000
c7	Chromium Electroplating	MACT codes 1610 (Decorative Chromium Electroplating) and 1615 (Hard Chromium Electroplating)
c8	Oil & Natural Gas Production	MACT code 0501 (Oil & Natural Gas Production)
c9	Natural Gas Transmission & Storage	MACT code 0504 (Natural Gas Transmission & Storage)
c10	Other Nonpoint Sources *Includes nonpoint sources not assigned to other categories. Includes diverse categories such as agricultural crop production (orchard heaters), livestock, petroleum refining, chemical manufacturing, animal cremation, hospital sterilizers, accidental releases, and non-perchloroethylene dry cleaning.*	Remaining categories after all other nonpoint sources were assigned.
c11	Solvent Use: Nonconsumer/Noncommercial *Includes various surface coating processes, graphic arts, miscellaneous industrial, solvent reclamation, tank and drum cleaning and general solvent use.*	SCC = 2401001000, 2401001001, 2401001005, 2401001006, 2401001010, 2401001011, 2401001015, 2401001020, 2401001025, 2401001050, 2401002000, 2401003000, 2401008000, 2401010000, 2401015000, 2401020000, 2401025000, 2401030000, 2401035000, 2401040000, 2401045000, 2401050000, 2401055000, 2401060000, 2401065000, 2401070000, 2401075000, 2401080000, 2401085000, 2401090000, 2401100000, 2401200000, 2401990000, 2425000000, 2425010000, 2425020000, 2425030000, 2425040000, 2430000000, 2440000000, 2440020000, 2461100000, 2461160000, 2495000000
c12	Autobody Refinishing Paint Shops	SCC = 2401005000, 2401005500, 2401005600, 2401005700, 2401005800, 2840010000
c13	Solvent Use: Paint Stripping Operations	MACT code 1621 (Paint Stripping Operations)
c14	Halogenated Solvent Cleaners *Includes processes involving degreasing for a variety of manufacturing, repair processes such as furniture, metals, auto dealers, and repair.*	MACT code 1614 (Halogenated Solvent Cleaners) and SCC = 2415000000, 2415005000, 2415015000, 2415020000, 2415025000, 2415030000, 2415035000, 2415040000, 2415045000, 2415055000, 2415060000, 2415065000, 2415100000, 2415105000, 2415110000, 2415120000, 2415125000, 2415130000, 2415135000, 2415140000, 2415145000, 2415150000, 2415155000, 2415160000, 2415165000, 2415200000, 2415205000, 2415210000, 2415220000, 2415225000, 2415230000, 2415235000, 2415240000, 2415245000, 2415250000, 2415255000, 2415265000, 2415300000, 2415305000, 2415310000, 2415320000, 2415325000, 2415330000, 2415335000, 2415340000, 2415345000, 2415350000, 2415355000, 2415360000, 2415365000

Exhibit D-4. Categories for Grouping Results for Non-point Sources

Category ID	Description	Basis for Assigning Categories
c15	Solvent Use: Consumer and Commercial Products Usage *Includes household products, personal care products, automotive after-market products, adhesives and sealants, and consumer pesticides.*	SCC = 2460000000, 2460100000, 2460110000, 2460120000, 2460130000, 2460150000, 2460160000, 2460180000, 2460190000, 2460200000, 2460220000, 2460400000, 2460500000, 2460600000,, 2460610000, 2460800000, 2460900000, 2465000000, 2465100000, 2465200000, 2465400000, 2465600000, 2465800000, 2465900000
c16	Pesticide Application *Includes commercial pesticide application.*	SCC = 2461800000, 2461850000, 2461850001, 2461850004, 2461850005, 2461850006, 2461850009, 2461850051, 2461850054, 2461850055, 2461850056, 2461850099
c17	Petroleum Product Storage, Transportation and Marketing *Excludes gasoline distribution, Stage I and Stage II.*	SCC = 2501000000, 2501050090, 2501070052, 2501080050, 2501080100, 2505000000, 2505000120, 2505010000, 2505020000, 2505020030, 2505020060, 2505020090, 2505020120, 2505020121, 2505020150, 2505020180, 2505030180
c18[a]	Gasoline Distribution (Stage I and II)	MACT code 0601 (Gasoline Distribution (Stage I)
c19	Open Burning – Other *Includes Waste Disposal, Treatment, and Recovery; Open Burning: total, yard waste, household waste, land clearing debris, municipal. Also includes structure fires, fire fighting, and motor vehicle fires.*	SCC = 2610000000, 2610000100, 2610000300, 2610000400, 2610000500, 2610030000, 2610040400, 2810030000, 2810035000, 2810050000
c20	Landfills	SCC = 2620000000, 2620030000
c21	Publicly Owned Treatment Works (POTWs)	MACT code 0803 (Publicly Owned Treatment Works (POTWs))
c22	Agricultural Field Burning *Includes agricultural burning of various field crop types, orchard crop types, and use of various techniques.*	SCC = 2801500000, 2801500100, 2801500111, 2801500130, 2801500170, 2801500191, 2801500261, 2801500300, 2801500320, 2801500330, 2801500350, 2801500360, 2801500390, 2801500410, 2801500420, 2801500430, 2801500440, 2801500450, 2801500500, 2801501000
c23	Open Burning - Forest and Wildfires	SCC = 2810001000
c24	Open Burning – Prescribed, Managed, Slash	SCC = 2810005000, 2810015000, 2810020000, 2810015001
c25	Swimming Pools	SCC = 2862000000
c26	Dry Cleaning Facilities: Perchloroethylene *Includes only dry cleaning categories in which perchloroethylene is emitted*.	MACT code 1643 (Dry Cleaning Facilities: Perchloroethylene) and any SCC = 2420000000, 2420000055, 2420010000, 2420010055 2420010370, 2420020055 in which the pollutant emitted is perchloroethylene
c27	Portable Fuel Containers (Gas Cans) *Includes residential, commercial fuel containers exhibiting permeation, evaporation, spillage, refilling at the pump.*	SCC = 2501011011, 2501011012, 2501011013, 2501011014, 2501011015, 2501012011, 2501012012, 2501012013, 2501012014, 2501012015

[a] For c18 – Gasoline Distribution (Stage I and II), the following SCC codes with MACT = 0601 appear to include some processes that are not Stage I; even so, all SCCs associated with 0601 were used for grouping purposes.

The SCC codes are as follows (note that the last one is a code that was changed in the NEI data to facilitate the assignment of sources to categories using EMS-HAP, as discussed previously in Section 1 of this document).

2501050120: Storage and Transport; Petroleum and Petroleum Product Storage; Bulk Terminals: All Evaporative Losses; Gasoline

2501055120: Storage and Transport; Petroleum and Petroleum Product Storage; Bulk Plants: All Evaporative Losses; Gasoline

2501060051: Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Submerged Filling

2501060052: Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Splash Filling

2501060053: Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Balanced Submerged Filling

2501060100: Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 2: Total

2501060201: Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Breathing and Emptying

2505030120: Storage and Transport; Petroleum and Petroleum Product Transport; Truck; Gasoline

2505040120: Storage and Transport; Petroleum and Petroleum Product Transport; Pipeline; Gasoline

250108005A: Code developed for NATA grouping purposes only. It includes 2002 NEI records originally with SCC = 2501080050 where MACT = 0601.

Exhibit D-5. Categories for Grouping Results for Mobile Sources

Category ID	Description	Basis for Assigning Categories
c28	On-road gasoline	All Source Classification Codes (SCC) with first five digits = 22010
c29	On-road diesel	All SCCs with first 5 digits = 22300
c30	Non-road SI Bond Rule *Includes non-road equipment expected to be covered by the Small Ignition engine rule (known as "Bond" rule). Includes gasoline engines only.*	SCC = 2260001060, 2260002000, 2260002006, 2260002009, 2260002021, 2260002027, 2260002039, 2260002054, 2260003000, 2260003030, 2260003040, 2260004000, 2260004015, 2260004016, 2260004020, 2260004021, 2260004025, 2260004026, 2260004030, 2260004031, 2260004035, 2260004036, 2260004071, 2260005035, 2260006000, 2260006005, 2260006010, 2260006015, 2260006035, 2260007000, 2260007005, 2265001050, 2265001060, 2265002003, 2265002006, 2265002009, 2265002015, 2265002021, 2265002024, 2265002027, 2265002030, 2265002033, 2265002039, 2265002042, 2265002045, 2265002054, 2265002057, 2265002066, 2265002072, 2265002078, 2265002081, 2265003010, 2265003030, 2265003040, 2265003050, 2265003060, 2265004000, 2265004010, 2265004011, 2265004015, 2265004016, 2265004025, 2265004026, 2265004030, 2265004031, 2265004035, 2265004036, 2265004040, 2265004041, 2265004046, 2265004051, 2265004055, 2265004056, 2265004066, 2265004071, 2265004075, 2265004076, 2265005010, 2265005015, 2265005030, 2265005035, 2265005040, 2265005055, 2265005060, 2265006000, 2265006005, 2265006010, 2265006015, 2265006025, 2265006030, 2265006035, 2265007000, 2265007010, 2265007015, 2265008000, 2265008005, 2265010010, 2282005000, 2282005010, 2282005015, 2282010000, 2282010005, 2285004015
c31	Other Non-road *Includes compressed natural gas and gasoline from non-road sources not expected to be covered by "Bond" rule.*	SCC = 2260001010, 2260001020, 2260001030, 2265001010, 2265001020, 2265001030, 2265002000, 2265002060, 2265003000, 2265003020, 2265003070, 2265005000, 2265005020, 2265005025, 2265005045, 2268003000, 226800600, 2268008000, 2280004000
c32	Non-road Diesel	All SCCs with first 5 digits = 22700 and SCC = 2285002015
c33	Diesel Pleasure Craft	SCC = 2282020000, 2282020005, 2282020010
c34	Locomotive	SCC = 2285002006, 2285002007, 2285002008, 2285002009, 2285002010
c35	Commercial Marine Vessel Diesel	SCC = 2280002100, 2280002200
c36	Commercial Marine Vessel Residual Fuel	SCC = 2280003100, 2280003200

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Appendix E

Emissions Data and Processing Activities for the 2005 NATA

Appendix E presents additional information on how emissions data of each source type were used specifically for NATA 2005 modeling.

E.1 Point Source Data and NEI Data Processing

More general details on NEI and specifically on the point source NEI are provided in Section 2.1of this document. For the 2005 NATA, the compilation of the point source emissions inventory began with the 2005 NEI Version 2 annual emissions inventory (see the 2005 NEI webpage (EPA 2010a) for more details on the 2005 NEI). Before use in the 2005 NATA, the 2005 Point Source NEI Version 2 was modified significantly based on comments and revisions received after its release in October 2008. These revisions included pollutant reconciliations, landfill emissions adjustments, lead revisions, coordinate corrections, and Risk and Technology Review (RTR) updates. To further prepare the point source emissions inventory for modeling with the AERMOD version of the Human Exposure Model-3 (HEM-3; see Section 3.1 of this document for more details on HEM-3). The preprocessing steps listed below were performed on the 2005 NATA point source data.

- Some incorrect pollutant identifiers were corrected, and some duplicated facilities were removed.
- Various changes were made to stack parameters and fugitive parameters for sources in the RTR Source Category Groups 1, 2A, 2B, and 3. These changes were made so that the parameters could be modeled for the 2005 NATA in the same way they were modeled for RTR. These changes primarily involved stack heights, whether the point source was modeled as a point or fugitive source, and how large the fugitive sources were.
- The stack heights of most coke oven charge lids, doors, charging, pushing, and off-take sources were set to a minimum of 38.4 meters (as described in Section 2.2.4).
- For airports, revised airport-wide emissions data were developed after Version 2 of the 2005 NEI was developed. These revised airport-related emissions are considered representative of 2008. The coordinates for a few airports were corrected from the values originally provided.

  For more than 400 major airports, the runway length, width, orientation, and elevation data had been gathered for the 2002 NATA from detailed airport maps. For the 2002 NATA and for the 2005 NATA, these runway details were used to allocate airport-wide emissions to runway area sources based on runway surface area.

  For the remaining thousands of non-major airports, airport-wide emissions were allocated to a single runway area source with a default length and width. Non-major airport runway orientations were set to a default of 0 degrees. The default runway length and width for non-major airports were derived for the 2002 NATA from FAA runway data corresponding to these non-major airports (FAA 2007). The non-major airports in the 2002 NATA were joined to the FAA data. The distributions of runway lengths and widths from all matching non-major-airport runways were developed. The approximate modal length and width values from these distributions became the default length and width values for all non-major airport runways for the 2002 and 2005 NATAs. These default non-major airport runway configurations typically will not reflect the actual runway configurations at the individual airports, but they should be roughly representative of most runways at most non-major airports.

The following errors were found and corrected during the NATA modeling process due to certain restrictions in HEM-3 (AERMOD Version):

- Several facilities in Alaska were not modeled because they were not within 50 kilometers of a populated census block.
- The coordinates of some sources were corrected because they appeared to have been reported or transcribed incorrectly, making them unrealistically distant from other sources at the facility.
- Some emission amounts were corrected because their values were too small to have been measured and to be modeled, indicating a likely reporting error.
- Some NEI identifiers were corrected because they contained incorrect characters, indicating a likely reporting error.
- Some fugitive dimensions were corrected because their values were too small to be modeled.

After all the above revisions and modifications were made, the resulting emissions inventory can effectively be referred to as the 2005 NATA Point Source Emissions Inventory.

E.2 Non-Point Source Data and NEI Data Processing

More general details on NEI and specifically on the non-point NEI are provided in Section 2.2. For the 2005 NATA, the non-point data and results from the 2002 NATA (EPA 2009n) were used. The non-point inventory used in the 2002 NATA and the 2005 NATA was derived from the 2002 NEI Non-point Version 3 (EPA 2006a) for more information on the 2002 NEI). The following modifications were made to the non-point NEI data for NATA modeling:

- The arsenic emissions were removed from Source Classification Code (SCC) 2102012000 for all counties in Maine because Maine does not believe the arsenic levels are realistic for that SCC.
- Because Broomfield County, Colorado (Federal Information Processing Standards [FIPS] = 08014) was created after the 2000 Census, its reported non-point emissions were apportioned back into its component counties (FIPS = 08001 35%, FIPS = 08013 62%, FIPS = 08059 2%, and FIPS = 08123 <1%).

After these modifications were made, the resulting emissions inventory may effectively be referred to as the 2002 and 2005 NATA Non-point Source Emissions Inventory.

E.3 Mobile Source Data and NEI Data Processing

More general details on the NEI and specifically on the mobile source NEI are provided in Section 2.3. For the 2005 NATA, mobile source emissions data were derived from Version 2 of the 2005 Mobile Source NEI (EPA 2008b) and from the EPA Motor Vehicle Emission Simulator (MOVES; EPA 2009h). More specifically, for on-road mobile sources for the 2005 NATA, gasoline emissions in all states except for California were based on data from MOVES for the pollutants listed in Exhibit E-1. The merger of the MOVES data and NEI data followed the specifications of the 2005 Modeling Platform Version 4 (EPA 2009f). For non-road mobile sources for the 2005 NATA, emissions from gasoline and from diesel commercial marine vessels and locomotives were from the 2002 NEI. After these modifications were made, the resulting emissions inventory is the 2005 NATA Mobile Source Emissions Inventory.

Exhibit E-1. Pollutants Estimated by the Motor Vehicle Emission Simulator (MOVES) for Gasoline Emissions for On-Road Mobile Sources for the 2005 NATA

particulate matter (PM) ≤ 2.5 microns[a]	volatile organic compounds (VOCs)[a]	nitrogen oxide compounds (NO_x)[a]
carbon monoxide[a]	naphthalene	formaldehyde
butadiene	benzene	acrolein
acetaldehyde		

[a] These pollutants are criteria pollutants, not hazardous air pollutants.

E.4 Use of NEI Data for Modeling Formation of Secondary Pollutants

The primary pollutant emissions data for input into the Community Multiscale Air Quality (CMAQ; see Section 3.4 for more information on CMAQ) model came from all emission source types addressed in NATA (point, non-point, on-road mobile, non-road mobile, background). The point source data corresponded to the 2005 data described in Section 2.1. The non-point data corresponded to the 2002 inventory noted in Section 2.2, with some residential wood combustion data updated and without using a 2005-specific data set for wildfires and prescribed burning. The mobile data corresponded to the 2005 inventory noted in Section 2.3, where the emissions of Type C3 ships inventory were based on 2002 data grown regionally to 2005 estimated emissions.

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Appendix F

Estimation of Background Concentrations for NATA 2002

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ESTIMATION OF BACKGROUND CONCENTRATIONS FOR NATA 2002

FINAL REPORT

U.S. Environmental Protection Agency
Office of Air Quality, Planning and Standards
Air Quality Analysis Division
109 TW Alexander Drive
Research Triangle Park, NC 27711

June 11, 2008

FORWARD

In the January 2008, Sonoma Technology prepared a final technical report under Contract No. EP-D-06-115, Work Assignment 1-17. The report was prepared for Barbara Driscoll of the Air Quality Assessment Division (AQAD) within the Office of Air Quality Planning and Standards (OAQPS) in Research Triangle Park, North Carolina. The report was written by Mike McCarthy, Juli Rubin, Bryan Penfold and Hilary Hafner. That report was incorporated into this final report.

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1. INTRODUCTION

NATA 2002 uses the Assessment System for Population Exposure Nationwide (ASPEN) model-to-estimate concentrations of air toxics by census tract in the United States. The modeling methodologies in the national-scale assessment estimate long-term outdoor concentrations of air toxics attributable to 2002 anthropogenic, or human-generated, emissions. However, the ASPEN model does not estimate outdoor concentrations of air pollutants attributable to long-range pollutant transport, unidentified emission sources, and natural emission sources. These "background" contributions can be significant for some air toxics and should be taken into account to accurately model concentrations. For NATA, background concentration estimates are defined as those concentrations reflecting transported contributions from farther than 50 km, unidentified emissions sources within the 50-km buffer, and natural emissions sources. Therefore, background estimates should cover any pollutant concentrations not accounted for by the modeled emissions represented in the National Emissions Inventory (NEI).

Two previous NATA exercises were performed for the model years 1996 and 1999. These iterations used background concentrations developed specifically for NATA. In the 1996 exercise, background concentrations were gathered in a literature search performed as part of the Cumulative Exposure Project (CEP). The CEP literature review was originally performed to acquire background concentrations for 1990 (Rosenbaum et al., 1999; Woodruff et al., 1998). The result of the literature search was a single remote background value representing 12 air toxics.

In the 1999 exercise, two approaches were used to estimate background concentrations (Bortnick et al., 2003). The primary approach estimated background concentrations using measurements from ambient monitors. Estimates from individual locations were extrapolated to counties without measurements based on a population regression. When ambient measurements were not available from the ambient monitoring network, background concentrations from the CEP were used.

Table 1-1 lists the pollutants for which background concentrations were estimated for NATA 1996 and 1999. This table is adapted from the NATA 1999 web site.[1]

[1] http://www.epa.gov/ttn/atw/nata1999/99pdfs/backgroundtable.pdf

Table 1-1. Pollutants for which background concentrations were estimated in the NATA 1996 and 1999 modeling exercises. Pollutant names in italics were assigned values from the CEP literature search and were not spatially variable.

NATA 1996	NATA 1999	
Benzene	Benzene	1,3-Butadiene
Carbon tetrachloride	Carbon tetrachloride	*Bis(2-ethylhexyl)phthalate*
Chloroform	Chloroform	*Bromoform*
Dichloromethane	Dichloromethane	*Carbon disulfide*
Ethylene dibromide	Ethylene dibromide	*Chlordane*
Ethylene dichloride	Ethylene dichloride	*Hexachlorobutadiene*
Formaldehyde	Formaldehyde	*Hexachloroethane*
Mercury	*Mercury*	*Lindane*
Polychlorinated biphenyls	*Polychlorinated biphenyls*	*Methyl bromide*
Tetrachloroethylene	Tetrachloroethylene	*Methyl chloride*
Trichloroethylene	Trichloroethylene	*Methyl chloroform*
Hexachlorobenzene	Acetaldehyde	*Phosgene*
	1,1,2,2-Tetrachloroethane	Vinyl chloride
	1,2-Dichloropropane	*Xylenes*

2. TECHNICAL APPROACH

Two methods were used to develop estimates of background air toxics concentrations for the NATA 2002. The first method relies on ambient air toxics measurements (ambient-based method), and the second method relies on hazardous air pollutant (HAP) s emission inventory data (emissions-based method). The ambient-based method is preferred because the background estimates are based on measured air toxics concentrations throughout the United States. However, reliable ambient measurements are not always available for every pollutant of interest. Therefore, an emissions-based method was developed to handle those pollutants for which ambient measurements are inadequate. In addition, a few pollutants were assigned uniform spatial concentrations based on their long lifetimes and well-characterized concentrations. These pollutants are carbon tetrachloride, methyl chloride, methyl bromide, and methyl chloroform. All are routinely measured at remote sites and have well-mixed concentrations in the Northern Hemisphere[2] (Montzka et al., 1999; Montzka et al., 2000; Prinn et al., 2000). The values for these pollutants are presented as standard estimates in Section 2.3.

2.1 METHOD SELECTION

Prior to developing background concentration estimates, an assessment of ambient air toxics data availability and quality was performed to identify the pollutants that were candidates for the ambient-based method and those that would require the emissions-based method. Two criteria were used to determine if adequate data were available for a pollutant for the ambient-based method:

1. For a given pollutant, at least 100 ambient measurement locations were required for adequate spatial representativeness. In general, 100 monitoring sites resulted in a reasonable spatial distribution of monitoring locations across the United States for most pollutants.
2. For a given pollutant, at least 85% of the ambient measurements had to be above the method detection limit (MDL). The MDL is a measurement process characteristic that establishes the level at which a reported measurement is considered to be statistically significantly greater than zero. Concentrations reported at or below the MDL have a high relative uncertainty. When a high percentage (>85%) of measurements for a given pollutant are below the MDL, the average pollutant concentration has a high relative uncertainty and is considered to be poorly characterized. Ambient measurements that are consistently reported below MDL are unlikely to provide useful quantitative information for estimating spatial variability in background concentrations.

The two criteria were applied to the ambient measurements for 30 air toxics of interest. The ambient-based methodology was used to estimate background concentrations for those HAPs with ambient measurements that met both criteria. **Table 2-1** lists the number of monitoring sites and the percentage of data below detection for the HAPs of interest.

[2] ftp://ftp.cmdl.noaa.gov/hats/

Table 2-1. List of pollutants and the criteria for inclusion in the ambient- or emissions-based method of analysis. Red shading indicates more than 85% of samples were below MDL or there were less than 100 sites. Yellow shading indicates more than 50% but less than 85% of samples were below MDL.

Pollutant	Number of Sites	% of Samples Below MDL	Pollutant	Number of Sites	% of Samples Below MDL
Toluene	317	3	Beryllium PM_{10}	27	84
Acetaldehyde	187	5	Beryllium TSP	69	86
Chloromethane	260	6	Trichloroethylene	291	87
Benzene	332	10	Bromomethane	241	93
Formaldehyde	188	30	Cadmium $PM_{2.5}$	269	93
Carbon tetrachloride	304	43	Ethylene dichloride	267	96
Manganese $PM_{2.5}$	442	49	Vinyl chloride	269	96
Lead $PM_{2.5}$	442	49	1,2-Dichloropropane	244	97
Dichloromethane	295	54	1,1,2,2-tetrachloroethane	244	98
1,4-Dichlorobenzene	220	64	Ethylene dibromide	252	99
1,3-Butadiene	294	67	Benzidine	1	100
Tetrachloroethylene	296	70	Bis(2-ethylhexyl)phthalate	12	13
Methyl chloroform	281	72	Ethylene oxide	16	34
Nickel $PM_{2.5}$	436	77	Naphthalene	44	49
Chloroform	296	77	Chromium VI TSP	21	55
Arsenic $PM_{2.5}$	442	78	Acrylonitrile	129	73
Chromium $PM_{2.5}$	436	82			

The emissions-based method was applied to HAPs for which ambient data failed to meet the ambient-based method criteria. An exception was chromium, which was characterized using both methods. Chromium has a specific oxidation state (hexavalent chromium) that is toxic, but most ambient measurements do not distinguish its oxidation state and simply measure total chromium. The ambient measurements reflect this total chromium value, while the emissions-based method specifically represents chromium VI. **Table 2-2** lists the air toxic pollutants for which background estimates were developed and the methodology used for each.

Table 2-2. Methods used to estimate background concentrations for HAPs of interest for NATA 2002.

Ambient-based Method	Emissions-based Method	Assigned Concentrations
1,3-Butadiene	Hydrazine	Carbon tetrachloride
1,4-Dichlorobenzene	Chromium (VI)	Methyl chloride
Acetaldehyde	Ethylene dichloride	Methyl bromide
Arsenic	Naphthalene	Methyl chloroform
Benzene	Propylene dichloride	
Chloroform	Ethylene oxide	
Chromium	Acrylonitrile	
Dichloromethane	Cadmium	
Formaldehyde	Beryllium	
Lead	Ethylene dibromide	
Manganese	Benzidine	
Nickel	Quinoline	
Tetrachloroethylene	Bis(2-ethylhexyl)phthalate	
Toluene	1,2-Dibromo-3-chloropropane	
	Trichloroethylene	
	1,1,2,2-Tetrachloroethane	

2.2 DATA AVAILABILITY

Ambient air toxics data were acquired for 2002 through 2005 from EPA's Air Quality System (AQS). These data were supplemented with measurements from the Interagency Monitoring of Protected Visual Environments (IMPROVE) and the Southeastern Aerosol Research Characterization Study experiment (SEARCH). Data from AQS were downloaded in July 2007, while the supplemental data were previously acquired in August 2006.

Air toxics measurements are primarily collected as 24-hr duration samples. These samples are most often collected at 1-in-3-, 1-in-6-, or 1-in-12-day frequencies. Any samples collected with less than 24-hr duration (e.g., 1-hr or 3-hr samples) were aggregated into 24-hr averages if at least 75% of the day was measured. For example, at least 18 1-hr samples were required for aggregation to a 24-hr average. This criterion ensured reasonable diurnal concentration representation.

The 2002 NEI was acquired and used for the emissions-based method. Total emissions by county and pollutant are reported in the NEI.

2.3 AMBIENT-BASED METHODOLOGY

Background concentration estimates for 14 HAPs were developed using the ambient-based method. This method consists of four general steps:

1. Create annual average concentrations and select monitoring sites with seasonally representative measurements for each of the 14 HAPs.
2. Determine the quality of measurements for each pollutant at each monitoring location and calculate initial background concentrations.
3. Quality assure (QA) and quality control (QC) the results.
4. Apply standard background values to areas lacking ambient measurements.

2.3.1 Create Annual Averages and Select Representative Monitoring Sites

Ambient concentration data from AQS, IMPROVE, and SEARCH were aggregated to annual averages using the completeness criteria for the 14 HAPs listed in column 1 of Table 2-2. To create annual averages that adequately represent the entire year, quarterly calendar averages were created first.

Only 24-hr averages, based on both sub-daily data and 24-hr duration measurements, were used to create the quarterly average data. The quarterly averages were computed as follows:

- Calendar quarters were defined as January through March, April through June, July through September, and October through December.
- Quarterly averages were calculated using a 75% data completeness criterion based on the sampling frequency for a given monitoring location. If sampling frequency information was not available, a minimum of six valid daily average values were required per quarter for each monitoring location; this minimum count coincides with the 75% completeness criterion applied to a 1-in-12-day sampling frequency.

Annual averages were then calculated by averaging the quarterly averages at a monitoring location. At least three of four quarterly averages were required to adequately represent the seasonal variability in pollutant concentrations.

We ensured that individual measurements represented the seasons of the year for a given location and pollutant by requiring a valid annual average at a monitoring location. This requirement meant that at least three of four seasons are represented with at least six measurements for each. Separately, we required 30 samples from each monitoring location to provide slightly more robust statistics for the percentiles used (i.e., 30 samples will provide a better number than 18 samples when trying to determine a 10^{th} percentile value or the percentage of samples below MDL). The actual background estimation was then performed using 24-hr averages as described in the next section.

2.3.2 Determine the Quality of Measurements for Each Pollutant at Each Monitoring Location and Calculate Initial Background Concentrations

Data for each site and HAPs were assessed to determine the number of samples below the reported MDL. Each monitoring site was then assigned to one of three MDL bins based on the percentage of samples reported below the MDL: (1) <10%, (2) 10-85%, and (3) >85% as shown in **Table 2-3**. Sites with less than 10% of data below the MDL were assigned to the first bin. For these locations, the 10^{th} percentile concentration reported at that site was used as the background concentration. The 10^{th} percentile concentration corresponds to the cleanest days monitored at a site, which we would expect to be representative of "clean air" background concentrations. Choosing the 10^{th} percentile rather than another small percentile will have relatively small influence on the final background results. Given the typical lognormal distribution of pollutant concentrations at monitoring locations, the difference between the 5^{th}, 10^{th}, and 20^{th} percentile concentrations are small at the lower end of the distribution.

Table 2-3. MDL bins and corresponding methods used to calculate initial background concentration estimates for each site and pollutant.

Percent of Data Below MDL	Estimation Method
<10%	10^{th} percentile concentration
10-85%	Fraction of samples above MDL * MDL
>85%	0.10 * MDL

Sites with 10-85% of data reported below the MDL were assigned to the second bin. When 10-85% of data are reported below the MDL, the 10^{th} percentile concentration is considered unreliable; therefore, an alternate method was required to estimate the 10^{th} percentile concentration for site data assigned to the second bin. For those site data, the fraction of samples reported above the MDL was multiplied by the MDL to estimate the 10^{th} percentile concentration. For example, if 35% of samples were above the MDL, the estimated background concentration would equal (0.35)*MDL. This approach ensured that the percentage of samples above the MDL for a given site was reflected in the background concentration estimates.

Sites with at least 85% of data reported below the MDL were assigned to the third bin. The equation (0.10)*MDL was used to estimate background concentrations for site data assigned to the third bin because data that fall below the MDL do not provide useful information about the distribution of concentrations at a site and are, therefore, treated homogeneously. Of the three MDL bins, site data assigned to the third bin are considered the least representative for estimating background concentrations.

After the site data and HAPs were assigned to MDL bins, background concentrations were estimated using the methods discussed above. Summary statistics were then calculated for each pollutant including 5^{th}, 20^{th}, 50^{th}, 80^{th}, and 95^{th} percentiles. The summary statistics were used to QA and QC the background estimates and to assign background concentrations to counties without ambient measurements.

2.3.3 Quality Assure and Quality Control the Results

A flowchart illustrating the QA and QC methods used to assess the background concentrations is shown in **Figure 2-1**. Statistical and visual tests were performed to QA and QC the site-specific background estimates:

- Comparing results from each location to remote background concentrations. Concentrations below the remote background concentrations were replaced with the remote estimate.
- Identifying all sites with background concentrations more than two times greater than the 80th percentile background concentration. These estimates were replaced with the 80th percentile background concentration.
- Flagging the highest and lowest 5% of sites for further visual inspection of the data.
- Identifying all sites with background concentration estimates below the MDL when the MDL is more than twice the national average. These data were flagged for further visual inspection.
- Flagging all locations with background concentration estimates above the MDL when the background concentration is above a health benchmark threshold (i.e., 0.5-in-a-million cancer or 0.1 hazard quotient) for further visual inspection.

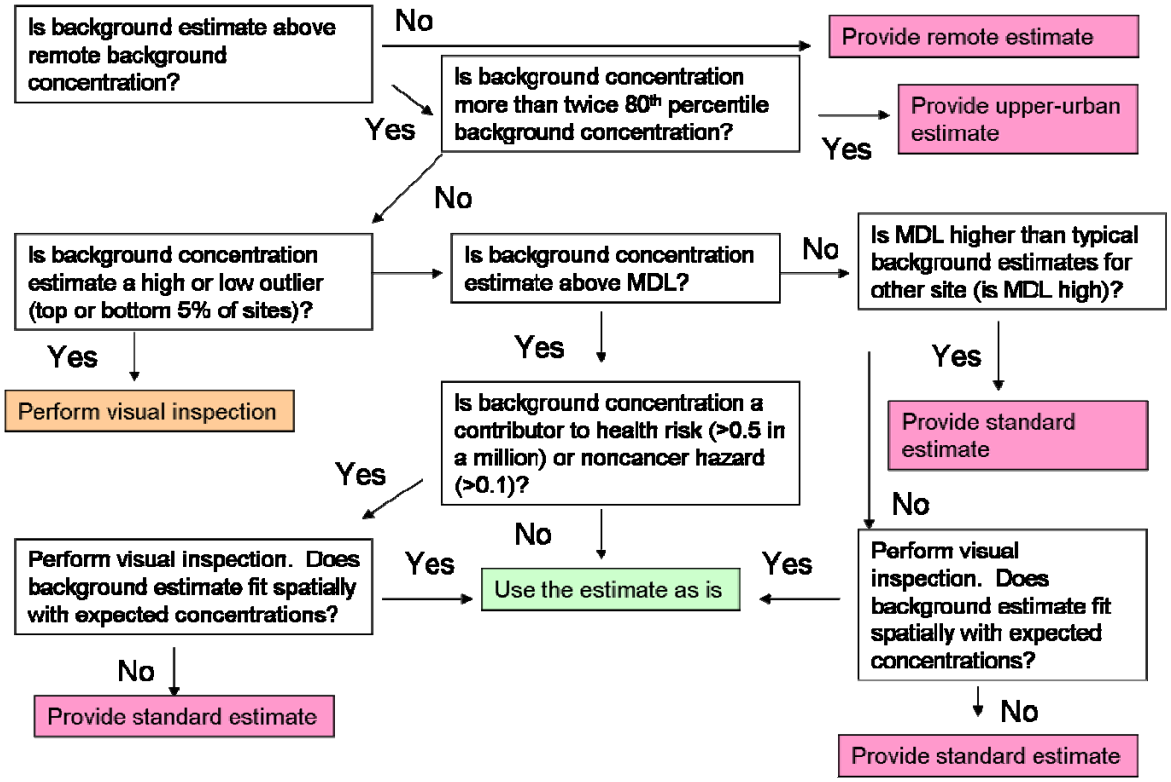


Figure 2-1. Flow chart illustrating the QA and QC steps performed on site-specific background concentration estimates.

Site data that appeared to be suspect were then further inspected by an analyst using maps of background concentration estimates, average MDL values, and average concentration values for all locations. **Figure 2-2** is an example of a map used to visually inspect concentrations for benzene. Visual inspections included the following steps:

- Comparing background estimates to average pollutant concentrations for a particular location. The background estimates should be between 10-50% of the average concentration for most pollutants. Most sites reporting high background concentrations relative to average concentrations were in the >85% below MDL bin.
- Inspecting background concentration maps to identify spatial patterns in concentrations. Data from areas with high or low background concentrations that appeared inconsistent with regional patterns were flagged.
- Inspecting individual outliers with high or low background estimates. Location data that appear unrealistic given the spatial patterns of concentrations were flagged.

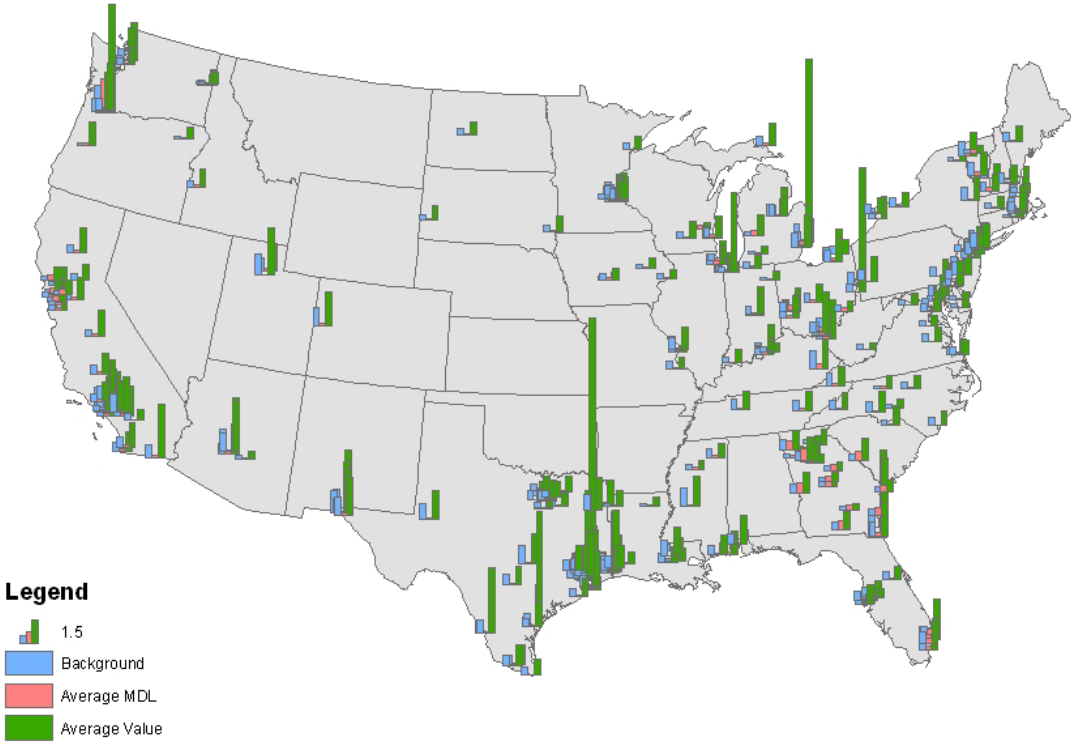


Figure 2-2. Example visual inspection map for benzene. Background estimates, average MDL values, and average concentrations (all in $\mu g/m^3$) are displayed for all sites with monitoring data (2002-2005).

After performing QA and QC on the site-specific data for the 14 pollutants, county estimates were generated. Because monitoring sites do not exist in all counties, and/or some counties are quite large and may only have a single monitoring location, the background

estimates were applied to the county level. The following rules were used to create the site-to-county assignments:

1. For all counties with only one monitoring location, the estimate for that location was assumed to represent the county.
2. For counties with multiple monitoring locations, the location with the minimum concentration was used. The minimum concentration was assigned as the background to provide an estimate of the lowest county concentrations.
3. Counties with no available ambient measurements were assigned a standard estimate (Section 2.3.4).

2.3.4 Apply Standard Background Values to Areas Lacking Ambient Data

Because background concentration estimates are influenced by many factors, some estimates were unlikely to be reliable or representative of the real atmosphere. For example, some sites reported concentrations with very high MDLs that would result in high background estimates using our approach. For these and similar cases for which the reliability of the background estimate is questionable, a "standard" estimate was assigned to the site. In addition, many counties had no available ambient data to estimate background concentrations. For these counties, the standard estimates were assigned.

Standard estimates were defined for four population bins based on the population distribution of U.S. counties and the subset of counties with ambient HAP monitors. The bins and definitions follow:

1. Remote – population < 25,000 and rural county
2. Small urban – population between 25,000 and 100,000 and rural, or population < 25,000 and classified as an urban county by NATA 1999
3. Medium urban – population between 100,000 and 1,000,000
4. Large urban – population > 1,000,000

Figure 2-3 illustrates the population distribution of U.S. counties and the subsets of counties with ambient measurements.

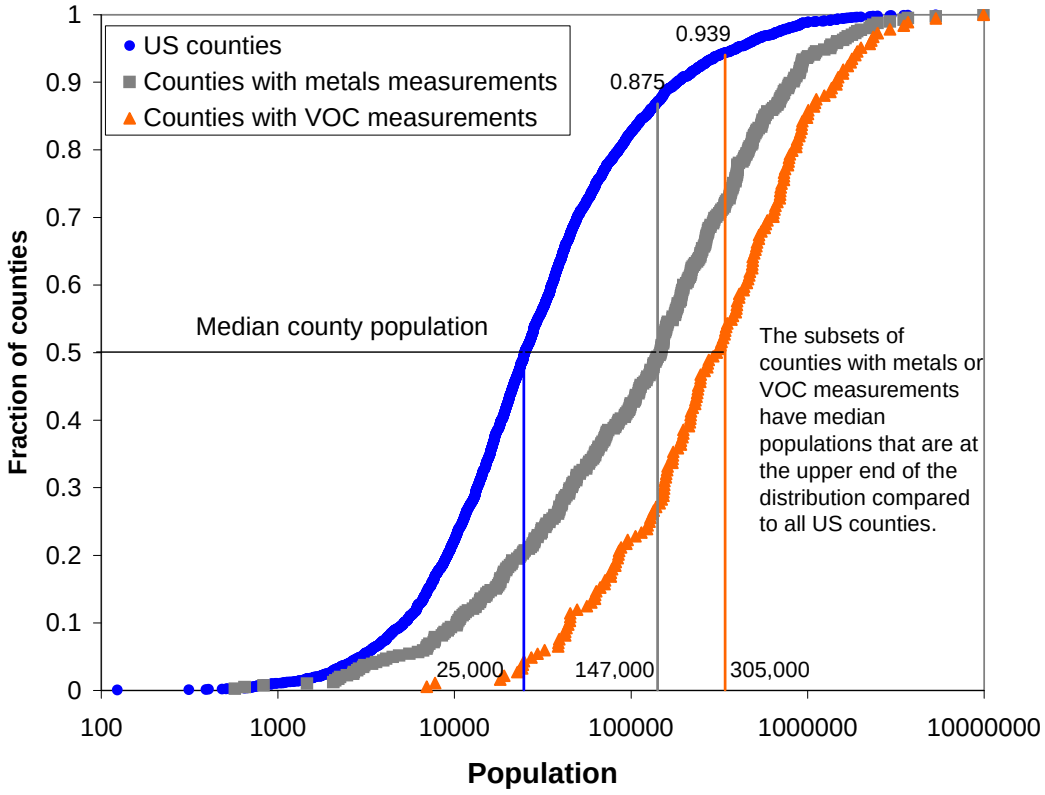


Figure 2-3. Cumulative distribution function illustrating the relative distribution of population of U.S. counties (blue circles) compared with the subsets of counties with metals measurements (gray squares) and VOC measurements (orange triangles) (2002 census estimates).

From counties with available measurements of ambient data, (1) small-urban estimates were developed using the 20th percentile concentrations; (2) medium-urban estimates were developed using the 50th percentile concentrations; and (3) large-urban estimates were generated using the 80th percentile concentrations. Counties lacking ambient data values were assigned to one of the four population bins based on their characteristics (i.e., population and urban/rural designation) and corresponding standard background concentration values were applied. Standard background concentration estimates are listed in **Table 2-4**.

Table 2-4. Standard estimates ($\mu g/m^3$) for use in NATA 2002 for counties of varying population sizes.

Pollutant	Remote	Small Urban	Medium Urban	Large Urban
1,3-Butadiene	4.0×10^{-4}	2.6×10^{-2}	4.0×10^{-2}	6.6×10^{-2}
1,4-Dichlorobenzene	0.021	0.021	0.046	0.1
Acetaldehyde	0.16	0.57	0.90	1.2
Arsenic	1.3×10^{-4}	1.3×10^{-4}	3.5×10^{-4}	6.4×10^{-4}
Benzene	0.14	0.35	0.54	0.82
Chloroform	0.059	0.059	0.059	0.082
Chromium	4.1×10^{-5}	4.1×10^{-5}	2.9×10^{-4}	5.4×10^{-4}
Dichloromethane	0.11	0.11	0.19	0.30
Formaldehyde	0.20	0.69	1.2	1.7
Lead	4.9×10^{-4}	4.9×10^{-4}	1.0×10^{-3}	1.8×10^{-3}
Manganese	5.8×10^{-4}	5.8×10^{-4}	5.8×10^{-4}	1.0×10^{-3}
Nickel	6.5×10^{-5}	6.5×10^{-5}	1.5×10^{-4}	4.0×10^{-4}
Tetrachloroethylene	0.022	0.034	0.065	0.17
Toluene	0.041	0.45	0.87	1.5
Carbon tetrachloride	0.61	0.61	0.61	0.61
Methyl chloride	1.2	1.2	1.2	1.2
Methyl bromide	0.035	0.035	0.035	0.035
Methyl chloroform	0.17	0.17	0.17	0.17

2.4 EMISSIONS-BASED METHODOLOGY

Sixteen of the 34 air toxics listed in Table 2-2 were identified as having inadequate ambient data to apply the ambient-based method. Background estimates based on the available ambient data for these pollutants would either be represented by too few sites from which to extrapolate data or represent poor quality measurements on which to base background estimates. To provide spatially representative background concentrations for these pollutants, an alternative approach was required. The following emissions-based method was developed and is best applied to pollutants that are emitted directly by a few large sources and that have short residence times in the atmosphere. The emissions-based method consists of four general steps:

1. Import emission inventory data into a geographic information system (GIS) and create emissions density maps.
2. Apply a spatial weighting scheme for deriving emissions gradients.

3. Normalize the emissions gradients.
4. Convert emissions gradient values to background concentration values.

The emissions-based method uses GIS technology to spatially weight and distribute county-level emissions estimates for each pollutant based on its residence time and air parcel transport potential. These county-level emissions gradient values were then post-processed using lower- and upper-bound anchor points to convert emissions values to background concentrations.

2.4.1 Import Emission Inventory Data into a GIS and Create Emissions Density Maps

The 2002 county-level NEI data were imported into a GIS, and county-level emissions density maps were generated. Because the NEI data consist of a single emissions value for each county by pollutant, it is necessary to spatially distribute the emissions values across county boundaries to account for pollutant transport. To address this, emission inventory data were spatially weighted and distributed across county boundaries using a distance-residence time weighting scheme for each pollutant. To account for differences in pollutant lifetimes, or residence times (i.e., some pollutants remain in the air longer than others), a weighting function was derived and applied within the GIS to create emissions gradients for each pollutant. **Figure 2-4** shows the countywide 2002 NEI data for ethylene dibromide.

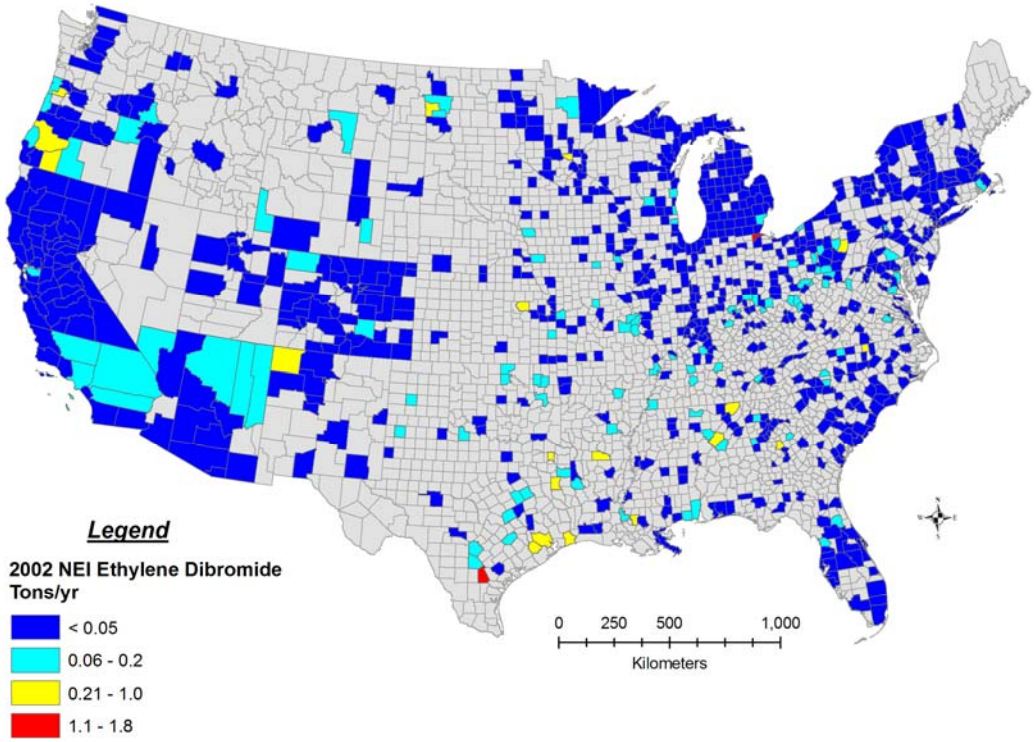


Figure 2-4. Countywide ethylene dibromide emissions (tons/year) as reported in the 2002 NEI. Each county is colored according to the magnitude of its total emissions, with gray indicating no reported emissions.

2.4.2 Development of Spatial Weighting Scheme for Deriving Emissions Gradients

The dispersion and dilution assumptions in a Gaussian plume dynamics model lead to concentration dilution of multiple orders of magnitude within a few kilometers. This approach is appropriate for modeling plume movement away from a discrete point source; however, it is less useful for modeling county-level transport. Based on an average wind speed of 3 m/s, air parcel transport is approximately 250 km per day. Consequently, significant transport can occur over two days for pollutants with long residence times. While pollution can be transported farther distances, it is likely that emissions contributions from counties at distances greater than 500 km will be relatively small.

Residence time is another factor contributing to pollutant concentrations over time. Chemical or physical removal competes with dilution if the residence time is on the same order of magnitude as the transport time. If pollutants are removed at rates much slower than they are diluted, they can be treated as inert on the timescale of a few days. In contrast, if pollutants are removed on the timescale of a few hours, the removal processes will compete with dilution and the observed gradient in concentrations will be sharper.

For each pollutant of interest, buffer distances were calculated based on the residence time and dilution factors. For the dilution factor of a completely inert pollutant with no deposition, a maximum buffer distance of 500 km was assumed to be the range of influence. While pollution can be transported around the globe, most point source emissions of pollution will have been fully diluted well within 500 km. This initial 500-km distance was then reduced as a function of the pollutant residence time. Equation 2-1 defines the drop-off as a function of distance,

$$B_x = \frac{500}{1.5^{\frac{0.5}{t}}} \qquad \textbf{(2-1)}$$

where B_x is buffer distance and *t* is residence time in days. The exponential equation 1.5^(0.5/t) was empirically selected to provide buffer distances that reflect our expectations. **Table 2-5** summarizes the buffer distances computed using Equation 2-1. Metals in particulate matter were assigned a 10-day residence time based on estimated residence times of $PM_{2.5}$ in the atmosphere. Because emissions are not broken out by particle size fractions in the NEI, these estimates will likely overestimate the range of influence of particulate metals. This approach was chosen because it is more conservative and protective of human health.

Table 2-5. Calculated buffer distances for HAPs of interest.

Pollutants	Buffer Distance (km)
Hydrazine	222
Chromium (VI)	498
Ethylene dichloride	498
Naphthalene	222
Propylene dichloride	496
Ethylene oxide	485
Acrylonitrile	482
Cadmium	490
Beryllium	490
Ethylene dibromide	498
Benzidine	409
Quinoline	499
Bis(2-ethylhexyl)phthalate	500
1,2-dibromo-3-chloropropane	497
Trichloroethylene	483
1,1,2,2-Tetrachloroethane	499
Vinyl chloride	451
Chloroprene	40
Acrolein	333
1,3-Dichloropropene	425

To provide a conceptual model of how the buffer distances are applied, consider chloroprene and cadmium. Chloroprene has a relatively short residence time and a resulting buffer distance of 40 km. Assume that the emissions point source for chloroprene is located at the county centroid. As the distance away from the county centroid increases, the concentration of chloroprene will rapidly decrease due to dilution and chemical reaction. When the distance away from the county centroid equals 40 km, it is assumed that the concentration of chloroprene will equal zero. Therefore, the contribution of chloroprene from one county to another is likely to be small because this pollutant has a relatively short residence time. In contrast, cadmium has a much longer residence time and a buffer distance of 490 km. The concentration of cadmium does not reach zero until the distance away from the county centroid is 490 km; therefore, the contribution or influence of cadmium from one county to an adjacent one is likely to be relatively high.

For each pollutant, the buffer distance (B_x) was used in Equation 2-2 to estimate the fraction of emissions contribution from a particular county as the distance away from the county centroid increases.

$$f_1 = [(B_x - r)/B_x)]^2 \quad \textbf{(2-2)}$$

where *r* is the distance between county centroids, B_x is the distance from the county centroid where the pollutant concentration equals zero, and f_1 is the fraction of emissions contribution from a specific county. The resultant value, f_1, is the fraction of the total emissions of a particular county that are transported to a nearby county.

Example Calculation

Contribution of chloroprene from County 1 assuming a distance away from the centroid of 30 km (r = 30 km):

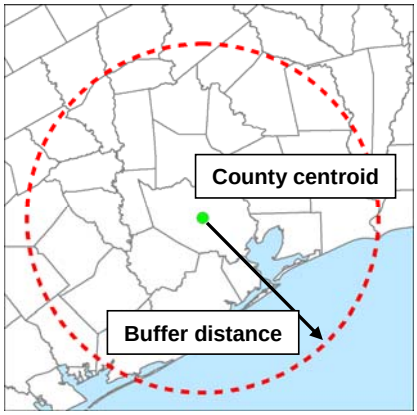
$f_1 = [(40 \text{ km} - 30 \text{ km})/40 \text{ km }]^2 = (0.25)^2 = 0.063$

Contribution of Cadmium from County 1 assuming a distance away from the centroid of 30 km (r = 30 km):

$f_1 = [(490 \text{ km} - 30 \text{ km})/490 \text{ km }]^2 = (0.94)^2 = 0.882$

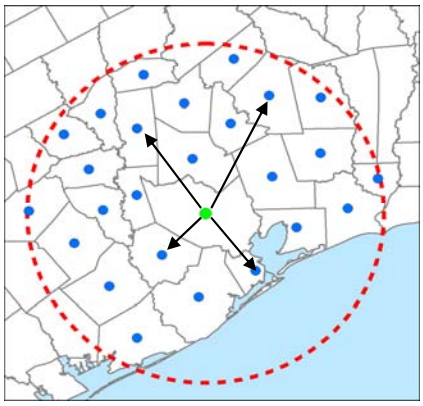
Figure 2-5 illustrates the process used to develop and apply the spatial weighting scheme.

(1)



Calculate buffer distances for each pollutant and create buffers centered on county centroids.

(2)



Calculate the distance(s) between all county centroids within the buffer. Each county centroid has an associated emissions value representing total county emissions for a specific pollutant.

(3)

Use the following distance weighting equation to calculate the fraction of influence that each adjacent county has on the center county :

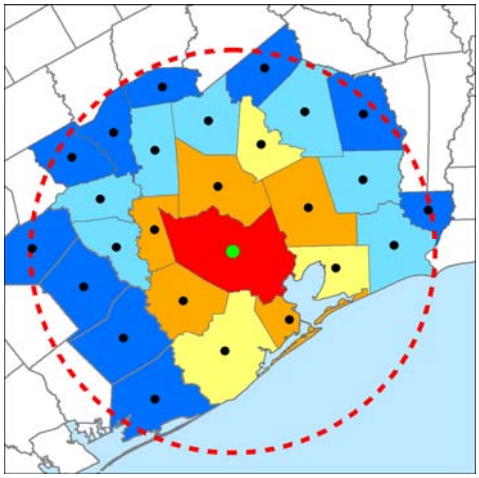
$$f_1 = [(Bx - r)/Bx)]^2$$

(4)

Use the following summation equation to compute the additive influence of each emission value within the buffer:

$$F_{county} = \frac{\sum_{1}^{n} f_n E_n}{\max(\sum_{1}^{x} f_x E_x)}$$

(5)



Spatially distributed emissions values based on the spatial weighting scheme. Note that red indicates areas of high emissions influence and blue represents areas of low influence. Also note that emissions are higher in the center of the buffer zone because as the distance from the county centroid increases the pollutant emissions value decreases as a function of the pollutant buffer distance (listed in Table 5 by pollutant).

Figure 2-5. Illustration of the process used to apply the weighting scheme to spatially distribute county-level emissions.

2.4.3 Normalize the Emissions Gradients

Circular buffers centered on a county centroid were created within the GIS. The size of the buffer was determined by the buffer values corresponding to each pollutant listed in Table-2-5. The f_1 values for all counties were calculated within the GIS, and the combined contribution of each county was summed for a given buffer region. Equation 2-3 was then used

to normalize the emissions contributions from all counties that influence a single county within the buffer zone.

$$F_{county} = \frac{\sum_{1}^{n} f_n E_n}{\max(\sum_{1}^{x} f_x E_x)} \quad \textbf{(2-3)}$$

where F_{county} is the county of interest, n is the number of counties with emissions that influence that county, f_n is the fraction emissions value calculated using Equation 2-2, E_n is the county emissions value from the 2002 NEI, x is the number of counties that influence the highest emissions county in the country, and max indicates the county with the highest emissions in the country for a given pollutant. This calculation is repeated for all counties with reported emissions by pollutant. The weighted emissions values for individual counties were summed and normalized using the county with the maximum emissions contribution (post-calculation). The resulting F_{county} is a unitless value between 0 and 1 representing the lowest and highest transport values in the country, respectively. The normalized F_{county} values were mapped to display the resulting emissions gradient by pollutant. The emissions gradient for each pollutant represents a unitless number corresponding to a range of emissions values. **Figure 2-6** shows an example map of a normalized emissions gradient field for ethylene dibromide.

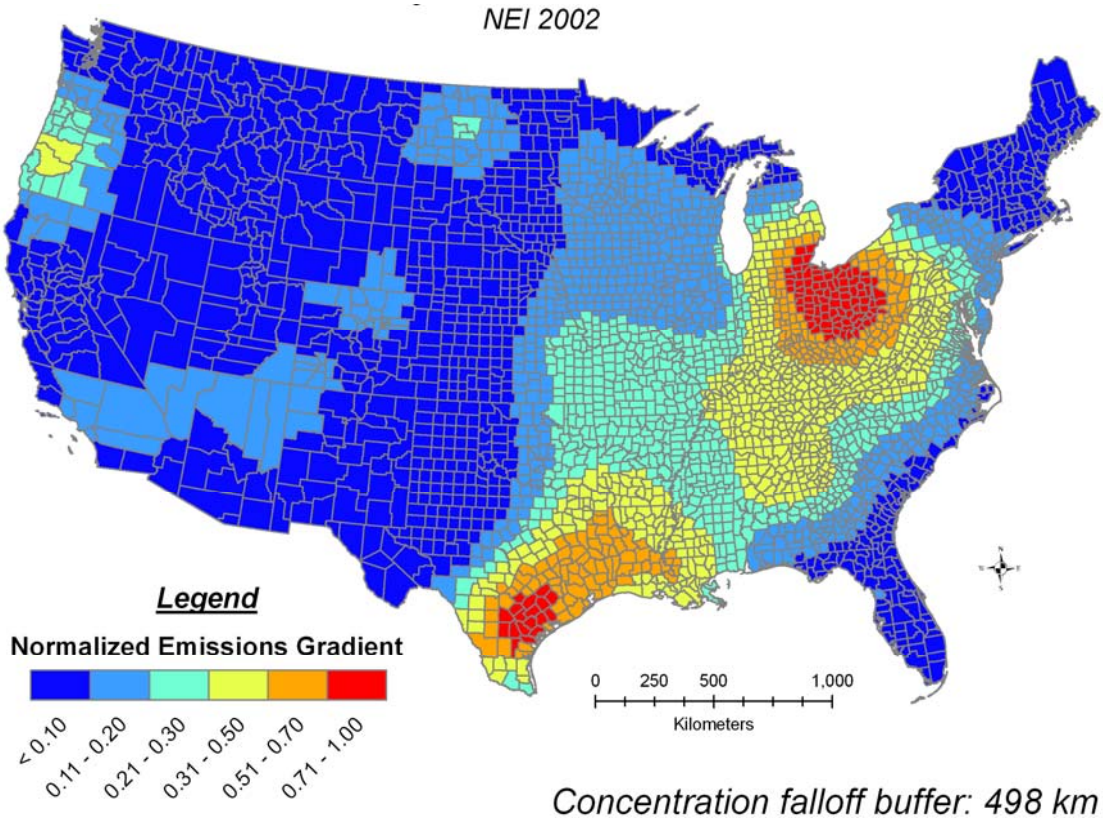


Figure 2-6. Example normalized emissions gradient map for ethylene dibromide.

2.4.4 Convert Emissions Gradient Values to Background Concentration Values

Emissions gradients were converted to the corresponding concentration values using minimum and maximum ambient concentration values. Estimating these minimum and maximum background concentration values requires multiple steps. The minimum ambient concentration represents a geographically remote concentration estimate. Remote concentrations for these pollutants are not typically measured or available in the published literature. Therefore, remote concentrations were estimated based on the 2002 NEI and a comparison to a pollutant with measured remote concentrations. Equation 2-4 shows the relationship used to derive these remote estimates.

$$[C_i] = \frac{E_i * t_i * [C_{tetrachloroethylene}]}{E_{tetrachloroethylene} * t_{tetrachloroethylene_i}} \quad \textbf{(2-4)}$$

where *[C]* is the remote concentration, *E* is the 2002 NEI value in tons per year, *t* is the residence time in years, and *i* is the pollutant of interest. **Table 2-6** provides the calculations and estimated concentrations for selected HAPS.

Maximum concentrations used to develop scaling factors are based on the ASPEN model-predicted pollutant concentration for the county with the highest concentration. We expect this county to contribute the most to background concentrations in adjacent counties. However, we also expect the concentrations from this county to be diluted during transport to the adjacent and downwind counties. Therefore, the 10^{th} percentile concentration in the highest county in the United States from the ASPEN model predictions from NATA 1999 was used as the highest background concentration in the county.

The minimum and maximum background concentration estimates were used to develop a linearly interpolated scaling system to apply to the emissions gradient data. A simple linear relationship was derived relating the minimum and maximum concentrations to the highest and lowest emissions gradient values for each county. In a linear slope equation of $y = mx + b$, b is equal to the remote background estimate and m is equal to the maximum background estimate minus the minimum background estimate. This equation was used to predict (or convert) emissions gradient values to concentration values for all counties in the United States by setting x to the county-specific normalized emissions gradient value and solving the equation for y.

Table 2-6. Calculation of remote concentration estimates using residence times and 2002 NEI emissions.

Name	Residence Time (days)	2002 Emissions (tons per year)	Emissions x Residence Time (tons)	Fraction of Tetrachloroethylene	Measured Remote Concentration ($\mu g/m^3$)	Estimated Remote Concentration ($\mu g/m^3$)
Benzyl chloride	3	325	2.7	0.004		9.3E-05
Ethylene dibromide	50	24	3.2	0.005		1.1E-04
Vinyl chloride	2	1306	7.1	0.011		2.5E-04
Naphthalene	0.25	14729	10.1	0.02		3.5E-04
1,2-Dichloropropane	30	160	13.2	0.02		0.0005
Ethylene OXIDE	7	695	13.3	0.02		0.0005
Acrylonitrile	5.6	1024	15.7	0.02		0.0005
Bromoform	540.0	22	32.6	0.05		0.0011
1,3-Dichloropropene	1.25	11518	39.4	0.06		0.0014
Acrolein[a]	0.5	29647	40.6	0.06		0.0014
Ethylene dichloride	42	453	52.0	0.08		0.0018
1,1,2,2-Tetrachloroethane	91.3	296	74.0	0.12		0.0026
1,1,2-Trichloroethane	49	851	114.1	0.18		0.0040
Bis(2-ethylhexyl) phthalate	200.0	271	148.5	0.23		0.0052
Trichloroethylene	6	10808	177.5	0.28	0.005	0.0062
Carbon disulfide	7.0	15545	297.9	0.47		0.010
Xylenes	0.2	584519	320.1	0.51		0.011
1,4-Dichlorobenzene	31.0	7231	613.7	0.97		0.021
Tetrachloroethylene	6.5	35577	633.1	1.00	0.022	0.022
Toluene	0.5	891520	1220.4	1.93	0.041	0.042
Chloroform	80.0	6782	1485.5	2.35	0.059	0.052
Benzene	3.0	410892	3374.9	5.33	0.140	0.12
Dichloromethane	30.0	51057	4193.6	6.62	0.110	0.15
Carbon tetrachloride[2]	10950.0	454	13620.3	21.51	0.610	0.47
Methyl bromide	365.0	14777	14766.5	23.32	0.056	0.51

[a] Acrolein is formed secondarily and may not be well-represented using primary emissions estimates.
[2] Carbon tetrachloride has a very long residence time, which makes predictions based on current emissions moot.

Figure 2-7 shows an example of how the normalized emissions gradients were associated with ambient concentrations using a linear interpolation approach for ethylene dibromide. In this figure, the two endpoint concentrations are anchored at the highest (1.0) and lowest (0.0) normalized emissions gradient for ethylene dibromide. All other county background concentrations are then interpolated between these two points based on their emissions gradient values.

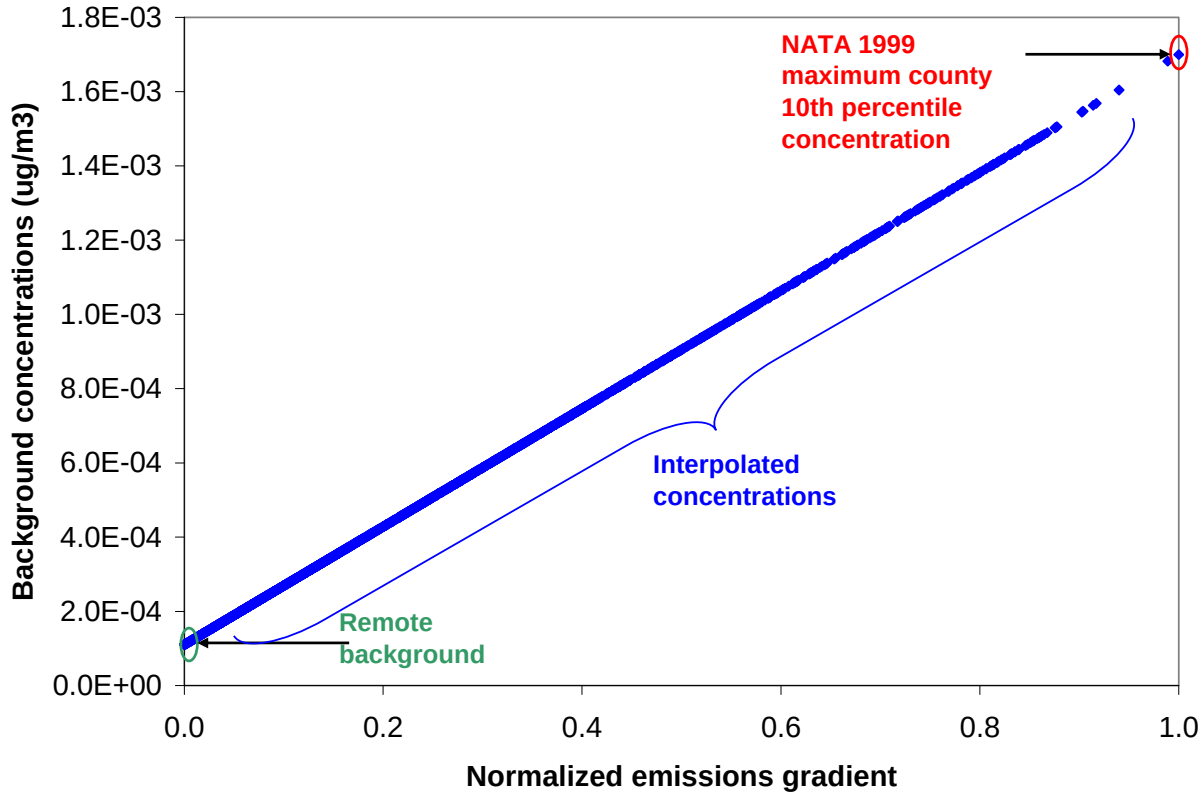


Figure 2-7. Example of how the normalized emissions gradient data were converted to concentration data for ethylene dibromide using a linear interpolation approach.

An automated GIS-based methodology was used to carry out the emissions-based method to enable rapid creation of these values. The GIS-based approach was scalable across pollutants. The 16 HAPs selected for the emissions-based method were identified using the criteria discussed in the Section 1 and the following criteria:

- Pollutants are likely contributors to cancer risk or non-cancer hazard values based on previous NATA assessments (i.e., on the background list or risk driver/contributor list).
- Pollutants were poorly characterized by ambient concentrations (i.e., lack of monitoring sites or MDLs insufficient to characterize concentrations).

- Pollutants are predominantly emitted by major stationary sources (i.e., not area or mobile emissions sources):
  - Due to the nature of the methodology, the emissions-based method is most applicable to pollutants emitted by a few large sources because the emissions gradients were developed assuming that the emissions are released at a specific point and decrease as the distance from the point increases. Ubiquitous sources such as motor vehicles or area sources are unlikely to be represented well by this methodology because the gradients will be more diffuse.
  - Based on natural breaks in the NEI data distribution, most of the proposed pollutants were (1) emitted in fewer than 50 counties nationwide, (2) emitted in fewer than 150 counties that contributed two-thirds of total emissions, or (3) dominated by emissions sources other than point sources.
- Pollutants are not produced secondarily or biogenically and/or have a residence time exceeding one year. The 2002 NEI will not be representative of the actual emissions sources and concentrations for these types of pollutants using this method because emission inventories only report primary emissions.

Table 2-7 lists candidate air toxics and the two criteria that were applied to determine candidate pollutants for the emissions-based method. Column 1 lists the candidate pollutants, column 2 lists the number of counties that contribute at least two-thirds of total emissions nationally (from point sources), and column 3 lists the known sources of these pollutants that would not be accounted for by the NEI. Pollutants emitted primarily by non-point source emissions (i.e., area and mobile sources) are less likely to be represented well by the emissions-based method. In particular, secondary production or pollutants with very long residence times are not considered good candidates for this method.

To identify pollutants that are likely to have maximum "background" concentrations that exceed 10^{-6} risk, an analysis of the NATA 1999 results was performed on the pollutants listed in Table 2-5 to assess the magnitude of concentrations expected in counties surrounding high emissions areas. This analysis was performed by examining the 10^{th} percentile concentration minus background contribution for the highest concentration counties. These concentrations were then compared to the relevant benchmark to illustrate the potential risk/hazard associated with these background concentrations. **Table 2-8** lists the estimated background contributions derived by this approach compared to the NATA 1999 background estimates.

The typical county will likely have far lower background concentrations than those estimated in Table 2-8. A list of prioritized HAPs for which to perform the emissions-based approach was created based on the summary of analyses in Table 2-6 and the following criteria:

1. The estimated risk/hazard in the highest counties and the risk/hazard associated with previous NATA results.
2. The suitability of emissions sources (i.e., point-sources and primary emissions) and the number of high-emitting counties.

Table 2-7. Candidate air toxics for the emissions-based approach.

Pollutants	Point Source Dominated (# Counties >66% of Total)	Non NEI Sources?
Chloroprene	2	No
Chlordane	4	No
Hexachloroethane	6	Yes (decadal residence time)
Propylene dichloride	7	No
1,2-dibromo-3-chloropropane	8	No
Hydrazine	10	No
Hexachlorobutadiene	10	No
Carbon disulfide	10	No
Benzidine	11	No
Phosgene	11	Yes (secondary)
Ethylene dichloride	18	No
Quinoline	25	No
Bis(2-ethylhexyl)phthalate	36	No
Acrylonitrile	47	No
Beryllium	56	No
Vinyl chloride	61	No
Ethylene dibromide	74	No
Chromium (VI)	85	No
Benzyl chloride	100	No
1,1,2,2-Tetrachloroethane	109	No
Cadmium	133	No
Trichloroethylene	149	No
Acrolein	<50% point source emissions	Yes (secondary production)
Naphthalene	<50% point source emissions	No
Ethylene oxide	<50% point source emissions	No
1,1,2-Trichloroethane	<50% point source emissions	No
1,3-Dichloropropene	<50% point source emissions	No
Lindane	<50% point source emissions	No

Table 2-8. Maximum contribution to background risk for counties near emissions based on the highest county's 10th percentile NATA 1999 concentration. Pollutants in italics were not risk drivers or contributors in NATA 1999.

Pollutants	NATA 1999 Characterization	Estimated 2002 Upper Background Risk *(Hazard)*
Chromium (VI)	Regional risk driver	100.0
Acrolein	National noncancer driver	*25.0*
Hydrazine	Regional risk driver	10.0
Naphthalene	Regional risk driver	3.0
Ethylene oxide	Regional risk driver	2.8
Cadmium	Regional noncancer driver	2.5
Trichloroethylene	Regional risk contributor	2.2
Acrylonitrile	Regional risk contributor	2.0
Beryllium	Regional risk contributor	2.0
1,1,2-Trichloroethane		1.5
1,3-Dichloropropene	Regional risk contributor	1.3
Ethylene dibromide	National risk contributor	1.0
1,1,2,2-Tetrachloroethane	National risk contributor	0.5
1,2-Dibromo-3-chloropropane		0.5
Ethylene dichloride	National risk contributor	0.5
Quinoline	Regional risk contributor	0.5
Benzyl chloride		0.4
Propylene dichloride	Regional risk contributor	0.4
Vinyl chloride	Regional risk contributor	0.3
Bis(2-ethylhexyl)phthalate	National risk contributor	0.1
Lindane		0.1
Hexachlorobutadiene		0.1
Hexachloroethane		0.1
Chloroprene		*0.0*
Benzidine	Regional risk driver	0.0
Carbon disulfide		*0.0*
Phosgene		*0.0*
Chlordane		0.0

Table 2-9 lists the final set of candidate air toxics for the emissions-based approach in ranked order. The pollutants are color-coded to highlight breakpoints that appear in the data.

Table 2-9. Candidate air toxics for which background concentrations were estimated using the emissions-based method. Pollutants are ordered using the ranking criteria described above.

Pollutants	NATA 1999 Characterization	Estimated 2002 Upper Background Risk *(Hazard)*	Rank
Hydrazine	Regional risk driver	10.0	4.5
Chromium (VI)	Regional risk driver	100.0	7
Ethylene dichloride	National risk contributor	0.5	9.75
Naphthalene	Regional risk driver	3.0	9.75
Propylene dichloride	Regional risk contributor	0.4	10
Ethylene oxide	Regional risk driver	2.8	10
Acrylonitrile	Regional risk contributor	2.0	10.25
Cadmium	Regional noncancer driver	2.5	10.25
Beryllium	Regional risk contributor	2.0	10.75
Ethylene dibromide	National risk contributor	1.0	10.75
Benzidine	Regional risk driver	0.0	10.75
Quinoline	Regional risk contributor	0.5	11.5
Bis(2-ethylhexyl)phthalate	National risk contributor	0.1	11.75
1,2-Dibromo-3-chloropropane		0.5	12
Trichloroethylene	Regional risk contributor	2.2	12
1,1,2,2-Tetrachloroethane	National risk contributor	0.5	12.5
Vinyl chloride	Regional risk contributor	0.3	13.5
Chloroprene		*0.0*	13.75
Acrolein	National noncancer driver	*25.0*	13.75
1,3-Dichloropropene	Regional risk contributor	1.3	14
Hexachlorobutadiene		0.1	14.75
Chlordane		0.0	15
Carbon disulfide		*0.0*	16
1,1,2-Trichloroethane		1.5	16.5
Benzyl chloride		0.4	16.75
Lindane		0.1	19.25
Hexachloroethane		0.1	19.25
Phosgene		*0.0*	22

3. RESULTS AND DISCUSSION

Background concentrations for all the pollutants listed in Table 1-1 were estimated using either the ambient- or the emissions-based method. Results from the ambient-based method are described in Section 3.1, followed by the results of the emissions-based method in Section 3.2.

3.1 AMBIENT-BASED METHOD RESULTS

The ambient-based method was applied to 14 HAPs, and an additional 4 HAPs were assigned concentrations based on remote background estimates from other networks. The results of the ambient-based method provide county-level background concentration estimates for a few hundred counties in the United States and associated territories. For all other counties, standard background concentration estimates were assigned (as listed in Table 2-4) based on the characteristics of the county (i.e., remote, small-urban, medium-urban, and large-urban). The ambient-based results can be best examined by looking at the counties for which background concentrations will be assigned to one of the four bins. **Table 3-1** provides summary data on the number of counties and corresponding populations living in counties assigned to the four bins. Overall, about 80% of all counties fall into the remote or small-urban categories. However, as a function of population, the remote and small-urban counties account for only 5.3% and 22.2% of the U.S. population, respectively. In contrast, while the 35 largest urban counties account for 25% of the population, they only make up 1% of the total number of counties. The medium-urban counties account for the remaining 47.4% of the U.S. population.

Table 3-1. Statistics on population bins used for classifying background concentrations.

County Type	Number of Counties	Total Population	Average Population
Remote	1,354	15,526,420	11,467
Small urban	1,385	64,955,977	46,900
Medium urban	448	138,446,014	309,031
Large urban	35	73,078,709	2,087,963

The standard urban estimates listed in Table 2-4 are weighted by their unit risk estimates as provided by EPA Office of Air Quality Planning and Standards (OAQPS) (U.S. Environmental Protection Agency, 2008) and displayed cumulatively as risk-weighted concentrations in **Figure 3-1**. The magnitude of each bar indicates the cumulative risk-weighted value for each pollutant in each of the standard estimates. Cumulative risk-weighted background concentrations for these pollutants increase from 11.6 per million in remote areas to 26.8 per million in large urban areas. In remote and small urban areas, the cumulative risk-weighted concentrations are dominated by carbon tetrachloride, with a smaller contribution from benzene. In the medium and large urban areas, contributions from benzene, arsenic, acetaldehyde, chromium, and 1,3-butadiene are all above 1-in-a-million. The cumulative risk-weighted concentrations from these pollutants are higher than results from NATA 1999 and NATA 1996,

largely as a result of the addition of the metals background concentrations. Metals were not included in background estimates for either of the two previous iterations and their predicted concentrations were among the most underestimated of all air toxics.

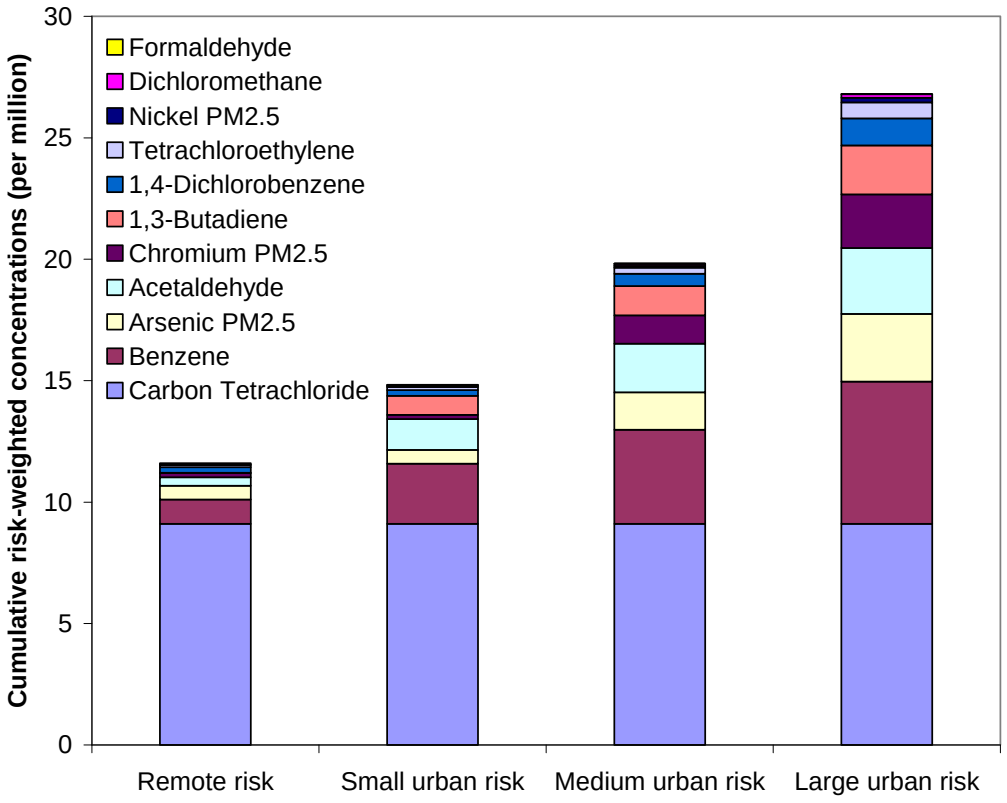


Figure 3-1. Cumulative risk-weighted concentrations of ambient-methods air toxics pollutants and carbon tetrachloride across the standard bins.

Figure 3-1 indicates that background concentrations will contribute more than 10-in-a-million risk to the total population, and more than 20-in-a-million risk to almost two-thirds of the U.S. population. The largest contributor to this risk is carbon tetrachloride which has been phased out under the Kyoto Protocol and is no longer produced in the United States. All other pollutants continue to be emitted throughout the United States, and most of their influence is a result of downwind transport.

Hazard-weighting of the air toxics was also performed and the results are shown in **Figure 3-2**; concentrations are weighted by chronic non-cancer reference concentrations. The cumulative hazard-weighted background concentrations are all below the hazard quotient level of one, which indicates that background concentrations for these pollutants are not expected to be at levels of non-cancer concern. In urban areas, the largest contributors to cumulative hazard among these pollutants are formaldehyde and acetaldehyde.

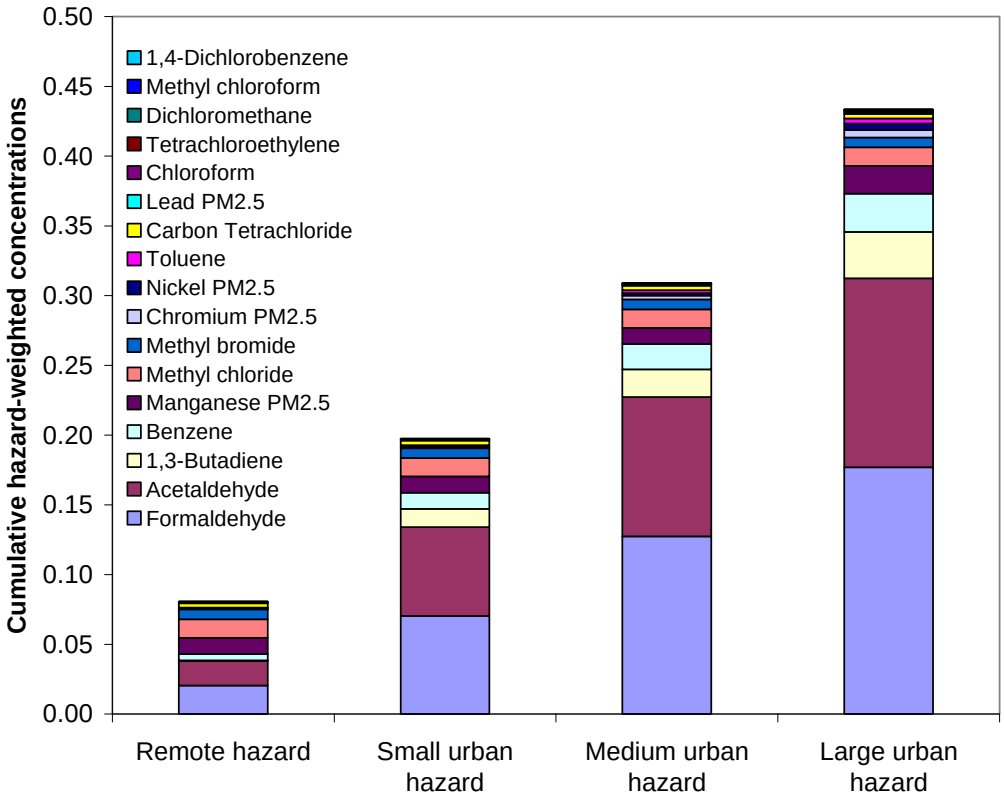


Figure 3-2. Cumulative hazard-weighted concentrations of ambient-methods air toxics pollutants across the standard-estimate bins and the spatially invariant pollutants.

3.2 EMISSIONS-BASED METHOD RESULTS

Normalized emissions gradients were created for 16 pollutants. These gradients were then scaled using the remote and maximum background estimates shown in **Table 3-2**. The results of the emissions-based method were also compared to chronic health benchmarks in Table 3-2. Pollutants with background concentrations that exceeded the health benchmarks in at least one county include acrylonitrile, beryllium, chromium VI, ethylene oxide, ethylene dibromide, and naphthalene. No pollutant concentrations exceeded the non-cancer reference concentration.

Table 3-2. Range of concentrations applied to emissions gradients. Shaded boxes indicated pollutants with concentrations that substantially exceeded the health benchmark in at least one county.

Pollutant	Remote Estimate	1999 NATA Max County 10th Percentile	Cancer Benchmark	RfC	CB Remote	CB Max	RFC Max
Acrylonitrile	0.00055	0.0302	1.47E-02	2	0.0	2.1	0.02
Beryllium	1.80E-05	1.05E-03	4.10E-04	0.020	0.0	2.6	0.05
Benzidine	9.90E-09	6.78E-06	1.49E-05	10	0.0	0.5	0.00
Bis(2-ethylhexyl)phthalate	0.0052	7.77E-03	4.17E-01	10	0.0	0.0	0.00
Cadmium	3.70E-05	1.29E-04	5.50E-04	0.020	0.1	0.2	0.01
Chromium VI	2.20E-05	4.27E-03	8.33E-05	0.100	0.3	51.2	0.04
Dibromochloropropane	1.30E-06	9.05E-05	5.00E-04	0.200	0.0	0.2	0.00
Ethylene dibromide	1.10E-04	1.70E-03	1.66E-03	9	0.1	1.0	0.00
Ethylene dichloride	0.0018	1.98E-02	3.85E-02	2400	0.0	0.5	0.00
Ethylene oxide	4.63E-04	3.00E-02	1.14E-02	30	0.0	2.6	0.00
Hydrazine	1.30E-07	1.79E-04	2.04E-04	0.20	0.0	0.9	0.00
Naphthalene	3.50E-04	3.38E-01	2.94E-02	3	0.0	11.5	0.11
1,2-Dichloropropane	4.60E-04	1.05E-02	5.26E-02	4	0.0	0.2	0.00
Quinoline	8.80E-07	1.89E-03					
1,1,2,2-Tetrachloroethane	2.60E-03	0.00875	1.72E-02		0.2	0.5	
Trichloroethylene	0.005	1.75E-01	5.00E-01	600	0.0	0.3	0.00

CB = cancer benchmark, OAQPS
RFC = reference concentration (chronic non-cancer benchmark)

Figure 3-3 shows the number of counties for those pollutants that exceeded the cancer benchmark using the emissions-based method. The results indicate that a large number of counties exceed the cancer benchmark for chromium VI. This result is inconsistent with measurements of chromium $PM_{2.5}$ for which concentrations are typically far lower than those estimated using this method. Given the discrepancy between the two methods, we think the ambient-based method produces more reliable values for chromium VI than does the emissions-based method. We recommend using the ambient-based method estimates of chromium VI at this time. For other air toxics, naphthalene was the only pollutant with a single high background prediction. However, the total number of counties exceeding the cancer benchmark is small. This is consistent with what would be expected given naphthalene transport times. It is possible that these discrepancies are the result of a single high prediction for the 10th percentile background concentrations in NATA 1999. These results should be compared to NATA 2002 before they are used.

Aside from the pollutants shown in Figure 3-3, the emissions-based method indicates that most of the pollutants investigated will not contribute substantially to health risk. Of those that do contribute, most are limited to large impacts in less than 3% of all U.S. counties. Only chromium VI is contributing to health risk in most counties, and it is likely that its impact is overestimated by using the emissions-based method. These results make sense given the small quantities of these pollutants that are emitted relative to those that are more routinely measured.

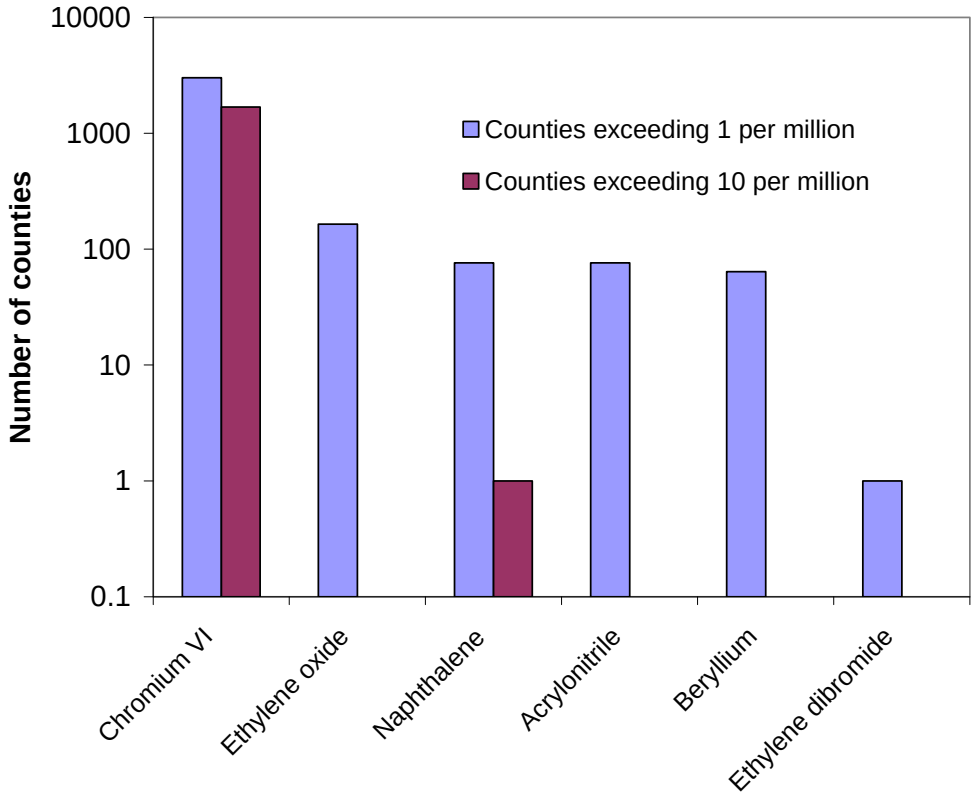


Figure 3-3. Number of counties exceeding the 1-in-a-million and 10-in-a-million cancer benchmark for emissions-based pollutants.

4. SUMMARY

Background concentrations were estimated for the NATA 2002 analysis. These estimates were developed using two methods: an ambient-based method and an emissions-based method. The method chosen for each pollutant was based on the availability and reliability of ambient data. Fourteen pollutant concentrations were estimated using the ambient-based method, and 16 pollutant concentrations were estimated using the emissions-based method.

Overall, the ambient-based results indicate that carbon tetrachloride, benzene, arsenic, acetaldehyde, and chromium have background concentrations above the 10^{-6} cancer benchmark for large portions of the population. The emissions-based method indicates that chromium VI is above the health benchmark for most counties, an observation that conflicts with the results of the ambient-based method. Finally, the emissions-based method shows that ethylene oxide, naphthalene, acrylonitrile, and beryllium background concentrations above the 10^{-6} cancer benchmark in 50 to 150 counties.

5. REFERENCES

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Appendix G

Average Exposure (HAPEM-to-ASPEN) Ratios Used for the 2005 NATA

Ratios comparing Hazardous Pollutant Exposure Model (HAPEM)-predicted and Assessment System for Population Exposure Nationwide (ASPEN)-predicted concentrations were developed for 140 of the chemicals modeled for the 2005 NATA. The ratios vary by chemical and census tract. Exhibit G-1 shows the ratios (averaged across census tract) for each chemical and each emission source sector (i.e., point, non-point, on-road mobile, non-road mobile, and background).

Although these average ratios are not actually used in NATA, they provide a general summary of the tract-level ratios that are used. These ratios account for the difference between the ambient outdoor concentration at a location and the exposure concentration that individuals are assumed to actually inhale in the risk assessment. Most of these averaged HAPEM-to-ASPEN ratios are less than 1, meaning that HAPEM-predicted concentrations tend to be lower than ASPEN-predicted concentrations. From among these average ratios, HAPEM exposure predictions range from 49 percent smaller than ASPEN (for diesel particulate matter for the non-road mobile sector) to 41 percent larger than ASPEN (for 1,3-butadiene for the on-road mobile sector). The overall average value of all averaged HAPEM-to-ASPEN ratios is 94.5 percent. The lower exposure concentrations for HAPEM are likely due to the inability of many chemicals to penetrate efficiently into indoor environments.

A proximity term is required to adjust the ASPEN-predicted ambient level (which is assumed to be representative of the census-tract centroid) to the level that EPA would expect immediately outside of the microenvironment. This proximity term was set to unity for most microenvironments. For the transportation-related microenvironments, however, ambient concentrations immediately outside the vehicle (i.e., very close to the pollutant source) are assumed to be considerably higher than at the census tract centroid value that ASPEN predicts. Thus, for chemicals where on-road mobile sources are the major sources of emissions, EPA developed and applied a specific proximity term appropriate for this assessment.

Some of the tract-level ratios had unrealistically large or small values. For the 2005 NATA, each tract-level HAPEM-to-ASPEN ratio for each chemical was limited to a range of 0.5 to 2 for the point, non-point, and mobile sectors, and to a range of 0.5 to 1 for the background sector.

Exhibit G-1. Averages of the Tract-Level HAPEM-to-ASPEN Ratios Used in the 2005 National-Scale Air Toxics Assessment

Chemical Name	Average Exposure Ratio by Source Sector					Overall Average (All Sources)
	Point	Non-point	On-road Mobile	Non-road Mobile	Estimated Background	
1,1,1-Trichloroethane	1.03	0.98	1.00	1.00	0.77	0.96
1,1,2,2-Tetrachloroethane	0.98	0.91	1.00	1.00	0.79	0.94
1,1,2-Trichloroethane	0.98	0.92	1.00	1.00	1.00	0.98
1,2,4-Trichlorobenzene	0.98	0.91	1.00	1.00	1.00	0.98
1,2-Dibromo-3-chloropropane	0.99	1.00	1.00	1.00	1.00	1.00
1,2-Diphenylhydrazine	1.00	0.99	1.00	1.00	1.00	1.00
1,2-Epoxybutane	0.99	0.99	1.00	1.00	1.00	0.99
1,3-Butadiene	1.04	0.88	1.41	1.08	0.80	1.04
1,3-Dichloropropene	0.99	0.90	1.00	1.00	1.00	0.98
1,3-Propane sultone	1.00	1.00	1.00	1.00	1.00	1.00
1,4-Dioxane	0.99	0.90	1.00	1.00	1.00	0.98
2,4,6-Trichlorophenol	0.99	0.99	1.00	1.00	1.00	1.00
2,4-Dinitrotoluene	0.97	0.92	1.00	1.00	1.00	0.98
2,4-Toluene diamine	1.00	0.99	1.00	1.00	1.00	1.00
2,4-Toluene diisocyanate	0.99	0.95	1.00	1.00	1.00	0.99
2-Chloroacetophenone	0.97	1.00	1.00	1.00	1.00	0.99
2-Nitropropane	1.00	0.91	1.00	1.00	1.00	0.98
3,3'-Dichlorobenzidine	1.00	0.70	1.00	1.00	1.00	0.94
3,3'-Dimethoxybenzidine	1.00	1.00	1.00	1.00	1.00	1.00
3,3'-Dimethylbenzidine	1.00	1.00	1.00	1.00	1.00	1.00
4,4'-Methylene bis(2-chloroaniline)	0.98	0.97	1.00	1.00	1.00	0.99
4,4'-Methylenedianiline	0.98	0.70	1.00	1.00	1.00	0.94
Acetaldehyde	0.93	0.85	1.18	0.91	0.77	0.93
Acetonitrile	0.98	0.90	1.00	1.00	1.00	0.97
Acrolein	1.01	0.86	1.18	0.91	1.00	0.99
Acrylamide	0.99	1.01	1.00	1.00	1.00	1.00
Acrylic acid	1.00	0.92	1.00	1.00	1.00	0.98
Acrylonitrile	0.95	0.88	1.00	1.00	0.87	0.94
Allyl chloride	0.98	0.91	1.00	1.00	1.00	0.98
Aniline	0.98	0.92	1.00	1.00	1.00	0.98
Antimony compounds	0.67	0.59	1.00	0.95	1.00	0.84
Arsenic compounds	0.64	0.54	1.00	1.00	0.53	0.74
Arsine	1.00	0.99	1.00	1.00	1.00	1.00
Benzene	0.99	0.88	1.28	0.98	0.76	0.98
Benzidine	0.99	0.97	1.00	1.00	0.97	0.99
Benzotrichloride	1.00	0.91	1.00	1.00	1.00	0.98

Exhibit G-1. Averages of the Tract-Level HAPEM-to-ASPEN Ratios Used in the 2005 National-Scale Air Toxics Assessment

Chemical Name	Average Exposure Ratio by Source Sector					Overall Average (All Sources)
	Point	Non-point	On-road Mobile	Non-road Mobile	Estimated Background	
Benzyl chloride	0.96	0.92	1.00	1.00	1.00	0.98
Beryllium compounds	0.66	0.55	1.00	0.57	0.53	0.66
Bis(2-ethylhexyl) phthalate	0.84	0.86	1.00	1.00	0.58	0.86
Bis(chloromethyl) ether	1.00	0.91	1.00	1.00	1.00	0.98
Bromoform	0.99	1.00	1.00	1.00	0.78	0.95
Cadmium compounds	0.64	0.53	1.00	0.57	0.52	0.65
Captan	1.00	0.69	1.00	1.00	1.00	0.94
Carbon disulfide	1.04	1.01	1.00	1.00	0.77	0.96
Carbon tetrachloride	1.05	1.01	1.00	1.00	0.78	0.97
Chlordane	1.00	0.84	1.00	1.00	0.58	0.88
Chlorine	0.98	0.92	1.00	0.99	1.00	0.98
Chlorobenzene	0.99	0.90	1.00	1.02	1.00	0.98
Chloroform	1.06	0.93	1.00	1.00	0.77	0.95
Chloroprene	0.99	0.91	1.00	1.00	1.00	0.98
Chromium VI compounds	0.63	0.55	0.69	0.55	0.53	0.59
Cobalt compounds	0.63	0.57	1.00	0.95	1.00	0.83
Coke Oven Emissions	0.95	0.99	1.00	1.00	1.00	0.99
Cresols (mixed)	0.94	0.85	1.28	0.84	1.00	0.98
Cumene	0.98	0.92	1.00	0.99	1.00	0.98
Cyanide compounds	0.86	0.67	1.00	1.00	1.00	0.91
Dichloroethyl ether	0.99	0.91	1.00	1.00	1.00	0.98
Dichlorvos	1.00	0.91	1.00	1.00	1.00	0.98
Diesel engine emissions	1.00	1.00	0.71	0.51	1.00	0.84
Diethanolamine	1.01	0.99	1.00	1.00	1.00	1.00
Dimethylformamide	1.03	0.99	1.00	1.00	1.00	1.00
Epichlorohydrin	0.98	0.92	1.00	1.00	1.00	0.98
Ethyl acrylate	0.99	0.93	1.00	1.00	1.00	0.98
Ethyl carbamate	1.00	0.99	1.00	1.00	1.00	1.00
Ethyl chloride	0.97	0.93	1.00	1.00	1.00	0.98
Ethylbenzene	0.98	0.94	1.24	0.95	1.00	1.02
Ethylene dibromide	0.96	0.94	1.00	1.00	0.80	0.94
Ethylene dichloride	1.01	0.93	1.00	1.00	0.78	0.94
Ethylene glycol	0.99	0.94	1.00	1.00	1.00	0.99
Ethylene oxide	0.99	0.93	1.00	1.00	0.89	0.96
Ethylene thiourea	1.00	1.00	1.00	1.00	1.00	1.00
Ethylidene dichloride	0.94	0.88	1.00	1.00	1.00	0.96
Formaldehyde	0.96	0.85	1.31	0.94	0.77	0.97

Exhibit G-1. Averages of the Tract-Level HAPEM-to-ASPEN Ratios Used in the 2005 National-Scale Air Toxics Assessment

Chemical Name	Average Exposure Ratio by Source Sector					Overall Average (All Sources)
	Point	Non-point	On-road Mobile	Non-road Mobile	Estimated Background	
Hexachlorobenzene	0.99	0.89	1.00	1.00	1.00	0.97
Hexachlorobutadiene	0.99	1.04	1.00	1.00	0.78	0.96
Hexachlorocyclopentadiene	0.99	0.91	1.00	1.00	1.00	0.98
Hexachloroethane	1.00	1.13	1.00	1.00	0.78	0.98
Hexamethylene-1,6-diisocyanate	0.97	0.92	1.00	1.00	1.00	0.98
Hydrazine	0.98	1.00	1.00	1.00	0.88	0.97
Hydrochloric acid	0.94	0.92	1.00	1.00	1.00	0.97
Hydrofluoric acid	0.93	0.96	1.00	1.00	1.00	0.98
Isophorone	0.98	0.98	1.00	1.00	1.00	0.99
Lead compounds	0.65	0.57	1.00	0.59	0.55	0.67
Lindane (all isomers)	1.00	0.98	1.00	1.00	0.58	0.91
Maleic anhydride	0.97	0.91	1.00	1.00	1.00	0.98
Manganese compounds	0.64	0.53	0.71	0.56	0.52	0.59
Mercury compounds	0.77	0.75	1.00	1.00	0.58	0.82
Methanol	1.01	0.90	1.00	0.99	1.00	0.98
Methyl bromide	0.98	0.92	1.00	1.00	0.77	0.94
Methyl chloride	1.00	0.95	1.00	1.00	0.78	0.94
Methyl ethyl ketone	0.94	0.97	1.10	0.83	1.00	0.97
Methyl isobutyl ketone	0.94	0.97	1.00	1.00	1.00	0.98
Methyl isocyanate	1.00	0.92	1.00	1.00	1.00	0.98
Methyl methacrylate	1.02	0.95	1.00	1.00	1.00	0.99
Methyl tert-butyl ether	0.99	0.94	1.23	0.97	1.00	1.03
Methylene chloride	1.02	0.98	1.00	1.00	0.78	0.96
Methylene diphenyl diisocyanate	0.86	0.70	1.00	1.00	1.00	0.91
Naphthalene	1.10	0.88	1.28	1.01	0.86	1.03
n-Hexane	1.01	0.94	1.25	0.94	1.00	1.03
Nickel compounds	0.64	0.54	0.69	0.60	0.53	0.60
Nitrobenzene	0.99	0.92	1.00	1.00	1.00	0.98
N-Nitrosomorpholine	1.00	1.00	1.00	1.00	1.00	1.00
o-Toluidine	0.99	0.99	1.00	1.00	1.00	1.00
PCB Group	0.89	0.75	1.00	1.00	0.58	0.84
p-Dichlorobenzene	0.97	0.90	1.00	1.00	0.87	0.95
p-Dimethylaminoazobenzene	1.00	1.00	1.00	1.00	1.00	1.00
Pentachloronitrobenzene	1.00	0.70	1.00	1.00	1.00	0.94
Pentachlorophenol	0.99	0.70	1.00	1.00	1.00	0.94
Perchloroethylene	1.02	0.98	1.00	1.00	0.79	0.96
Phenanthrene	0.89	0.63	0.96	0.70	1.00	0.84

Exhibit G-1. Averages of the Tract-Level HAPEM-to-ASPEN Ratios Used in the 2005 National-Scale Air Toxics Assessment

Chemical Name	Average Exposure Ratio by Source Sector					Overall Average (All Sources)
	Point	Non-point	On-road Mobile	Non-road Mobile	Estimated Background	
Phenol	1.03	0.90	1.00	1.01	1.00	0.99
Phosgene	0.99	0.91	1.00	1.00	1.00	0.98
Phosphine	1.00	0.89	1.00	1.00	1.00	0.98
Phthalic anhydride	0.96	0.94	1.00	1.00	1.00	0.98
POM 71002	0.88	0.67	1.00	0.88	1.00	0.88
POM 72002	0.91	0.64	0.95	0.70	1.00	0.84
POM 73002	0.99	0.64	1.00	1.00	1.00	0.93
POM 74002	0.99	0.98	1.00	1.00	1.00	0.99
POM 75002	0.87	0.64	0.96	0.73	1.00	0.84
POM 76002	0.87	0.64	0.97	0.73	1.00	0.84
POM 77002	0.90	0.64	0.97	0.72	1.00	0.85
POM 78002	0.89	0.70	1.00	0.84	1.00	0.89
Propylene dichloride	0.99	0.93	1.00	1.00	0.79	0.94
Propylene oxide	0.99	0.89	1.00	1.00	1.00	0.98
Quinoline	0.99	0.91	1.00	1.00	0.88	0.96
Selenium compounds	0.66	0.53	1.00	0.77	1.00	0.79
Styrene	1.13	0.99	1.37	1.00	1.00	1.10
Styrene oxide	1.00	0.91	1.00	1.00	1.00	0.98
Titanium tetrachloride	0.95	0.55	1.00	1.00	1.00	0.90
Toluene	0.96	0.90	1.25	0.94	0.88	0.99
Toxaphene	1.00	1.00	1.00	1.00	1.00	1.00
Trichloroethylene	0.97	1.11	1.00	1.00	0.76	0.97
Triethylamine	1.00	0.88	1.00	1.00	1.00	0.98
Triethylene glycol	0.97	0.93	1.00	1.00	1.00	0.98
Trifluralin	1.00	0.67	1.00	1.00	1.00	0.93
Vinyl acetate	0.99	0.92	1.00	1.00	1.00	0.98
Vinyl bromide	1.00	0.91	1.00	1.00	1.00	0.98
Vinyl chloride	0.97	0.90	1.00	1.00	0.80	0.94
Vinylidene chloride	0.95	0.91	1.00	1.00	1.00	0.97
Xylenes (mixed)	0.98	0.94	1.26	0.97	0.75	0.98

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Appendix H

Toxicity Values Used in the 2005 NATA

Exhibit H-1 lists the toxicity values and for cancer and non-cancer effects used in the 2005 NATA. Hazard indices were calculated for all target systems in the 2005 NATA (see Sections 5.2 and 6.3 of this document for the definitions of hazard quotients and hazard indices and an explanation of how they are used in NATA).

Exhibit H-1. Toxicity Values Used in the 2005 NATA

Chemical Name	CAS Number	Inhalation Unit Risk Estimate (URE), 1/(µg/m^3)	Reference Concentration (RfC), mg/m^3
1,1,1-Trichloroethane	71556	0	5
1,1,2,2-Tetrachloroethane	79345	0.000058	0
1,1,2-Trichloroethane	79005	0.000016	0.4
1,1-Dimethylhydrazine	57147	0	0
Lindane (gamma-HCH)	58899	0.00031	0.0003
1,2,4-Trichlorobenzene	120821	0	0.2
1,2-Dibromo-3-chloropropane	96128	0.002	0.0002
1,2-Epoxybutane	106887	0	0.02
1,2-Propyleneimine	75558	0	0
1,3-Butadiene	106990	0.00003	0.002
1,3-Dichloropropene	542756	0.000004	0.02
1,3-Propane sultone	1120714	0.00069	0
p-Dichlorobenzene	106467	0.000011	0.8
p-Dimethylaminoazobenzene	60117	0.0013	0
1,4-Dioxane	123911	0.0000077	3.6
2,2,4-Trimethylpentane	540841	0	0
2,4,5-Trichlorophenol	95954	0	0
2,4,6-Trichlorophenol	88062	0.0000031	0
2,4-D, salts and esters	94757	0	0
2,4-Dinitrophenol	51285	0	0
2,4-Dinitrotoluene	121142	0.000089	0.007
2,4-Toluene diamine	95807	0.0011	0
2,4-Toluene diisocyanate	584849	0.000011	0.00007
2-Nitropropane	79469	0.0000056	0.02
3,3'-Dichlorobenzidine	91941	0.00034	0
3,3'-Dimethoxybenzidine	119904	0.000004	0
3,3'-Dimethylbenzidine	119937	0.0026	0
4,4'-Methylene bis(2-chloroaniline)	101144	0.00043	0
4,4'-Methylenedianiline	101779	0.00046	0.02
Methylene diphenyl diisocyanate	101688	0	0.0006
4,6-Dinitro-o-cresol	534521	0	0
4-Aminobiphenyl	92671	0	0
4-Nitrobiphenyl	92933	0	0
4-Nitrophenol	100027	0	0
Acetaldehyde	75070	0.0000022	0.009
Acetamide	60355	0.00002	0
Acetonitrile	75058	0	0.06
Acetophenone	98862	0	0
Acrolein	107028	0	0.00002
Acrylamide	79061	0.00016	0.006
Acrylic acid	79107	0	0.001
Acrylonitrile	107131	0.000068	0.002
Allyl chloride	107051	0.000006	0.001
Aniline	62533	0.0000016	0.001
Anisidine	90040	0	0
Antimony compounds	7440360	0	0.0002
Antimony oxide	1327339	0	0.0002
Antimony trioxide	1309644	0	0.0002
Arsenic acid	7778394	0.0043	0.000015

Exhibit H-1. Toxicity Values Used in the 2005 NATA

Chemical Name	CAS Number	Inhalation Unit Risk Estimate (URE), 1/(µg/m^3)	Reference Concentration (RfC), mg/m^3
Arsenic compounds	7440382	0.0043	0.000015
Arsenic pentoxide	1303-28-2	0.0043	0.000015
Arsenic trioxide	1327533	0.0043	0.000015
Arsine	7784421	0	0.00005
Asbestos	1332-21-4	0.00767	0
Benzene	71432	0.0000078	0.03
Benzidine	92875	0.1072	0.01
Benzotrichloride	98077	0.0037	0
Benzyl chloride	100447	0.000049	0
Beryllium compounds	7440417	0.0024	0.00002
Beryllium oxide	1304-56-9	0.0024	0.000007
Biphenyl	92524	0	0
Bis(2-ethylhexyl)phthalate	117817	0.0000024	0.01
Bis(chloromethyl)ether	542881	0.062	0
Bromoform	75252	0.0000011	0
Cadmium acetate	543908	0.0018	0.00001
Cadmium compounds	7440439	0.0018	0.00001
Cadmium nitrate	10325947	0.0018	0.00001
Cadmium oxide	1306190	0.0018	0.00001
Captan	133062	0.000001	0
Carbaryl	63252	0	0
Carbon disulfide	75150	0	0.7
Carbon tetrachloride	56235	0.000006	0.1
Carbonyl sulfide	463581	0	0
Catechol	120809	0	0
Chlordane	57749	0.0001	0.0007
Chlorine	7782505	0	0.00015
Chloroacetic acid	79118	0	0
Chlorobenzene	108907	0	1
Chlorobenzilate	510156	0.000078	0
Chloroform	67663	0	0.098
Chloromethyl methyl ether	107302	0	0
Chloroprene	126998	0	0.007
Ammonium chromate	7788989	0.012	0.0001
Barium chromate	10294403	0.012	0.0001
Calcium chromate	13765190	0.012	0.0001
Chromic acid (VI)	7738-94-5	0.012	0.0001
Chromic oxide	1308389	0	0
Chromic sulfate	10101538	0	0
Chromic sulfuric acid	13530682	0.012	0.0001
Chromium (III) compounds	16065831	0	0
Chromium (VI) as Lead chromate	7758976	0.012	0.0001
Chromium (VI) compounds	18540299	0.012	0.0001
Chromium (VI) trioxide, chromic acid mist	11115745	0	0.000008
Chromium chloride	10025-73-7	0	0
Chromium zinc oxide	12018198	0	0
Potassium chromate	7789006	0.012	0.0001
Potassium dichromate	7778509	0.012	0.0001
Sodium chromate	7775113	0.012	0.0001

Exhibit H-1. Toxicity Values Used in the 2005 NATA

Chemical Name	CAS Number	Inhalation Unit Risk Estimate (URE), 1/(µg/m^3)	Reference Concentration (RfC), mg/m^3
Sodium dichromate	10588019	0.012	0.0001
Strontium chromate	7789062	0.012	0.0001
Zinc chromate	13530659	0.012	0.0001
Zinc chromite	50922297	0	0
Zinc potassium chromate	11103869	0.012	0.0001
Cobalt aluminate	1345160	0	0.0001
Cobalt compounds	7440484	0	0.0001
Cobalt hydrocarbonyl	16842-03-8	0	0.0001
Cobalt oxide	1307966	0	0.0001
Cobalt oxide (ii,iii)	1308061	0	0.0001
Hexanoic acid, 2-ethyl-, cobalt(2+) salt	136527	0	0.0001
Benzene soluble organics (BSO)	141	0.00062	0
Coke oven emissions	8007452	0.00062	0
Methylene chloride soluble organics (MCSO)	142	0.00062	0
Cresols (mixed)	1319773	0	0.6
m-Cresol (3-methylphenol)	108394	0	0.6
o-Cresol	95487	0	0.6
p-Cresol (4-methy phenol)	106445	0	0.6
Cumene	98828	0	0.4
2-Methyl-Propanenitrile	78820	0	0.003
Calcium cyanamide	156-62-7	0	0.003
Copper cyanide	544923	0	0.003
Cyanide compounds	57125	0	0.003
Hydrogen cyanide	74908	0	0.003
Potassium cyanide	151508	0	0.003
Sodium cyanide	143339	0	0.003
Zinc cyanide	557211	0	0.003
DDE (1,1-Dichloro-2,2-bis(p-chlorophenyl) ethylene	72559	0.000097	0
Diazomethane	334-88-3	0	0
Dibenzofuran	132649	0	0
Dibutylphthalate	84742	0	0
Dichloroethyl ether	111444	0.00033	0
Dichlorvos	62737	0.000083	0.0005
Diethanolamine	111422	0	0.003
Diethyl Sulfate	64675	0	0
Dimethyl formamide	68122	0	0.03
Dimethyl phthalate	131113	0	0
Dimethyl sulfate	77781	0	0
Dimethylcarbamoyl chloride	79447	0	0
Epichlorohydrin	106898	0.0000012	0.001
Ethyl acrylate	140885	0	0
Ethyl benzene	100414	0.0000025	1
Ethyl carbamate	51796	0.000464	0
Ethyl chloride	75003	0	10
Ethylene dibromide	106934	0.0006	0.009
Ethylene dichloride	107062	0.000026	2.4
Ethylene glycol	107211	0	0.4
Ethylene imine (aziridine)	151564	0	0
Ethylene oxide	75218	0.000088	0.03

Exhibit H-1. Toxicity Values Used in the 2005 NATA

Chemical Name	CAS Number	Inhalation Unit Risk Estimate (URE), 1/(µg/m^3)	Reference Concentration (RfC), mg/m^3
Ethylene thiourea	96457	0.000013	0.003
Ethylidene dichloride	75343	0.0000016	0.5
Fine mineral fibers	383	0	0
Formaldehyde	50000	0.000013	0.0098
(Ethylenebis(Oxyethylenenitrilo)) tetraacetic acid	67425	0	0.02
1,2-Dimethoxyethane	110714	0	0.02
2-(Hexyloxy)Ethanol	112254	0	0.02
2-Butoxyethyl acetate	112072	0	0.02
3-Methoxy-1-propanol	1589497	0	0.02
Butyl carbitol acetate	124174	0	0.02
Carbitol acetate	112152	0	0.02
Di(ethylene glycol monobutyl ether) phthalate	16672392	0	0.02
Diethylene glycol dibenzoate	120558	0	0.02
Diethylene glycol diethyl ether	112367	0	0.02
Diethylene glycol dimethyl ether	111966	0	0.02
Diethylene glycol ethyl methyl ether	1002671	0	0.02
Diethylene glycol monobutyl ether	112345	0	0.02
Diethylene glycol monoethyl ether	111900	0	0.02
Diethylene glycol monomethyl ether	111773	0	0.02
Ethoxytriglycol	112-50-5	0	0.02
Ethylene glycol diethyl ether	629141	0	0.02
Ethylene glycol ethyl ether	110805	0	0.2
Ethylene glycol ethyl ether acetate	111159	0	0.3
Ethylene glycol methyl ether	109864	0	0.02
Ethylene glycol methyl ether acetate	110496	0	0.09
Ethylene glycol mono-sec-butyl ether	7795917	0	0.02
Ethylene glycol monovinyl ether		0	0.02
Glycol ethers	171	0	0.02
Methoxytriglycol	112356	0	0.02
N-Hexyl carbitol	112594	0	0.02
Phenyl Cellosolve	122996	0	0.02
Triethylene glycol	112276	0	0.02
Triglycol monobutyl ether	143226	0	0.02
Heptachlor	76448	0.0013	0
Hexachlorobenzene	118741	0.00046	0.003
Hexachlorobutadiene	87683	0.000022	0.09
Hexachlorocyclopentadiene	77474	0	0.0002
Hexachloroethane	67721	0.000004	0.08
Hexamethylene-1,6-diisocyanate	822060	0	0.00001
n-Hexane	110543	0	0.7
Hydrazine	302012	0.0049	0.0002
Hydrochloric acid	7647010	0	0.02
Hydrofluoric acid	7664393	0	0.014
Hydroquinone	123319	0	0
Isophorone	78591	0.00000027	2
Lead (II) oxide	1317368	0	0.00015
Lead as Lead arsenate	7784409	0	0.00015
Lead as Lead chromate oxide	18454121	0	0.00015
Lead compounds	7439921	0	0.00015

Exhibit H-1. Toxicity Values Used in the 2005 NATA

Chemical Name	CAS Number	Inhalation Unit Risk Estimate (URE), 1/(µg/m^3)	Reference Concentration (RfC), mg/m^3
Lead dioxide	1309600	0	0.00015
Lead subacetate	1335326	0	0.00015
Lead sulfate	7446142	0	0.00015
Maleic anhydride	108316	0	0.0007
Manganese compounds	7439965	0	0.00005
Manganese dioxide	1313139	0	0.00005
Manganese nitrate	10377669	0	0.00005
Manganese sulfate	7785877	0	0.00005
Manganese tetroxide	1317357	0	0.00005
Manganese trioxide	1317346	0	0.00005
Mercuric chloride	7487947	0	0.00003
Mercury (elemental)	7439976	0	0.0003
Mercury (organic)	22967926	0	0.00003
Methanol	67561	0	4
Methoxychlor	72435	0	0
Methyl bromide	74839	0	0.005
Methyl chloride	74873	0	0.09
Methyl hydrazine	60344	0	0
Methyl iodide	74884	0	0
Methyl isobutyl ketone	108101	0	3
Methyl isocyanate	624839	0	0.001
Methyl methacrylate	80626	0	0.7
Methyl tert-butyl ether	1634044	0.00000026	3
Methylene chloride	75092	0.00000047	1
N,N-dimethylaniline	121697	0	0
Naphthalene	91203	0.000034	0.003
Nickel (II) sulfate hexahydrate	10101970	0.000312	0.00009
Nickel acetate	373024	0.000312	0.00009
Nickel chloride	7718549	0.000312	0.00009
Nickel compounds	7440020	0.000312	0.00009
Nickel nitrate	13138459	0.000312	0.00009
Nickel oxide	1313991	0	0.0001
Nickel sulfamate	13770893	0.000312	0.00009
Nickel sulfate	7786814	0.000312	0.00009
Nitrobenzene	98953	0.00004	0.009
Nitrosodimethylamine	62759	0.014	0
N-Nitrosomorpholine	59892	0.0019	0
o-Toluidine	95534	0.000051	0
Pentachloronitrobenzene	82688	0.000074	0
Pentachlorophenol	87865	0.0000051	0.1
Phenol	108952	0	0.2
Phosgene	75445	0	0.0003
Phosphine	7803512	0	0.0003
Phosphorus, white	7723140	0	0
Phthalic anhydride	85449	0	0.02
Polychlorinated biphenyls	1336363	0.0001	0
2-Acetylaminofluorene	53-96-3	0	0
2-Chloroacetophenone	532274	0	0.00003
POM 71002		0.000088	0

Exhibit H-1. Toxicity Values Used in the 2005 NATA

Chemical Name	CAS Number	Inhalation Unit Risk Estimate (URE), 1/(µg/m^3)	Reference Concentration (RfC), mg/m^3
POM 72002		0.000088	0
POM 73002		0.16	0
POM 74002		0.016	0
POM 75002		0.0016	0
POM 76002		0.00016	0
POM 77002		0.000016	0
POM 78002		0.00032	0
p-Phenylenediamine	106503	0	0
Propionaldehyde	123386	0	0.008
Propoxur	114261	0	0
Propylene dichloride	78875	0.000019	0.004
Propylene oxide	75569	0.0000037	0.03
Quinoline	91225	0	0
Quinone	106514	0	0
Radionuclides	605	0	0
Radon and its decay products	606	0	0
Uranium	7440611	0	0.0003
Selenium compounds	7782492	0	0.02
Selenium dioxide	7446084	0	0.02
Selenium hexafluoride	7783791	0	0.02
Selenium oxide	12640890	0	0.02
Styrene	100425	0	1
Styrene oxide	96093	0	0.006
Tetrachloroethene	127184	0.0000059	0.27
Titanium tetrachloride	7550450	0	0.0001
Toluene	108883	0	5
Toxaphene	8001352	0.00032	0
Trichloroethylene	79016	0.000002	0.6
Triethylamine	121448	0	0.007
Trifluralin	1582098	0.0000022	0
Vinyl acetate	108054	0	0.2
Vinyl bromide	593602	0.000032	0.003
Vinyl chloride	75014	0.0000088	0.1
Vinylidene chloride	75354	0	0.2
m-Xylene	108383	0	0.1
o-Xylene	95476	0	0.1
p-Xylene	106423	0	0.1
Xylenes (mixed)	1330207	0	0.1

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APPENDIX I

Polycyclic Organic Matter (POM) Groups

Not all polycyclic organic matter (POM) reported to EPA's National Emission Inventory (NEI) is reported as individual compounds; the estimated carcinogenicity of POM compounds, however, varies. Thus, for NATA, EPA makes some simplifying assumptions to model and assess the risks from POM. The assumptions involve establishing various POM "groups," each of which is assigned a cancer unit risk estimate (URE), and modeling dispersion and exposure for each group separately. In establishing these groups, EPA considered the need to provide the most detailed information about risks from the individual POM pollutants while accounting for variations in the degree of speciation reported in the NEI.

EPA used two overlapping POM groups for the 1996 NATA. The method EPA used to establish POM groups for the 1999, 2002, and 2005 NATAs was more refined, reflecting improvements in both the reporting of POM to NEI and the speciation of POM within NEI. For the 1999, 2002, and 2005 NATAs, EPA established eight distinct (non-overlapping) groups. POM emissions reported to NEI are assigned to one of these groups based on available toxicity information (i.e., current knowledge and estimates regarding carcinogenicity of emitted compounds) and information and assumptions regarding the composition of POM groups. The approach to assigning compounds to POM groups implemented for the 2005 NATA is analogous in principle to the approach used for the 1996 NATA.

Details of the approach for the 1996 NATA are described in Appendix H to EPA's report to the Science Advisory on that assessment.[1] Briefly, EPA used information on relative carcinogenic potency factors for POM compounds (obtained primarily from the California Environmental Protection Agency) and emission factors for individual POM compounds for four large POM source categories. These four source categories were assumed to encompass about three-quarters of the total emissions of POM in the 1996 NEI and to adequately represent all types sources that emit POM (at least for the purposes of the current analysis). EPA evaluated the POM speciation profiles for these categories, taking into account the cancer potency of individual POM species in each profile, to obtain an estimate of the toxicity-weighted emissions for each category. Emission factors were expressed as mass of POM compound emitted per ton of raw material processed or burned to obtain results for comparison among source categories. The emission factors were adjusted according to each compound's cancer potency by multiplying by the compound's carcinogenicity relative to benzo[a]pyrene (i.e., the emission factor was multiplied by the ratio of the URE for the compound to the URE for benzo[a]pyrene).

The results of EPA's analysis for the 1996 NATA were estimates of the contributions of individual POM compounds, expressed as benzo[a]pyrene-equivalent values, to total POM emissions for each of the four source categories. Toxicity-weighted emissions were estimated for the three types of unspeciated POM (polyaromatic hydrocarbons or PAHs) reported in the 1996 NEI (i.e., "Total PAH," "16-PAH," and "7-PAH") for each of the four major source categories. Based on these results, emissions of Total PAH and 16-PAH were estimated to have a cancer potency of up to 5 percent benzo[a]pyrene; for example, emissions of 1 ton reported as Total PAH would have the same cancer potency as 0.05 ton of pure benzo[a]pyrene. Emissions reported as 7-PAH were estimated to have a potency of up to 18 percent benzo[a]pyrene.

[1] EPA. 2001. *National-scale Air Toxics Assessment for 1996. Draft for EPA Science Advisory Board Review: January 18, 2001.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-453/R-01-003.

POM reporting to NEI for 1999, 2002, and 2005 has improved in three ways since 1996. First, more NEI emissions were speciated into individual POM compounds. Second, double-counting of POM groups from individual stacks in the point-source inventory was eliminated. Third, naphthalene was reported and assessed in the 2005 NATA as a separate air toxic and was not included in any PAH group. For these assessments, POM emissions reported to NEI were assigned to non-overlapping groups for which similar inhalation risks are assumed, based on the unit risk estimates (URE) for members of each group. The UREs for individual POM species were based on cancer dose-response assessments conducted by the California Environmental Protection Agency (for more information, refer to the OAQPS discussion of sources for chronic dose-response information for air toxics available at http://www.epa.gov/ttn/atw/toxsource/chronicsources.html). Because carcinogenic POM species are suspected of causing cancer via a mutagenic mode of action, these UREs were then adjusted upward by a factor of 1.6 to account for the assumption of increased cancer potency for mutagens during early life stages.[2] For groups containing individual POM compounds with UREs, the toxicity value for the group was set to the midpoint of the range of UREs for members of that group.

The eight POM groups and corresponding UREs used in the 2005 NATA are presented in Exhibit I-1. Exhibit I-2 shows the compounds included in each POM group.

Exhibit I-1. Polycyclic Organic Matter Groups and Unit Risk Estimates for the 2005 NATA

POM Group			URE[a] 1/(µg/m^3)	Basis for URE
No.	Code	Description		
1	71002	Contains unspeciated POM (e.g., "Total PAH")	8.8×10^{-5}	5% of URE for benzo(a)pyrene (BaP); consistent with URE used for total POM group in NATA 1996
2	72002	Contains individually reported POM compounds for which no UREs have been established	8.8×10^{-5}	5% of URE for benzo(a)pyrene; same URE as used for unspeciated POM (71002)
3	73002	Contains individual POM with UREs between 9×10^{-2} and 9×10^{-1}	1.6×10^{-1}	Midpoint of range (100 × BaP URE)
4	74002	Contains individual POM with UREs between 9×10^{-3} and 9×10^{-2}	1.6×10^{-2}	Midpoint of range (10 × the BaP URE)
5	75002	Contains individual POM; UREs between: 9×10^{-4} and 9×10^{-3}	1.6×10^{-3}	Midpoint of range (equal to BaP URE)
6	76002	Contains individual POM; UREs between: 9×10^{-5} and 9×10^{-4}	1.6×10^{-4}	Midpoint of range (0.01 × the BaP URE)
7	77002	Contains individual POM; UREs between: 9×10^{-6} and 9×10^{-5}	1.6×10^{-5}	Midpoint of range (0.01 × the BaP URE)
8	78002	Contains HAPs reported as 7-PAH[b]	3.2×10^{-4}	Used URE for 7-PAH in 2005 NATA (18% of BaP URE)

[a] UREs are cancer inhalation unit risk estimates, in units of 1/(µg/m^3); they are based on the potency of benzo(a)pyrene (BaP). Each group represents a different percentage of the BaP URE. For example, Group 1 has a URE of 8.8×10^{-5}, which is 5% of the BaP URE (BaP URE = 0.00176 x 0.05 = 0.000088).

[b] The 7-PAH group includes seven chemical species: benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene.

[2] See EPA's 2005 *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA/630/R-03/003F); available on-line at http://epa.gov/raf/publications/pdfs/CHILDRENS_SUPPLEMENT_FINAL_.PDF.

Exhibit I-2. List of Polycyclic Organic Matter (POM) Groups and Group Members Included in the 2005 NATA

POM Group		POM Compound as Reported in NEI[a]
Number	Code	
1	71002	15-PAH
		16-PAH
		16-PAH with HAPs in 7-PAH removed
		Polycyclic organic matter
		Total PAH
2	72002	1-Methylnaphthalene
		2-Chloronaphthalene
		2-Methylnaphthalene
		Acenaphthene
		Acenaphthylene
		Anthracene
		Benzo(a)fluoranthene
		Benzo(c)phenanthrene
		Benzo(g,h,i)fluoranthene
		Benzo[e]pyrene
		Benzofluoranthenes
		Coal tar
		Fluoranthene
		Fluorene
		Perylene
		Phenanthrene
		Pyrene
3	73002	7,12-Dimethylbenz[a]anthracene
4	74002	3-Methylcholanthrene
		Dibenzo[a,h]pyrene
		Dibenzo[a,i]pyrene
5	75002	5-Methylchrysene
		Benzo[a]pyrene
		Dibenzo[a,e]Pyrene
		Dibenzo[a,h]anthracene
6	76002	1-Nitropyrene
		Benz[a]anthracene
		Benzo[b]fluoranthene
		Benzo[b+k]fluoranthene
		Benzo[j]fluoranthene
		Benzo[k]fluoranthene
		Dibenzo[a,j]acridine
		Indeno[1,2,3-c,d]pyrene
7	77002	Chrysene
8	78002	7-PAH

[a] PAH = polyaromatic hydrocarbons