ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

TSCA INCINERATOR
U.S. DEPARTMENT OF ENERGY OAK RIDGE RESERVATION
OAK RIDGE, ANDERSON COUNTY, TENNESSEE
EPA FACILITY ID: TN1890090003
DECEMBER 27, 2005

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

TSCA INCINERATOR
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EPA FACILITY ID: TN1890090003

Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and cleanup of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations — the structure may vary from site to site. Whatever the form of the public health assessment, the process is not considered complete until the public health issues at the site are addressed.

Exposure

As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects

If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances than adults. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high-risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic, and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is

not available. When it touches on cases in which this is so, this report suggests what further public health actions are needed.

Conclusions

This report presents conclusions about the public health threat, if any, posed by a site. Any health threats that have been determined for high-risk groups (such as children, the elderly, chronically ill people, and people engaging in high-risk practices) are summarized in the Conclusions section of the report. Ways to stop or reduce exposure are recommended in the Public Health Action Plan section.

ATSDR is primarily an advisory agency, so its reports usually identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community

ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments

If, after reading this report, you have questions or comments, we encourage you to send them to us. Letters should be addressed as follows:

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Atlanta, GA 30333

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List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CNF	Central Neutralization Facility
CREG	Cancer Risk Evaluation Guide
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DRE	destruction and removal efficiency
EMEG	Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
ERAMS	Environmental Radiation Ambient Monitoring System
ETTP	East Tennessee Technology Park
ISCST	Industrial Source Complex, Short Term
LLNL	Lawrence Livermore National Laboratory
MACT	maximum achievable control technology
mixed LLW	mixed low-level radioactive and hazardous waste
MRL	Minimal Risk Level
NAAQS	National Ambient Air Quality Standard
NEI	National Emissions Inventory
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NPL	National Priorities List
NTP	National Toxicology Program
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRHES	Oak Ridge Reservation Health Effects Subcommittee
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PHA	public health assessment
PHAWG	Public Health Assessment Work Group
PM	particulate matter
PM10	particulate matter with aerodynamic diameters less than 10 microns
PM2.5	particulate matter with aerodynamic diameters less than 2.5 microns
POHC	principal organic hazardous constituent
ppm	parts per million
RBC-N	risk-based concentration for non-cancer effects
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TEQ	toxic equivalent
TLD	thermoluminescent dosimeter
TRI	Toxics Release Inventory
TRV	thermal relief vent

TSCA	Toxic Substances Control Act
TSP	total suspended particulates
TVA	Tennessee Valley Authority
UCLA	University of California at Los Angeles
VOC	volatile organic compound

I. Summary

This public health assessment (PHA) evaluates environmental exposures to contaminants released from the "TSCA Incinerator" at the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) in Roane County, Tennessee. The incinerator's name comes from the Toxic Substances Control Act, or TSCA, one of the environmental regulations governing the incinerator's operations. DOE contractors operate the TSCA Incinerator at a facility currently known as East Tennessee Technology Park (ETTP), formerly known as the K-25 site and as the Oak Ridge Gaseous Diffusion Plant. The TSCA Incinerator destroys organic chemicals in waste material and reduces the volume of waste materials that contain low-level radioactive contamination. The TSCA Incinerator began routine operations in 1991, and continues to operate today.

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this PHA to evaluate environmental health issues related to the TSCA Incinerator. The scientific approaches used in this PHA are consistent with relevant policies and guidance documents that ATSDR and other agencies have developed specifically for assessing human health risks posed by incineration facilities. The PHA focuses almost entirely on direct inhalation exposures to airborne contaminants, which presents the most likely pathway by which residents might come into contact with site-related contaminants. A separate PHA will consider the possibility of the TSCA Incinerator's air emissions causing environmental contamination in other media, such as surface water, soils, and food items.

What are the objectives of this PHA? (1) To determine whether local residents, other than workers, have been harmed by contaminants released by the TSCA Incinerator; (2) to respond to specific community concerns about the TSCA Incinerator; and (3) to make recommendations to help ensure that residents will not be exposed to harmful levels of site-related contaminants in the future.

This PHA's conclusions are based largely on environmental sampling data, stack tests, and other records generated by multiple parties. Over the last 2 years, ATSDR obtained documents and insights from

- the U.S. Environmental Protection Agency,
- the Tennessee Department of Environment and Conservation,
- the Tennessee Valley Authority,
- the DOE and its contractors,
- a group of independent experts chartered by the Governor of Tennessee,
- members of the Public Health Assessment Working Group (now known as the Exposure Evaluation Work Group),
- the ORR Local Oversight Committee, and
- local community members.

ATSDR considered all information provided by these parties when preparing this PHA.

The TSCA Incinerator has been studied extensively and continuously since it began routine operations in 1991. Multiple parties have quantified what the TSCA Incinerator releases into the air, modeled how contaminants move through the air, and measured what levels of air contamination are found beyond the ETTP facility property line. To date, ATSDR has reviewed tens of thousands of environmental measurements taken over the entire time that the TSCA Incinerator has operated. This PHA's conclusions, therefore, are based on an extremely large volume of data, especially when compared with data available for other incineration facilities that ATSDR has evaluated over the years. The remainder of this section presents ATSDR's key findings on the TSCA Incinerator, starting with the main conclusion, followed by summary statements on other issues.

Main Conclusion

The TSCA Incinerator releases trace levels of contaminants into the environment, but in amounts far below levels associated with health effects. Continued operation of the TSCA Incinerator is not expected to cause harmful exposures because numerous safeguards, pollution controls, and strict permitting requirements are in place to prevent unsafe operating conditions from occurring.

The following paragraphs review ATSDR's key findings on several individual topics. As Figure 1 illustrates, these individual findings paint a consistent picture of the limited air quality impacts from the TSCA Incinerator, and they form the foundation for the main conclusion stated above.

- **Design and operation of the TSCA Incinerator.** The TSCA Incinerator is designed to meet the strict requirements of multiple environmental regulations intended to protect human health and the environment. The TSCA regulations, for instance, require the incinerator to destroy at least 99.9999% of polychlorinated biphenyls (PCBs) in wastes. To reduce environmental impacts, a series of air pollution control devices minimize releases from the incinerator into the atmosphere. Moreover, sophisticated controls automatically shut down the entire incineration process if operating conditions are not maintained within limits specified in health-protective environmental permits. Using these and other observations, ATSDR concludes that the TSCA Incinerator is designed and is operated in a manner consistent with current best practices for thermal treatment facilities.

- **Amounts and types of wastes treated by the TSCA Incinerator.** The TSCA Incinerator treats liquid and solid wastes that contain various hazardous chemicals, including radioactive contaminants. All wastes must be thoroughly characterized before they arrive at the TSCA Incinerator, and their contamination levels must meet strict criteria before they can be treated. Health-protective environmental permits dictate the maximum amount of waste that the incinerator can process each year. In recent years, the amount of waste treated at the TSCA Incinerator has been only 5% of the permitted limits. In short, systems are in place to help ensure that the TSCA Incinerator does not process wastes that cannot be treated safely.

- **Air emissions from the TSCA Incinerator.** Stack tests and trial burns have measured emission rates under various operating scenarios for the eight groups of contaminants considered in this PHA:
    - particulate matter,
    - volatile organic compounds,
    - PCBs,
    - metals,
    - acidic gases,
    - dioxins and furans,
    - polycyclic aromatic hydrocarbons, and
    - radionuclides.

  With few exceptions, measured emission rates have been below health-protective limits established in the incinerator's environmental permits. In the isolated instances where higher emission rates were observed, ambient air monitoring data collected at the time show that air contamination at off-site locations was not affected. For many pollutants, the TSCA Incinerator's emissions account for an extremely small fraction of the total airborne emissions estimated for all of Roane County.

- **Dispersion modeling studies of the TSCA Incinerator's air emissions.** Both the independent panel previously chartered by the Governor of Tennessee and DOE have conducted extensive air modeling studies to understand how emissions from the TSCA Incinerator move through the air to off-site locations. ATSDR has also conducted a modeling evaluation to account for limitations in the previous studies. While air quality models have inherent uncertainties and can only estimate a source's potential air quality impacts, all three studies strongly suggest that the TSCA Incinerator's air quality impacts at off-site locations are minimal — a finding that has been supported by trends in the extensive air quality measurements at this site.

- **Relevant air quality measurements.** Since the TSCA Incinerator began treating wastes in 1991, multiple parties have measured the site's potential air quality impacts. These studies have appropriately focused on contaminants that incinerators cannot destroy, such as metals, particulates, and radionuclides. Several thousand ambient air sampling results are available for numerous locations that surround the TSCA Incinerator, including locations where air models predict the greatest impacts. These measurements strongly suggest that air emissions from the incinerator do not cause exposure levels of public health concern at off-site locations. Section IX of this PHA presents ATSDR's recommendations for enhancing the ongoing ambient air monitoring activities.

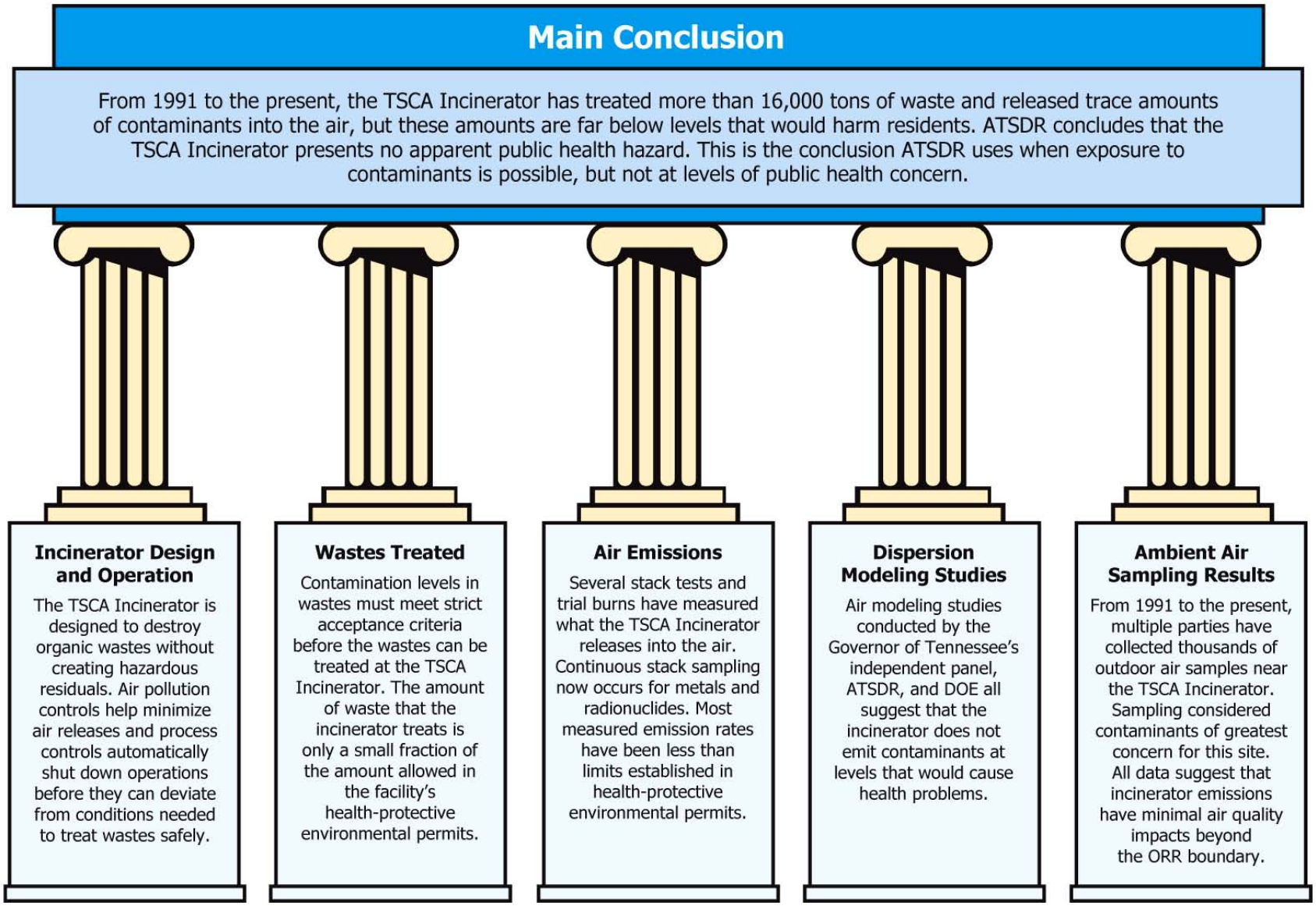


Figure 1. ATSDR's Main Conclusion and Supporting Lines of Evidence

Although the previous statements clearly support ATSDR's main conclusion for this site, it has become apparent to ATSDR that some community members have long-standing health concerns about the incinerator's ongoing operations, despite evidence suggesting that the site does not cause unhealthful exposures. To bridge this information gap, ATSDR recommends that TDEC annually issue fact sheets to brief residents on the incinerator's ongoing operations. These fact sheets should address inspection outcomes, regulatory compliance, agency oversight, and quantitative comparison of environmental sampling results collected by various parties.

When preparing this PHA, ATSDR identified regional air quality issues of potential health concern; namely, air quality across the Knoxville metropolitan area is occasionally poor when airborne levels of ozone and fine particles reach unhealthful levels. These air quality issues are regional in nature and result from industrial and motor vehicle emissions over a broad geographic area — emissions from the TSCA Incinerator appear to contribute little to these problems. When exposed to elevated levels of these pollutants, some people — particularly children, the elderly, and those with respiratory conditions — could experience lung irritation, difficulty breathing, and other health effects. On days with poor air quality, TDEC issues warnings that explain how people can reduce their exposure and how they can avoid adverse health effects. It is especially important for residents to heed these warnings and for adults to convey these warnings to their children, particularly asthmatic children.

The remainder of this PHA describes how ATSDR reached the conclusions and summary statements listed above. Those interested in only a brief summary of the main conclusions and recommendations should proceed to Sections VIII through X of this PHA. Those interested in a detailed account of ATSDR's scientific analyses are encouraged to read the entire report. Appendixes E and F of this PHA present a glossary and definitions of units of measurement used throughout this report.

II. Background

Since 1942, the U.S. government and contractors have conducted various research and development activities at the Oak Ridge Reservation (ORR), located in Anderson and Roane Counties in Tennessee. These activities were primarily conducted at four separate facilities previously known as the Y-12 plant, the K-25 site, the S-50 site, and the X-10 site. For much of ORR's history, the research and development activities focused on designing and producing materials and components for nuclear weapons. In recent years, however, the ORR facilities' missions have changed considerably. While some ORR facilities continue to conduct nuclear research and production projects vital to national security, other ORR facilities devote considerable resources to environmental research and restoration.

The U.S. Department of Energy's (DOE's) environmental restoration activities address contamination that remains from past research, development, and production operations. A challenge faced by DOE has been how to handle "mixed wastes," or wastes that contain both chemical and radioactive contamination.

What is "mixed low-level radioactive and hazardous waste?" Waste management regulations define what materials should be considered "hazardous waste" and what materials should be considered "radioactive waste." Some wastes, however, meet the criteria set forth in both definitions. Such materials are considered "mixed low-level radioactive and hazardous waste," which is commonly referred to as mixed LLW. Depending on the source of the waste, mixed LLW can be liquid or solid. The TSCA Incinerator treats mixed LLW.

One way DOE and its contractors have addressed the challenge of mixed LLW is to design and operate an incinerator that treats and reduces the volume of waste materials. The incinerator is located at East Tennessee Technology Park (ETTP), formerly the K-25 site (see Figure 2). The incinerator is commonly known as the "TSCA Incinerator" because this operation is authorized under the Toxic Substances Control Act (TSCA) to treat wastes containing polychlorinated biphenyls (PCBs). The incinerator is also permitted under the Resource Conservation and Recovery Act (RCRA) to treat hazardous wastes. Construction of the incinerator was completed in 1989, and the incinerator began routinely treating wastes from ORR and other DOE facilities in 1991. The TSCA Incinerator continues to operate today.

This public health assessment (PHA) evaluates the public health implications of environmental releases from the TSCA Incinerator, including air emissions, solid wastes, and discharges to surface water. This PHA focuses almost entirely on *environmental* health concerns; that is, whether local residents living in communities near ETTP have contacted contamination at levels that might cause health problems. ATSDR is aware that some residents also have concerns about past and ongoing *occupational* exposures to contaminants at ORR. However, ATSDR's mandate does not include evaluating most occupational exposure scenarios. Those who are interested in learning more about occupational health issues for this site should refer to resources listed in Section V of this PHA.

This PHA presents the most extensive environmental health review to date of the TSCA Incinerator. ATSDR gathered and critically reviewed data and reports published by many parties, including environmental and health agencies, a local citizens' oversight committee, DOE and its contractors, and a group of independent experts chartered by the Governor of Tennessee. The PHA examines emissions monitoring data, environmental sampling data, and other observations that were collected over the entire history of the TSCA Incinerator's operations.

ATSDR's approach to evaluating the TSCA Incinerator started with collecting background information on topics such as operational history, community health concerns, environmental setting, and demographics. This section summarizes background information by presenting facts and observations about the TSCA Incinerator without any analyses or interpretations. Later sections in this report (Sections III through VII) describe how the background information fits into the overall environmental health analysis.

II.A. Site and Process Description

As Figure 2 shows, the TSCA Incinerator is located in the northeast corner of ETTP, which was formerly known as both the K-25 site and the Oak Ridge Gaseous Diffusion Plant. ETTP spans approximately 700 acres to which the public has no access, unless accompanied by an escort from the facility (see Section II.D). DOE constructed the TSCA Incinerator to help manage a growing volume of mixed LLW generated from various processes at ORR and at other DOE facilities. The purpose of the incinerator is to reduce the amount of waste that requires management, both by destroying hazardous organic chemicals in wastes and by reducing the volume of wastes containing radionuclides. The remainder of this section provides background information on incineration technology (see Section II.A.1) and describes the unit operations in the TSCA Incinerator (see Section II.A.2).

II.A.1. General Information on Incineration

Incinerators burn waste, thereby destroying some waste materials and reducing the volume of others. Although many different incineration technologies exist, nearly all incineration facilities share some common input and output streams, as Figure 3 depicts. The primary inputs at most incineration facilities are the wastes to be treated, along with air and additional fuel to support combustion. Incineration occurs within combustion chambers, which destroys most organic material in waste, but in the process generates two general types of output streams:

- **Air emissions.** All incinerators have air emissions. Stack air emissions are gaseous, vapor, and particle-bound by-products of combustion. More information on these emissions is presented later in the section. Facilities also have fugitive air emissions, which are releases to the air from process points other than stacks (e.g., equipment leaks, wind-blown dust). The design of an incinerator, including waste and residual handling, largely determines the amount of fugitive air emissions that might occur. Refer to Section III.B for more information on the specific contaminants released from the TSCA Incinerator, both in fugitive and in stack emissions.

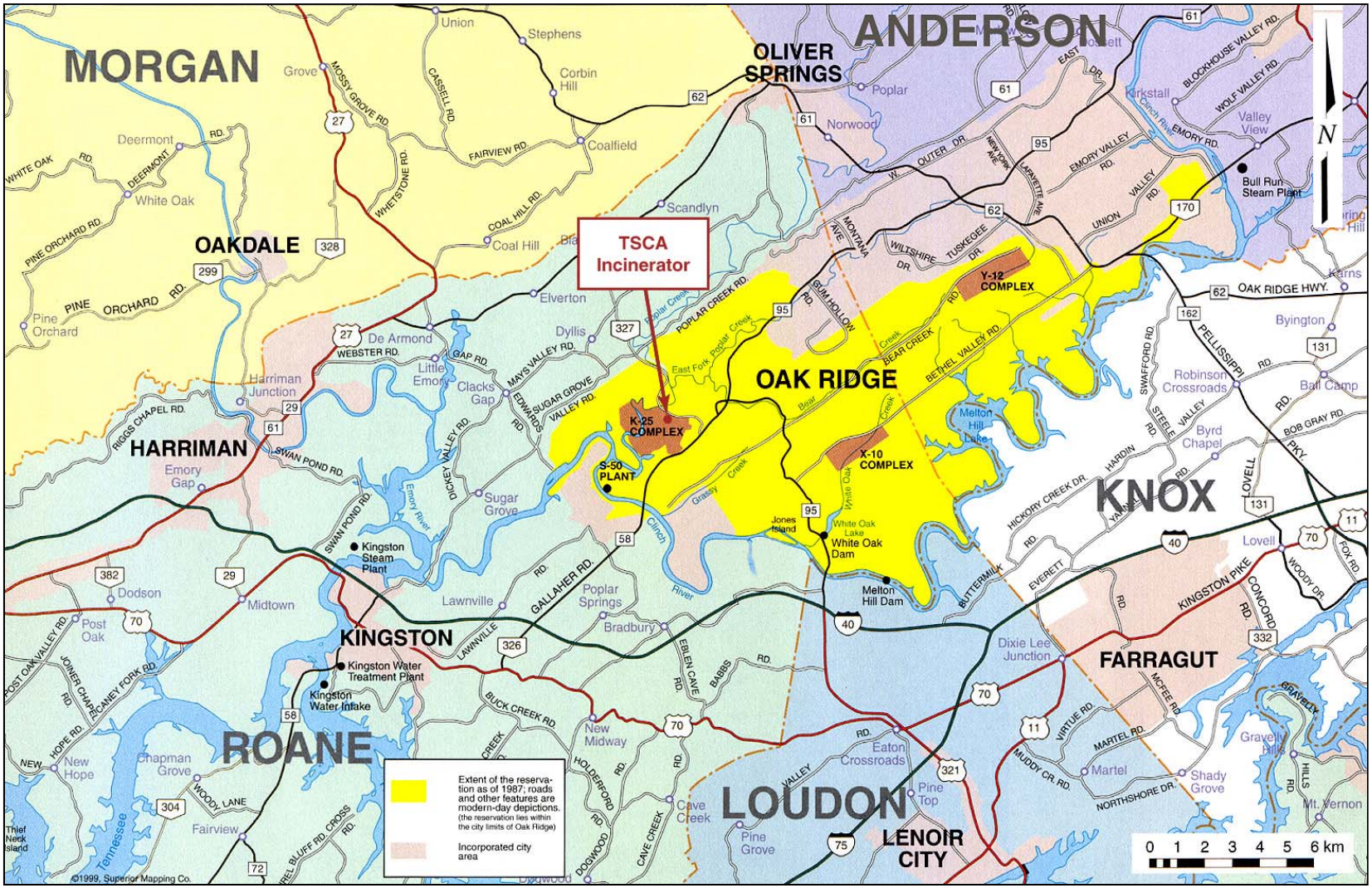
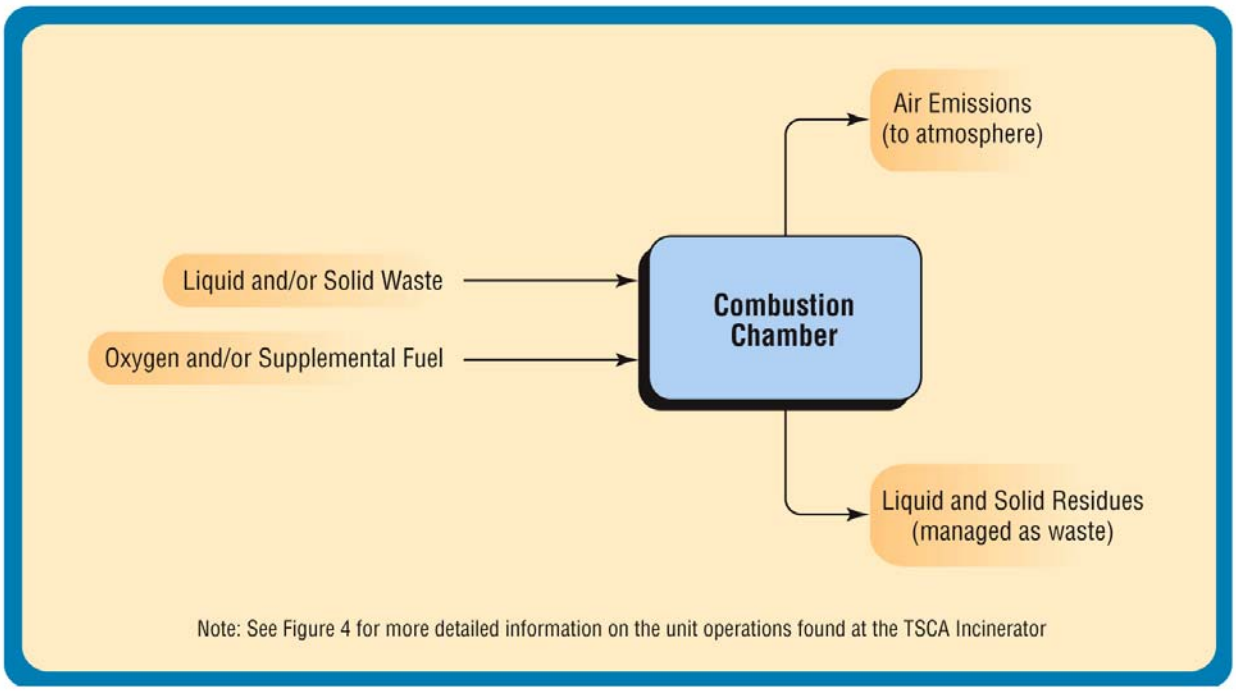


Figure 2. Location of the TSCA Incinerator

Figure 3. Generic Process Streams at Most Incineration Facilities



- **Residuals.** Incineration facilities also generate solid and liquid residuals. These typically include wastewater from air pollution control devices and solid wastes, such as ash that remains in the combustion chamber and sludge that settles from wastewater treatment operations. Residuals are handled according to applicable waste management regulations. Section V of this PHA presents ATSDR's evaluation of the residuals generated at the TSCA Incinerator.

Those interested in more detailed information on incineration are referred to various documents published by government agencies on environmental health concerns related to thermal treatment technologies (e.g., ATSDR 2002; EPA 1998; NRC 2000).

ATSDR is aware that many parties continue to debate whether incineration is a viable method of waste management. This PHA is not designed to enter this debate. Rather, its purpose is to evaluate the environmental health concerns specific to the TSCA Incinerator at ETTP. It is worth noting, however, that ATSDR has already conducted an extensive public health review of incineration and thermal treatment technologies (ATSDR 2002). That review found that the design and operation of an incinerator (see text box) must be considered when evaluating a particular site. Accordingly, this PHA not only reviews environmental sampling data collected near ETTP, but also considers specific information on how DOE designed and operates the TSCA Incinerator.

"Thermal treatment technologies [including incinerators] are inherently neither safe nor unsafe; whether they are safe depends on how they are designed and operated" (ATSDR 2002).

II.A.2. Process Description of the TSCA Incinerator

This section describes key elements of the engineering processes at the TSCA Incinerator, focusing on how the engineering design relates to potential air emissions and how waste material passes through the facility. This section provides an overview of the incinerator design, without necessarily identifying and commenting on the countless individual components (e.g., buildings, trailers, tanks, piping, connections) installed at the incinerator. Readers interested in a more detailed account of the engineering design should refer to DOE's permit application for the TSCA Incinerator, which includes highly detailed information about the incinerator design and operation (Radian 1997).

All equipment at the TSCA Incinerator can be classified into five general categories, as shown in Figure 4, on the following page. The following paragraphs describe the role each category of equipment plays and identify the main air emissions sources from the facility:

- **Waste handling (see box 1 in Figure 4).** The TSCA Incinerator treats solid wastes, liquid wastes, and mixtures of the two. These wastes must be thoroughly characterized before arriving at the TSCA Incinerator, and the facility's environmental permits greatly restrict the types and amounts of waste that the incinerator can treat. EPA and TDEC set these restrictions, commonly referred to as "Waste Acceptance Criteria," based on specific tests demonstrating how effectively the TSCA Incinerator destroys wastes. Refer to Section II.C of this PHA for more detailed information on the Waste Acceptance Criteria.

  The composition of the wastes treated at the TSCA Incinerator can vary considerably throughout the year. Composition data comes largely from analytical data for the incoming wastes. For every year the TSCA Incinerator has operated, DOE has reported "rolling totals" that document the total amount of various chemical and radiological constituents in the waste (DOE 2003a). ATSDR thoroughly reviewed these records when preparing this PHA. As an example of the constituents, the 2003 "rolling totals" data include waste throughput estimates for approximately 200 organic chemicals, more than 25 metals, and more than 25 radionuclides. It should be noted that many of the constituents were tested for in the incoming waste, but never detected.

  Solid wastes arrive at the TSCA Incinerator in enclosed containers, such that dusts or particles cannot blow from the waste material into the environment. Solid waste materials are repackaged into combustible containers, which are kept in storage areas before they are fed to the incinerator. The repackaging occurs over a ventilated table, further reducing the possibility of untreated wastes becoming airborne; exhaust air from repackaging areas passes through filters before being vented to the atmosphere. Examples of the types of solid wastes processed at the TSCA Incinerator include pallets, spent carbon, used wash rags, filters, trash, and spent personal protective equipment.

  Liquid wastes are stored at the TSCA Incinerator primarily in tanks. While these tanks do have passive vents to the atmosphere, all vapors released from tanks first pass through carbon adsorption filters that capture volatile chemicals which might otherwise enter the air. The liquid wastes are piped directly into the incinerator, either to the rotary kiln or to the afterburner (see below for more information on these operations). With this design,

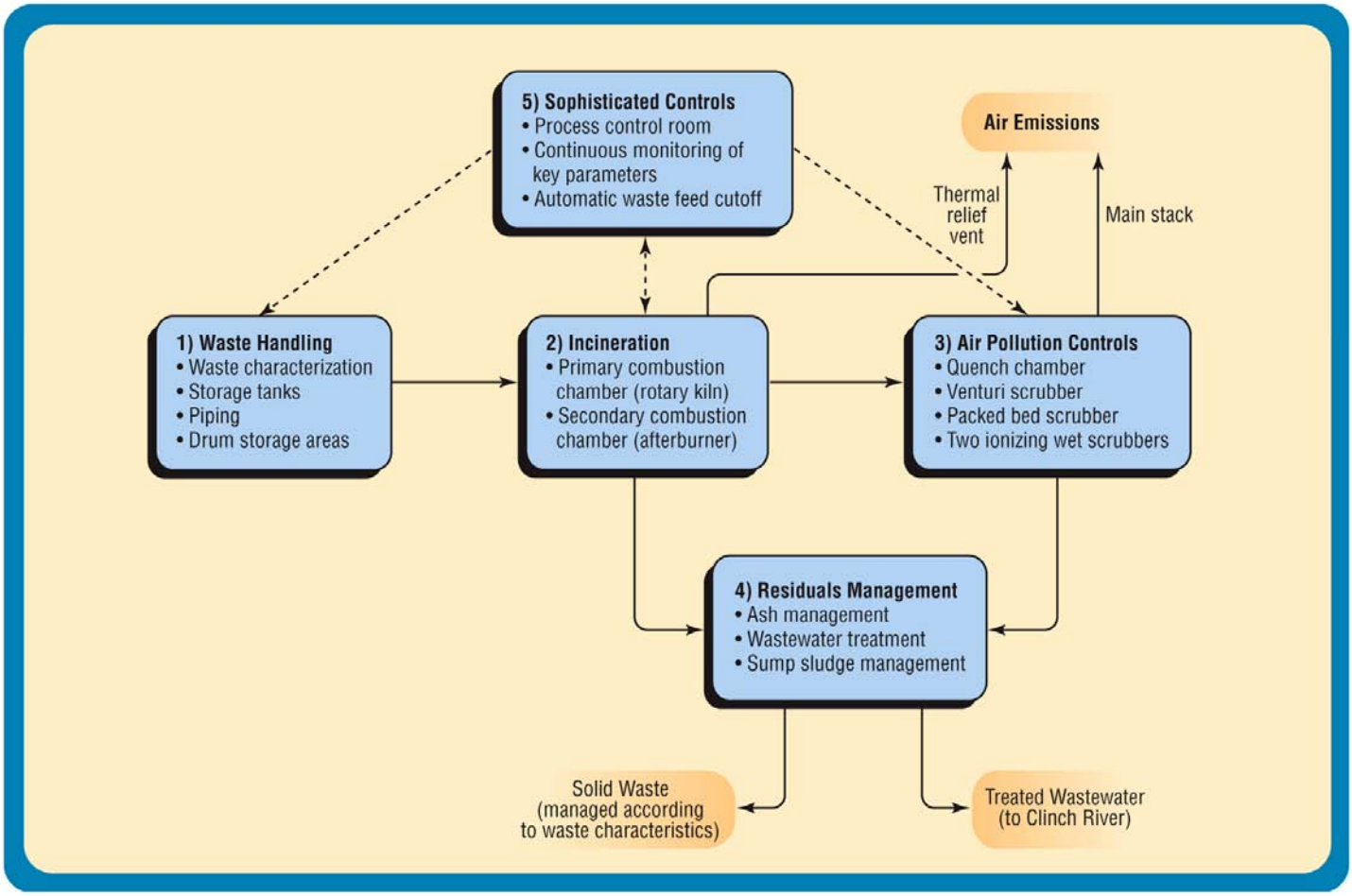


Figure 4. Block Diagram of the TSCA Incinerator

evaporative losses and other fugitive emissions of untreated liquid wastes are expected to be minimal. The TSCA Incinerator is permitted to treat both aqueous waste (e.g., wastewater) and organic waste (e.g., oils, solvent mixtures, degreaser fluids).

- **Incineration (see box 2 in Figure 4).** The TSCA Incinerator has two combustion chambers in which wastes are burned. The fuel for combustion comes from organic material in the waste itself and from supplemental fuel sources. Natural gas is the primary supplemental fuel used at the TSCA Incinerator, but fuel oil can also be used. Oxygen in air is drawn through the incinerator to support combustion. Further details on the two combustion chambers follow.

  First, all solid waste (along with some liquid waste) is fed into the primary combustion chamber, which is a rotary kiln. The kiln is cylindrical in shape, 6 feet in diameter, and 25 feet long. The inside temperature varies with the type of waste treated, but is generally at least 1,580 degrees Fahrenheit. Incineration of waste in the kiln generates gases which pass

into the secondary combustion chamber (see next paragraph) for further treatment. Incombustible material in the waste leaves the rotary kiln in the form of ash. At the end of the kiln, the ash drops into a water pool and enters the residuals management part of the process, as described further below.

The secondary combustion chamber at the TSCA Incinerator is an afterburner, which serves two general purposes. First, some liquid waste is sprayed directly into the afterburner for purposes of treatment. Second, the afterburner destroys organic material in the gases generated in the rotary kiln. The temperature in the afterburner is typically at least 2,205 degrees Fahrenheit, and gases are exposed to this temperature for at least 4 seconds. With one exception, the treated air stream from the afterburner always passes directly into air pollution controls (see below). As the exception, a thermal relief vent (TRV) on the afterburner opens on infrequent occasions to avoid dangerous buildup of gases and to prevent situations that might harm the downstream air pollution controls. When the TRV opens, the waste feed to the incinerator is instantly cut off, and gases in the afterburner bypass air pollution controls and vent directly to the atmosphere. In the first 14 years that the TSCA Incinerator operated (1991 to 2004), the TRV opened 18 times. Sections III.B.2 and III.D.2 comment further on the significance of the TRV openings.

The fate of waste constituents within the incinerator varies. For instance, organic chemicals are very efficiently destroyed in the incinerator (see Section II.C for quantitative information on the destruction efficiency). Incineration of organic chemicals primarily generates a mixture of low molecular weight by-products (e.g., water, oxygen, carbon dioxide) that are relatively harmless from a health perspective. However, some potentially harmful by-products do form, such as inorganic acids, dioxins, and furans. Metals and radionuclides in the waste feed are not destroyed in the combustion chambers. Thus, the effluent from the combustion chambers contain a mixture of vapors products and particles that pass through a series of air pollution controls (see below) before being vented to the atmosphere.

- **Air pollution controls (see box 3 in Figure 4).** The gases from the afterburner contain a mixture of chemicals (e.g., water, oxygen, carbon dioxide) that, from a health perspective, are relatively benign. But the gas stream also includes trace amounts of toxic contaminants (e.g., acids, dioxins, furans, metals, radionuclides) from the wastes or that were formed as combustion by-products. Consequently, environmental regulations require most incinerators to have air pollution controls to "clean" their effluents before they are vented to the atmosphere.

  The gases generated in the TSCA Incinerator's afterburner pass through multiple air pollution control devices designed to remove contaminants (primarily particle-bound contaminants and acidic gases) from the effluent stream. The sequence of air pollution controls — a quench chamber, a Venturi scrubber, a packed bed scrubber, and two ionizing wet scrubbers — efficiently removes numerous contaminants, including very fine particles, that would otherwise escape to the air. The contaminants that are removed (e.g.,

As Figure 4 indicates, the main air emissions points from the TSCA Incinerator are (1) routine releases through the main process stack and (2) infrequent non-routine releases through the thermal relief vent. Section III of this PHA evaluates the public health implications of both types of releases.

metals, acids, radionuclides) are primarily captured in water that circulates through the air pollution controls. The next bullet item further discusses how the contaminants are handled in the wastewater streams. After passing through these multiple air pollution controls, the process gases are vented to the atmosphere through a 100-foot tall stack.

- **Residuals management (see box 4 in Figure 4).** The main process residuals from the TSCA Incinerator are ash from the rotary kiln, wastewater from the air pollution control devices, and sludge from a water sump. The wastewater and the sludge include the contaminants that the air pollution controls removed from the gases from the afterburner. DOE manages all three types of residuals according to applicable permits and waste management regulations.

  Specifically, the wet ash from the water pool at the end of the rotary kiln is transferred via conveyor belt to 55-gallon drums. (Keeping the ash wet minimizes the possibility of wind blowing contaminants into the atmosphere.) Ash samples from the drums are analyzed to determine whether the waste should be disposed of in a landfill or subjected to further treatment. When PCB-containing wastes are being burned, all ash found to contain more than 2 parts per million (ppm) PCBs must pass through the incinerator a second time for further treatment.

  The liquid residuals from the air pollution control devices are collected in a sump, which generates both solid waste (sludge) and liquid waste (wastewater). Radionuclides, metals, and other low-solubility substances removed by the air pollution controls will largely collect in the incinerator's sludge. DOE handles this sludge, similar to the ash, according to applicable solid waste management regulations. The wastewater, on the other hand, is either recycled to the air pollution control devices or pumped to the Central Neutralization Facility (CNF) — the main wastewater treatment plant at ETTP. The treated water is discharged to the Clinch River. DOE's National Pollutant Discharge Elimination System (NPDES) permit requires frequent sampling of the treated water to demonstrate that the effluent will not harm human health or the environment. Refer to Section V of this PHA for ATSDR's evaluation of the environmental health issues associated with the incinerator's residuals.

- **Sophisticated controls (see box 5 in Figure 4).** The TSCA Incinerator has sophisticated controls that help ensure the incinerator efficiently destroys wastes without causing air emissions possibly harmful to health and the environment. These automated controls monitor waste handling operations, incineration, and air pollution controls. Specifically, throughout the TSCA Incinerator process they initiate continuous readings of more than 30 different operating parameters. For instance, temperature in the combustion chambers, waste feed rates, and concentrations of selected gases in the stack exhaust are continuously measured whenever the incinerator operates. Further, the controls quickly shut down incineration operations whenever critical parameters are found to fall outside the TSCA Incinerator's environmental permits. (These shutdowns are more commonly known as automatic waste feed cutoffs, or AWFCOs.) In short, sophisticated automated controls help ensure that the TSCA Incinerator operates safely. Section II.C presents more information on this topic.

The previous discussion highlights general design features of the TSCA Incinerator that are most relevant to environmental releases and to ATSDR's evaluations presented in this PHA. Generally speaking, the incinerator is designed to ensure that organic material in the wastes is efficiently destroyed, with no hazardous residuals generated.

II.B. TSCA Incinerator Operational History

The TSCA Incinerator treats waste material consistently — but not continuously — throughout the year. DOE waste treatment records suggest that the incinerator typically operates up to 250 days per year. Downtime occurs due to various reasons, such as routine or non-routine maintenance.

ATSDR gathered three general types of information to characterize key features of the TSCA Incinerator's operational history:

- **Major permitting milestones (see Table 1).** Table 1 highlights milestones related to the permitting status of the TSCA Incinerator. While this table identifies many key events, it is not intended to be an exhaustive account of the incinerator's entire operational history.

Table 1. Selected Milestones in the TSCA Incinerator's Operational History

Date	Milestone
1984	Construction of TSCA Incinerator begun
May 1988	Final TSCA trial burn prior to permitting
June 1989	Final RCRA trial burn prior to permitting
June 1990	Final state emissions test prior to permitting
April 1991	***Start of routine waste treatment operations at the TSCA Incinerator***
June 1995	Updated state emissions test
November 2000	Updated state emissions test
May 2001	Updated RCRA/TSCA trial burn

Three important observations are evident from the table. First, unlike other emissions sources at ORR that ATSDR has evaluated to date, the TSCA Incinerator has only operated for the past 14 years. Therefore, as Section III explains, this PHA focuses only on potential exposures that have occurred since 1991. Second, the table indicates that DOE performed numerous emissions tests and trial burns before regulatory agencies would permit routine operations. This means that DOE had to characterize thoroughly the incinerator's performance before operations could commence. Third, the table notes that DOE performed several updates to its emissions tests and trial burns. Regulatory agencies required DOE to demonstrate, through these additional tests, that the incinerator continues to meet health-protective requirements specified in environmental permits. Taken together, these observations give some sense of the regulatory oversight of the incinerator's operations, an issue that Section II.C discusses further.

- **Amount of waste treated (see Figure 5).** Between April 1991 and December 2002, the TSCA Incinerator has treated approximately 16,000 tons of waste (DOE 2003a). Over the years, the waste constituents have varied; they typically include a mixture of volatile organic compounds, semi-volatile organic compounds (including PCBs), metals, inorganic compounds, and radionuclides. To illustrate waste-stream variability, the amount of PCBs treated per year has ranged from less than 1 ton to more than 50 tons.

  The amount of waste that the TSCA Incinerator treats is only a small fraction of the amount allowed under the facility's health-protective permits.

  Figure 5 shows how the annual amount of wastes treated at the TSCA Incinerator has varied from year to year. Waste treatment activity at the incinerator peaked in the mid-1990s and has decreased considerably since then. Not shown in Figure 5 is the fact that the TSCA Incinerator treats only a small fraction of the waste allowed in its environmental permits. Specifically, the current operating permits allow the TSCA Incinerator to treat no more than 1,836 pounds of liquid waste per hour and 964 pounds of solid waste per hour. Given these limits and assuming 10% downtime for routine maintenance, the TSCA Incinerator is currently permitted to treat approximately 10,000 tons of waste per year. Since 2000, however, the amount of waste treated at the TSCA Incinerator has been only 5% of the health-protective permitted limits.

  Thus, in recent years, the TSCA incinerator has clearly been operating at levels much lower than the overall capacity expressed in terms of total liquid waste feed per hour or total solid waste feed per hour. However, it should be noted that there are many permit conditions for specific contaminants and parameters in the feed that could potentially cause the allowable waste feed rate to be lower than the maximum limits based on liquid and solid mass throughput.

- **Thermal relief vent (TRV) openings (see Table 2).** As noted previously, the TRV on the TSCA Incinerator is a vent that opens to avoid situations where gases in the afterburner might harm or destroy the air pollution control devices. During the short time that the TRV is open, gases in the afterburner vent directly to the atmosphere without first passing through the air pollution controls — a situation that has raised concerns among some community members (see Section V). Accordingly, ATSDR obtained information on the history of TRV openings at the facility.

  As Table 2 shows, during the first 14 years of the TSCA Incinerator's operations, the TRV opened 18 times. The most frequent cause of the TRV openings was interruptions to the electrical power system. To minimize the likelihood of power losses shutting down operations, the incinerator is equipped with two separate feeders from the electric switchyard. But power outages have still caused 10 shutdowns (and TRV openings) over a 14-year period. The second most frequent cause was failures in the magnetic latch that keeps the TRV closed. After the last such failure (in July 1996), engineers at the facility designed and installed a new TRV closure mechanism that has addressed this problem (Iglar et al. 1998). The frequency of TRV openings has varied from year to year, with no TRV openings in some years and as many as five TRV openings in others.

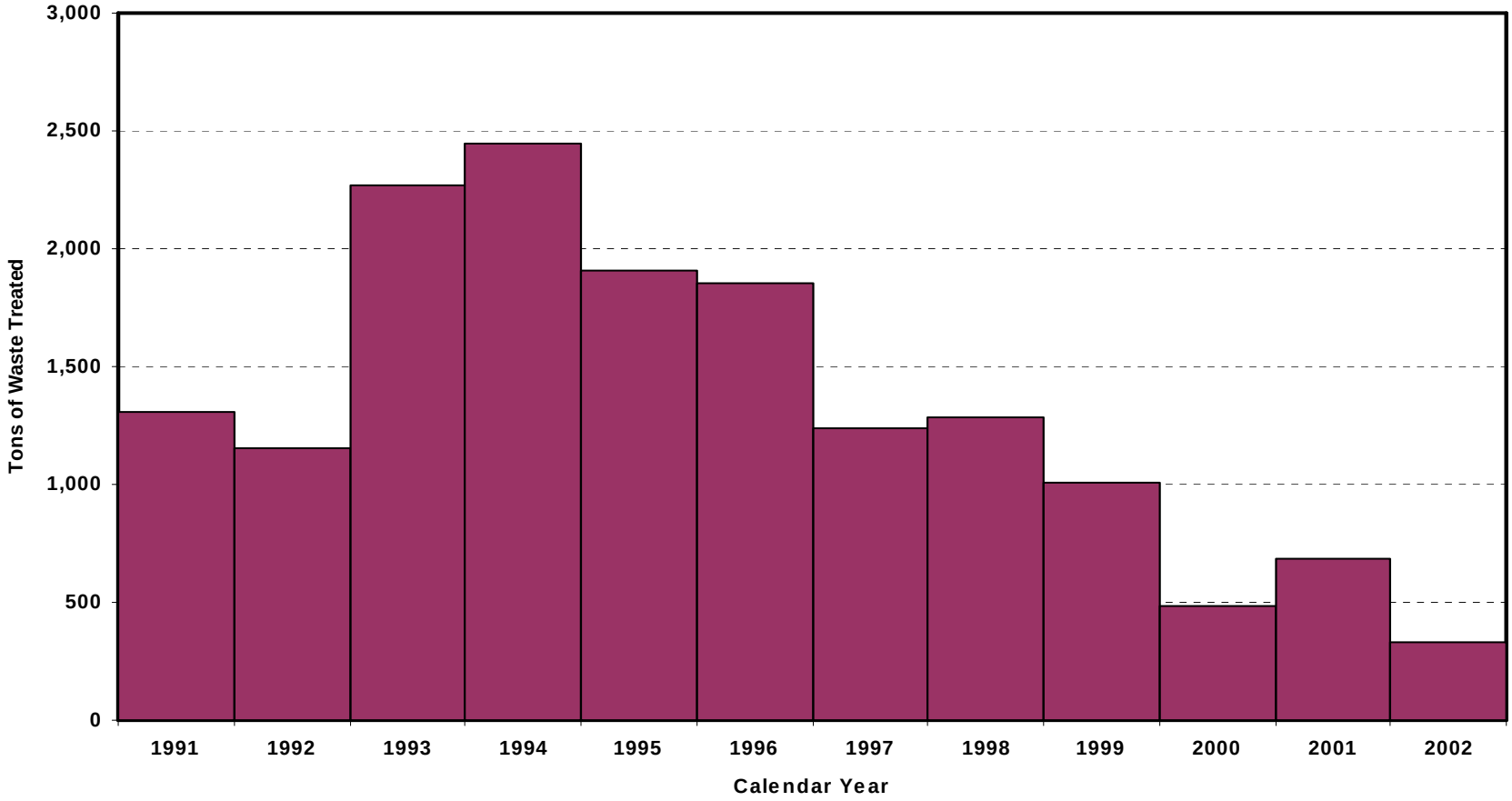


Figure 5. History of Waste Treatment Totals, by Calendar Year

Source of data: DOE 2003a.

Table 2. History of TRV Openings (1991–2004)

Date	*Cause*	*Ambient Air Sample Analyzed?*
December 20, 1991	Electrical power interruption	Yes
May 5, 1993	Electrical power interruption	Yes
May 6, 1993	False radiation criticality alarm	Yes
February 25, 1995	Electrical power interruption	Yes
May 31, 1995	Electrical power interruption	Yes
June 18, 1995	Electrical power interruption	Yes
December 9, 1995	Loss of TRV magnet	No
December 22, 1995	Loss of programmable logic controller	No
January 28, 1996	Loss of TRV magnet	Yes
January 31, 1996	Loss of TRV magnet	Yes
April 30, 1996	Loss of programmable logic controller	No
July 7, 1996	Loss of TRV magnet	Yes
July 12, 1999	Electrical power interruption	No
December 29, 1999	Loss of programmable logic controller	No
June 29, 2002	Electrical power interruption	No
July 22, 2002	Electrical power interruption	No
February 27, 2004	Electrical power interruption	No
May 13, 2004	Electrical power interruption	No

Source of data: DOE 2003b.

To ensure that air releases during TRV openings do not reach unsafe levels, immediately after gases are vented to the air DOE collects air samples at two off-site locations. If waste feed and operating conditions at the time of the TRV opening are not bracketed by those observed during previous events, the samples are analyzed. Table 2 notes that air samples were analyzed for nine out of the 18 TRV openings that occurred between 1991 and 2004. Section III.D of this PHA reviews the results of samples collected during these episodic releases.

The preceding discussion reviews key observations pertaining to the TSCA Incinerator's operational history. Still, as the next section of this PHA further describes, the facility's environmental permits largely dictate how DOE routinely operates the incinerator.

II.C. Remedial and Regulatory History

DOE could not begin waste treatment operations at the TSCA Incinerator until environmental regulatory agencies, primarily EPA and TDEC, issued the necessary permits. The permitting process for such a facility is quite extensive, as is demonstrated by the fact that more than 2 years passed between the time the TSCA Incinerator was constructed and when permitted operations began. Operations at the TSCA Incinerator must comply with multiple federal regulations (e.g., the Clean Water Act, the Clean Air Act, TSCA, and the Resource Conservation and Recovery Act, or RCRA) and supplemental regulations issued by the state of Tennessee. Further, many activities for operations involving radioactivity must meet standards established by DOE. Although the many permits governing the incinerator's operations address different issues, the

environmental permits share one common feature: they are intended to prevent situations in which releases from the TSCA Incinerator can harm human health or the environment.

The remainder of this section reviews notable features of the environmental permits that pertain to environmental releases from the TSCA Incinerator:

- **Waste acceptance criteria.** DOE cannot burn simply any waste in the TSCA Incinerator. Rather, the facility's environmental permits have codes for specific wastes that the facility can treat. Further, the permits establish a Waste Analysis Plan that requires DOE to characterize all wastes sent to the TSCA Incinerator. Under this plan the waste generator must first characterize the chemical composition of waste, typically through rigorous laboratory sampling. The generator could be another department at ETTP, a different ORR facility, or possibly a different DOE facility. After reviewing the waste constituents, operators at the TSCA Incinerator decide whether further waste characterization is needed or whether the waste can be safely treated. Currently, DOE tracks the amounts of more than 250 different constituents in the wastes processed through the TSCA Incinerator (Radian 1997). Ultimately, these waste acceptance criteria help ensure — but do not guarantee — that DOE only accepts wastes the TSCA Incinerator can safely treat.

- **Operating parameters and automatic waste feed cutoffs.** In addition to an incinerator's design, the process operating parameters largely determine the waste destruction and removal efficiency. For instance, waste destruction efficiencies depend on many factors, including the combustion temperatures themselves, how long wastes remain in the combustion chambers, and how well wastes (particularly solid wastes) mix in them. Further, the efficiencies of waste destruction and removal are functions of the ash content in the waste and how the air pollution control devices are operated. The following text box defines the waste destruction and removal efficiency.

What is the waste destruction and removal efficiency (DRE)? The overwhelming majority of waste material fed to an incinerator is not released to the air. Rather, organic chemicals are destroyed in the combustion chambers; metals and radionuclides are largely removed from process streams by air pollution controls and eventually accumulate in solid residuals, whether the ash at the end of the rotary kiln or the sludge from the water used in the air pollution controls.

The destruction and removal efficiency refers to the percent of waste material that is either destroyed or otherwise removed from the waste feed. For most hazardous waste incinerators, DREs for organic compounds are greater than 99.99% and well over 90% for many metals and radionuclides. The DRE for a given chemical is calculated using the following equation:

$$DRE = (Feed\ Rate - Emission\ Rate) / (Feed\ Rate)$$

The feed rate is the measured amount of chemical in the wastes fed to the incinerator and the emission rate is the measured amount of chemical in the stack exhaust.

Recognizing that operating parameters are closely linked to incinerator performance, environmental regulatory agencies require thermal treatment facilities to determine, typically through trial burns, the ranges of operating parameters needed to achieve the required destruction removal efficiencies (DREs). For the TSCA Incinerator, DOE had to demonstrate that the incineration process could achieve DREs greater than 99.9999% for PCBs and greater than 99.99% for other organic chemicals expected to be found in hazardous waste. To date, DOE has conducted multiple trial burns at the TSCA Incinerator, all of which have challenged the incinerator to destroy wastes under unfavorable conditions, such as lower combustion temperatures and higher feed rates.

The trial burns conducted at the TSCA Incinerator served two critical purposes. First, they proved that the incinerator could meet the numerous and extensive requirements set forth in environmental regulations, such as minimum DREs and maximum emission rates for certain pollutants. (Appendix A presents detailed summaries of the trial burns conducted at the TSCA Incinerator.) Second, they provided information that regulators could use to establish limits on critical operating parameters. Table 3, for instance, lists several critical operating parameters that DOE must continuously monitor to ensure that the TSCA Incinerator operates in a manner consistent with conditions observed during the trial burns. Whenever operating parameters deviate from the limits shown in Table 3, an automatic waste feed cutoff occurs: the waste feed automatically shuts down, wastes remaining within the incinerator are fully treated, and no further waste is treated until the operating parameters return to acceptable values. Through this continuous monitoring and automatic waste feed cutoff process, regulators help ensure that the TSCA Incinerator only operates in a manner that has been shown to achieve the required waste-destruction efficiencies.

- **Inspections.** The TSCA Incinerator is inspected frequently. For example, TDEC officials typically conduct thorough inspections once a year, during which its representatives observe operations, review records, and interview staff. While inspectors have identified some minor violations of permit conditions, all such violations have been promptly addressed and corrected. Moreover, DOE's environmental permits require extensive self-inspections at regular intervals, ranging from daily to quarterly. These required self-inspections are intended to help DOE identify and promptly correct operational or equipment problems. Taken together, the DOE and TDEC oversight helps minimize the likelihood that critical operational problems at the TSCA Incinerator could go undetected.

Table 3. Limits Established in Permits for Selected Operating Parameters

Parameter	*Permit Limit*	*Rationale*	*Monitoring Status*
Outlet temperature of rotary kiln	> 1,580 °F	Lower temperatures could lead to more products of incomplete combustion and failure to meet required waste destruction efficiencies for organic wastes.	DOE must monitor all of the parameters listed in this table continuously. Outputs from the monitors are fed directly to the control room. Values found outside of permitted limits will trigger automatic waste feed cutoffs. DOE must frequently test and calibrate the sensors that measure the listed parameters.
Outlet temperature of afterburner	> 2,205 °F		
Gas residence time in the afterburner	> 2 seconds	The afterburner will not destroy organic compounds that move through the system too rapidly.	
Stack exit velocity	< 21.4 feet/second		
TRV opening	Must be closed	Operating with the TRV open would release exhaust gases to the air without first sending them through air pollution controls.	
Concentrations of carbon monoxide in the stack exhaust	<100 ppm (1-hour rolling average)	Higher carbon monoxide levels are an indicator of incomplete combustion or organic material.	
Solid waste feed rate to kiln	<1,008 lb/hour	The trial burns demonstrated that the incinerator can efficiently destroy wastes at these feed rates. Destruction efficiencies at higher feed rates have not been verified.	
Organic liquid waste feed rate to kiln	<812 lb/hour		
Aqueous liquid waste feed rate to kiln	<478 lb/hour		
Organic liquid waste feed rate to afterburner	<710 lb/hour		
Water recycle flow through venturi scrubber	<121 gallons/minute	Values outside these ranges would indicate that the air pollution controls might not be treating the exhaust streams efficiently.	
Effluent pH in the packed bed scrubber	<6.1 (with 30-minute delay)		

Notes:
Source of data: Radian 1997.
The temperature and residence time requirements only apply to TSCA conditions (i.e., incinerating wastes containing PCBs). The RCRA requirements for these parameters are less stringent.
The table lists only a subset of the operating parameters specified in the various environmental permits.

- **Other requirements.** The previous discussion reviews some important requirements set forth in the TSCA Incinerator's environmental permits. But this discussion is not exhaustive — the permits require numerous other actions, such as operator training, equipment testing and calibration, emergency planning, and extensive recordkeeping and reporting requirements. ATSDR carefully reviewed these aspects of the environmental permits and generally concurs with the regulatory agencies that the required controls are sufficient (e.g., frequency of equipment testing and calibration is adequate). Moreover, under a recent EPA regulation requiring hazardous waste combustion facilities to implement "maximum achievable control technologies" (MACT) in their processes, the incinerator is now subject to more stringent emissions limits. According to EPA, MACT represents the maximum degree of air emissions reductions that can be realistically achieved, when one considers the available emissions control technologies and their costs and benefits. The MACT standards came into effect on September 30, 2003.

Overall, the purpose of the previous discussion is to emphasize that the TSCA Incinerator is a closely regulated air emissions source. Due to the extensive environmental regulations and permitting requirements, DOE invested considerable effort to obtain its original permits and, to comply with those permits, closely monitors the incinerator's performance.

II.D. Environmental Setting

The environmental setting for a site largely determines how close residents can come to sources of contamination and how contaminants move through the environment. Accordingly, when evaluating environmental health issues for the TSCA Incinerator, ATSDR considered the following observations:

- **Land use.** As noted previously, ETTP is located on approximately 700 acres of land, which is primarily developed for industrial use. According to Figure 2, ETTP lies entirely within ORR, near the westernmost point of the DOE property. The ORR lands surrounding ETTP are largely undeveloped forest areas. Just beyond the ORR boundary near ETTP, some lands have been developed (mostly for light residential, commercial, and agricultural uses), but undeveloped areas are found throughout the Oak Ridge area. The farms in the area produce a variety of products, including beef, dairy, fruits, and vegetables. Home gardens are also present throughout the area. Hunting occurs at many off-site locations, and sometimes even occurs within the ORR boundary — but never within ETTP. Section II.F of this PHA presents detailed information on the residential populations nearest to the TSCA Incinerator.
- **Site access.** ETTP is completely surrounded by a chain-link fence topped with barbed wire. Signs reading "Danger — Unauthorized Personnel Keep Out" are posted at regular intervals along this fence. Only authorized employees and contractors are permitted to enter ETTP and the TSCA Incinerator area, and then only through guarded and gated entries. Visitors are allowed to enter ETTP, but only when accompanied by an escort. Security guard patrols and video surveillance cameras help prevent unauthorized entry to ETTP property. Given these extensive security measures and the extremely low likelihood of trespassers accessing the TSCA Incinerator site, this PHA does not address exposure scenarios for trespassers (see Section III.A). In a response to a community health concern (see Section V), ATSDR does provide insights on exposure scenarios for authorized visitors to the TSCA Incinerator.

- **Terrain.** The TSCA Incinerator is located in a small valley between two ridges (Black Oak Ridge and Pine Ridge) which, like most of the mountain ridges in this area, run from southwest to northeast. Both ridges reach elevations of more than 1,000 feet above sea level, which is approximately 200 feet higher than the base elevation of the TSCA Incinerator. These terrain features are notable because they strongly influence the prevailing wind patterns, which largely determine where any contaminants from the TSCA Incinerator might disperse. As evidence of this, some reports have noted that the prevailing winds generally follow the orientation of the southwest-to-northeast terrain features in the area: daytime prevailing winds tend to be "up-valley" from the southwest, while nighttime prevailing winds tend to be in the opposite direction (Iglar et al. 1998).

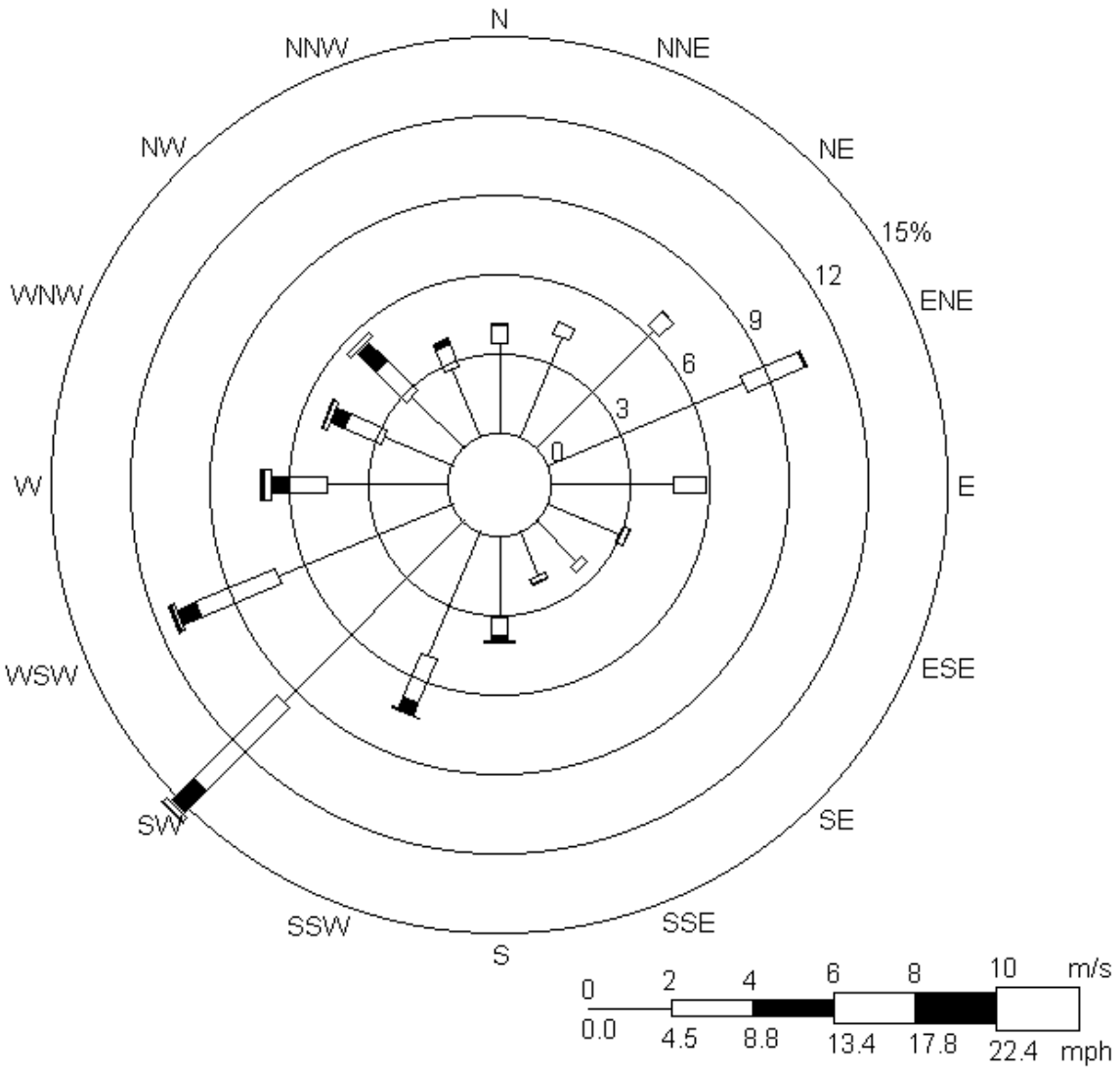
- **Climate and prevailing wind patterns.** The Oak Ridge area has a moderate climate. According to 30 years of data compiled by the National Climatic Data Center, the average annual temperature at Oak Ridge is 68.9 degrees Fahrenheit, with strong seasonal variations. Each year, the area receives approximately 55 inches of precipitation, mostly in the form of rain.

  The prevailing wind patterns in the Oak Ridge area tend to be along the valley floor directions. To illustrate this, Figure 6 summarizes hourly wind speed and wind direction measurements in a format known as a wind rose. The wind rose displays the statistical distribution of wind speeds and wind directions recently observed at a meteorological station located at ETTP. As Figure 6 depicts, the prevailing wind patterns near the TSCA Incinerator are from the general southwest direction (i.e., west-southwest, southwest, south-southwest) toward the northeast and, to a lesser extent, from the general northeast direction toward the southwest. These directions correspond to up-valley and down-valley flows — directions consistent with local terrain features. Despite the dominance of winds along the valley axis, Figure 6 indicates that winds occasionally blow in other directions. As Section III.D further discusses, when reviewing the ambient air monitoring data and ambient air sampling data for this site, ATSDR focused on exposures that might occur to residents located in the prevailing wind directions, with the understanding that residents who do not live in the prevailing wind directions would experience lower exposures.

- **Surface water.** Precipitation runoff near the TSCA Incinerator either enters storm drains or drains directly into Mitchell Branch, a small stream at ETTP that flows into Poplar Creek. Additionally, wastewater from the TSCA Incinerator, after being treated at the CNF, discharges through a permitted outfall at ETTP into the Clinch River. Therefore, when evaluating potential exposures to water contaminants associated with the TSCA Incinerator, this PHA considers only those exposures that might occur in the Clinch River, at locations downstream from its confluence with Poplar Creek. ATSDR addresses this issue as a community concern in Section V of this PHA.

The previous discussion is intended to identify aspects of the environmental setting that are most relevant to releases from the TSCA Incinerator. Those interested in further information on the environmental setting are referred to other resources (e.g., DOE 1991–2002).

Figure 6. Typical Wind Rose for the ETTP Area



Notes:
This wind rose was generated from meteorological data collected in 1999 at a weather station at ETTP. Wind measurements were made at 10 meters above ground surface. Wind roses for other years display nearly identical prevailing wind patterns.
Bars in the figure indicate the direction *from which* wind was blowing. The shading and thickness of the bars indicate the wind speeds observed for each wind direction. Specifically, the circular grid lines represent the percent of time that the wind blows in a particular direction, and the wind direction for a given bar is from the end of the bar towards the center of the wind rose.

II.E. Local Emissions Sources and Regional Air Quality

Although this PHA focuses on environmental health concerns specific to the TSCA Incinerator, ATSDR identified some general air quality issues for the Knoxville metropolitan area that need to be reviewed to better appreciate the significance of the incinerator's releases. The remainder of this section provides perspective on these related issues, which include other air emissions sources near ETTP (Section II.E.1) and regional air quality concerns (Section II.E.2).

II.E.1. Other Air Emissions Sources

When evaluating the air exposure pathway, ATSDR typically considers not only emissions from the source of concern (in this case, the TSCA Incinerator) but also emissions from other sources in the area. ATSDR takes this approach because community members ultimately are exposed to air contaminants released from all local sources, not just contaminants released from a single source. Accordingly, this section presents information ATSDR gathered on two types of emissions sources near ETTP.

- **Industrial emissions sources.** For insights on industrial emissions sources near ETTP, ATSDR first accessed data from EPA's Toxics Release Inventory (TRI). The TRI reporting regulations require many industrial and federal facilities to disclose annually the amounts of toxic chemicals that they release to the environment and manage as waste. While these regulations do not apply to all facilities or to all possible contaminants (such as radionuclides), the TRI data provide an extensive account of air emissions from industrial sources.

  According to the most recent data available to ATSDR when preparing this PHA, for calendar year 2001 six industrial facilities located within 10 miles of the TSCA Incinerator submitted air emissions data to TRI. Table 4 summarizes the air emissions data that the facilities reported, and Figure 7 shows the locations of these facilities. Two observations can be made from the table: first, the TSCA Incinerator is somewhat isolated from large industrial air emissions sources, as the closest facility that disclosed any air emissions to TRI is 4 miles from ETTP. Second, the TSCA Incinerator accounts for an extremely small fraction (<0.02%) of the total toxic chemicals reported to TRI by other industrial facilities located within 10 miles. Readers should refer to Section V.B of this PHA for further insight on the inferences that should be drawn from the TRI data.

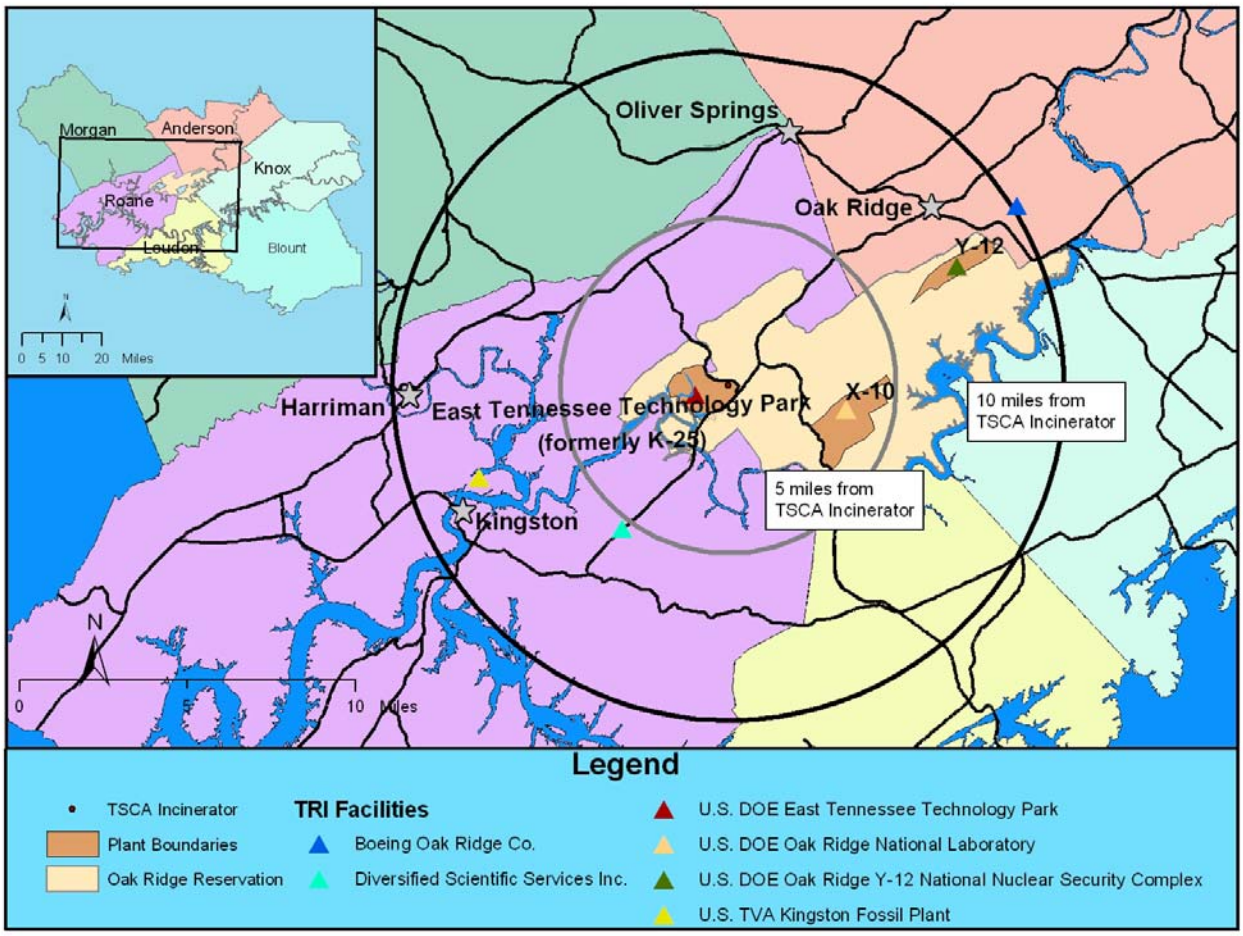
ATSDR is aware that community members have expressed concerns about other air emissions sources more than 10 miles from the TSCA Incinerator. For instance, community members have asked about the significance of TVA's Bull Run Steam Plant, which is located northeast of ORR, about 13 miles from the TSCA Incinerator. In Section V.B of this PHA, ATSDR provides some context on that facility's emissions.

Table 4. Air Toxics Emissions Data from EPA's 2001 Toxic Release Inventory (TRI) for Industrial Facilities within Approximately 10 Miles of ETTP (see notes on following page)

Facility Name	*Approximate Distance from ETTP (See Figure 7)*	*Total Air Emissions of Toxic Contaminants Disclosed to TRI in Reporting Year 2001*
U.S. DOE East Tennessee Technology Park	0 miles	Hydrochloric acid = 25 lbs.
		Lead = 58 lbs.
U.S. DOE Oak Ridge Natl. Lab.	4 miles	Lead = 1 lbs.
Diversified Scientific Services, Inc. (DSSI)	5 miles	Acetonitrile = 14 lbs.
		Methylene chloride = 11 lbs.
		Methanol = 22 lbs.
		n-Hexane = 15 lbs.
		Toluene = 20 lbs.
		Xylenes = 21 lbs.
U.S. TVA Kingston Fossil Plant	8 miles	1,2,4-Trimethylbenzene = 500 lbs.
		Arsenic compounds = 1,505 lbs.
		Barium compounds = 1,250 lbs.
		Chromium compounds = 755 lbs.
		Cobalt compounds = 255 lbs.
		Copper compounds = 755 lbs.
		Hydrochloric acid = 4,000,005 lbs.
		Hydrogen fluoride = 510,005 lbs.
		Lead compounds = 242 lbs.
		Manganese compounds = 1,000 lbs.
		Mercury compounds = 450 lbs.
		n-Hexane = 500 lbs.
		Nickel compounds = 255 lbs.
		Polycyclic aromatic cmpds. = 27 lbs.
		Selenium compounds = 7,705 lbs.
		Sulfuric acid = 1,400,005 lbs.
		Vanadium compounds = 755 lbs.
		Zinc compounds = 255 lbs.
U.S. DOE Oak Ridge Y-12 National Security Complex	8 miles	Freon 113 = 16,530 lbs.
		Hydrochloric acid = 102,332 lbs.
		Lead compounds = 4 lbs.
		Mercury compounds = 2 lbs.
		Methanol = 21,417 lbs.
		Nitric acid = 2,601 lbs.
		Sulfuric acid = 44,221 lbs
Boeing Oak Ridge Co.	10 miles	Nitric acid = 143 lbs.

Notes on Table 4:
Source of data: EPA 2004a.
Air emissions for ETTP should include amounts of chemicals released from the TSCA Incinerator that are subject to the TRI reporting requirements. The 2001 TRI data for ETTP include forms for PCBs and hexachlorobenzene. However, both forms reported zero air emissions and are therefore not included in the table above.
Data are presented for calendar year 2001. These were the most recent TRI data available when this PHA was first drafted.
The TRI regulations require facilities in certain industries to disclose the amounts of specific toxic chemicals that are released to the environment or managed as waste. However, the regulations do not require that all facilities report, and they do not apply to all toxic chemicals. As a result, this table should not be viewed as a comprehensive inventory of industrial air emissions for the Oak Ridge area. Further, the data in this table likely do not represent all toxic air emissions for the facilities listed. TRI data are self-reported; the accuracy of the release data and the geographic coordinates for individual facilities is not known.

Figure 7. Facilities within 10 Miles of ETTP that Disclosed Air Emissions to EPA's Toxics Release Inventory in Reporting Year 2001



Notes:
Source of data: EPA 2004.
Only facilities that reported air releases to TRI were considered for this figure.
The TRI regulations require facilities in certain industries to disclose the amount of specific toxic chemicals they release to the environment or manage as waste. Still, the regulations do not require that all facilities report, and do not address all contaminants; this is presumably why this figure does not identify every industrial facility in the Oak Ridge area. Therefore, this figure does not present a comprehensive account of industrial air emissions sources near ETTP. TRI data are self-reported; the accuracy of the release data and the geographic coordinates for individual facilities is not known.

- **Other emissions sources.** Recognizing that TRI data characterize air emissions from only industrial emissions sources, ATSDR accessed additional data from EPA's National Emissions Inventory (NEI) — an emissions inventory that accounts for releases from industrial sources, mobile sources, agricultural sources, natural sources, and other types of releases. Table 5 summarizes the most recent NEI data for Roane County for selected criteria pollutants, which are pollutants commonly associated with general air quality concerns. Table 5 clearly indicates that air emissions from ETTP, which include emissions from the TSCA Incinerator, account for an extremely small portion (less than 0.2%) of the county's air emissions of carbon monoxide, nitrogen oxides, particulate matter smaller than 10 microns (PM10), sulfur dioxide, and volatile organic compounds (VOCs). As Section II.E.2 describes further, the data in Table 5 provide important context for two general air quality concerns for the Knoxville metropolitan area.

Overall, the previous discussion reveals that the TSCA Incinerator not only is a relatively isolated source of air emissions, but also appears to account for a small fraction of the total air emissions throughout Roane County and the Oak Ridge area. Consequently, the levels of air pollution measured in the area generally cannot be assumed to result entirely from the TSCA Incinerator. Nevertheless, this PHA thoroughly evaluates the public health implications of all emissions and ambient air sampling data collected for this site, including contaminants (e.g., radionuclides) not typically reported in TRI, NEI, and other emission inventories.

II.E.2. General Air Quality in the Knoxville Metropolitan Area

For more than 20 years, EPA and state environmental agencies have evaluated general air quality concerns by measuring ambient air concentrations of six common air pollutants, also known as criteria pollutants. The criteria pollutants are

- carbon monoxide,
- lead,
- nitrogen dioxide,
- ozone,
- two forms of particulate matter, and
- sulfur dioxide.

Many different air emissions sources contribute to the airborne levels of these pollutants. For every criteria pollutant EPA has established a health-based National Ambient Air Quality Standard (NAAQS). In cases where air quality does not meet an NAAQS, states are required to develop and implement plans to bring air pollution levels into attainment with the health-based standards. The following paragraphs review the general air quality in the Knoxville metropolitan area:[1]

1 For the purposes of this PHA, ATSDR considered the following counties to be part of the Knoxville metropolitan area: Anderson County, Blount County, Jefferson County, Knox County, Loudon County, Roane County, Sevier County, and Union County. This list of counties is based primarily on counties that EPA considered when evaluating the attainment status for 8-hour average ozone concentrations (EPA 2004f) and PM2.5 concentrations (EPA 2004c).

Table 5. EPA's 1999 National Emissions Inventory (NEI) Data for Roane County

Source Category	*Emissions Data for Selected Pollutants*									
	Carbon Monoxide		*Nitrogen Oxides*		*PM10*		*Sulfur Dioxide*		*VOCs*	
	Tons per Year	*% of Total*	*Tons per Year*	*% of Total*	*Tons per Year*	*% of Total*	*Tons per Year*	*% of Total*	*Tons per Year*	*% of Total*
ETTP (includes TSCA Incinerator)	5	<0.1%	30	0.1%	5	<0.1%	1	<0.1%	7	0.2%
Other major industrial sources	1,357	5.1%	26,782	86.8%	5,529	73.0%	110,795	99.6%	267	6.1%
Mobile sources	23,879	88.9%	3,898	12.6%	156	2.1%	221	0.2%	2,350	53.6%
All other sources	1,611	6.0%	153	0.5%	1,883	24.9%	169	0.2%	1,764	40.1%
Totals for Roane County	26,852	100%	30,863	100%	7,573	100%	111,186	100%	4,388	100%

Notes:
Source of data: EPA 2004b.
EPA updates its NEI data every 3 years. Results for 1999 are shown, as that is the most recent year for which final NEI data are available.
Air emissions for ETTP should include releases from the TSCA Incinerator.
The PM10 emissions data shown here include the sum of filterable and condensable particulate matter smaller than 10 microns.
"Other major industrial sources" is the sum of releases EPA has reported for the "major" air emissions sources in Roane County. A "major" source emits a threshold amount (or more) of at least one criteria pollutant; thus, this category includes the largest industrial emissions sources in the county. These include Oak Ridge National Laboratory, U.S. TVA Kingston Fossil Plant, Clinch River Corporation, Horsehead Resource Development Company, and Fortafil Fibers, Inc.
"Mobile sources" include a wide range of on-road and off-road mobile sources that burn gasoline, diesel fuel, and other types of fuels. These emissions sources include automobiles, trucks, and various commercial, industrial, recreational, and agricultural vehicles.
"All other sources" include industrial sources that are not categorized as major sources, residential emissions sources (e.g., fireplaces, wood-burning stoves, trash burning), and miscellaneous other sources (e.g., wind-blown dust, forest fires, structural fires).

- **Ozone.** Currently, at least eight ambient air monitoring stations throughout the Knoxville metropolitan area measure airborne levels of ozone throughout the summer months. In recent years, ozone levels at several stations exceeded EPA's health-based standards, suggesting that the air quality is at times unhealthy. As a result, the Knoxville metropolitan area is classified as a "non-attainment area" for ozone, and TDEC was required to develop a plan to improve the air quality. Refer to Section V of this PHA for more information on the health implications of exposure to elevated ozone levels.

What is ozone? Ozone forms in air when emissions from numerous sources, including motor vehicles and industry, mix together and react with sunlight. Ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is greatest. When airborne ozone levels are high enough, people may experience respiratory health problems.

The ozone air quality issue in the Knoxville metropolitan area is not unique. In fact, nearly every major metropolitan area along the East Coast has unhealthy ozone levels occasionally during the summer months. Moreover, more than 150 million residents nationwide live in ozone non-attainment areas. It is also important to note that the ozone problems in the Knoxville area are complex and result from industrial and motor vehicle emissions over a broad geographic region. Sources that release nitrogen oxides and VOCs (both known as ozone precursors) contribute significantly to ozone formation. As Table 5 shows, the TSCA Incinerator releases relatively small amounts of these precursors, especially when compared to other sources in Roane County and beyond. In short, the Knoxville area's ozone air quality issue is regional in nature and is largely unrelated to air emissions from the TSCA Incinerator. Consequently, this PHA addresses ozone issues in response to community concerns about general air quality (see Section V), and not as a site-specific issue.

Particulate matter. TDEC and other parties monitor airborne levels of particulate matter (PM) at several locations throughout the Knoxville metropolitan area. Monitoring currently occurs for three different size fractions of PM. While the monitoring data found airborne levels of larger particles (PM10 and TSP) to be safely below EPA's corresponding health-based standards, airborne levels of fine particulates (PM2.5) in Knox County are not. Therefore, Knox County has been designated a non-attainment area for PM2.5. EPA and TDEC are currently deciding which neighboring counties, if any, should be included in this non-attainment area (TDEC 2004; EPA 2004c).

What is particulate matter (PM)? PM is airborne particles and droplets of varying sizes and chemical composition. Many different industrial, mobile, natural, agricultural, and other sources release PM directly to the air or release pollutants that form PM while in the air. Environmental regulations have addressed total suspended particulates (TSP), particulate matter smaller than 10 microns (PM10), and particulate matter smaller than 2.5 microns (PM2.5). Section III.D comments further on the different size fractions of PM.

Like the area's ozone problems, the PM2.5 issues in the Knoxville metropolitan area are not unique. According to EPA's most recent estimates, approximately 99 million U.S. residents — mostly in urban areas in the Midwest, northeast, and along the Appalachian Mountains —

live in PM2.5 "non-attainment areas." In many cases, the PM2.5 problems cannot be attributed to a single source; PM2.5 forms in the air from many precursors that originate from multiple combustion and industrial sources over broad areas. That said, however, emission inventory data (e.g., Table 5) have shown that the TSCA Incinerator emits insignificant amounts of PM2.5 precursors, particularly when compared to other emissions sources in the Knoxville metropolitan area. Therefore, this PHA addresses the elevated PM2.5 levels in the Knoxville metropolitan area as a regional air quality issue (see Section V), not one resulting from the TSCA Incinerator's emissions.

Airborne levels of ozone and PM2.5 are sometimes unhealthy in the Knoxville metropolitan area. The air quality problems for both pollutants are ***regional issues***—not directly the result of air emissions from the TSCA Incinerator. Section V of this PHA discusses the public health implications of living in areas where airborne ozone and PM2.5 levels are occasionally elevated.

- **Other pollutants.** The Knoxville metropolitan area is considered to be in attainment with the NAAQS for the remaining criteria pollutants: carbon monoxide, lead, nitrogen oxide, and sulfur dioxide. This means that ambient air concentrations of these pollutants are believed to be safely below EPA's corresponding health-based air quality standards. As a result, this PHA does not discuss these pollutants any further.

II.F. Demographics

ATSDR examines demographic data to determine the number of people who are potentially exposed to environmental contaminants and to consider the presence of sensitive populations, such as children (age 6 years and younger), women of childbearing age (between ages 15 and 44 years), and the elderly (age 65 years and older). This section considers general population trends for residents nearest to the TSCA Incinerator and also identifies the residential areas closest to the site.

- **General population trends.** Figure 8 summarizes demographic data for areas within 3 miles of the TSCA Incinerator, based on information compiled in the 2000 U.S. Census. As the figure shows, most areas within 3 miles of the TSCA Incinerator are also within the ORR property boundary, where no one lives. Overall, an estimated 1,224 persons live within 3 miles of the site, and many of these individuals are life-long residents. These individuals live primarily northwest of the site (e.g., in the communities of Dyllis and Sugar Grove) and southwest of the site. The nearest school is approximately 3 miles from the TSCA Incinerator (IT Corporation 2000). According to the Census data, 8% of the population within 3 miles of the incinerator are children, and 11% are considered elderly.
- **Residents closest to the site.** The two residential areas nearest to the TSCA Incinerator are both more than 1 mile from the site. First, several homes and farms, mostly isolated, are located northwest of the incinerator along Blair Road, Sugar Grove Valley Road, Poplar Creek Valley Road, and other streets. The home in this area nearest to ETTP is

approximately 1.7 miles from the TSCA Incinerator. Black Oak Ridge, however, separates this entire residential area from the site. This ridge likely limits (but does not prevent) the incinerator's emissions from blowing directly into the residential neighborhoods. Second, additional homes and farms are located southwest of, and across the Clinch River from, the TSCA Incinerator. These homes and farms are along Gallaher Road, Lawnville Road, and side streets of these roads. All residences in this area are at least 2.0 miles from the TSCA Incinerator, but in this case a large ridge does not separate this area from the site.

In addition to the aforementioned residential neighborhoods, where prolonged or chronic exposures to site contaminants are feasible, ATSDR also considered short-term exposures residents might experience when they are closer to the TSCA Incinerator. The nearest publicly accessible area is Blair Road, which at its closest point passes about ¼ mile from the base of the TSCA Incinerator stack. Residents are not expected to spend extended periods of time outdoors on the parts of Blair Road nearest to the TSCA Incinerator, though such activity is not prohibited.

Later sections of this PHA refer to the demographic data. Specifically, Section IV evaluates public health implications of chronic exposure for residential populations, and Section V presents health-related information specific to children and the elderly, which are known to be sensitive to exposures to certain air pollutants.

II.G. Summary of Public Health Activities Pertaining to the TSCA Incinerator

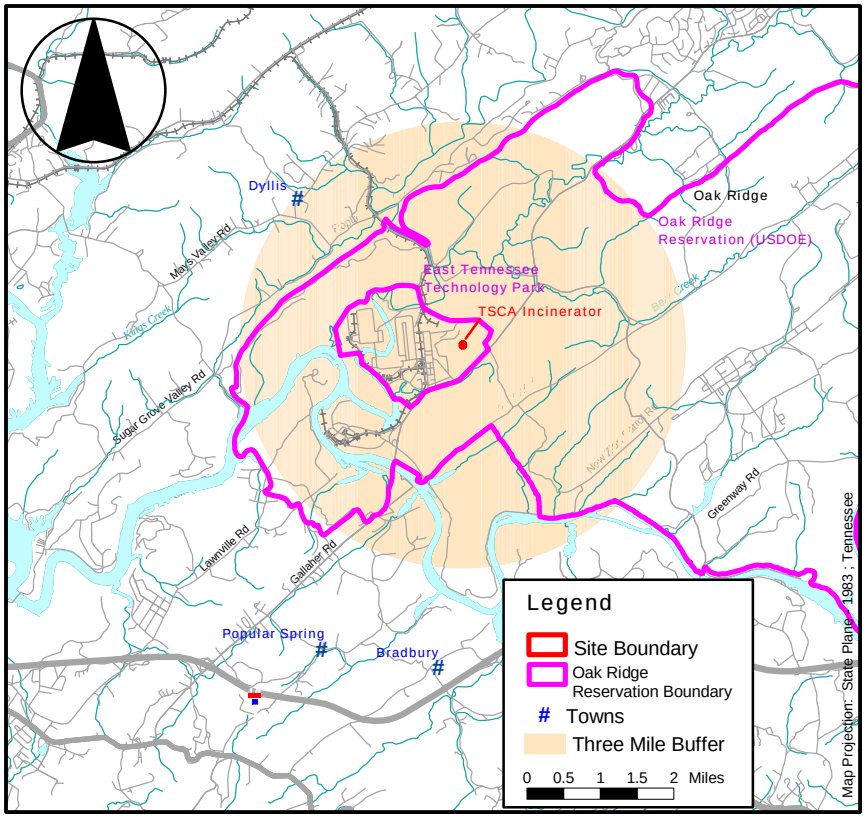
For more than 12 years, ATSDR has been evaluating environmental health issues related to other facilities at ORR. The text box at the end of this section describes how residents can get more information on ATSDR's past and ongoing environmental health activities for those other facilities. A timeline for the main public health activities specific to the TSCA Incinerator follows:

- In May 1997, amid growing community concerns regarding the TSCA Incinerator, the Governor of Tennessee convened an independent panel of environmental scientists, occupational health professionals, and engineers to evaluate DOE's operation of the site. The panel was charged with reviewing the operations and making recommendations to ensure that releases from the incinerator do not harm human health or the environment. The independent panel issued its final report on the TSCA Incinerator in January 1998 (Iglar et al. 1998). The report acknowledges that some workers and community members are sick from undetermined causes, but notes that the incinerator's emissions and local air quality measurements were generally within permissible values.
- In June 1997, TDEC prepared a report to respond to community concerns regarding the TSCA Incinerator (TDEC 1997). The report is titled *Responses to the 101 Questions from Citizens Presented to the Tennessee Department of Environment and Conservation*. While this report does not focus exclusively on public health activities, it addresses a wide range of community concerns related to the operation and oversight of the TSCA Incinerator.

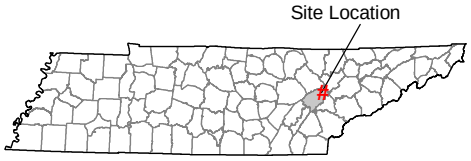
TSCA Incinerator

INTRO MAP

Oak Ridge, Tennessee



Base Map Source: 1995 TIGER/Line Files



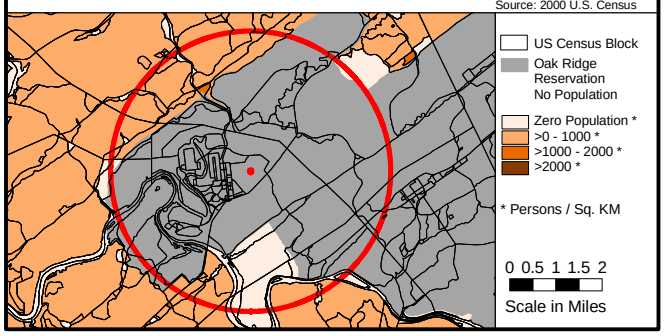
Roane County, Tennessee

Demographic Statistics
Within Three Miles of Site*

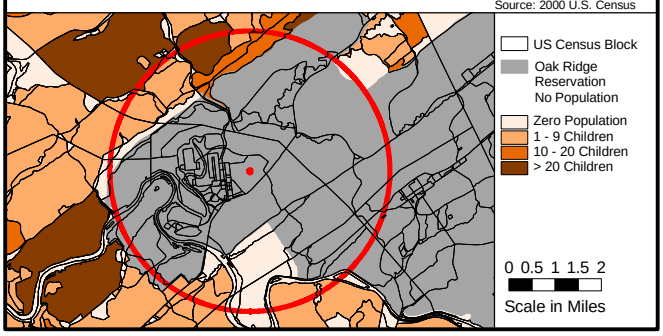
Total Population	1224
White alone	1181
Black alone	14
Am. Indian and Alaska Native alone	3
Asian alone	13
Native Hawaiian and Other Pacific Islander alone	0
Some other race alone	0
Two or More races	13
Hispanic or Latino	12
Children Aged 6 and Younger	96
Adults Aged 65 and Older	138
Females Aged 15 - 44	229
Total Housing Units	489

Demographics statistics Source: 2000 U.S. Census
*Calculated using an area-proportion spatial analysis technique

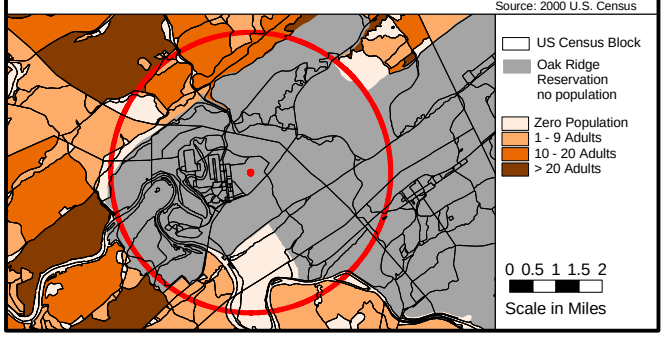
Population Density



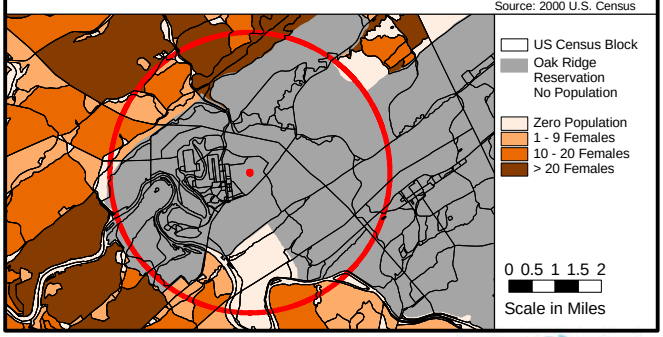
Children 6 Years and Younger



Adults 65 Years and Older



Females Aged 15 - 44



GRASP

JVA090904

Where can one obtain more information on ATSDR's activities at Oak Ridge?

In addition to completing this PHA, ATSDR and other agencies have evaluated numerous other environmental health issues related to ORR facilities. Community members can find more information on ATSDR's past activities by:

Visiting one of the records repositories. Copies of ATSDR's publications for ORR, along with publications from other agencies, can be viewed in records repositories at the DOE Information Center, the Harriman Public Library, the Kinsgton Public Library, the Oak Ridge Public Library, the Roane State Community College, and the Rockwood Public Library.

Visiting the ORRHES or ATSDR Web sites. These Web sites have links to past publications, schedules of future events, and related informational materials. The ORRHES site is http://www.atsdr.cdc.gov/HAC/oakridge and the ATSDR site is http://www.atsdr.cdc.gov. The most comprehensive summary of past activities is available online at http://www.atsdr.cdc.gov/HAC/oakridge/phact/c_toc.html.

Contacting ATSDR directly. Residents can contact representatives from ATSDR directly by dialing the agency's toll-free number, 1-888-42ATSDR (or 1-888-422-8737).

- In August 2003, ATSDR began the public health assessment process for the TSCA Incinerator. In the months that followed, ATSDR obtained and reviewed site documents prepared by numerous parties, including DOE and its contractors, EPA, TDEC, and local community groups. ATSDR contacted these and other parties (e.g., TVA) for access to relevant environmental sampling data.
- After thoroughly evaluating the information gathered to date, ATSDR presented its technical approach for the TSCA Incinerator PHA to community members at the Public Health Assessment Work Group (PHAWG) meeting held on March 15, 2004, in Oak Ridge, Tennessee. During this meeting community members asked ATSDR to address several health concerns specific to the TSCA Incinerator. ATSDR's responses to these concerns are included in Section V of this report.
- In March 2004, a team of ATSDR scientists and contractors, including air quality specialists, conducted a tour of the ETTP site. During the tour, ATSDR viewed the entire TSCA Incinerator process, reviewed selected records and reports maintained at the TSCA Incinerator, viewed meteorological and ambient air monitoring equipment at several locations, and drove around the perimeter of ETTP and through surrounding residential neighborhoods.
- On November 15, 2004, ATSDR presented its preliminary findings on the TSCA Incinerator PHA to community members at the newly formed Exposure Evaluation Work Group meeting. During this meeting, community members identified a few health concerns that had

not been communicated to the agency previously. ATSDR's responses to these concerns are included in Section V of this report.

- On March 22, 2005, ATSDR presented the main findings of the Public Comment Release PHA to the Oak Ridge Reservation Health Effects Subcommittee (ORRHES).
- On September 22, 2005, ATSDR gave a presentation before ORRHES to summarize comments received from the public and peer reviewers on the Public Comment Release PHA.

II.H. Quality Assurance and Quality Control

To prepare this PHA, ATSDR reviewed and evaluated information provided in the documents listed in the References (see Section XII). The environmental data presented in this PHA are from reports produced by many parties, including DOE, EPA, TDEC, and TVA. The limitations of these data have been identified in the associated reports, and, where appropriate, they are restated in this document. After reviewing the studies conducted to date, ATSDR determined that the quality of environmental data available in the site-related documents for the TSCA Incinerator is adequate to support public health decisions. ATSDR has made specific recommendations to improve, or better characterize, the quality of certain environmental sampling efforts. Refer to Appendix C for ATSDR's specific conclusions regarding the quality of the ambient air monitoring and ambient air sampling studies.

ATSDR also used an extensive review process for quality control purposes. Earlier drafts of this PHA and draft findings were presented to numerous parties, including ATSDR scientists with extensive experience in incineration and radiation exposure assessment, DOE, EPA, TDEC, ORRHES, and the PHAWG. ATSDR hopes that this extensive review process has helped ensure that all information and scientific analyses presented in this PHA are scientifically sound and technically accurate.

III. Evaluation of the Air Exposure Pathway

This section presents ATSDR's evaluation of the air exposure pathway for the TSCA Incinerator. The PHA focuses largely on the air exposure pathway because it presents the most likely route by which residents might come into contact with the incinerator's environmental releases. ATSDR considers other exposure pathways (e.g., drinking surface water, contacting soils, eating fish and other locally harvested food items) in Section V of this PHA. Further, ATSDR is currently preparing another PHA that evaluates off-site environmental contamination levels in multiple media, whether that contamination originates from the TSCA Incinerator or from other sources.

This section describes the use of a screening procedure to identify contaminants of potential health concern for the TSCA Incinerator; Section IV then evaluates the public health implications of exposures to those contaminants. This section begins by describing the methodology ATSDR routinely uses to evaluate air exposures (see Section III.A), and then reviews what contaminants have been measured in the TSCA Incinerator's air emissions (see Section III.B), how those contaminants move through the air (see Section III.C), and what levels of contamination have been measured in the local air (see Section III.D). Those interested in only an overview of the air exposure pathway should refer to the summary (see Section III.E), which synthesizes the information on emissions, fate and transport, and ambient air monitoring.

III.A. Introduction

ATSDR's public health assessment process emphasizes the importance of exposure pathways, or the different ways that people can come into contact with environmental contaminants. Analyzing exposure pathways is important because, if residents *are not exposed* to a site's environmental contamination, then the contaminants cannot pose a public health hazard and additional analyses are not necessary. If residents *are exposed* to site-related contaminants, then further analysis is needed to characterize the exposure — that said, however, the fact that exposure occurs does not mean that residents necessarily will have health effects or get sick. In fact, for many contaminants, environmental exposures are often far lower than the exposures people experience through their diets and perhaps through their occupations. In cases where exposures do occur, ATSDR must answer several questions to understand the public health implications:

- To what contaminants are people exposed?
- How often are people exposed, and for how long?
- What are the contaminant levels to which people are exposed?

These are just some of the issues ATSDR considers when assessing whether harmful health effects might result from exposure.

An initial step in the exposure pathway evaluation is clearly defining the issues to be evaluated. As stated previously, this section focuses entirely on the air exposure pathway in order to address the issues of greatest concern to residents. ATSDR has not overlooked the possibility that contaminants released from the TSCA Incinerator might be found in other environmental media (e.g., surface water, groundwater, soil). Rather, ATSDR will consider this possibility in an upcoming PHA that examines an extremely broad data set of recent off-site contamination levels. To define further the air exposure issues for this PHA, ATSDR identified the populations of concern and the time frames, locations, and contaminants of greatest interest. The text box below outlines the scope of the air exposure pathway evaluation.

Scope of the Air Exposure Pathway Evaluation

Who: What populations are considered in the exposure evaluation? As Section II explains, this PHA addresses exposures that local community members might experience, outside of any ORR-related occupational exposures.

When: What exposure time frame does this PHA consider? This PHA examines exposures only for when the TSCA Incinerator conducted routine operations—1991 to the present. Future exposures may occur as long as the incinerator operates.

Where: Over what area does this PHA evaluate exposures? Modeling studies predict that the highest residential exposure levels to the TSCA Incinerator's emissions are at off-site locations nearest to ETTP, and exposure levels steadily decrease with distance from the site. However, there is no "magic line" that separates exposed and non-exposed populations. This PHA evaluates exposures for locations within 5 miles of the TSCA Incinerator, with the understanding that the highest exposures occur in this area and that all exposures at locations further away are undoubtedly lower.

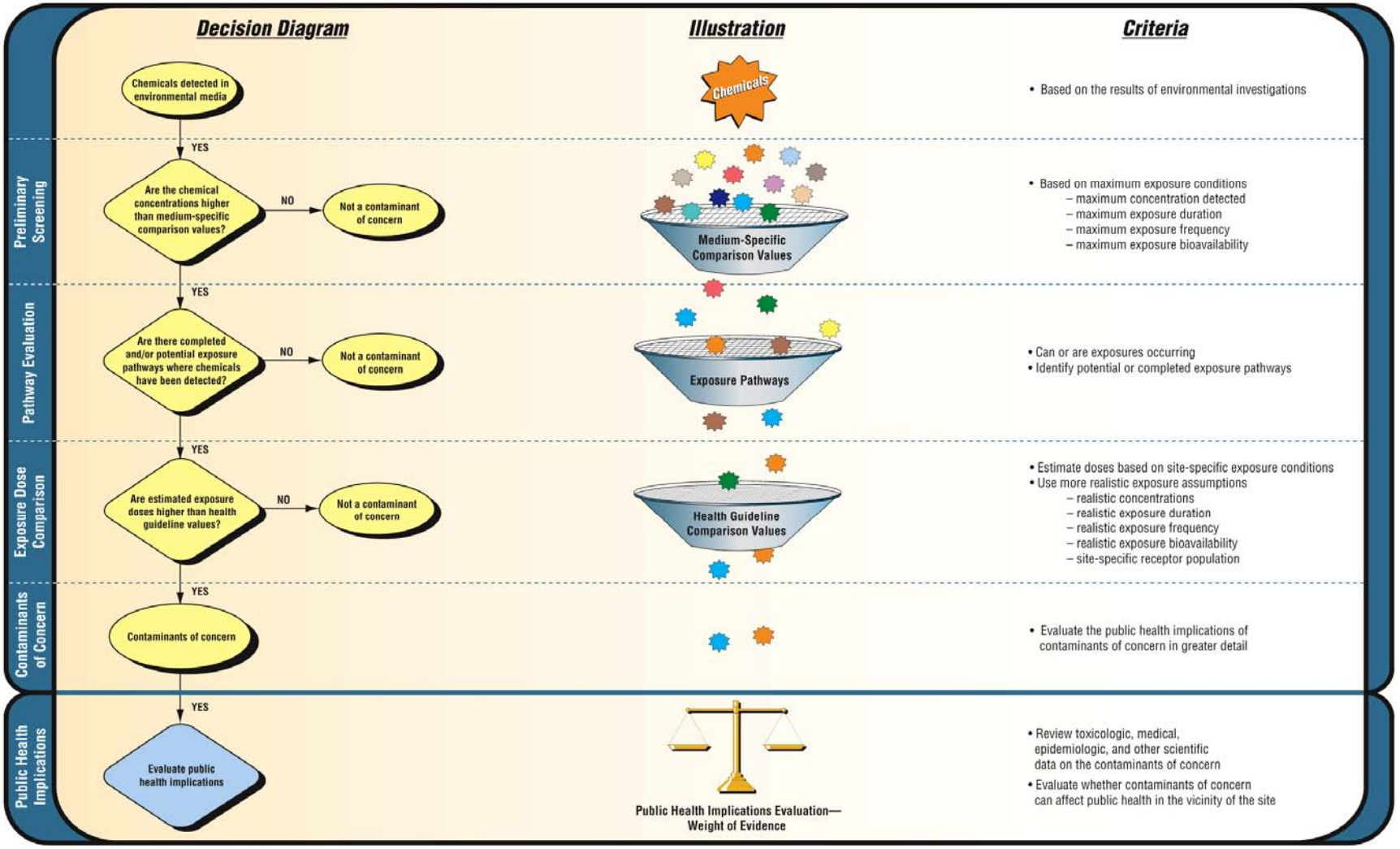
What: What contaminants does this PHA consider? The PHA examines exposures to contaminants that the TSCA Incinerator likely releases. Emissions from sources other than the TSCA Incinerator are considered in these evaluations, as appropriate, to provide perspective on exposures. Section III.B.1 identifies eight groups of contaminants that ATSDR considers in this PHA.

After establishing the scope of this evaluation, ATSDR used a screening process to identify the contaminants of potential health concern that warrant more detailed consideration (see Section IV). Figure 9 depicts this screening process, in which measured or estimated environmental contamination levels — in this case, ambient air concentrations and radiation levels — are compared with medium-specific comparison values. Comparison values (see definition in Appendix E) are developed from the scientific literature concerning exposure and health effects. To be protective of human health, most comparison values have safety factors built into them. For some contaminants, the safety factors are quite large (a factor of 100 or greater). As a result, contamination levels lower than their corresponding health-protective comparison values are generally considered to be safe and not expected to cause harmful health effects. In other words, these comparison values are generally (and intentionally) selected to be lower than the lowest

environmental concentrations known to be associated with adverse health effects, considering an ample margin of safety. But the opposite is not true: contamination levels greater than comparison values are not necessarily harmful. Rather, contaminants found above comparison values require a more detailed toxicologic or radiologic evaluation. In short, ATSDR uses health-protective comparison values to identify contaminants of potential health concern, which require more detailed evaluations (see Section IV) to assess the public health implications of exposure. Appendix D defines the specific comparison values used in this PHA.

The remainder of this section draws from emissions studies, air dispersion modeling studies, and ambient air monitoring or ambient air sampling studies to identify contaminants released by the TSCA Incinerator and to select contaminants of potential health concern. Section III.E summarizes the findings of this exposure pathway evaluation.

Figure 9. Process for Selecting Contaminants of Potential Health Concern



III.B. Emissions: What Contaminants Are Released to the Air?

Since 1991, DOE and other parties have compiled extensive information on the amounts of air pollutants that the TSCA Incinerator releases. This section reviews that information, both for stack emissions (Section III.B.2) and for fugitive emissions (Section III.B.3). As noted earlier in this PHA, stack emissions from the TSCA Incinerator are air releases through confined streams, specifically the main stack and the TRV. "Fugitive emissions" refers to all other releases, such as passive venting, wind-blown dust, and evaporative losses. Before reviewing information on stack and fugitive emissions, this section first identifies eight groups of contaminants that hazardous waste incinerators commonly release. The analyses throughout this PHA focus entirely on these groups of contaminants.

This section then reviews emissions data primarily to identify contaminants released from the incinerator. ATSDR typically does not base conclusions on emissions data alone — air emissions disperse considerably between their sources and the locations where people might be exposed. For this reason, ATSDR's environmental health conclusions are based on a combined assessment of emissions data, fate and transport studies, and ambient air monitoring and ambient air sampling studies.

III.B.1. Groups of Contaminants to Evaluate

Incinerators release many different contaminants into the air. These include typical combustion by-products, products of incomplete combustion, and incombustible materials in the waste stream. The emission rate of a given contaminant typically varies with time and depends on the composition of waste material being treated, the incinerator's operating parameters, and the effectiveness of air pollution controls. Multiple federal agencies have published review documents evaluating general public health issues for incineration facilities and identify contaminants that tend to be of greatest concern (ATSDR 2002; EPA 1998; NRC 2000). Using information in these review documents, ATSDR identified eight groups of contaminants to evaluate in this PHA. Table 6 identifies these groups, defines what contaminants fall into them, and explains how they relate to the TSCA Incinerator. The analyses that follow are organized around these contaminant groups.

Groups of contaminants ATSDR evaluated. This PHA evaluates the public health implications of exposure to the following eight groups of contaminants:

1. Particulate matter
2. Volatile organic compounds
3. Polychlorinated biphenyls
4. Metals
5. Acidic gases
6. Dioxins and furans
7. Polycyclic aromatic hydrocarbons
8. Radionuclides

Taken together, these groups include more than 500 individual contaminants. Refer to Table 6 for more information on these groups.

Table 6. Contaminant Groups Evaluated in this PHA

Group Name	*Contaminants within the Group*	*Relationship to Incineration Facilities*
Particulate matter	PM2.5, PM10, TSP	Virtually all combustion processes generate airborne particles and droplets. Air pollution controls at the TSCA Incinerator remove most particulate matter from the air exhaust, but some particulates are released.
VOCs	Numerous organic compounds with low molecular weight and high volatility	Waste feeds at the TSCA Incinerator, especially the liquid feeds, contain many VOCs. While the incineration process efficiently destroys most VOCs in the waste feed, trace amounts might pass through untreated. Incomplete combustion might generate trace amounts of other VOCs.
PCBs	209 individual chemicals, known as PCB congeners, that share a common chemical structure	PCBs are found in liquid and solid waste feeds to the TSCA Incinerator. Although the incinerator must destroy more than 99.9999% of the PCBs in these feeds, trace amounts might pass through the incinerator untreated. PCBs are not combustion by-products.
Metals	Numerous elements which, when pure, conduct heat and electricity and are generally hard and strong	Metals pass through incineration processes untreated., either into the residuals (e.g., ash) or into the air emissions. Though air pollution controls at the TSCA Incinerator remove considerable amounts of metals from the air exhaust, some metals from the waste feed do pass into the air untreated.
Acidic gases	Multiple inorganic compounds, such as hydrogen chloride and hydrogen fluoride	Acidic gases form in nearly all fuel and waste combustion processes, including incineration. The TSCA Incinerator's air pollution controls remove over 99% of hydrogen chloride in the process gas stream.
Dioxins and furans	210 individual chemicals, known as congeners, that share some common chemical structures	Dioxins and furans form in processes that burn mixtures containing both chlorine and organic material. Incinerator and air pollution control design can greatly reduce, but not eliminate, formation and release of dioxins and furans.
PAHs	Numerous organic compounds characterized by having multiple aromatic rings	The TSCA Incinerator likely destroys PAHs in the waste feed efficiently. Most PAHs in air emissions likely result from incomplete combustion of organic materials in the waste feeds.
Radionuclides	Unstable or radioactive forms of any element	The waste feed to the TSCA Incinerator contains radionuclides, which pass through the combustion chambers untreated. The radionuclides leave the facility either in residuals (e.g., ash) or in air emissions. Air pollution controls remove most radionuclides from the gas stream, but trace amounts do pass through the entire process and vent into the air.

Note: In this PHA, the term "dioxins" refers to the group of chemicals known as chlorinated dibenzo-p-dioxins, and "furans" refers to the group of chemicals known as chlorodibenzofurans. ATSDR notes that the TSCA Incinerator likely emits additional pollutants, such as trace amounts of additional semi-volatile organic compounds. However, the waste composition data that ATSDR reviewed (DOE 2003a) suggests that the quantities of these compounds emitted are likely immeasurably small.

III.B.2. Stack Emissions

Since 1988, DOE and its contractors have conducted numerous studies to measure both how efficiently the TSCA Incinerator destroys wastes and how much contamination the site releases into the air. The following discussion summarizes the available information on the TSCA Incinerator's emissions, first for routine releases through the main process stack and then for episodic releases through the TRV:

- **Routine releases through the main stack.** DOE and its contractors, under EPA and TDEC oversight, have measured emission rates from the TSCA Incinerator using three types of studies: trial burns, performance tests, and continuous emissions monitoring. Appendix A defines the different types of test and presents ATSDR's detailed reviews of the studies conducted to date.

  Table 7 summarizes key findings of the stack emissions tests and reveals two notable findings. First, the table shows that emission rates have been measured for all eight groups of contaminants that ATSDR is evaluating in this PHA. While some groups of contaminants have been studied more extensively than others, there are no notable data gaps in terms of the contaminants that have been considered. Second, the final column in Table 7 indicates that the measured emission rates generally met permitted limits, in cases where such limits have been established. As the exceptions, a small fraction of the measured emission rates for particulate matter have exceeded permitted limits, and some stack gas concentrations for semi-volatile metals (cadmium and lead) in 2000 and 2001 exceeded technology-based (i.e., not health-based) emissions standards that EPA would later establish in MACT standards. Fortunately, fairly extensive ambient air monitoring data are available for these contaminants. As Section III.D details, those ambient air monitoring data indicate that off-site airborne levels of particulate matter, cadmium, and lead have always been below levels of health concern, despite the fact that emission rates and stack gas concentrations have occasionally exceeded permitted limits or emissions standards.

Table 7. Emissions Data Available for the Groups of Contaminants

Contaminant Group	*Air Emission Rates Measured Using:*			*Overall Findings*
	Trial Burns	*Performance Tests*	*Continuous Sampling*	
Particulate matter	√	√	√	The overwhelming majority of tests, but not every test, have shown compliance with permitted limits for stack gas concentrations and emission rates. In addition, an extremely large volume of ambient air monitoring is available to support health conclusions on particulate matter (see Section III.D). Continuous emissions monitoring is about to begin.
VOCs	√			No permit limits are available for individual VOCs. Conclusions are based on dispersion modeling analyses (see Section III.C).
PCBs	√			Both trial burns showed that the incinerator's DRE for PCBs is higher than the required limit (99.9999%). Modeling estimates (see Section III.C) and monitoring data (see Section III.D) for PCBs were also considered.
Metals	√	√	√	All tests conducted since the incinerator began routine operations have shown compliance with health-protective *emissions* limits for beryllium, lead, and mercury. *Stack gas concentration* limits have consistently been met for mercury and low-volatile metals (arsenic, beryllium, and chromium). In 2000 and 2001, some stack gas concentrations for cadmium and lead exceeded limits that EPA would later establish in MACT standards. ATSDR used an extensive database of ambient air monitoring results to evaluate the metals further (see Section III.D, Appendix A.3).
Acidic gases	√	√		Every measured emission rate of hydrogen fluoride and hydrogen chloride to date has been at least an order of magnitude lower than the corresponding permitted emission limits.
Dioxins and furans	√			Stack gas concentrations of dioxins and furans have always been lower than levels set in the recent emissions standards. Ambient air monitoring data for dioxins and furans were also reviewed (see Section III.D).
PAHs	√			There are no permit limits for individual PAHs. Conclusions are based on dispersion modeling analyses (see Section III.C).
Radionuclides			√	There are no permit limits for individual radionuclides. Conclusions are based on dispersion modeling analyses (see Section III.C) and ambient air monitoring data (see Section III.D).

Notes: Refer to Appendix A for detailed reviews of the trial burns, performance tests, and continuous emissions monitoring at the TSCA Incinerator.

- **Episodic releases following TRV openings.** As Table 2 of this PHA notes, on 18 occasions between 1991 and 2004, the TRV at the TSCA Incinerator opened. These openings prevent high-temperature gases from damaging air pollution controls or harming employees, but they also result in afterburner gases briefly venting into the atmosphere without first passing through air pollution controls. Increased emissions during the TRV events are extremely short-lived.

  Emission rates have never been measured during times when the TRV is open. Measuring such emissions presents several logistical challenges. For instance, specialized equipment would be necessary to sample releases, given that afterburner gases would likely be at temperatures (>2,200 degrees Fahrenheit) that would damage conventional stack testing equipment. Further, field personnel who sample air in close proximity to such high-temperature gases face very serious health and safety issues. Finally, the short time scales of TRV releases present difficulties — many EPA stack testing methods require sampling of at least an hour's duration to get adequate sample volumes. For these reasons, ATSDR is not convinced of the feasibility of measuring emission rates when the TRV is open, especially considering that DOE already collects ambient air samples at upwind and downwind locations during these times. Refer to Section III.D for ATSDR's review of the ambient air sampling that has occurred during the TRV events.

Residents are not exposed directly to the incinerator's emissions. ATSDR reviews emissions data to better characterize what is released. Air monitoring data (see Section III.D) offer the best insights into airborne contamination levels that people might breathe.

In summary, DOE has extensively characterized routine emissions through the incinerator's main stack. In reaching health conclusions for the TSCA Incinerator, ATSDR considered the measured emission rates, along with findings from the fate and transport and ambient air monitoring studies. ATSDR does not view the absence of measured emission rates for TRV openings as a critical data gap, given the fact that air samples are collected during all TRV events and that the events occur so infrequently. (Note, not all samples collected during TRV events are currently analyzed.)

III.B.3. Fugitive Emissions

Measuring fugitive emission rates is inherently difficult, considering that industrial facilities' releases can occur from numerous locations. The exact amount of fugitive emissions from the TSCA Incinerator is not known, but two observations suggest that the amount is relatively low. First, DOE is required to implement a fugitive emissions monitoring program, in which periodic measurements of organic vapors are taken throughout the facility to ensure that process leaks and other fugitive emissions sources are identified and promptly controlled. Second, the following facility design features help minimize fugitive emissions:

- The entire incinerator operates under negative pressure, which helps prevent vapors and dusts from blowing out of the incineration process.
- Liquid wastes are handled in a manner that minimizes releases of untreated wastes. For instance, the wastes that arrive in tank trucks, are pumped into storage tanks in closed

systems. Further, all organic liquid storage tanks have vents equipped with carbon adsorption units that help prevent VOCs from evaporating directly into the atmosphere and prevent releases during tank loading operations. The carbon adsorption units have breakthrough indicators that give advance warning of when the units need to be changed. Facility personnel inspect the breakthrough indicators daily.

- All ash generated in the rotary kiln is discharged into water in the ash sump, which greatly reduces the amount of ash that might otherwise blow into the air.

Combined, these observations suggest that the fugitive emissions are minimal, though the exact amount of fugitive emissions remains unknown. The independent panel of experts chartered by the Governor of Tennessee reached a similar finding regarding the TSCA Incinerator's fugitive emissions (Iglar et al. 1998).

ATSDR does not view the lack of quantitative fugitive emissions data as a critical data gap — the extensive ambient air monitoring data and ambient air sampling data for this site (see Section III.D) characterize the air quality impacts from all local sources of emissions, including the fugitive emissions from the TSCA Incinerator.

III.C. Fate and Transport: How Do the Contaminants Move through the Air?

Dispersion models estimate air quality impacts from an emissions source based on a scientific understanding of how contamination moves through the air. The models can only estimate ambient air concentrations, and these estimates may understate or overstate actual air quality impacts. The accuracy of modeling outputs largely depends on the scientific rigor of the model itself and the quality and representativeness of model input parameters.

ATSDR identified two air dispersion modeling studies of the TSCA Incinerator's emissions. The independent panel chartered by the Governor of Tennessee conducted one study (Iglar et al. 1998) and DOE conducted the other (DOE 1997–2002). To address limitations in these studies, ATSDR conducted an additional modeling evaluation. Appendix B presents detailed reviews of these three modeling studies.

The independent panel's modeling study concludes that the incinerator's air quality impacts are greatest at locations southwest and northeast of the TSCA Incinerator. This finding is not surprising, given the prevailing wind patterns and local terrain features. The exact point of maximum impact was predicted to be 0.4 miles southwest of the stack, at a location within ETTP (Iglar et al. 1998). ATSDR used modeling results predicted at this on-site location to identify contaminants of concern. This approach is believed to be health-protective because the maximum air quality impacts found within ETTP are higher than the incinerator-related impacts that most residents experience, whether for short-term or long-term exposures.

Table 8 outlines key findings from the three modeling studies reviewed in this PHA. While detailed reviews of the individual studies are in Appendix B, several general observations should be noted. First, between the three modeling studies, all eight groups of contaminants of interest for the TSCA Incinerator were evaluated, leaving no notable data gaps. Second, with one exception addressed below, the modeling for every contaminant group found that estimated annual average ambient air concentrations were lower than health-based comparison values. In

the cases of particulate matter, most VOCs, PCBs, acidic gases, dioxins and furans, and PAHs, the estimated concentrations were all more than 100 times lower than the corresponding health-based comparison values. While ATSDR acknowledges that modeling analyses such as these have inherent uncertainties, these analyses appear to be scientifically sound and to offer reasonable accounts of the incinerator's air quality impacts (see Appendix B). Of course, no air dispersion model is perfect; for this reason, ATSDR carefully reviewed the extremely large volume of ambient air monitoring data (see Section III.D) for this site to assess the accuracy of the modeling estimates. Overall, the information in Table 8 suggests that the TSCA Incinerator's air emissions do not cause residents to be exposed to unhealthful levels of air contaminants, at least over the long term.

Three additional comments on the modeling analyses deserve mention. 1) all of the modeling studies considered for this PHA predicted ambient air concentrations representative of chronic exposures as a result of routine stack releases, and did not consider potential acute exposures nor non-routine releases through the TRV. ATSDR's review of ambient air sampling data during TRV events (see Section III.D) provides perspective on the acute exposure scenarios that appear to be of greatest concern. 2) the extensive ambient air monitoring data (see Section III.D) for many of the contaminants, especially particulate matter, metals, and radionuclides, compensates for any inherent uncertainties in the modeling analyses. 3) using the independent panel's modeling analysis, ATSDR selected chromium as a contaminant of concern. This selection was made due to the lack of information on the relative amounts of trivalent and hexavalent chromium in the ambient air. Section IV.C of this PHA revisits this issue.

Table 8. Fate and Transport Modeling Results Available for the Groups of Contaminants

Contaminant Group	*Modeling Evaluation Conducted by:*			*Overall Findings*
	Governor of Tennessee's Independent Panel	*DOE*	*ATSDR*	
Particulate matter	√			The estimated annual average concentration of particulate matter at the point of maximum impact was 0.067 µg/m^3 — considerably lower than both EPA's health-based air quality standards and the levels of airborne particulate matter routinely found in this part of the country.
VOCs	√		√	The TSCA Incinerator efficiently destroys VOCs. Even at the point of maximum impact, the estimated VOC concentrations were mostly three orders of magnitude below health-based comparison values.
PCBs	√		√	Modeling conducted by both the independent panel and ATSDR found that estimated ambient air concentrations of PCBs from routine operations are more than 1,000 times lower than health-based comparison values, even for the year when the greatest amount of PCBs was processed.
Metals	√			Chromium was selected as a contaminant of concern, but estimated air concentrations of all other metals were safely below health-based comparison values.
Acidic gases	√		√	Estimated ambient air concentrations of acidic gases are more than 400 times lower than their corresponding health-based comparison values.
Dioxins and furans			√	Estimated ambient air concentrations of dioxins and furans are immeasurably low, even at the point of maximum impact, where exposure concentrations are more than 100 times lower than health-based comparison values for cancer effects.
PAHs			√	ATSDR's modeling analysis of emissions data collected during a recent trial burn suggests that the highest annual average concentration of total PAHs (0.000005 µg/m^3) is far below levels of health concern, even if one conservatively assumed that only the most toxic PAH is present.
Radionuclides		√		DOE has estimated (using an EPA-approved model) that, in all years during which the TSCA Incinerator operated, air emissions of radionuclides from the entire ORR cause an effective dose equivalent to the maximally exposed resident of less than 1.7 mrem/year — a dose far below health-protective values established in EPA regulations. Extensive ambient air monitoring data are consistent with this estimated dose.

Notes: Appendix B reviews the three modeling evaluations listed above and identifies additional modeling studies that have been conducted.
Modeling addressed releases from routine operations. See Section III.D for ambient air sampling results during non-routine releases (i.e., TRV events).

III.D. Ambient Air Monitoring and Ambient Air Sampling: What Are the Levels of Air Contamination?

This section reviews the results of ambient air monitoring and ambient air sampling studies, or studies that measure contamination in the air that people breathe. Studies conducted by DOE, EPA, and TDEC weighed heavily in the conclusions ATSDR developed for this PHA. In response to a community concern, ATSDR also obtained and reviewed data compiled by TVA, but those data were not collected to assess air quality impacts from the TSCA Incinerator. Appendix C presents ATSDR's detailed reviews of the relevant ambient air monitoring and ambient air sampling studies.

Across all the studies conducted to date, an extremely large volume of ambient air monitoring and ambient air sampling data are available to characterize the TSCA Incinerator's air quality impacts. These data span the entire time frame during which the TSCA Incinerator has operated (1991 to the present), have been collected in locations believed to have the greatest air quality impacts, and have thoroughly characterized ambient air concentrations for multiple contaminant groups, especially particulate matter, metals, and radionuclides.

Terminology. In the field of air pollution, *ambient* air generally refers to outdoor air that people might breathe. Ambient air is commonly measured by equipment placed at a fixed outdoor location.
Ambient air monitoring differs from air sampling in that *monitoring* typically implies periodic measurement of air contamination levels. Monitoring provides useful insights on how air quality changes over the long term. Air *sampling*, on the other hand, generally refers to air quality measurements of discrete events, such as a TRV opening.

Both ambient air monitoring and ambient air sampling measure airborne contamination levels. But it is important to remember that measured concentrations reflect contributions from all nearby emissions sources and some distant ones. Thus, even though monitoring and sampling studies have been designed to characterize air quality impacts from the TSCA Incinerator, the air contamination levels measured do not necessarily originate only from the incinerator. ATSDR's interpretations throughout this section are sensitive to this issue. Nonetheless, the public health evaluations presented in this PHA are ultimately based on the measured air contamination levels that people might inhale, regardless of the source or sources believed to account for most of the contamination.

Table 9 gives an overview of the air quality measurements available for the eight groups of contaminants evaluated in this PHA. The remainder of this section provides more detailed summaries of the relevant air quality measurements collected both during routine operations at the TSCA Incinerator (see Section III.D.1) and during episodic releases, mainly TRV openings (see Section III.D.2). ATSDR used these measurements to characterize potential chronic and acute exposures to incinerator emissions.

Table 9. Ambient Air Monitoring and Ambient Air Sampling for the Groups of Contaminants

Contaminant Group	*Study Conducted by:*			*Overall Findings*
	DOE	*EPA*	*TDEC*	
Particulate matter	√			DOE has collected more than 2,000 particulate matter samples, both PM10 and TSP, at or near ETTP since the TSCA Incinerator first began operating. Every measured concentration and every annual average concentration has been well below EPA's corresponding health-based air quality standards.
VOCs				VOCs have not been measured in any studies at ETTP. However, air dispersion modeling studies estimated the incinerator's likely incremental impacts on airborne VOC levels: these air quality impacts were consistently more than 100 times lower than levels of public health concern.
PCBs	√			Routine PCB monitoring has not occurred, but DOE has measured PCB concentrations during TRV events, when emissions might be expected to peak. Even the highest total PCB concentration recorded during a TRV event (0.00082 $\mu g/m^3$) is well below health-based comparison values.
Metals	√		√	DOE has routinely monitored ambient air concentrations of metals since the TSCA Incinerator first processed wastes, and TDEC has conducted side-by-side monitoring to verify that DOE's monitoring results are valid. Combined, these measurements suggest that airborne levels of arsenic, cadmium, and chromium require more detailed evaluations. Section IV.B of this PHA assesses the public health implications of exposure to these contaminants.
Acidic gases				Although acidic gases have not been measured in any of the ambient air monitoring or ambient air sampling studies, estimated air concentrations of hydrogen chloride and hydrogen fluoride were both more than 400 times lower than levels of public health concern, even at the point of maximum air quality impacts.
Dioxins and furans	√			Like PCBs, dioxins and furans have not been monitored routinely near the TSCA Incinerator, but they have been measured during TRV events. The measurements did not find contamination to be at levels of health concern, especially considering the limited exposure durations for these events.
PAHs				Although PAHs have not been measured in any of the ambient air monitoring or ambient air sampling studies, ATSDR's air modeling study found incinerator-related air quality impacts from PAH emissions to be orders of magnitude below health-based comparison values.
Radionuclides	√	√	√	DOE, EPA, and TDEC have all conducted extensive monitoring near the TSCA Incinerator for ambient levels of radiation and radionuclides. This monitoring, which is continuous and has spanned almost the entire duration of TSCA Incinerator operations, has shown that concentrations of radionuclides are considerably lower than corresponding health-based comparison values.

Notes: Refer to Appendix C for detailed reviews of the ambient air monitoring and ambient air sampling results listed in this table.
Modeling addressed releases from routine operations. See Section III.D for ambient air sampling results during non-routine releases (i.e., TRV events).

III.D.1. Measurements During Routine Operations

The following paragraphs briefly review the results of the ambient air monitoring and air sampling that DOE, EPA, and TDEC have conducted during the TSCA Incinerator's routine operations. For three out of the eight groups of contaminants that ATSDR is evaluating, over the last 15 years an extremely large volume of air quality measurements have been made . While Appendix C describes detailed features of the individual monitoring efforts, the following paragraphs (and Table 9) highlight notable trends across the studies:

- **Particulate matter.** Between 1991 and the present, DOE has collected more than 2,000 valid 24-hour average particulate matter samples, both as PM10 and TSP. The samples were collected using appropriate methodologies and sampling schedules, and the measured concentrations appear to be of a known and high quality. The samples were collected at numerous locations around ETTP (see Figures C-1 and C-2), including locations where dispersion models predicted maximum ground-level impacts from the TSCA Incinerator. Every single 24-hour average PM10 and TSP concentration measured to date has been below EPA's corresponding health-based air quality standards, and the annual average concentrations calculated from these individual measurements have also been below appropriate health-based standards. Additionally, the sampling data did not reveal any pronounced spatial variations in particulate matter concentrations. In short, DOE has compiled an extremely extensive data set on particulate matter over the entire history of the TSCA Incinerator's operations, and the measured PM10 and TSP concentrations have not reached levels of health concern.

- **Metals.** As Appendix C describes in greater detail, both DOE and TDEC have measured ambient air concentrations of metals at multiple locations around the TSCA Incinerator. DOE has taken samples at regulator intervals for airborne metals since the TSCA Incinerator first operated, and TDEC has done so for the last 7 years. Both parties' sampling considered the same set of seven metals. Of these, beryllium, lead, nickel, and uranium had no concentrations greater than health-based comparison values. On the other hand, arsenic, cadmium, and chromium all had annual average concentrations greater than health-based comparison values (using a comparison value for hexavalent chromium to screen the chromium concentrations). The measured levels for these three metals did not exhibit notable spatial variations across the monitoring stations, suggesting that no single emissions source contributes most to these metals' ambient air concentrations. Nonetheless, ATSDR selected arsenic, cadmium, and chromium as requiring further evaluation. Section IV evaluates the public health implications of exposure to these metals in greater detail.

  When reviewing air quality measurements for metals, ATSDR identified several opportunities for improving and enhancing the existing ambient air sampling networks. First, ATSDR noted that a stated purpose of TDEC's program is "to provide an independent verification of monitoring results as reported by the DOE" (TDEC 1996–2002). ATSDR agrees that this is an important objective. Given that DOE and TDEC now operate metals sampling equipment at the same locations, TDEC should be able to perform a quantitative verification of the sampling results, consistent with the program goals. But no detailed data comparisons were documented in the site reports that ATSDR reviewed. Recognizing that independent co-located measures of the same air contaminants provide an excellent

opportunity for verifying the quality of DOE's metals data, ATSDR has recommended that TDEC conduct such an analysis and document findings in a future annual environmental report (see Section IX).

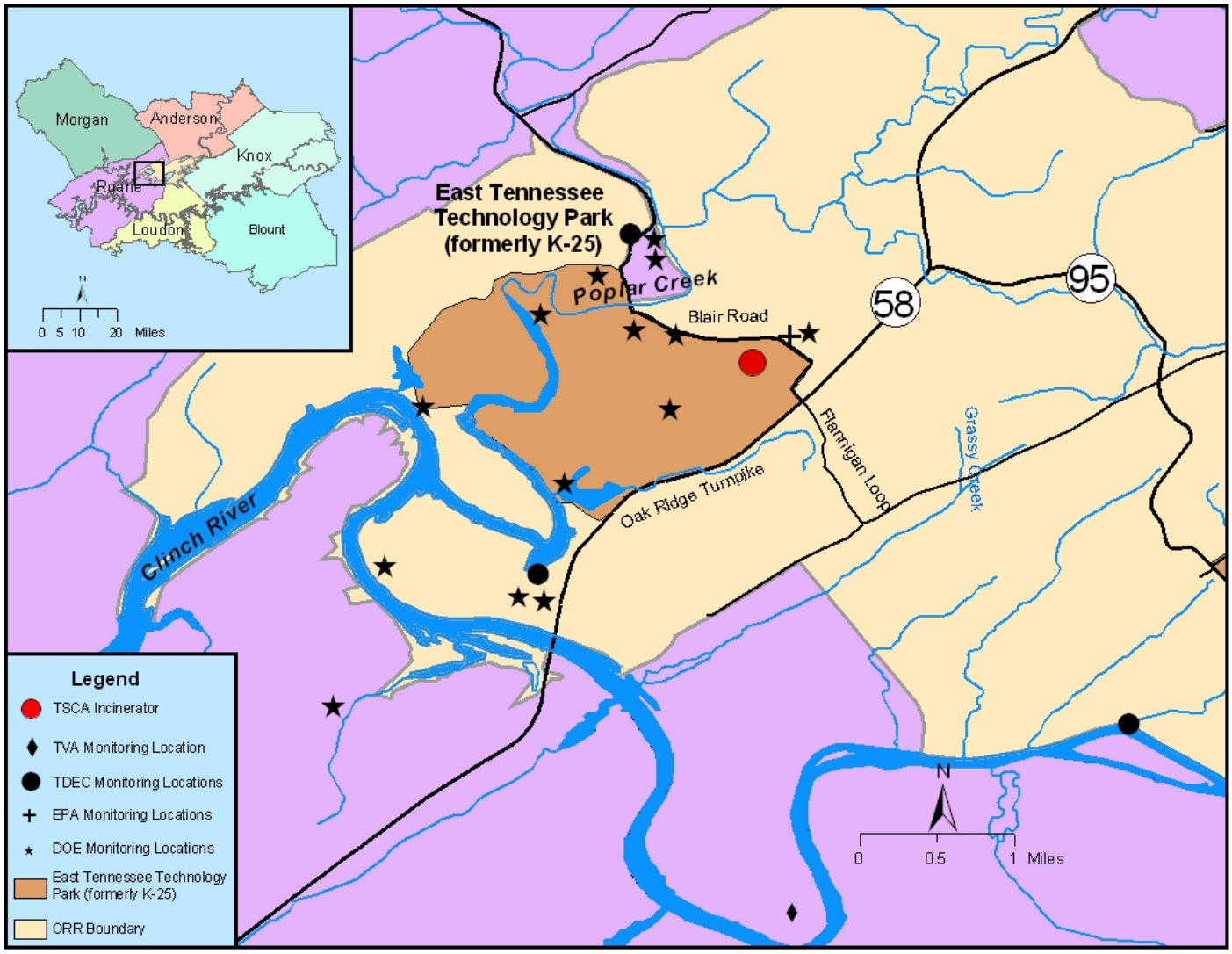
ATSDR was prepared to conduct its own comparison of DOE's and TDEC's ambient air sampling data for metals, but could not do so due to how the two agencies' annual environmental reports present metals data. Although general trends in the two data sets appear to be consistent, a quantitative comparison is impossible because the annual reports do not document detection limits and sometimes aggregate data from multiple stations into area-wide averages. Because these and other reporting practices limit the utility of the measurement results, ATSDR has recommended several improvements to the data presentation in DOE's and TDEC's annual environmental sampling reports. Section IX of this PHA lists these recommendations.

Some data trends illustrate potential conflicts between data reported by DOE and TDEC. In DOE's sampling, both arsenic and cadmium apparently were detected in an overwhelming majority of air samples. In TDEC's sampling, on the other hand, these metals appear to have been detected infrequently. This apparent conflict is best explained by the use of analytical methods with differing sensitivities. TDEC currently uses an analytical method with detection limits ranging from 0.001 to 0.01 $\mu g/m^3$, while the method DOE uses achieves much lower detection limits. ATSDR has recommended that TDEC independently verify the accuracy of DOE's metals data, whether through using more sensitive analytical methods or through other means.

- **Radionuclides.** From at least 1991 to the present, DOE's environmental surveillance network has included perimeter sampling at the main ORR facilities. At ETTP, for instance, DOE has operated two perimeter sampling stations to measure airborne concentrations of radionuclides in air masses before they blow into nearby communities. DOE's program has considered numerous gamma-emitting radionuclides, including those found to account for the highest portion of the effective dose equivalent at off-site receptors attributed to the TSCA Incinerator's air emissions (see Appendix B.2). The radionuclides reported most frequently were isotopes of beryllium, cesium, cobalt, potassium, thorium, and uranium. As Appendix C.1 documents in detail, DOE's ambient air sampling program never detected these and other radionuclides at levels greater than health-based comparison values (i.e., DOE's derived concentration guides). More importantly, even the highest annual average concentration measured was more than 100 times lower than levels of potential health concern.

  In addition to DOE's sampling efforts, TDEC has collected air samples at regular intervals for radionuclides at ETTP (see Appendix C.3), but this sampling did not commence until 1996. The samples that TDEC collected were all analyzed by an EPA laboratory. The sampling device is installed at DOE's K-2 station (see Figure 10), approximately ¾-mile from one of DOE's perimeter monitoring stations. As the text box below indicates, there is reasonable agreement between DOE's and EPA's measurements for uranium isotopes, especially considering that the sampling devices are not co-located. Also encouraging is the fact that both networks reported a similar relative abundance across the different uranium isotopes.

Figure 10. Locations of Ambient Air Monitoring and Ambient Air Sampling Stations



Overall, both DOE and EPA have reported extensive sampling results for airborne radionuclides at locations downwind from the TSCA Incinerator. Both sets of sampling results show that exposures to airborne radionuclides, even at the location believed to be most impacted by incinerator emissions, are well below levels of potential health concern. Also significant is the fact that the independent data measures are reasonably consistent, which suggests (but does not prove) that neither set suffers from serious data quality problems.

In summary, ambient air monitoring data and air sampling data for particulate matter, metals, and radionuclides have been collected in multiple locations around ETTP over the entire history of the TSCA Incinerator's routine operations. While the available data do not characterize all eight contaminant groups considered in this PHA, they do quantify air quality impacts for three groups of contaminants that incinerators cannot destroy. Section III.E describes how ATSDR factored trends and patterns among these data into the overall air exposure pathway evaluation.

III.D.2. Measurements During Episodic Releases

The chief episodic releases of concern for the TSCA Incinerator are those that occur during TRV events — gases that have passed through the afterburner are vented directly to the atmosphere without first passing through air pollution controls. It is important to note, however, that the waste feed to the TSCA Incinerator immediately shuts down when TRV events occur, thus the increased emissions are short-lived therefore minimizing the potential air quality impacts during these episodes. It should be noted that the extent to which emission rates increase during TRV events vary greatly from one pollutant to the next. On the one hand, mercury emissions are basically the same during routine operations and during TRV events, given the limited ability of the air pollution controls to remove this contaminant. On the other hand, emission rates for pollutants efficiently collected by air pollution controls (e.g., hydrochloric acid) will increase substantially for short periods of time. The effects of TRV events on emissions for other pollutants fall between these two extremes.

As Table 2 indicates, 18 TRV events occurred between 1991 and 2004, and DOE collected and analyzed valid air samples at two locations during 9 of these events. The sampling locations are located southwest and northeast of the TSCA Incinerator, and therefore lie in the path of the prevailing winds. In fact, the two sampling locations lie in between the TSCA Incinerator and the nearest off-site residents; thus, measurements at these locations likely provide an upper-bound estimate of short-term exposure concentrations that residents might have experienced during TRV events. Currently, DOE evaluates the circumstances surrounding each TRV event to determine whether off-site ambient air samples should be analyzed. For instance, DOE could judge that analyzing samples is not necessary if a TRV event occurs when small quantities of wastes are being processed or if a previous sampling event already characterized the anticipated air quality impacts. Following is a summary of the monitoring data that have been collected to date:

- **PCBs.** The highest ambient air concentration of total PCBs measured during a TRV event was 0.000817 $\mu g/m^3$. This concentration was measured on June 18, 1995, when a power outage shut down the incinerator operations. This concentration is more than 10 times lower than the most protective health-based comparison value. Therefore, ATSDR concludes that exposure to even the highest PCB concentration measured during TRV events would not cause adverse health effects, especially considering the limited duration of exposure.

- **Dioxins and furans.** The highest ambient air concentrations of total dioxins and total furans measured during TRV events were 0.00000223 $\mu g/m^3$ and 0.00000593 $\mu g/m^3$, respectively. Evaluating these exposure concentrations is complicated — no health-based comparison values have been published for "total dioxins" or "total furans."

  As an alternate approach to assessing these concentrations, ATSDR compared the highest measured values to the range of background concentrations reported for the ETTP area (DOE 2003b). According to sampling that occurred while the TSCA Incinerator was down, background total dioxin levels near ETTP range from 0.000000774 to 0.00000416 $\mu g/m^3$, and the highest measured dioxin concentration during a TRV event falls within this range. ATSDR notes that the range of background concentrations reported for ETTP is reasonably consistent with ranges of background concentrations that have been reported for other parts of the country (ATSDR 1998). Therefore, even the highest dioxin concentration measured

during a TRV event does not appear to be unusually elevated. Given this observation and the extremely short exposure duration, ATSDR believes that the measured concentrations are not at levels of health concern and do not warrant further evaluation.

For total furans, the highest measured concentration during a TRV event is actually three times greater than the upper bound of the background measurements made at ETTP (DOE 2003b), but furan levels during the other TRV events were generally consistent with background levels. After review of an evaluation of the highest likely acute exposures, ATSDR does not view this lone detection above background levels as being of public health concern. Although very limited information is available on health effects in humans or animals after inhalation exposure to furans (ATSDR 1994), ATSDR has published a minimal risk level (MRL) for acute ingestion exposures to a potent furan congener. The acute ingestion MRL is 0.001 µg/kg/day. By definition (see Appendix D), this MRL is an ingestion dose likely without an appreciable risk for adverse non-cancer effects following a short-term exposure. For a typical adult (who weighs 70 kg), this acute MRL would represent an approximate ingestion intake of 0.07 µg/day. During the TRV openings, however, the highest likely inhalation intake is approximately 0.000047 µg/day.2 Therefore, the highest inhalation intake that an individual might have reasonably experienced during TRV openings is nearly 500 times lower than the ingestion intake associated with the acute ingestion MRL. This large margin provides some confidence that acute furan exposures during TRV openings are not associated with adverse health effects. As Section IX of this PHA notes, ATSDR recommends that DOE continue to collect ambient air samples during TRV openings to ensure that these events do not cause residents to be exposed to harmful levels of air pollutants.

- **Radionuclides.** As noted previously, DOE and EPA have radionuclide monitoring stations downwind of the TSCA Incinerator that continuously sample air. Although this sampling cannot quantify the short-term incremental air quality impacts associated with TRV events, releases during these events are accounted for in the long-term average measurements. Therefore, the monitoring data for radionuclides outlined in the previous section implicitly account for contamination released during the infrequent TRV events.

In summary, DOE has analyzed ambient air samples during half of the TRV events that occurred between 1991 and 2004. These data suggest that ambient air concentrations of PCBs, dioxins, and furans are not unusually elevated following these events, especially when compared to background levels. This observation, combined with the infrequent nature of the events and their short duration, implies that air quality impacts for these pollutants during TRV openings are negligible.

When preparing this PHA, ATSDR considered the need for DOE to analyze a greater fraction of the ambient air samples collected during the TRV events. The conclusion regarding TRV events would change only if the ambient air concentrations of dioxins, furans, and PCBs were consistently and dramatically higher than those that have been measured to date. ATSDR has no reason to expect that such elevated concentrations will occur, but a sensible way of assessing this

2 This intake was calculated by multiplying the highest furan concentration (0.00000416 µg/m^3) by an inhalation rate for adults engaged in heavy activities (3.2 m^3/hour, from EPA 1997) and by an estimated exposure duration (8 hours). These assumptions likely represent the highest possible exposures during a TRV opening.

is to analyze only those samples collected during TRV events associated with high waste feed rates or PCB inputs. In other words, the criteria that DOE currently uses when deciding whether to analyze samples should provide sufficient insights on whether air quality impacts during TRV events are unusually higher than the concentrations that have been measured to date. Based on this analysis, ATSDR is not recommending any change to the current ambient air sampling and analysis framework for TRV events.

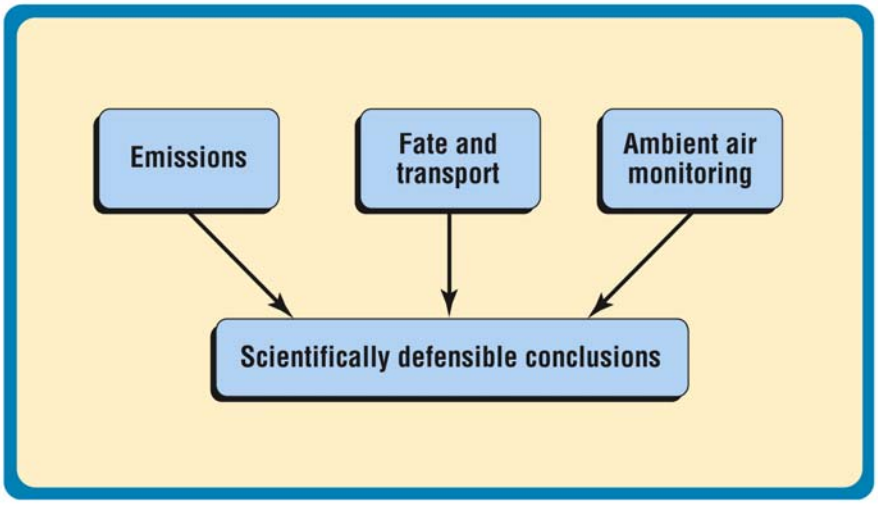
While there is limited evidence of short-term air quality impacts during these events based on the groups of contaminants measured, ATSDR acknowledges that it is possible for some groups of contaminants (namely acidic gases) to have substantially increased emissions during TRV events. As one example, the air pollution control efficiencies for hydrochloric acid suggest that air emissions during TRV events might be approximately 1,000 times greater than emissions during routine operations (see Comment #40 in Appendix G). Based on this observation, ATSDR has estimated that short-term ambient air concentrations of hydrochloric acid nearest the incinerator might reach levels of approximately 600 $\mu g/m^3$.3 Human exposure studies suggest that this upper-bound estimate of short-term exposure, while elevated, is not expected to be associated with adverse health effects. Specifically, a controlled exposure study found that human asthmatics exposed to hydrochloric acid at concentrations up to 2,700 $\mu g/m^3$ for 45 minutes did not experience any respiratory effects as gauged by multiple pulmonary function tests (Stevens et al. 1992). Considering that asthmatics did not develop respiratory symptoms when exposed to 2,700 $\mu g/m^3$ of hydrogen chloride, it is unlikely that any residents would experience adverse health effects should off-site ambient air concentrations of hydrochloric acid near the TSCA Incinerator ever reach 600 $\mu g/m^3$ during a TRV event.

III.E. Synthesis of Information

This entire section has focused on evaluating three critical elements of the air exposure pathway: emissions, fate and transport, and ambient air monitoring. One must consider all three elements in order to have a complete understanding of the air quality issues surrounding the TSCA Incinerator (see Figure 11).

3 ATSDR computed this estimate as follows: Appendix B.3 reports the estimated highest annual average concentration of hydrochloric acid to be 0.047 $\mu g/m^3$, based on modeling studies. Based on this annual average estimate, a reasonable estimate of maximum 1-hour average concentrations is approximately 12 times greater (EPA 1992), or 0.6 $\mu g/m^3$. If emissions during a TRV event are up to 1,000 times greater, then the estimated ambient air concentration would increase by the same factor, or could possibly reach 600 $\mu g/m^3$.

Figure 11. Synthesizing Information for the Air Exposure Pathway



The following discussion integrates the information presented above in an attempt to answer key questions: Is there enough information on the contaminant group to reach conclusions? Is the information in the available studies consistent? Are more detailed analyses required for any contaminants? Is further sampling needed for any of the contaminants? ATSDR's evaluation of these issues for the eight groups of contaminants follows:

- **Particulate matter.** More than 2,000 air samples for particulate matter have been collected at multiple locations around ETTP over the entire history that the TSCA Incinerator has operated. All of the sampling results are safely below EPA's corresponding health-based air quality standards. Consistent with these data are findings from the independent panel's modeling analysis, which predicted that the incinerator's particulate emissions would have limited air quality impacts at downwind locations. Further, nearly every stack test and trial burn conducted to date has found particulate matter emissions at levels below limits set in environmental permits. All these observations provide compelling evidence that the TSCA Incinerator does not emit particulate matter at levels expected to cause adverse health effects among residents.

- **VOCs.** During the RCRA trial burns, DOE demonstrated that the TSCA Incinerator destroys more than 99.99% of organic compounds in the waste feed. Further, continuous emissions monitoring for carbon monoxide and carbon dioxide provides a real-time indicator of how efficiently the incinerator is burning wastes. To evaluate potential air contamination levels, both the independent panel chartered by the Governor of Tennessee and ATSDR estimated VOC air concentrations using modeling techniques. Both modeling studies concluded that none of the VOCs released by the TSCA Incinerator are likely to ever exceed health-based comparison values. While ATSDR acknowledges that the modeling analysis has inherent uncertainty, the estimated concentrations for every VOC considered were more than 1,000 times lower than health-based comparison values. This ample "margin of safety" provides ATSDR some reassurance that small modeling uncertainties do not have a significant bearing

on the conclusion that the incinerator's emissions of VOCs are not at levels of health concern.

- **PCBs.** Every TSCA trial burn conducted to date has demonstrated that the incinerator destroys more than 99.9999% of the PCBs in the waste feed. Thus, for every 1,000,000 pounds of PCBs fed to the incinerator, less than 1 pound of PCBs is released to the air, assuming that the TSCA Incinerator consistently achieved the required DRE. For insights into potential air quality impacts, the independent panel's modeling study predicted that the maximum annual average PCB concentration at ETTP would be 0.000003 $\mu g/m^3$, which is more than 3,000 times lower than the most protective health-based comparison value. Given this large margin, ATSDR is confident in concluding that PCB exposures are not of public health concern. The sampling data collected during TRV openings provides further evidence that the incinerator's PCB emissions do not cause significant air quality impacts at off-site locations.

- **Metals.** Incinerators cannot destroy metals. Any metals fed to incinerators will either be released to the air or captured in process residuals (e.g., ash, sludge, wastewater). Both DOE and TDEC have conducted extensive ambient air monitoring for metals, which has more than adequate spatial and temporal coverage for reaching public health conclusions. Trends among the data suggest that ambient air concentrations of arsenic, cadmium, and chromium warrant further evaluation, while concentrations of beryllium, lead, nickel, and uranium are safely below health-based comparison values. These findings are reasonably consistent with the independent panel's modeling results. Refer to Section IV for ATSDR's evaluation of exposures to metals and to Section IX for suggested improvements to the metals sampling in the existing ambient air monitoring networks.

- **Acidic gases.** Ambient air concentrations of acidic gases have never been measured in the vicinity of the TSCA Incinerator. However, every measured emission rate of hydrogen fluoride and hydrogen chloride to date has been at least an order of magnitude lower than the corresponding permitted emission limits. Further, the highest concentrations of acidic gases (hydrogen chloride and hydrogen fluoride) estimated in ATSDR's modeling evaluation were more than 400 times lower than the chemicals' corresponding lowest health-based comparison values. ATSDR believes these observations sufficiently support the conclusion that the TSCA Incinerator does not release acidic gases at levels expected to harm off-site residents.

- **Dioxins and furans.** To date, all measured emission rates for dioxins at the TSCA Incinerator have met limits set in environmental permits and regulations. ATSDR evaluated potential air quality impacts in a modeling evaluation that considered the highest dioxin emission rate during a recent trial burn. This modeling estimated an annual average dioxin concentration at the point of maximum ground-level impacts, which lies within ETTP property, to be 3.75×10^{-10} $\mu g/m^3$ (on a TEQ basis). This estimated concentration, besides being immeasurably small and likely impossible to differentiate from background levels, is more than 100 times lower than the risk-based concentration of the most toxic dioxin congener. The dioxin levels measured during TRV events are also indistinguishable from background. For these reasons, ATSDR concludes that the air emissions of dioxins need not be evaluated further in this PHA.

- **PAHs.** ATSDR's modeling evaluation provides the best available information on potential exposures to PAHs from the TSCA Incinerator. Using PAH emission rates measured during a recent trial burn and a dispersion factor reported by the Governor of Tennessee's independent panel, ATSDR estimated that the incinerator's air emissions could cause annual average ambient air concentrations of total PAHs to increase by 0.000005 $\mu g/m^3$. Even if one assumes that the total PAHs consist entirely of the most potent individual compound, the estimated increase in concentration is more than 150 times lower than the corresponding risk-based concentration. ATSDR believes this information is a sufficient basis for conclusions for three reasons: 1) the emission rate used in the modeling analysis is expected to overstate air quality impacts, because it was measured during a trial burn that challenged the incinerator with the maximum allowed waste feed rate; 2) the estimated air concentration occurs at a location within the ETTP property, and off-site concentrations would be expected to be lower; and 3) an ample margin of safety separates the estimated concentration from the health-based comparison value.

- **Radionuclides.** Like metals, radionuclides pass through incinerators untreated. Most are captured in process residuals, but some are released to the air. To characterize the impacts of these releases, DOE has been collecting ambient air samples at regular frequencies for radionuclides at the ETTP perimeter since the TSCA Incinerator began operating. To date, the highest annual average concentrations for every radionuclide measured are more than 100 times lower than DOE's health-protective derived concentration guides (see Table C-3). Additionally, for the last 8 years, TDEC has collected air samples for radionuclides at a point directly downwind from the TSCA Incinerator. These samples were then forwarded to an EPA laboratory for analysis. EPA's measured concentrations are very consistent with DOE's, providing greater confidence that both programs are generating high-quality data. These trends, combined with extensive radiation dose modeling DOE conducts in fulfillment of regulatory requirements (i.e., NESHAPs), strongly suggest that the TSCA Incinerator's air emissions do not cause unsafe exposures to radiation or radionuclides. Given that incinerators do not destroy radionuclides (and the level of community concern regarding potential exposures), ATSDR has recommended, as a prudent public health measure, that DOE and EPA continue their ambient air sampling efforts for radionuclides into the future.

Referring to the previous discussion, ATSDR concludes that further analyses are needed to evaluate the public health implications of exposures to arsenic, cadmium, and chromium. For all other metals and groups of contaminants, the studies that have characterized emissions, fate and transport, and ambient air monitoring clearly show that the TSCA Incinerator's air emissions do not cause residents to be exposed to unhealthful levels of air contaminants.

IV. Public Health Implications

The previous section of the PHA used a screening analysis to select contaminants of concern for the TSCA Incinerator. In the screening, ATSDR compared the highest measured or estimated ambient air concentrations for all eight groups of contaminants with deliberately conservative health-based comparison values. Through that process, arsenic, cadmium, and chromium were found to warrant further evaluation, and all other air contaminants considered were safely below levels of public health concern. This section presents a more detailed analysis for the three contaminants requiring further evaluation, considering issues such as background concentrations, potential air quality impacts due to emissions from the TSCA Incinerator, and toxicological evaluations for both short-term (acute) and long-term (chronic) exposures and for both non-cancer and cancer health outcomes.

Residents near the TSCA Incinerator are exposed to airborne arsenic, cadmium, and chromium that originate from several nearby emissions sources. Extensive ambient air monitoring data suggest that the amounts of these metals in the air are below levels expected to cause adverse health effects. Ongoing monitoring will help ensure that ambient air concentrations of these metals remain at safe levels in the future.

In Sections IV.A, IV.B, and IV.C, the "toxicological evaluation" bulleted items first address potential non-cancer health outcomes, immediately followed by a separate evaluation for cancer health outcomes. It is appropriate to separate these evaluations due to the different approaches used to address public health implications. Additionally, sub-headers for "non-cancer evaluation" and "cancer evaluation" have been added to emphasize that the evaluations are indeed separate.

The remainder of this section presents ATSDR's detailed evaluations for arsenic (Section IV.A), cadmium (Section IV.B), and chromium (Section IV.C). Concluding statements (Section IV.D) discuss the adequacy of the data supporting ATSDR's evaluations and present recommendations for ensuring that inhalation exposures to the contaminants of concern remain at safe levels in the future.

IV.A. Arsenic

ATSDR selected arsenic as a contaminant requiring further evaluation because the highest annual average concentration of arsenic measured near ETTP (0.000809 $\mu g/m^3$) was approximately four times greater than a highly protective health-based comparison value for cancer effects (0.0002 $\mu g/m^3$) — this comparison does not mean that the measured arsenic concentrations are harmful or are even caused largely by the incinerator's emissions. Rather, the initial comparison simply means that further evaluation is needed to assess the public health implications of exposure, regardless of the origin of the airborne arsenic. To put potential inhalation exposures to arsenic into perspective, ATSDR considered the following observations:

- **Consistency with modeling results.** As Appendix B notes, the independent panel chartered by the Governor of Tennessee conducted a dispersion modeling analysis of the TSCA Incinerator's emissions. That analysis estimated that the incinerator's emissions alone contribute 0.000148 $\mu g/m^3$ to annual average concentrations at the point of maximum impact.

This estimated concentration is more than five times lower than the highest annual average concentration measured in the area. There can be many reasons why modeling and monitoring results differ. For instance, the difference might simply reflect uncertainties associated with the modeling analysis. However, given that the modeling was conducted in a manner that likely overstates air quality impacts (see Appendix B), a logical explanation for the difference is that contributions from other air emissions sources account for the difference between the measured concentrations and the modeled concentrations.

- **Comparison with typical airborne arsenic levels.** ATSDR's Toxicological Profile for Arsenic reports that average air concentrations of arsenic in remote areas of the United States typically range from <0.001 to 0.003 μg/m^3 (ATSDR 2000a). The measured arsenic levels near the TSCA Incinerator are at the lower end of this range. ATSDR makes this comparison only to demonstrate that residents near ETTP are not exposed to unusually high amounts of airborne arsenic.

- **Toxicological evaluation.** ATSDR's toxicological evaluation considers the public health implications of exposure to the measured concentrations of airborne arsenic, regardless of where it originated.

  Non-cancer evaluation. According to a literature review of numerous studies of arsenic exposure in humans and experimental animals, the lowest found exposure concentration that has been associated with non-cancer adverse health effects is 0.7 μg/m^3 (ATSDR 2000a). Specifically, a case-control epidemiological study among residents near a smelter found that exposures at this level were associated with a greater risk for stillbirths, compared with the risk for residents in a non-exposed group (Ihrig et al. 1998). ATSDR notes, however, that the highest annual average concentration of arsenic measured near the TSCA Incinerator is more than 850 times lower than the exposure concentration that might be associated with increased stillbirths. Because the measured airborne levels of arsenic are dramatically lower than exposure concentrations found to be associated with non-cancer health effects in humans and experimental animals, ATSDR concludes that inhalation of airborne arsenic near ETTP is not expected to cause similar non-cancer effects among local residents.

  Cancer evaluation. The National Toxicology Program (NTP), part of the U.S. Department of Health and Human Services, has classified arsenic as a "known human carcinogen." Accordingly, ATSDR assessed whether exposure to airborne arsenic near the TSCA Incinerator might be associated with cancer outcomes. Such assessments typically consider long-term exposure concentrations. In this case, the highest long-term average ambient air concentration of arsenic measured near ETTP is 0.0004 μg/m^3 — an average based on nearly 10 years of monitoring at a location immediately downwind from the site. In contrast, ATSDR's review of the literature has reported arsenic-related cancer effect levels in humans

What is a "cancer effect level"? ATSDR defines a cancer effect level as the lowest exposure dose in a study, or group of studies, that produces significant increases in the incidence of cancer between the exposed population and its appropriate control population.

What is a "lowest observed adverse effects level" (LOAEL)? ATSDR defines a LOAEL as the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

ranging from 50 to 380 μg/m^3 (ATSDR 2000a). Therefore, the highest annual average exposure concentration measured near the TSCA Incinerator is more than 100,000 times lower than the cancer effect levels reported in six different studies of human exposures. Given this large margin, ATSDR does not believe the measured concentrations of arsenic pose a significant health concern for cancer outcomes.

In summary, modeling studies predict that the TSCA Incinerator has little impact on ambient air concentrations of arsenic. This observation is consistent with the fact that measured airborne arsenic levels near the TSCA Incinerator fall within the range of concentrations measured in other remote locations of the United States. Using both these observations and a review of the toxicological and epidemiological literature, ATSDR concludes that inhalation exposures to airborne arsenic near the TSCA Incinerator are not expected to cause adverse health effects. Refer to Section IV.D for recommended actions to ensure that future exposures to arsenic near the TSCA Incinerator remain at safe levels.

IV.B. Cadmium

ATSDR selected cadmium as a contaminant requiring further evaluation — the highest annual average concentration of cadmium measured in the vicinity of ETTP (0.001963 μg/m^3) was approximately three times greater than the corresponding health-based comparison value for cancer effects (0.0006 μg/m^3) — this comparison does not mean that the measured cadmium levels are harmful or are even caused largely by the incinerator's emissions. Rather, the initial comparison simply means that further evaluation is needed to assess the public health implications of exposure, regardless of the origin of the airborne cadmium. After evaluating all information available on airborne cadmium near the incinerator, ATSDR made the following observations:

- **Consistency with modeling results.** The highest measured annual average concentration of cadmium (0.001963 μg/m^3) was 15 times greater than the peak ground level impacts (0.000129 μg/m^3) predicted by air dispersion modeling conducted by the Governor of Tennessee's independent panel. While the exact reasons for this discrepancy are not known, a reasonable explanation is that airborne levels of cadmium near the incinerator originate from many different sources, while the dispersion modeling analysis only considered the incinerator's air quality impacts. The considerable margin between the measured and modeled results is likely not explained by uncertainties in the modeling alone.

- **Comparison with typical airborne cadmium levels.** Ambient air concentrations of cadmium have been measured at two locations near the TSCA Incinerator (see K2 and K6 in Figure C-3) from 1994 to the present — almost the entire history of the incinerator's operations. Over this entire time frame, the average concentrations at these locations were 0.00044 μg/m^3 and 0.00033 μg/m^3, respectively, both of which fall below the lower bound of the range of average cadmium levels typically observed in urban areas across the country (0.003–0.040 μg/m^3) (ATSDR 1999a). ATSDR acknowledges that the general consistency between cadmium levels near ETTP and those measured in other parts of the country does not mean that the contamination levels near the TSCA Incinerator are safe or acceptable. Rather, ATSDR presents this information primarily for perspective, to indicate that local residents are not being exposed to unusually high amounts of cadmium.

- **Toxicological evaluation.** ATSDR's toxicological evaluation considers both non-cancer and cancer outcomes associated with inhalation exposure to airborne cadmium.

  Non-cancer evaluation. To evaluate non-cancer outcomes, ATSDR compared the measured concentrations near the TSCA Incinerator with exposure levels that have been shown to cause, or are suspected of causing, adverse health effects, whether in human or in experimental animals. More than 30 available peer-reviewed studies provide quantitative data related to inhalation toxicity of cadmium (ATSDR 1999a). Overall, the lowest concentration reported to produce non-cancer health effects, whether from acute or chronic exposure, is 13 $\mu g/m^3$ — an exposure concentration that caused increased non-cancerous cell growth in the lungs of experimental animals (ATSDR 1999a). All measured ambient air concentrations of cadmium near the TSCA Incinerator are at least 1,000 times lower than this level, which suggests that residents' inhalation exposures near ETTP are not at levels expected to cause non-cancer health effects. ATSDR acknowledges that using effects levels observed in animals to evaluate human exposures involves considerable uncertainty. It should be noted, however, that the lowest exposure concentration of cadmium shown to cause adverse non-cancer outcomes in humans (23 $\mu g/m^3$) is on the same order of magnitude as that shown to cause adverse outcomes in animals.

  Cancer evaluation. ATSDR also evaluated potential cancer outcomes associated with cadmium exposures, considering that NTP has classified cadmium as a "known human carcinogen." When evaluating potential cancer risks, ATSDR usually assesses potential lifetime average exposure levels. The highest long-term average ambient air concentration of cadmium near ETTP is 0.000044 $\mu g/m^3$, which is based on nearly 10 consecutive years of monitoring data collected at a location immediate downwind of the TSCA Incinerator. ATSDR's review of carcinogenic outcomes associated with cadmium found cancer effect levels in animals and humans ranging from 13.4 to 100 $\mu g/m^3$ (ATSDR 1999a). In this case, the cadmium exposures near the TSCA Incinerator are more than 300,000 times lower than the lowest cancer effect level derived from the literature. Accordingly, ATSDR concludes that the TSCA Incinerator's emissions do not result in nearby residents' exposure to cadmium at levels associated with cancer effects.

Overall, all information ATSDR reviewed to date suggests three key findings for cadmium: 1) the TSCA Incinerator has relatively minor air quality impacts; 2) the inhalation exposures that residents might experience are not unusually high when compared with those observed in other parts of the country; and 3) the actual exposure levels are not expected to cause adverse cancer or non-cancer health effects. Section IV.D discusses future actions that are warranted to ensure that cadmium exposures remain at safe levels in the future.

IV.C. Chromium

Evaluating ambient air contamination of chromium often presents challenges: chromium exists in multiple forms, each having a significantly different toxicity. The most common forms found in ambient air are trivalent chromium and hexavalent chromium. Trivalent chromium is relatively benign and is actually an essential nutrient for humans. Hexavalent chromium is considerably more toxic, both for cancer and non-cancer outcomes. Complicating matters is the fact that most commonly used environmental sampling and analytical methods measure ambient

air concentrations of total chromium, without specifying the relative amounts of the hexavalent and trivalent forms.

When conducting the screening analysis (see Section III), ATSDR initially assumed that all chromium is present in the more toxic hexavalent form. Under this assumption, both modeled and measured levels of total chromium exceeded the health-based comparison values for hexavalent chromium — this comparison does not mean that the measured chromium levels are necessarily harmful or are even caused largely by the incinerator's emissions. Rather, the initial comparison simply means that further evaluation is needed to assess the public health implications of exposure to chromium. The following paragraphs present ATSDR's more detailed evaluations of exposures to chromium, which consider the reality that total chromium includes both trivalent and hexavalent forms:

- **Consistency with modeling results.** The highest annual average concentration of total chromium reported for DOE's monitoring network is <0.0064 μg/m^3, at a monitoring station on the perimeter of ETTP.4 For comparison, the dispersion modeling analysis conducted by the Governor of Tennessee's independent panel estimated that the highest annual average air concentration of total chromium attributed to the TSCA Incinerator's emissions was only 0.000153 μg/m^3, which is more than 40 times lower than the detection limit for annual average concentrations in DOE's network. The considerably higher measured levels of total chromium probably reflect the influence of air emissions sources other than the TSCA Incinerator.

- **Comparison with typical airborne chromium levels.** Two ambient air monitoring stations at ETTP measured ambient air concentrations of total chromium for almost the entire history of the TSCA Incinerator's operations. Over nearly 10 years of monitoring at stations K2 and K6 (see Figure C-3 for their locations), the long-term average ambient air concentrations of total chromium were 0.0006 μg/m^3 and 0.0005 μg/m^3, respectively.

  The total chromium concentrations measured around ETTP clearly fall within the range of concentrations reported for similar settings. For instance, ATSDR reports that average airborne concentrations of total chromium in rural settings are generally lower than 0.010 μg/m^3 (ATSDR 2000b). Similarly, ambient air monitoring that EPA recently conducted at a remote location near Louisville, Kentucky, found an annual average concentration of total chromium of 0.0027 μg/m^3 (EPA 2002). Moreover, ongoing ambient air monitoring in Nashville for an EPA nationwide monitoring network has shown that average concentrations of total chromium are approximately 0.004 μg/m^3 (ERG 2004). In short, extensive ambient air monitoring data collected elsewhere in the country suggest that the annual average concentrations of total chromium measured near ETTP are not unusually elevated.

- **Toxicological evaluation.** ATSDR's toxicological evaluation focuses on hexavalent chromium, which is the most toxic form of chromium likely to be encountered in the environment.

4 The annual average concentration was calculated from a data set in which chromium was not detected in several samples. When calculating annual average concentrations, DOE apparently replaced non-detect observations with the detection limit to generate an upper-bound estimate of actual chromium levels. This is why a "less than" symbol appears before the annual average concentration.

Non-cancer evaluation. To assess potential non-cancer outcomes, ATSDR considered EPA's reference concentration (RfC) for hexavalent chromium particulates, which is 0.1 $\mu g/m^3$. By definition, an EPA RfC represents an exposure concentration that is likely to be without harmful health effects throughout a lifetime of continuous inhalation exposure. Because the highest long-term average measured concentration of total chromium (0.0006 $\mu g/m^3$) is more than 150 times lower than the RfC, ATSDR concludes that residents' exposures to chromium near the TSCA Incinerator are not expected to cause non-cancer health effects, even if one assumes that all of the airborne chromium is in the more toxic hexavalent form.

Cancer evaluation. According to NTP, hexavalent chromium is a "known human carcinogen." Consensus agencies have not classified the carcinogenicity of trivalent chromium, but ATSDR has noted that epidemiological studies in industries where workers are exposed to trivalent chromium have been consistently negative (ATSDR 2000b). Therefore, the evaluation of potential cancer outcomes in this PHA focuses primarily on hexavalent chromium exposures. ATSDR would prefer to base this evaluation on measured ambient air concentrations of hexavalent chromium, rather than on measures of total chromium. As is typical, however, at many sites that ATSDR evaluates, no data are available on the relative amounts of hexavalent and trivalent chromium in the air near the TSCA Incinerator.

Nonetheless, ATSDR believes the available data provide ample insights on the potential for cancer outcomes resulting from inhaling hexavalent chromium, even without the chemical speciation data. Specifically, ATSDR's Toxicological Profile for Chromium presents 11 different cancer effect levels: 10 for studies of human exposures (mostly occupational) and one for an animal study (ATSDR 2000b). The lowest cancer effect level reported is 40 $\mu g/m^3$ for an occupational cohort that was exposed to a mixture of trivalent and hexavalent chromium. In contrast, the highest long-term average exposure concentration near the TSCA Incinerator is more than 66,000 times below the lowest cancer effect level. Such a large margin of safety provides assurance that the exposures that community members near ETTP experience do not reach levels known to be associated with cancer outcomes.

An important consideration in this evaluation is the chemical form of chromium found in the air near the TSCA Incinerator, given that hexavalent chromium appears to be a much more potent carcinogen. While the chemical speciation issue cannot be resolved from the available measurements, ATSDR notes that a growing body of evidence from EPA monitoring networks is showing that hexavalent chromium typically accounts for less than 10% of total chromium in ambient air (e.g., Swift et al. 2003). Moreover, studies have suggested that hexavalent chromium typically accounts for less than 1% of air emissions of total chromium from municipal waste incinerators (ATSDR 2000b). The qualitative insights on chemical speciation combined with the large margin between exposure levels and cancer effect levels strongly suggest that the TSCA Incinerator does not emit chromium in amounts believed to be associated with cancer outcomes.

The previous evaluation shows that air emissions of chromium from the TSCA Incinerator appear to contribute only slightly to ambient air concentrations of chromium near ETTP. Further, the measured ambient air concentrations of total chromium fall within the range of concentrations expected for a rural location. While the relative amounts of trivalent chromium

and hexavalent chromium in ambient air near ETTP are not known, ATSDR's evaluation strongly suggests that realistic estimates of inhalation exposures are below levels of health concern, both for cancer and non-cancer outcomes.

IV.D. Summary

The foregoing is ATSDR's evaluation of public health implications of exposure to arsenic, cadmium, and chromium in ambient air near the TSCA Incinerator. For all three metals, the available sampling and modeling data suggest that emissions from multiple local sources, and not just the TSCA Incinerator, contribute to the measured airborne concentrations. Regardless of the predominant source of the metals, the airborne concentrations measured near ETTP are reasonably consistent with those measured in rural and suburban areas across the country. Further, and more importantly, inhalation exposures to the measured concentrations are at levels well below those observed to be associated with adverse health effects, both in animals and in humans.

The conclusions in this section rest heavily on trends among nearly 10 years of ambient air monitoring data that DOE has collected in the vicinity of the TSCA Incinerator, including at a location believed to be near where the incinerator's emissions have their greatest air quality impacts. While the data generated by DOE appear to be of a known and high quality and provide a sound basis for this PHA's conclusions, an excellent opportunity exists to provide independent verification of DOE's air quality measurements for arsenic, cadmium, and chromium. Specifically, TDEC is currently measuring ambient air concentrations of metals at one of the locations where DOE also measures ambient air concentrations of metals. To provide insights into measurement accuracy, ATSDR recommends TDEC quantify differences between metals monitoring data gathered by DOE and those gathered by TDEC at all stations with co-located samplers. Although the TSCA Incinerator does not appear to be the primary source of arsenic, cadmium, and chromium in the ambient air, ATSDR recommends that DOE and TDEC continue routine ambient air monitoring as long as the TSCA Incinerator processes waste. This will provide assurance that incinerator emissions, in combination with emissions from other sources, do not result in unacceptable exposures. Section IX of this PHA presents these and other recommendations that ATSDR has made for this site.

V. Community Health Concerns

One objective of this PHA is to respond to specific community concerns about the TSCA Incinerator. This section presents responses to all such concerns that residents have expressed to ATSDR to date. Throughout the health assessment process, ATSDR has compiled a list of community concerns by drawing from ATSDR's database of concerns for the ORR facilities[5], TDEC's report addressing community concerns (TDEC 1997), and the summary report issued by a group of independent experts chartered by the Governor of Tennessee (Iglar et al. 1998). ATSDR also identified community concerns by talking to local residents, whether at public meetings or through individual communications. The remainder of this section uses a question and answer format to address specific community concerns, which are organized into four topics.

V.A. Community Concerns Regarding Health

Sections III and IV of this PHA present ATSDR's findings regarding the public health implications of exposure to air contaminants released by the TSCA Incinerator. The following questions and answers elaborate on specific health issues of concern to some community members.

Question A-1:

Under certain meteorological conditions, air emissions from the TSCA Incinerator appear to blow directly to ground level at on-site locations. Does this situation present a health hazard to visitors to the property, particularly for exposures to mercury?

Answer A-1:

Many factors determine how contaminants disperse from a stack into the atmosphere. These factors include the stack gas temperature and exit velocity, the stack's dimensions, the stack's proximity to nearby buildings, and local meteorological conditions. Under certain circumstances, stack gas emissions have been observed to blow rapidly to the ground — a phenomenon known as "downwash."

The conditions that cause severe downwash at the TSCA Incinerator typically are short-lived; that is, they likely do not persist for hours on end. ATSDR has received no reports that during downwash conditions, site visitors were ever directly exposed to stack emissions. Further, ATSDR expects that should downwash conditions be observed while visitors are touring the facility, escorts would guide any visitors away from these emissions. Accordingly, ATSDR suspects that visitors' exposures to air emissions during downwash conditions are extremely limited, if they occur at all.

[5] From 2001 to 2003, ATSDR compiled more than 3,000 community health concerns obtained from the ATSDR/ORRHES community health concerns comment sheets, written correspondence, phone calls, newspapers, comments made at public meetings (ORRHES and work group meetings), and surveys conducted by other agencies and organizations. These concerns were organized in a consistent and uniform format and imported into the database. This section includes those concerns that (1) were specific to the TSCA Incinerator and (2) were not already addressed in other parts of this document.

A community member asked ATSDR specifically about whether this scenario could lead to mercury exposures that would cause visitors to get sick. Such an outcome is unlikely for two reasons. First, the TSCA Incinerator has extremely strict Waste Acceptance Criteria for materials that contain mercury to ensure that emissions are safely below levels that would lead to unacceptable air quality impacts. Second, according to ATSDR's Toxicological Profile for Mercury (ATSDR 1999b), the lowest air concentrations of mercury that have been shown to cause adverse health effects following exposures over short time frames (e.g., hours) are more than 20,000 $\mu g/m^3$. Considering that none of the metals reached concentrations of even 1 $\mu g/m^3$ at off-site locations, it is highly unlikely that mercury concentrations could reach harmful levels for acute exposures, even when considering direct downwash of the plume.

Question A-2:

Are workers at the TSCA Incinerator at risk for developing adverse health effects, due to their occupational exposures?

Answer A-2:

As noted earlier in this PHA, ATSDR's role at the ORR facilities is to evaluate environmental health issues, not occupational health issues. Nonetheless, ATSDR recognizes that many residents have health concerns specific to occupational exposures.

There are several resources that residents can consult for more information on occupational health issues. Web sites maintained by DOE (http://cedr.lbl.gov) and NIOSH (http://www.cdc.gov/niosh/2001-133.html), for example, describe ongoing worker health studies at several existing and former DOE facilities. One reference available is a NIOSH study that found no evidence of significant occupational exposures to hydrogen cyanide and related compounds at the TSCA Incinerator (Blade and Worthington 1996). Further, the independent panel's summary report (Iglar et al. 1998) and ATSDR's review of thermal treatment technologies (ATSDR 2002) comment on more general occupational health issues observed at incineration facilities.

Question A-3:

Will ATSDR establish a health clinic for residents who live near the TSCA Incinerator?

Answer A-3:

ATSDR does not establish site-specific health clinics. In a February 22, 1999, letter from Donna E. Shalala, Secretary of Health and Human Services, to The Honorable William H. Frist, M.D., United States Senate, Secretary Shalala stated that ATSDR and CDC cannot provide direct primary medical services to communities. ATSDR and CDC can, however, support the existing medical care systems to address public health concerns of communities that are near nuclear plants. ATSDR is working with ORRHES, EPA, TDEC, the Tennessee Department of Health, and DOE to plan appropriate public health follow-up activities to address the concerns of communities regarding the nuclear weapons complexes. In August 2002, the ORRHES recommended that formal consideration of establishment of a clinic,

clinical evaluations, medical monitoring, health surveillance, health studies, or biological monitoring be postponed until the ATSDR public health assessment process identified and characterizes an exposure of an off-site population at levels of health concern. As Sections III and IV of this PHA explain, ATSDR found no evidence of local residents being exposed to unhealthful levels of air pollution in the vicinity of the TSCA Incinerator. Accordingly, ATSDR does not believe follow-up public health activities are necessary to address the releases from the TSCA Incinerator.

Question A-4:

Does ATSDR's evaluation consider peak emission rates expected to occur from the TSCA Incinerator, such as those during TRV events?

Answer A-4:

Yes. This PHA examines both routine and peak exposures as characterized by average and maximum concentrations among ambient air monitoring data. It also presents detailed evaluations of TRV events, which are assumed to lead to the highest short-term exposures, given that incinerator gases are released without first passing through air pollution controls. ATSDR's evaluation found that both short-term and long-term exposures did not reach levels expected to cause adverse health effects.

Question A-5:

Does the TSCA Incinerator release beryllium at levels of health concern?

Answer A-5:

No. Ambient air monitoring for beryllium has occurred over nearly the entire history of the TSCA Incinerator's operations at the location predicted to have the greatest air quality impacts. As Table C-3 shows, even the highest concentration of beryllium measured to date did not exceed protective health-based comparison values. Therefore, ATSDR concludes that the air emissions of beryllium from the TSCA Incinerator are not at levels of health concern.

Question A-6:

Several community members expressed concern about the possibility of adverse health effects occurring as a result of exposure to air emissions from the TSCA Incinerator. In one case, for instance, a community member noted that the onset of adverse health effects corresponded with the time the TSCA Incinerator began routine operations. In another case, a community member noted that onset of adverse health effects occurred shortly after a perceived exposure to emissions from the source.

Answer A-6:

ATSDR considered the various community health concerns when preparing this PHA. The analyses in this PHA document the multiple lines of evidence ATSDR evaluated to assess the possibility of air emissions from the TSCA Incinerator causing adverse health effects among nearby community members. Specifically, ATSDR critically reviewed the design and operation of the incinerator, amount and composition of waste treated, emissions data, fate and transport modeling studies, and ambient air sampling and monitoring studies. Every line of evidence considered showed that the TSCA Incinerator's emissions do not lead to

exposure levels associated with adverse health effects. Further, continued operation of the TSCA Incinerator is not expected to cause harmful exposures in the future because numerous safeguards, pollution controls, and strict permitting requirements are in place to prevent unsafe operating conditions from occurring.

V.B. Community Concerns Regarding Environmental Contamination

Section III and Appendixes A through C of this PHA present ATSDR's evaluation of the air exposure pathway for the TSCA Incinerator. The following discussion addresses concerns that community members have previously expressed to ATSDR about local air emissions sources, measured environmental contamination levels, and potential ecological effects from the incinerator's emissions.

Question B-1:

Do available monitoring data form a sufficient basis for conclusions on this site?

Answer B-1:

As Appendixes A and C show, multiple parties have conducted numerous sampling and monitoring studies to characterize the TSCA Incinerator's emissions and air quality impacts. These studies considered the contaminants of greatest concern for incineration facilities, focused on locations where air quality impacts are expected to be greatest, and were conducted over almost the entire history of the incinerator's operations. ATSDR believes that the available emissions monitoring data and ambient air monitoring data are generally consistent and provide an adequate basis for scientifically defensible public health conclusions regarding the TSCA Incinerator.

Question B-2:

To what extent do air emissions from sources other than the TSCA Incinerator, particularly the nearby power plants, contribute to local air pollution?

Answer B-2:

The air that local residents breathe contains trace contamination that originates from many different sources, including industrial sources, mobile sources, and natural sources. Section II.E.1 of this PHA identifies several local air emissions sources and describes, in general terms, how they affect local air quality. For additional perspective on power plants, ATSDR examined the most recent TRI data for all electricity-generating facilities within 25 miles of ETTP and found the following:

Facility Name (as listed in TRI)	*Total Air Emissions of Toxic Chemicals in 2001 (Pounds)*
U.S. DOE East Tennessee Technology Park	83
U.S. TVA Kingston Fossil Plant	5,926,225
U.S. TVA Bull Run Fossil Plant	4,305,815

This previous data compilation shows that the local power plants emit far greater quantities of toxic chemicals into the air than does the TSCA Incinerator. ATSDR strongly cautions about what readers should infer from the data shown above, because comparisons of total TRI emissions does not consider a) releases of all contaminants, b) the toxicity of the individual chemicals emitted, and c) important air dispersion behavior. For instance, because the power plants have such tall stacks, the plants' emissions can travel long distances (and become increasingly less concentrated) before they ever reach ground level. In summary, ATSDR presented the TRI emissions data above to respond to a very specific community concern; however, it is critically important that these data be considered in proper context.

While this PHA does not focus on environmental health issues specific to the local power plants, ATSDR notes that the ambient air monitoring data collected in the vicinity of the TSCA Incinerator reflect potential air quality impacts from the local power plants, the TSCA Incinerator, and other air emissions sources. Therefore, this PHA implicitly considers how air emissions from nearby TVA facilities affect air quality near the TSCA Incinerator.

Question B-3:

Does the TSCA Incinerator contaminate environmental media other than air, whether through direct discharges (e.g., wastewater) or through indirect pathways (e.g., air contaminants depositing onto soils and being taken into the food chain)? If so, does this contamination present a health hazard?

Answer B-3:

The analyses in this PHA focus almost entirely on direct inhalation exposures to airborne contaminants near the TSCA Incinerator, which presents the most likely pathway by which residents might come into contact with site-related contaminants. ATSDR also considered the specific issues raised in the comment, regarding potential contamination of other environmental media:

- **Direct discharges.** Residuals from the TSCA Incinerator are managed according to applicable permits and waste management regulations; no residuals are released directly into the environment.

  The incinerator's liquid residuals, for instance, are pumped to ETTP's wastewater treatment plant, known as the Central Neutralization Facility. The treated water eventually flows into the Clinch River. To fulfill permit requirements, DOE regularly tests the treated water in outfalls to the Clinch River. The testing must measure concentrations of numerous contaminants, including metals, radionuclides, and selected

organic compounds. ATSDR reviewed data summaries for these sampling efforts, which show that contaminant levels in the water discharged from ETTP to the Clinch River have been consistently below maximum limits established in the environmental permits (DOE 1991–2002).

ATSDR also considered the fate of the ash and sludge residuals that the TSCA Incinerator generates. Since 1991, DOE has handled these wastes according to EPA's waste management regulations. These regulations require DOE to test the ash and sludge for chemical contamination, and then to handle the materials accordingly. Depending on the testing results, the ash and sludge are either treated further or sent off site (typically to landfills) for waste management. Thus, solid residuals also are not released directly into the environment.

- **Indirect contamination pathways.** Residents have asked that ATSDR consider the possibility that pollutants released by the TSCA Incinerator might eventually contaminate other media. For example, contaminants in air emissions might deposit on soils or surface waters, and then become available for accumulation into biota. ATSDR is currently preparing a separate PHA on the extent of environmental contamination that has recently been measured in soils, surface water, and biota at locations outside the ORR property line. That "chemical screening" PHA will consider the possibility of indirect contamination caused by the TSCA Incinerator's air emissions. ATSDR expects that the chemical screening PHA will be completed early in 2005.

Question B-4:

Have emissions from the TSCA Incinerator killed pine trees in downwind locations?

Answer B-4:

In the mid-1990s, residents expressed concern that air emissions from the TSCA Incinerator might have killed a group of pine trees located immediately downwind from the facility. The independent panel chartered by the Governor of Tennessee evaluated this issue and concluded that the pine trees were killed primarily by southern pine beetle infestations. These beetle infestations reportedly have caused extensive damage to local trees throughout and beyond ORR (Iglar et al. 1998).

Question B-5:

Has ATSDR considered ambient air monitoring data collected by TVA?

Answer B-5:

During the March 2004 PHAWG meeting when ATSDR presented its preliminary evaluation for the TSCA Incinerator, a community member recommended that ATSDR contact TVA to determine if that agency has collected ambient air monitoring data relevant to this PHA. ATSDR has since obtained data from TVA, which are summarized in Appendix C of this PHA.

Question B-6:

Are the locations chosen for ambient air monitoring and ambient air sampling adequate?

Answer B-6:

Yes. Parties who conduct ambient air monitoring and ambient air sampling studies face difficult decisions when deciding where to place their equipment. On the one hand, there is often a desire to know ambient air concentrations of contaminants at as many places as possible; on the other hand, operating numerous monitoring stations can be prohibitively expensive. To achieve an appropriate balance, scientists typically conduct and carefully review air dispersion modeling studies before deciding where to place monitoring stations. This was done for the TSCA Incinerator, and ambient air concentrations have been measured at locations (both upwind and downwind) believed to have the greatest air quality impacts. Additionally, ambient air monitoring and ambient air sampling takes places at locations between the incinerator and the nearest residential receptors. As a result, it is extremely unlikely that the current monitoring network is grossly underestimating site-related exposures. Consequently, ATSDR believes the monitoring and sampling data are a sufficient basis for reaching public health conclusions, especially when one considers the consistent insights offered by a review of information on emissions and fate and transport.

Question B-7:

Has DOE measured fugitive emissions from the TSCA Incinerator? If fugitive emissions have not been measured, how can ATSDR reach a definitive conclusion on this site, and should DOE be required to measure these emissions?

Answer B-7:

By their very nature, fugitive emissions are extremely difficult, if not impossible, to measure directly. Consequently, DOE has never measured, nor been required to measure, fugitive emissions from the TSCA Incinerator. ATSDR does not view the lack of fugitive emission measurements as a significant data gap for this PHA for two reasons. First, several design and operational features clearly minimize potential fugitive emissions from this source (see Section III.B.3). Second, the ambient air monitoring data that ATSDR reviewed reflects air quality impacts from all local emissions sources, including the fugitive emissions from the TSCA Incinerator. Consequently, ATSDR's evaluation implicitly considered the incinerator's fugitive emissions, even though they have never been directly measured.

Question B-8:

At what location do air emissions from the TSCA Incinerator have their greatest air quality impacts?

Answer B-8:

Local meteorological conditions determine how emissions move from the incinerator stack to off-site locations. As the wind speed and direction change, so does the location with the highest ground-level concentration. As Appendix B describes, the existing dispersion modeling studies have estimated where the incinerator's emissions are expected to have their

greatest air quality impacts over the long term. All the studies ATSDR reviewed place the point of maximum impact within ½-mile of the stack base, in areas where no residents live or frequent. It should be noted, however, that ambient air monitoring stations have been placed at the estimated locations of maximum impact.

Question B-9:

Did ATSDR consider air emissions from local medical waste incinerators and municipal solid waste incinerators?

Answer B-9:

To identify nearby medical waste incinerators and municipal waste incinerators, ATSDR consulted with EPA personnel responsible for tracking the permit status of selected facilities in the United States. Through this consultation, ATSDR learned that there currently are no medical waste incinerators or municipal waste incinerators in the Knoxville metropolitan area that process enough material to fall under EPA's most recent regulations on incineration. Thus, if any medical waste incinerators or municipal solid waste incinerators are located in the Knoxville area, they must process very small quantities of waste. Moreover, air quality impacts from such facilities, if they exist, would presumably be captured in the ambient air monitoring data that ATSDR reviewed for this site.

V.C. Community Concerns Regarding Incinerator Operations

ATSDR identified several community concerns regarding the operation of the TSCA Incinerator, with most expressed during the March 2004 PHAWG meeting. ATSDR's responses to these concerns follow. Recognizing that residents have lingering questions about the incinerator's operations and the extent of regulatory oversight, ATSDR has recommended that TDEC issue annual fact sheets to inform the public of the TSCA Incinerator's ongoing operational status (see Section IX for further information on this and other recommendations).

Question C-1:

Why has DOE not implemented continuous emissions monitoring systems for a wider set of pollutants?

Answer C-1:

As Appendix C indicates, DOE currently conducts continuous emissions monitoring for carbon dioxide, carbon monoxide, and oxygen. Additionally, DOE continuously samples stack gases to measure emission rates of metals and radionuclides. Taken together, these continuous emissions monitoring and continuous emissions sampling efforts meet all applicable regulatory requirements for emissions measurements.

While ATSDR can appreciate the desire to have real-time emissions measurements for a broader range of contaminants, reliable continuous measurement devices simply are not available for every contaminant released by incinerators. ATSDR does not view the lack of additional continuous monitoring data as a critical information gap for this site for two reasons. First, ATSDR emphasizes that continuous emissions sampling already occurs for metals and radionuclides — two groups of contaminants that incinerators do not destroy.

Second, safeguards are in place to ensure that air emissions of other contaminants do not exceed levels of health concern. For instance, maintaining operating parameters within limits established during the trial burns should ensure that organic compounds and PCBs in wastes are thoroughly destroyed. Therefore, ATSDR believes that DOE's current emissions monitoring and emissions sampling strategies are appropriate.

Question C-2:

If continuous emissions monitoring for PCBs does not occur, how does DOE know that the DRE for PCBs is consistently greater than 99.9999%?

Answer C-2:

No continuous emissions monitoring systems are currently available for PCBs in incinerator exhaust. However, EPA's permitting process for incinerators includes several measures that help ensure that facilities consistently meet required DREs. For instance, through the trial burn process, EPA requires facility operators to demonstrate that their incinerators can adequately destroy wastes, even under unfavorable operating conditions. Further, environmental permits are prepared that establish strict waste acceptance criteria and specify limits on several critical operating parameters in the interest of ensuring that adequate waste destruction occurs. Finally, continuous emissions monitoring is required for carbon dioxide, carbon monoxide, and oxygen; results from this monitoring can characterize incineration efficiency. Thus, even though continuous monitoring of DREs for PCBs is currently not feasible, multiple safeguards are in place to help ensure (though not necessarily prove) that the required DREs are met.

Question C-3:

How can stack tests conducted every 5 years characterize how air emission rates at the TSCA Incinerator vary from day to day?

Answer C-3:

This question addresses a key issue often debated in connection to regulatory strategies for air emissions sources. Given the costs of conducting stack tests, environmental regulators have long recognized that frequent stack testing can be prohibitively expensive for incinerator operators. Regulators have instead focused on an alternate approach to ensuring safe operation of incineration facilities: carefully establishing waste acceptance criteria and limits on critical operating parameters to ensure (with an adequate margin of safety) that incinerator emissions are not harmful. Periodic stack tests are then used to confirm that the permit conditions are indeed appropriate. ATSDR believes that this is a sensible approach and avoids placing an undue financial burden on incinerator operators to demonstrate regulatory compliance.

Question C-4:

Is all waste material being characterized before being treated at the TSCA Incinerator?

Answer C-4:

Wastes must be thoroughly characterized, whether through testing or demonstrated process knowledge, before they can be treated at the TSCA Incinerator. DOE must retain records of waste characterization efforts, and TDEC periodically reviews records to verify compliance with permit conditions. Failure to perform waste characterization carries serious consequences. For instance, the DOE contractors who operate the incinerator can be subject to expensive fines (and, in extreme cases, criminal investigation) if waste characterization is not adequately performed. Overall, ATSDR has no reason to believe that DOE is treating improperly characterized wastes at the TSCA Incinerator.

Question C-5:

Given that incinerators do not destroy metals or radionuclides, why is incineration used to treat wastes containing these contaminants?

Answer C-5:

It is ATSDR's understanding that DOE is not using incineration to treat wastes heavily contaminated with radionuclides. Rather, the wastes of concern predominately contain toxic organic constituents (like PCBs) that need to be destroyed. Incineration has been shown to safely destroy these toxic constituents without generating and emitting harmful levels of by-products.

The toxic organic wastes that DOE treats at the TSCA Incinerator also happen to contain small amounts of metals or radionuclides. Recognizing this, DOE designed the incinerator with extensive air pollution controls to remove metals, radionuclides, and other inorganic materials that are not destroyed in the process. Stack testing has shown that the air pollution control devices at the TSCA Incinerator efficiently remove metals or radionuclides from gases leaving the afterburner. Some estimates place these removal efficiencies well over 90%, depending on the metal or radionuclide of concern. Regardless of the actual removal efficiencies, trace amounts of metals and radionuclides undoubtedly pass through the incinerator untreated. However, an extremely large volume of ambient air monitoring data show that these emissions have only marginal impacts on local air contamination levels and the measured air concentrations of metals and radionuclides are below levels of health concern.

Question C-6:

Does DOE operate the TSCA Incinerator outside of the bounds established in the environmental permits?

Answer C-6:

The incinerator automatically shut downs whenever one of several critical operating parameters (see Table 3) falls outside acceptable ranges specified in the environmental permits. These critical operating parameters are continuously measured using automated

sensors. Therefore, ATSDR has no reason to believe that DOE or its contractors can or would intentionally operate the incinerator beyond its permitted bounds.

Question C-7:

Given that the TRV remains open when the TSCA Incinerator is not operating, do emissions routinely occur through the TRV during typical process startups and shutdowns?

Answer C-7:

The question correctly notes that the TRV at the TSCA Incinerator is in the open position when the incinerator is not operating. During startup, a process interlock prevents the incinerator from operating until the TRV is in the closed position. Therefore, all combustion gases generated after process startup cannot pass through the TRV. Similarly, during process shutdown, the TRV remains in the closed position until after all combustion gases have passed through the air pollution controls. Therefore, whether during startup conditions, routine operations, or shutdown conditions, incineration gases pass through the air pollution controls and are not vented through the TRV. Only during the 18 events listed in Table 2 were untreated gases released through the TRV.

V.D. Other Community Concerns

The following paragraphs present ATSDR's responses to general community concerns that do not fall under the categories listed above.

Question D-1:

Does trucking hazardous wastes to the TSCA Incinerator present a hazard?

Answer D-1:

As noted previously, the TSCA Incinerator treats wastes generated by multiple DOE facilities, not just the ORR facilities. Selected wastes from other DOE facilities are shipped to the TSCA Incinerator by truck. ATSDR acknowledges that untreated hazardous wastes might be released if any trucks were involved in serious accidents. However, the U.S. Department of Transportation has developed many regulations to prevent such releases or minimize their consequences. For instance, drivers who haul hazardous waste must have special licenses, waste materials must be packaged in containers designed to withstand traumas anticipated in certain accidents, and wastes must be labeled and tracked. ATSDR believes these and other safeguards help minimize any hazards associated with transporting hazardous wastes to the TSCA Incinerator. While none of these regulations can guarantee that no accidents involving waste shipments will ever occur, it is worth noting that the TSCA Incinerator has now operated for 14 years without any accidents involving hazardous waste shipments.

Question D-2:

Has ATSDR evaluated the quality of the monitoring data reported by DOE?

Answer D-2:

ATSDR carefully scrutinized the quality of all sampling results relevant to the TSCA Incinerator, regardless of which party had collected the data. For reasons stated in Appendix C, ATSDR believes the monitoring data provided by DOE are generally of a known and high quality. Moreover, ATSDR sought additional data sources to provide independent verification for the quality of DOE's data. For instance, the consistency between EPA's and DOE's environmental radiation measurements near ETTP provide assurance that the underlying measurements are accurate. Similarly, ATSDR recommends that TDEC conduct similar data comparisons between its metals monitoring data and DOE's or provide some other form of independent verification of DOE's metals data (see Section IX).

Question D-3:

Did ATSDR consider findings from researchers at the University of California at Los Angeles (UCLA) suggesting that metals should not be incinerated?

Answer D-3:

During the PHAWG meeting when ATSDR presented its preliminary evaluation of the TSCA Incinerator, a community member noted that researchers at UCLA published a paper suggesting that metals should never be incinerated. After the meeting, ATSDR asked the individual who made these comments to provide a copy of the publication cited. The information provided was not a peer-reviewed publication, but rather a printed copy of UCLA's Center for Clean Technology Web site. Thus, ATSDR has no knowledge of UCLA researchers making the statements attributed to them. More generally, however, ATSDR has already stated its position on the utility of incineration as a waste management alternative: "Thermal treatment technologies [including incineration] are inherently neither safe nor unsafe; whether they are safe depends on how they are designed and operated" (ATSDR 2002).

Question D-4:

Did ATSDR consider findings from DOE's Lawrence Livermore National Laboratory (LLNL) suggesting that radioactive materials should never be incinerated?

Answer D-4:

During the same PHAWG meeting in March 2004, a community member noted that DOE had previously reported that radioactive materials should never be incinerated. ATSDR obtained a copy of the report that appeared to form the basis for this comment (DOE 1990). The report evaluated whether DOE should install and operate an incinerator at LLNL to treat mixed LLW. After considering many factors, the authors of the report did in fact conclude that a new incinerator should not be constructed. It is important to note that the authors did not conclude that mixed LLW should never be incinerated; rather, the conclusion was that this incineration did not need to take place at LLNL, in part because these wastes could be shipped to other DOE installations that already have permitted incinerators.

Overall, the report that ATSDR obtained suggests that whether incineration is an appropriate waste treatment technology ultimately needs to be decided on a case-by-case basis. As stated earlier, the purpose of this PHA is not to enter into the debate on the utility of incineration, but rather to assess the public health implications of environmental releases specifically from the TSCA Incinerator.

Question D-5:

Is the white smoke in the incineration emissions harmful?

Answer D-5:

A major by-product of incineration processes is water. Because the stack gases at the TSCA Incinerator are typically at least 170 degrees Fahrenheit, some of the water in the air emissions exists as vapor. Once these gases come into contact with cooler ambient air, some water vapor condenses and becomes steam, which is visible. Of course, the incinerator emissions include trace amounts of other contaminants, as Section III of this PHA describes. Still, a large volume of measured and modeled data indicate that residents are not exposed to these chemicals at levels expected to cause adverse health effects.

Question D-6:

If most TRV events are caused by power outages, how does DOE collect air samples during these events?

Answer D-6:

The TSCA Incinerator and the off-site ambient air monitoring networks draw from different power sources. As evidence of this, valid air samples have been collected at the off-site monitoring network during several of the TRV events that were caused by power outages.

VI. Health Outcome Data

Health outcome data, or measures of disease occurrence in a population, can provide information on the general health status of a community. ATSDR scientists evaluate health outcome data in PHAs typically for one of two reasons: 1) to evaluate the possible health effects in a population that is known to have been exposed to enough environmental contamination to experience health effects or 2) to help address community concerns about a particular illness in a community. As the previous sections of this PHA have explained, ATSDR has found no evidence of residents being exposed to the TSCA Incinerator's emissions at levels of health concern. ATSDR found, however, ample evidence of general community health concerns regarding the TSCA Incinerator.

Over the past few decades, government agencies, academic researchers, and other parties have completed several epidemiological studies to evaluate incineration facilities. While none of the studies focused specifically on the TSCA Incinerator, the studies do provide useful perspective on environmental health issues at incineration facilities. The following paragraphs summarize two extensive literature reviews of selected, peer-reviewed environmental health studies on incinerators and related facilities. Occupational health studies are not considered below, but Section V provides some information on occupational health concerns associated with incineration facilities.

Epidemiological studies show that well-designed and properly operated incinerators generally can destroy wastes without presenting a substantial health risk to nearby residential populations.

- **ATSDR's review of health outcome data.** Since its inception, ATSDR has conducted or funded six health studies that focused on environmental health concerns associated with incineration facilities in the United States. In 2002, ATSDR reviewed the findings of these studies (ATSDR 2002). With one exception, the studies found no association between residents' proximity to incinerators and any biomarkers of exposure or adverse health effects. The exception was a study that found residents near a former incineration facility had a higher prevalence of self-reported respiratory symptoms (though not a higher prevalence of physician-diagnosed respiratory disease) than did residents in the study's control population. ATSDR concluded that this incinerator, because it operated without any air pollution controls and had a record of extremely poor waste handling practices, was "…not representative of hazardous waste combustion facilities operating today" (ATSDR 2002). From all studies combined, ATSDR concluded that hazardous waste incineration could be done in a safe manner, depending largely on the incinerator design and operational details.

- **NRC's review of selected epidemiological studies.** In 2000, NRC published a review of selected epidemiological studies conducted around incineration facilities in the United States, the United Kingdom, France, Taiwan, and Australia (NRC 2000). NRC concluded that the epidemiological studies provide no evidence of an association between exposure to incinerator emissions and acute or chronic respiratory symptoms among exposed residential populations. NRC acknowledges, however, that the failure to detect effects might reflect methodological limitations of epidemiological studies, such as evaluating small study populations and not fully considering impacts from confounding factors. In its review of epidemiological studies and other issues pertaining to incineration facilities, NRC ultimately

concluded that "…a well-designed and properly operated incineration facility emits relatively small amounts of [air] pollutants, contributes little to ambient concentrations, and so is not expected to pose a substantial health risk" (NRC 2000).

In summary, no researchers have conducted epidemiological studies of residents who live in the vicinity of the TSCA Incinerator. However, ATSDR's environmental health evaluations presented earlier in this PHA strongly suggest that such a study is not warranted, given that residents are not exposed to site-related contaminants at levels of health concern. Further supporting this conclusion are health outcome data suggesting that well-designed and properly operated incinerators — such as the TSCA Incinerator — can destroy wastes in a safe manner without compromising the health of local residents.

VII. Children's Health Considerations

Because children often are at greater risk than adults of being exposed to toxic chemicals, and because 8% of the residential population within 3 miles of the TSCA Incinerator are children (age 6 year and under), ATSDR specifically considered children's health issues when preparing this PHA. Children are more likely than adults to suffer from adverse health effects due to environmental exposures for several reasons, such as:

- Children's developing bodies can be particularly sensitive to environmental exposures during certain critical growth stages, especially when children are exposed to contaminants known to cause developmental effects.
- Children weigh less than adults. Thus, when children and adults ingest or inhale the same amount of chemicals, children receive a greater dose than adults, on a pound of contaminant per pound of body weight basis.
- Because children often spend more time outdoors than do adults, children can be more likely to come into contact with contaminated soils and to inhale greater amounts of outdoor air pollution.

Throughout the PHA process, ATSDR considered these and other children's health issues. For instance, when selecting health-based comparison values for the exposure evaluation, ATSDR identified, when available, comparison values protective of children's exposure and of health conditions more common in children, like asthma. As one example, ATSDR used EPA's air quality standards to screen air contamination levels for lead, ozone, and particulate matter. EPA developed these standards to protect the health of sensitive populations, including children.

ATSDR identified one environmental health issue of particular concern to children for this site: elevated airborne levels of ozone and fine particulates. Many children who live near the TSCA Incinerator, just like children who live in numerous urban and suburban areas across the country, have a greater risk of suffering from ozone- and particulate-related adverse health effects than do adults.

Ozone and PM2.5 are general air quality issues for the Knoxville metropolitan area. This pollution is caused by numerous air emissions sources, both local and distant. Air emissions from the TSCA Incinerator appear to contribute little to the region's ozone and PM2.5 problems.

ATSDR's concern stems partly from the fact that ozone and PM2.5 levels are generally highest during the afternoon hours on sunny summer days, when most children are not in school and are likely to be playing outdoors. Another reason for concern is that people with asthma have been identified as a sensitive population for both ozone and PM2.5 exposure, and asthma is more prevalent among children than among adults (Mannino et al. 2002). Finally, children might not seek or understand information in important air quality forecasts. These factors are of concern because asthmatic children or children who engage in moderate to strenuous exercise (e.g., swimming and running) during poor air quality days are at risk for respiratory problems.

Fortunately, many resources are available to help prevent children from exposure to unhealthful levels of ozone and PM2.5. As noted earlier, TDEC issues air quality forecasts, and the local media usually broadcast them. Parents should encourage their children, especially asthmatic children, to play indoors on days when levels are predicted to be unhealthful. Further, EPA's Web site now includes a tremendous amount of information on ozone, PM2.5, and related air quality issues. Adults are encouraged to access this information, whether from their home computers or those at local libraries, at www.epa.gov/airnow. Additionally, EPA has recently launched a Web site that targets health-related air pollution information to children. The site, *Air Quality Index for Kids!*, is available in English and Spanish at www.epa.gov/airnow/aqikids.

VIII. Conclusions

ATSDR has reached the following conclusions regarding the TSCA Incinerator:

1. The TSCA Incinerator efficiently destroys organic wastes, and in so doing releases trace amounts of contaminants into the air. Nevertheless, an extremely large volume of high-quality environmental data, both measured and modeled, confirm that the amounts of contamination released during both routine and non-routine operations have not harmed local residents. Accordingly, **ATSDR classifies releases from the TSCA Incinerator as creating no apparent public health hazard.** This is the conclusion category ATSDR uses when environmental exposures are known to occur, but not at levels expected to be harmful.

2. Because of potentially unhealthful levels of ozone and fine particulate matter, general air quality in the Knoxville metropolitan area is sometimes poor. Such air quality problems are not, however, unique to Knoxville: they are found in many urban and suburban settings in the United States. The occasionally poor air quality does not result from a single source (e.g., the TSCA Incinerator), but rather results from industrial and motor vehicle emissions over a broad area. People exposed to the infrequently elevated ozone and fine particulate matter levels could experience adverse health effects, such as lung irritation, aggravated asthma conditions, and difficulty breathing. Health effects are expected to be most likely among sensitive populations, which include children, the elderly, and people with respiratory conditions.

3. TDEC's collection of air samples at existing DOE sampling locations provides an excellent opportunity to verify independently the quality of DOE's ambient air monitoring measurements for metals. While general trends from the two data sets are qualitatively similar, TDEC should independently verify the accuracy of DOE's measurements, whether through using more sensitive laboratory analytical methods or by other means (e.g., performing critical technical oversight of DOE's sampling and analytical procedures, sending a small number of "split samples" from DOE's filters to an independent laboratory).

4. The Public Health Action Plan (Section X) outlines completed, ongoing, and future actions that various agencies will take to evaluate environmental health issues related to this site.

IX. Recommendations

ATSDR recommends the following actions, either to provide greater confidence in this PHA's conclusions or to ensure that residents are not exposed to unhealthful levels of contaminants in the future. The recommendations are classified into two categories:

Public Health Recommendations

DOE, EPA, and TDEC should continue operating their routine ambient air monitoring networks at ETTP to measure metals and radionuclides — two groups of contaminants that the TSCA Incinerator does not destroy.

TDEC should continue to issue air quality warnings on days when ozone or fine particulate concentrations in the Knoxville metropolitan area are expected to reach potentially unhealthful levels.

Local residents should heed air quality warnings issued by TDEC, which typically encourage residents (especially children, the elderly, and those with respiratory conditions) to remain indoors and to avoid any moderate or strenuous exercise. It is especially important for parents to communicate these warnings to their children, who often either do not seek or do not understand information on air quality.

TDEC should independently verify the quality of DOE's ambient air monitoring data for metals. This can be done several ways, such as achieving lower detection limits in its metals monitoring network (particularly for arsenic, cadmium, and chromium), performing critical technical oversight of DOE's sampling and analytical procedures, or sending a small number of "split samples" from DOE's filters to an independent laboratory.

Recommendations to Help Improve Communications on Environmental Health Issues

Even though the TSCA Incinerator does not present a public health hazard, some community members remain very concerned about the site's air emissions. Providing the public with annual fact sheets summarizing environmental conditions at the TSCA Incinerator might help address these concerns. Accordingly, TDEC should issue annual fact sheets that document the environmental status of the TSCA Incinerator. The fact sheets should address issues such as inspection outcomes, regulatory compliance issues, and other important agency oversight activities.

After independently verifying the accuracy of DOE's ambient air monitoring data for metals, TDEC document its findings in its annual environmental monitoring reports. Any notable discrepancies should be documented and explained.

For purposes of transparency, both DOE and TDEC should improve the annual reporting on their environmental monitoring networks. Recommended improvements include identifying the specific sampling and analytical methods used, presenting the method detection limits, and better documenting data quality (e.g., completeness fractions, estimated measurement precision, and comments on measurement accuracy).

X. Public Health Action Plan

This Public Health Action Plan describes specific actions that have been taken, are scheduled to be taken, or should be taken by numerous parties, including ATSDR, DOE, EPA, and TDEC. The purpose of this plan is to document past public health activities and set priorities to ensure that ongoing operation of the TSCA Incinerator will not cause harmful human health effects to occur in the future. This plan addresses issues specific to the TSCA Incinerator — it does not consider the many other public health actions that pertain to the other ORR facilities.

Actions Completed

From 1991 to the present, DOE has completed several tests to measure emissions from the incinerator. ATSDR, an independent panel chartered by the Governor of Tennessee, and DOE have modeled how these emissions move through the air. DOE, EPA, and TDEC have conducted extensive ambient air monitoring to characterize the TSCA Incinerator's potential air quality impacts.

In June 1997, TDEC prepared a report titled *Responses to the 101 Questions from Citizens Presented to the Tennessee Department of Environment and Conservation*. The report addresses health, environmental, and operational concerns regarding the TSCA Incinerator.

In January 1998, an independent panel chartered by the Governor of Tennessee prepared a report that evaluated community health concerns related to the TSCA Incinerator.

In March 2004, ATSDR conducted a site tour of the TSCA Incinerator and presented preliminary information on this PHA to the Public Health Assessment Working Group.

Actions Ongoing

DOE, EPA, and TDEC continue to conduct ambient air monitoring near the TSCA Incinerator.

ORRHES continues to meet to provide a forum for communication and collaboration between citizens and the agencies that are conducting public health activities at ORR.

To fulfill permit renewal requirements, DOE has plans to prepare a human health risk assessment and ecological risk assessment of selected environmental releases from the TSCA Incinerator. Both risk assessments will be completed after environmental agencies approve DOE's written risk assessment plans.

Recommendations for Further Action

DOE, EPA, and TDEC should continue their routine ambient air monitoring for metals and radionuclides in the vicinity of the TSCA Incinerator.

TDEC should prepare annual fact sheets documenting the environmental status of the TSCA Incinerator. These fact sheets should address inspection outcomes, regulatory compliance issues, and other agency oversight activities. If requested, ATSDR will assist TDEC with preparing a

visually appealing fact sheet for the first year, which will then be usable as a template in the future.

TDEC should independently verify the accuracy of DOE's ambient air monitoring data for metals. Once this is done, TDEC should summarize its evaluation in future annual environmental monitoring reports.

TDEC should continue to issue air quality warnings on days when ozone or fine particulate concentrations in the Knoxville metropolitan area are expected to reach potentially unhealthful levels.

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Appendix A: Review of Air Emissions Studies

This appendix presents ATSDR's review of measured air emission rates from the TSCA Incinerator. To date, emissions data have been generated during trial burns, performance tests, and continuous monitoring and continuous sampling evaluations. The following discussion defines these different types of tests and reviews the emissions data that each test measured. Overall, the emissions data provide an extensive account of the TSCA Incinerator's air releases for many pollutants. With three exceptions, the data reviewed in this appendix strongly suggest that the incinerator routinely destroys organic compounds at the required efficiencies while not exceeding maximum emission rates for selected contaminants.

The three exceptions are instances in which measured emission rates did not meet existing regulatory requirements or requirements that regulatory agencies would later implement. First, *before routine operations began*, a performance test in 1988 using surrogate non-waste materials found that beryllium and lead emissions were higher than those to be included in TDEC's air permits. The elevated emissions, however, probably resulted from miscalculations of waste feed rates. A follow-up test and all future performance tests have shown that the actual beryllium and lead emissions are considerably lower than the maximum levels allowed. Second, a recent trial burn performed to demonstrate compliance with RCRA emission limits found a particulate emission rate slightly higher than the maximum levels allowed in the state permit. This finding is likely not representative of actual emission rates for two reasons: trial burns challenge incinerator performance under very unfavorable operating conditions, and particulate emission rates measured during several performance tests (which better represent actual operating conditions) fell well within the air permit limit. ATSDR is further comforted by the fact that the extremely large volume of ambient air monitoring data for particulate matter, beryllium, and lead have shown that these contaminants do not reach harmful levels at off-site locations (see Appendix C). Third, continuous emissions sampling data collected in 2000 and 2001 suggest that the combined amounts of cadmium and lead in stack gases did not always meet levels that EPA has since established in its technology-based standards. This statement is not intended to imply that the TSCA Incinerator failed to comply with the MACT standards, because those standards were not enacted until 2 years after the sampling occurred. Fortunately, considerable ambient air monitoring data are available to evaluate these contaminants further.

In Section III.B of this PHA, ATSDR briefly summarizes the emissions data presented in this appendix. Section III.E places the emissions data in context with the two other critical elements of the air exposure pathway (i.e., fate and transport and ambient air monitoring).

A.1. Trial Burns

State and federal environmental agencies require incineration facilities to perform trial burns to demonstrate compliance with regulatory requirements and to establish limits on operating conditions for permitting purposes. At a minimum, trial burns must be performed *before* hazardous waste incinerators begin routine operations; multiple trial burns may be required at some facilities, depending on the regulatory requirements and significant changes in the waste feeds. Trial burns are very extensive and expensive tests that challenge incinerators to achieve required destruction efficiencies and compliance with emission limits, all while the facility

operates under conditions unfavorable to complete combustion (e.g., high feed rates, low combustion temperatures, high stack flow rates).

Following is ATSDR's technical review of the trial burns that DOE has conducted at the TSCA Incinerator.6 Tables A-1 and A-2 summarize the main findings from the trial burns. Overall, the trial burns demonstrated that the TSCA Incinerator is capable of destroying organic material in waste streams, including PCBs, without creating hazardous residuals or unsafe air emissions.

May 1988 TSCA Trial Burn (Engineering-Science 1988a)

The first trial burn to evaluate the incinerator's efficiency at destroying PCBs was conducted in May 1988. The trial burn involved six individual tests, each of which lasted at least 6 hours. The tests evaluated two different types of feed:

The first type of waste was a mixture of liquid and solid wastes that included contaminated soil, capacitors, PCB oil, and aqueous waste. These wastes were fed to both the primary and secondary combustion chambers. During the three tests of this feed type, the primary combustion chamber's temperature was 1,800 degrees Fahrenheit, and the secondary combustion chamber's temperature was 2,200 degrees Fahrenheit.

The second type of waste was only solid material fed to the primary combustion chamber; these wastes included contaminated soil, shredded capacitors, and contaminated sludge. This waste was treated at lower temperatures: roughly 1,550 degrees Fahrenheit in the primary combustion chamber, and 1,850 degrees Fahrenheit in the secondary combustion chamber.

For both waste types, the average feed rate was 1,600 pounds per hour, which included approximately 250 pounds per hour of PCBs. Both state and federal officials observed the trial burn, which used well-established sampling and analytical methodologies for all measurements.

As Table A-1 shows, PCBs were measured in the stack gases to determine how efficiently the incinerator destroyed the waste material. In all six tests, PCBs were detected in the stack gases, but the detected amounts indicated that the incinerator's DRE was 99.99997% for both types of wastes. Thus, the trial burn demonstrated that the incinerator's DRE met the minimum requirement of TSCA regulations (99.9999%). Other key findings during the trial burn were that stack gas concentrations of particulate matter and hydrogen chloride removal efficiencies both fell well within limits later set in RCRA permits. Additionally, PCB concentrations in the process residuals met TSCA requirements: the ash generated during the tests contained less than 2 ppm PCBs, and the wastewater contained less than 3 ppb PCBs. After this trial burn EPA issued DOE a letter that approved use of the TSCA Incinerator to treat wastes containing PCBs (EPA 1989).

6 In addition to the "official" trial burns listed in this section, ATSDR also reviewed results of an initial performance test conducted in July 1987 (PEI/Metcalf and Eddy 1987). That performance test provided a preliminary evaluation of the TSCA Incinerator's ability to destroy organic compounds, including PCBs. The performance test included seven individual stack tests, all of which showed that the incinerator would likely meet the DRE requirements for both RCRA and TSCA without exceeding emissions limits for particulate matter or hydrogen chloride.

Table A-1. Summary of TSCA Trial Burn Data

Requirements	*Results from May 1988 TSCA Trial Burn*	*Results from May 2001 TSCA Trial Burn*
DRE for PCBs required to be at least 99.9999%	DRE = 99.99997%	DRE was >99.9999996%
PCB concentration in scrubber water blow-down must be less than 3 ppb	PCB concentration: <3 ppb	PCB concentration: <3 ppb (Highest level detected was 0.63 ppb)
PCB concentration in ash not to exceed 2 ppm	PCB concentration: < 2 ppm	PCB concentration: <2 ppm (Highest level detected was 0.017 ppm)
Other notable findings	The average particulate concentration in stack gases was 0.048 grains/dscf, which is lower than the RCRA permit requirement of 0.08 grains/dscf); the average emission rate of hydrogen chloride was 0.11 pounds/hour, which is lower than the RCRA permit requirement of 4.0 pounds/hour.	Dioxins and furans were not detected in the stack gases. Based on the detection limits used, the total stack gas concentration of dioxins and furans was <0.054 ng/dscm on a TEQ basis. This emission rate meets EPA's MACT emission rate limit of 0.2 ng/dscm on a TEQ basis.

Notes: Sources of data: Engineering-Science 1988a; TRC 2001.

The first three rows present the main TSCA requirements for the incinerator (i.e., the incinerator must be able to destroy PCBs, without generating hazardous residuals). The additional information provided summarizes additional observations reported in the trial burn reports that relate to regulatory requirements outside of TSCA.

Table A-2. Summary of RCRA Trial Burn Data

Parameter	*RCRA Requirement*	*Results from RCRA Trial Burns*		
		June 1988 Test	*June 1989 Test*	**May 2001 Test**
DRE for POHCs	>99.99%	POHC 1: 99.99976% POHC 2: 99.9997%	POHC 1: >99.9988% POHC 2: 99.998% POHC 3: >99.9974%	POHC 1: >99.999999% POHC 2: >99.999907%
Stack gas concentration of particulate matter	<0.08 grains/dscf	Average: 0.028 grains/dscf Maximum: 0.041 grains/dscf	Average: 0.0249 grains/dscf Maximum: 0.0327 grains/dscf	Average: 0.0455 grains/dscf Maximum: 0.064 grains/dscf
HCl emission rate	<4.0 lb/hour	Average: 0.13 lb/hour Maximum: 0.358 lb/hour	Average: 0.24 lb/hour Maximum: 0.32 lb/hour	Average: 0.07 lb/hour Maximum: 0.11 lb/hour
HCl removal efficiency	>99%	>99.9%	>99.912%	>99%

Notes: Sources of data: Engineering-Science 1988b; IT Corporation 1989; TRC 2001.
In the June 1988 test, the POHCs were (1) carbon tetrachloride and (2) trichlorofluoromethane. In the June 1989 test, the POHCs were (1) carbon tetrachloride, (2) trichlorofluoromethane, and (3) hexachloroethane. In the May 2001 test, the POHCs were (1) carbon tetrachloride and (2) 1,2,4-trichlorobenzene.
For HCl, RCRA regulations require operators of hazardous waste incinerators to demonstrate that either the HCl emission rate is less than 4 lb/hour or, in cases where emissions exceed this level, that HCl removal efficiencies are at least 99%.

June 1988 RCRA Trial Burn (Engineering-Science 1988b)

In June 1988, contractors to DOE conducted a trial burn to demonstrate that the TSCA Incinerator would comply with EPA's RCRA requirements. Specifically, the trial burn evaluated destruction efficiencies for two POHCs, stack gas concentrations of particulate matter, and emission rates of hydrogen chloride. The trial burn considered two different waste feeds, similar to those that would eventually be treated during routine operations. The first waste feed was a combination of contaminated soil, aqueous waste, and organic liquids. The second waste feed was only organic liquid. The POHCs selected for this trial burn were trichlorofluoromethane and carbon tetrachloride.

Table A-2 summarizes the results from this initial RCRA trial burn. In general, the incinerator's performance exceeded the minimum requirements EPA established for DREs of organics, stack gas concentrations of particulates, and emission rates of hydrogen chloride. While this testing strongly suggested that the TSCA Incinerator complied with RCRA requirements, an additional trial burn was conducted one year later. ATSDR has received two accounts for why this additional trial burn was required. By one account, the additional trial burn was conducted to better establish permitting limits on key operating conditions (e.g., combustion temperature, waste feed rates) before routine waste treatment operations began. By the other account, the additional trial bun was required after TDEC ruled the initial test report inconclusive (see Comment #11 in Appendix G). Regardless of which reason is correct, it is important to note that an additional trial burn was conducted before permitted operations could commence. The next item reviews the findings of the follow-up RCRA trial burn.

June 1989 RCRA Trial Burn Retest (IT Corporation 1989)

In June 1989, contractors to DOE conducted a trial burn at the TSCA Incinerator to demonstrate again compliance with EPA's RCRA requirements. The trial burn was designed to measure the destruction efficiency of organic materials, the concentration of particulates in stack gases, and the emission rate of hydrogen chloride. When conducting the trial burn, field personnel followed specifications outlined in a Tribal Burn Plan and a Quality Assurance Project Plan, both of which had multiple versions sent to EPA and TDEC for review and approval. The trial burn challenged incinerator performance by using the highest feed rates allowed (up to 3,000 pounds/hour of combined solid and liquid waste), minimum temperatures in the primary and secondary combustion chambers, and maximum gas flow rates through air pollution controls and the stack. Three POHCs — trichlrofluoromethane, carbon tetrachloride, and hexachloroethane — were selected to evaluate how efficiently the TSCA Incinerator destroys organic waste.

Over the 3-day test, three different stack tests were conducted for the operating parameters specified in the trial burn. These tests, both individually and combined, all showed that the TSCA Incinerator destroyed organic waste constituents without causing elevated emission rates for particulate matter or hydrogen chloride. Of the three POHCs selected, only trichlorofluoromethane was detected in the stack exhaust. These detections suggested that the DRE was at least 99.998%, which surpasses the minimum required DRE of 99.99%. Further, the highest particulate concentration in the stack gases was 0.0327 grains/dscf, which meets the permit restriction of particulate concentrations being no higher than 0.08 grains/dscf. Finally, the air pollution controls were found to remove at least 99.912% of the hydrogen chloride generated

during combustion, while the required removal efficiency is only 99%. In short, this trial burn found that the TSCA Incinerator met the main permit restrictions outlined in RCRA waste management regulations.

June 1997 RCRA Metals Trial Burn.

In 1997, TDEC published a report that included a list of historical stack testing activities at the TSCA Incinerator (TDEC 1997). That list mentions a "RCRA Metals Trial Burn" reportedly conducted in June 1997. After reviewing site documents, ATSDR determined this trial burn was actually a performance evaluation of continuous emissions monitoring technologies for metals. Refer to Appendix A.3 for ATSDR's review of the metals emissions data measured during this test.

May 2001 Joint RCRA/TSCA Trial Burn (TRC 2001)

In May 2001, DOE contractors conducted a trial burn to demonstrate compliance with applicable RCRA and TSCA hazardous waste incineration requirements. Another objective of this trial burn was to measure emission rates for use in risk assessments. All testing activities followed specifications in a trial burn plan that DOE contractors prepared and both EPA and TDEC approved. The trial burn lasted nearly 2 weeks, and representatives from both EPA and TDEC observed much of the stack testing.

The trial burn evaluated three different operating scenarios: a combined waste feed of solid wastes (863 pounds/hour) and liquid waste (2,000 pounds/hour), with the waste containing PCBs and other hazardous constituents; a combined waste feed of solid wastes (275 pounds/hour) and liquid wastes (1,070 pounds/hour) containing PCBs; and a feed of entirely liquid wastes (1,370 pounds/hour) containing metals. To ensure that results from individual tests were representative and not spurious, the DOE contractor ran four separate stack tests for each operating scenario. Therefore, the May 2001 trial burn included 12 separate stack tests, with the individual tests typically lasting at least 3 hours. All stack tests were conducted using standard sampling and laboratory analytical methods and according to procedures outlined in the Trial Burn Quality Assurance/Quality Control (QA/QC) Plan. Key findings for the trial burn follow:

Compliance with TSCA requirements

The trial burn found that the TSCA Incinerator destroyed at least 99.9999996% of the PCBs originally in the waste feed. This DRE far exceeds the level (99.9999%) required by TSCA. Also notable was that the total dioxin and furan emission rate was less than 0.054 ng/dscm, expressed on a TEQ basis, which is roughly a factor of four lower than 0.2 ng/dscm — the maximum emission rate EPA has proposed in its most recent regulations for hazardous waste incinerators. Moreover, PCB concentrations in the ash and wastewater residuals were below thresholds mandated by TSCA. Overall, these observations suggest that the TSCA Incinerator efficiently destroyed PCBs without creating hazardous air emissions or toxic residuals.

Compliance with RCRA requirements

To evaluate compliance with RCRA, the DOE contractors selected two POHCs (1,2,4-trichlorobenzene and carbon tetrachloride) for the trial burn. Because these contaminants rank

among the most difficult to incinerate, it can be inferred that the waste destruction efficiencies for most other organic compounds are at least as high as those observed for the POHCs. In all of the tests conducted, neither POHC was detected in the stack gases. Using the detection limits for these contaminants, the DRE was reported to be at least 99.9993%, far surpassing the minimum DRE (99.99%) that RCRA requires. The highest hydrogen chloride emission rate measured was 0.11 pounds/hour — nearly 40 times lower than the maximum level allowed by RCRA (4.0 pounds/hour).

Other emissions data (metals and organic compounds). Though designed to characterize compliance with the aforementioned TSCA and RCRA requirements, the 2001 trial burn also measured emission rates of many additional contaminants. For instance, the stack tests included 12 metals: antimony, arsenic, beryllium, mercury, selenium, silver, and thallium were not detected in any of the samples; barium, cadmium, chromium, lead, and nickel were detected. The lead levels measured were safely below the emission limits specified in the incinerator's operating permit. The lack of air permit emission limits for the other metals is not a data gap, as this PHA's conclusions for metals rest largely on the dispersion modeling data and ambient air monitoring data documented in Appendixes B and C, respectively.

DOE contractors also measured air emission rates for 42 VOCs and 20 PAHs. ATSDR's modeling analysis (see Appendix B.3) lists the measured emission rates for the chemicals that were detected and estimates ambient air quality impacts that might result from these emissions. Conclusions cannot be drawn from the emission rates alone; rather, the ambient air concentrations must be compared to health-based comparison values. Refer to Appendix B for this comparison.

Notice of violation for particulate emissions

During the trial burn, particulate concentrations and emission rates were measured under three operating scenarios. Although the particulate *concentrations* in the stack exhaust were safely below the maximum level allowed by RCRA (0.08 grains/dscf), the highest *emission rate* for one of the test conditions (3.7 pounds/hour) exceeded the TDEC air permit emission limit for the source (3.0 pounds/hour) by approximately 25%. As a result, TDEC issued DOE a Notice of Violation (TDEC 2003). It should be emphasized, however, that particulate matter emission rates observed during trial burns are expected to be higher than those during routine operations, given that trial burns are designed to challenge incinerators' operations under unfavorable conditions. Of particulate note, however, is that the waste feed rates routinely used at the incinerator tend to be considerably lower than those used during the trial burns. As a result, the particulate emission rates observed during the trial burns likely exceed those during routine operations. As evidence that the elevated particulate matter emission rates observed during the trial burn are not representative of typical conditions, the TSCA Incinerator has repeatedly complied with TDEC particulate matter emission limits in all performance tests (see Section A.2). Moreover, trends among the extremely extensive ambient air monitoring data for particulate matter (see Appendix C) weighed much more heavily in this site's evaluation, given that ambient air monitoring is a far better measure of the community's potential exposures.

A.2. Performance Tests

DOE and its contractors have conducted four performance tests to obtain and renew the TSCA Incinerator's operating permit with the state of Tennessee. This permit sets maximum emission rates for the following contaminants: particulates, sulfur dioxide, nitrogen oxides, hydrogen fluoride, hydrogen chloride, volatile organic compounds, lead, mercury, and beryllium (TDEC 1991). The permit requires DOE to conduct stack tests every 5 years, starting in 1990, to verify compliance with the permitted emission rates. It is important to note that waste feed rates and other operating parameters during performance tests tend to be more representative of actual operating conditions, while those in trial burns are usually set to challenge incinerator performance. Accordingly, air emissions measured during the performance tests are likely more representative of incinerator's typical emission rates.

ATSDR thoroughly reviewed results of the four performance tests that DOE has conducted to date (see Table A-3). In summary, although a single test conducted before permitted operations began found beryllium and lead emission rates higher than TDEC's emission limits, DOE has since completed three extensive performance tests that show that the TSCA Incinerator efficiently destroys hazardous waste without generating air emissions greater than maximum levels allowed by the state. The following paragraphs review the findings from the individual tests:

November 1988 Performance Test (Martin Marietta 1988)

The purpose of this performance test was to evaluate compliance with TDEC's permitted emission limits for beryllium, fluorine, and lead. DOE was not required to measure emission rates for particulates, chlorine, and sulfur, because the May 1988 trial burn (see Section A.1) had adequately demonstrated compliance for those pollutants. Stack sampling and analytical methods in this performance test followed those outlined in a "pre-test agreement." Representatives from both EPA and the Tennessee Department of Health and Environment observed the test.

The performance test included three separate stack tests, all of which were conducted on November 21, 1988. The test measured emissions for a combined feed of organic waste (contaminated with beryllium and fluorine), aqueous waste (contaminated with lead), and solid waste (contaminated with beryllium, fluorine, and lead). Table A-3 summarizes the test results, which found that fluorine emission rates complied with TDEC's limits but the beryllium and lead emission rates did not. According to DOE, failure to meet the anticipated permit limits might have resulted from miscalculated amounts of beryllium and lead in the waste feed, due to stratification of waste material in the feed tank. Regardless of the cause of the exceedance, DOE was not allowed to operate the TSCA Incinerator routinely until it demonstrated compliance with beryllium and lead emission limits. As the next item indicates, a performance test conducted in June 1990 showed that the TSCA Incinerator could adequately destroy wastes while not exceeding TDEC's emission limits.

Table A-3. Summary of TSCA Incinerator Performance Tests

Parameter	*TDEC Permitted Emissions Limit*	*Emission Rates Measured During Performance Tests*			
		November 1988 Test	*June 1990 Test*	*June 1995 Test*	*November 2000 Test*
Particulate	3.0 lb/hour	Not tested	Not tested	0.18 lb/hour	0.385 lb/hour
Beryllium	0.002 lb/day	*0.0348 lb/day*	< 0.00017 lb/day	0.00016 lb/day	0.0012 lb/day
Lead	3.15 lb/day	*4.61 lb/day*	0.048 lb/day	0.075 lb/day	0.13 lb/day
Mercury	0.48 lb/day	Not tested	Not tested	0.059 lb/day	0.0067 lb/day
Chlorine (as HCl)	3.68 lb/hour	Not tested	Not tested	0.009 lb/hour	0.214 lb/hour
Fluorine (as HF)	0.68 lb/hour	0.023 lb/hour	Not tested	0.002 lb/hour	0.054 lb/hour
Sulfur (as SO_2)	8.8 lb/hour	Not tested	Not tested	0.036 lb/hour	0.036 lb/hour
Summary:		In the November 1988 test, emission rates of beryllium and lead exceeded limits established by TDEC. The elevated emission rates apparently resulted from miscalculations in the waste feed (DOE 1991–2002). Routine operations at the TSCA Incinerator were not allowed until DOE could demonstrate compliance with TDEC requirements, as was done in the test on June 1990. All tests conducted since 1990 have also shown compliance with emission limits.			

Notes: Each performance test involved at least three separate emissions measurements for two different operating scenarios (i.e., liquid waste only and a combination of liquid and solid wastes). Average emission rates were calculated for each operating scenario. The data in the table are the higher of the two average emission rates.
In the November 1988 test, DOE was required to measure emissions of only beryllium, fluorine, and lead. TDEC did not require measurement of particulates, mercury, chlorine, or sulfur, because an earlier trial burn had adequately demonstrated compliance these permit requirements.
Emissions data in italics exceed TDEC emission limits.
The "TDEC Permitted Emissions Limits" shown in this table are those that were active at the time that ATSDR initially prepared this public health assessment. ATSDR has since learned that the permitted emission limits for some parameters have changed, largely to reflect application of Maximum Achievable Control Technology standards for pollutants with limits under that regulation. For instance, ATSDR has been informed that the permitted emission limit for beryllium is now 0.02 pounds per day, rather than 0.002 pounds per day (as shown in the table).

June 1990 Performance Test (IT Corporation 1990).

The purpose of this performance test was to demonstrate compliance with emission limits for beryllium and lead, because an earlier performance test (see previous bulleted item) suggested that the TSCA Incinerator did not meet these requirements. This 3-day performance test followed requirements in a detailed QA/QC Plan, which was approved by representatives from the Tennessee Department of Health and Environment (some of whom observed the stack testing).

The performance test considered waste streams, both liquid and solid, comparable to those considered in the test done in November 1988. Table A-3 summarizes this test's results. In short, beryllium was not detected in any of the stack gas samples, which indicated that the emission rate was less than 0.00017 pounds/day and the system removal efficiency was at least 99.4%. Lead, on the other hand, was detected in stack gases at levels suggesting an emission rate of 0.048 pounds/day — more than 50 times lower than the current permitted limit. The test found that 99.2% of lead in the input waste stream was removed, mostly into the ash. Having successfully demonstrated that beryllium and lead emissions comply with permitted limits, DOE was allowed to begin routine operations of the TSCA Incinerator in 1991.

June 1995 Performance Test (Martin Marietta 1995)

DOE contractors conducted the required performance test on 6 days, between June 26 and July 1, 1995. All testing followed a sampling plan that DOE submitted to TDEC for review and approval. A TDEC representative observed operations and sampling activities on several days of the performance test. All tests were performed using sampling and analytical methods published by EPA and following specifications of a Quality Assurance Project Plan. Multiple quality assurance measures were used, such as analyzing field blanks and method blanks, running laboratory control samples, and analyzing matrix spike samples. The laboratory successfully analyzed all samples collected during the program.

The performance test measured emission rates for two operating scenarios. The first involved only liquid wastes, which were processed, on average, at 888 pounds/hour. These wastes included organic waste, aqueous waste, caustic feed, and ash sump water. The second scenario involved a combined feed of liquid and solid wastes, with a total waste feed of 1,589 pounds/hour. As Table A-3 shows, all emission rates measured during the performance test were below the corresponding limits specified in the TDEC permits. During the tests, the air pollution controls were shown to be highly efficient, with system removal efficiencies in the range of 96% to over 99% for most contaminants (i.e., particulates, hydrogen chloride, sulfur dioxide, beryllium, and lead). As was expected, the system removal efficiency for mercury was near zero. For this reason, the TSCA Incinerator has strict Waste Acceptance Criteria for materials that contain mercury to ensure that emissions are safely below levels that would lead to unacceptable air quality impacts.

November 2000 Performance Test (IT Corporation 2001)

Between November 8 and November 13, 2000, DOE contractors conducted a required performance test to determine compliance with TDEC air emission limits. All sample collection and laboratory analyses involved standard methodologies documented in an Air Performance

Test Plan that DOE submitted to TDEC. Further, the field methods followed specifications in a detailed Quality Assurance Project Plan. The analytical data generated during the performance test appear to be of a known and high quality.

The performance test evaluated two scenarios using feed rates, combustion temperatures, and other parameters that are typical of routine operating conditions. The first scenario involved treating liquid wastes. The feed rates, on average, were 342 pounds/hour of organic waste and 312 pounds/hour of aqueous waste. The second scenario involved treating a combination of solid and liquid wastes, and the average feed rates were 235 pounds/hour of solid waste, 317 pounds/hour of organic waste, and 323 pounds/hour of aqueous waste.

Table A-3 lists the highest emission rates measured during the performance test for particulates, beryllium, lead, mercury, chlorine, fluorine, and sulfur. All emissions were safely below limits established in the TDEC permits. Not shown in Table A-3 are the system removal efficiencies that were observed during the tests. On average, the air pollution control devices removed particulate matter with an efficiency of 98.79% during liquid waste feeds and 99.52% during combined liquid and solid waste feeds. Removal efficiencies of similar magnitude were also observed for hydrogen chloride, beryllium, and lead. Conversely, the incinerator is rather inefficient at removing mercury, due to its high volatility. The mercury removal efficiency during liquid waste feeds is close to 0%; during combined liquid and solid waste feeds, a removal efficiency of 87.3% was observed. For this reason, the TSCA Incinerator has strict Waste Acceptance Criteria for materials that contain mercury.

A.3. Continuous Emissions Monitoring and Continuous Emissions Sampling

In addition to trial burns and performance tests, DOE conducts continuous monitoring and continuous sampling of the TSCA Incinerator's stack gases. "Continuous *monitoring*" refers to nearly instantaneous measurements of stack gas concentrations. Thus, these monitoring devices inform operators of emission rates in real time. "Continuous *sampling*" occurs in devices that continuously collect stack gases while the TSCA Incinerator operates, but, due to technological limitations, release amounts can only be measured at regular intervals (e.g., weekly or monthly), not instantaneously. The following paragraphs summarize results from DOE's continuous monitoring and continuous sampling efforts:

Carbon monoxide, carbon dioxide, and oxygen

Monitoring systems at the TSCA Incinerator continuously measure stack gas concentrations of carbon monoxide, carbon dioxide, and oxygen. Because these gases are relatively benign, certainly in comparison to hazardous air pollutants, this PHA does not evaluate the continuous emissions monitoring data for these compounds. Rather, these three parameters are measured primarily to monitor the incinerator's combustion efficiency and to trigger automatic waste feed cutoffs, as appropriate. Operational data indicate that approximately 30% of the automatic waste feed cutoffs in a recent year resulted from readings from carbon monoxide and oxygen concentrations being too high and too low, respectively (IT Corporation 2000). More details on this continuous monitoring follow:

Carbon monoxide

According to the RCRA permit, 1-hour average concentrations of carbon monoxide (corrected to 7% oxygen) must remain below 100 ppm, as higher levels would indicate poor combustion efficiency. Thus, automatic waste feed cutoffs occur whenever stack carbon monoxide levels exceed permitted limits.

Carbon dioxide

The relative amounts of carbon monoxide and carbon dioxide in the stack gas also characterize the combustion efficiency. Combustion is virtually complete when carbon dioxide levels in the stack are 1,000 times greater than carbon monoxide levels. An automatic waste feed cutoff occurs whenever this balance between carbon monoxide and carbon monoxide levels is not met.

Oxygen

Excess oxygen in the stack gas indicates that ample oxygen is available to support combustion in the rotary kiln and afterburner. Conversely, inadequate combustion might occur when limited oxygen is available in the combustion chambers. Therefore, DOE continuously measures oxygen levels in the stack gas. An automatic waste feed cutoff occurs whenever oxygen concentrations in the exhaust stack fall below 3% by volume.

Metals and particulate matter

Although environmental scientists have worked extensively in recent years to develop robust continuous monitoring technologies for metals and particulate matter, the state-of-the-science in this field continues to emerge. Over the last 5 years, DOE has tested the reliability of several candidate continuous emissions monitoring devices at the TSCA Incinerator, as discussed below:

Metals (other than mercury)

Although environmental regulations do not require DOE to implement continuous emissions monitors for metals at the TSCA Incinerator, DOE has investigated various methods for doing so. Most notably, in 1997, a field study was conducted at the TSCA Incinerator to evaluate the performance of three methodologies, two continuous monitoring devices and one continuous sampling device (Dunn et al. 1998). In the field test, DOE contractors compared emission rates measured by conventional EPA stack sampling techniques to emission rates measured by the candidate technologies. The study found that the two continuous emissions monitoring technologies did not meet the performance criteria for reliably measuring concentrations of metals. But the continuous sampling technology, which involved collecting 7-day average samples for subsequent laboratory analyses, met the performance criteria for several metals.

Because of this study, DOE eventually decided to implement continuous sampling of metals emissions for informational purposes at the TSCA Incinerator, and this system became operational in 1999. Particulate emissions are also obtained from the sampling device through gravimetric analysis of the particulate-bound filter. Annual data reports for this monitoring are currently available for calendar years 2000 and 2001 (DOE 2001, 2002). In these 2 years, stack

gas concentrations and emission rates for metals and particulate matter were reported for 52 intervals, most lasting 1 week. The lack of additional data results from incinerator downtime and maintenance to the monitoring equipment. The majority of measurements were collected during routine operations, with the exception of those collected during the May 2001 trial burn.

Table A-4 summarizes the continuous emissions sampling results collected during 2000 and 2001. Overall, these data show that emission rates of beryllium, lead, and mercury complied with TDEC permit limits in every sample that was analyzed. Similarly, every stack gas concentration of low volatile metals (arsenic, beryllium, and chromium) and all but one of the stack gas concentrations of particulates were below the corresponding "maximum achievable control technology" (MACT) standards that EPA had proposed at the time. On the other hand, in 8 out of the 48 valid samples collected outside the trial burn period, the stack gas concentration of semi-volatile metals (lead and cadmium) exceeded concentration limits that EPA would *later establish* in the technology-based MACT standard. This statement is not intended to imply that the incinerator operated out of compliance, especially considering that EPA enacted the MACT standards more than 2 years after these emissions data were collected. Readers should refer to Appendix C and Section III of the PHA for a more complete evaluation of the air quality issues for lead and cadmium, given that ambient air has been monitored for these metals in the vicinity of the TSCA Incinerator for more than 10 years.

Table A-4. Summary of Continuous Emissions Sampling Data for Metals and Particulate Matter Collected in 2000 and 2001

Parameter	***Regulatory Limit******	***Source of Regulatory Limit***	***Number of Measured Values Found Below Regulatory Limit (Maximum = 48)***
Beryllium	0.002 lb/day	TDEC permit	48 (or 100%)
Lead	3.15 lb/day	TDEC permit	48 (or 100%)
Mercury	0.48 lb/day	TDEC permit	48 (or 100%)
	130 µg/dscm	MACT	48 (or 100%)
Low volatile metals	97 µg/dscm	MACT	48 (or 100%)
Semi-volatile metals	240 µg/dscm	MACT	40 (or 83%)
Particulates	0.015 grains/dscf	MACT	47 (or 98%)

Notes: The regulatory limits in this table include both stack concentrations (i.e., those expressed in µg/dscm and grains/dscf) and emission rates (i.e., those expressed in lb/day).
Low-volatile metals include concentrations of arsenic, beryllium, and chromium.
Semi-volatile metals include concentrations of cadmium and lead.
Emissions data collected during the May 2001 trial burn are not included in this tally.
***The MACT limits represent "maximum achievable control technology" among hazardous waste incinerators. Thus, these values are technology-based and not necessarily health-based. Moreover, these standards came into effect on September 30, 2003 — more than 2 years after the air sampling results summarized above were collected. Comparisons to the MACT standards are presented merely to identify the metals that warrant closer inspection in the ambient air monitoring data.

Mercury.

The previous item summarizes continuous emissions sampling data available for particulate matter. In addition, DOE has recently completed an evaluation of six candidate continuous mercury emissions monitoring devices (Dunn et al. 2003). This evaluation involved two test conditions, in which measurements made using continuous emissions monitors were compared to those made with conventional EPA sampling methodologies. While some of the mercury monitoring devices showed great promise, only one met the accuracy criteria in the first test condition. Accordingly, Section III of this PHA draws from the continuous sampling data (as summarized in Table A-4), rather than the limited continuous monitoring data, to evaluate the TSCA Incinerator's mercury emissions.

Particulate matter

DOE has also recently evaluated the viability of three commercially available continuous emissions monitoring devices for metals and particulate matter (IT Corporation 2002). After characterizing the measurement accuracy and reliability of the three devices in a 15-month field study, DOE contractors recommended use of a particulate matter monitor in future continuous emissions monitoring applications. During a March 2004 site visit to the TSCA Incinerator, ATSDR scientists learned that DOE was preparing to install the continuous particulate monitor. ATSDR does not consider the lack of validated continuous emissions monitoring data for particulates to be a critical data gap for this PHA, given that numerous performance tests have been conducted to date (see Table A-3), that continuous emissions sampling data are available (see Table A-4), and that an extremely large volume of particulate ambient air monitoring data have been collected (see Appendix C).

Radionuclides

While continuous emissions monitoring data for radiounclides is clearly desirable, ATSDR is not aware of any technology that can provide such measurements accurately and precisely. On the other hand, continuous emissions sampling for radionunclides is not only feasible, but a required element in one of DOE's environmental permits for the TSCA Incinerator. Accordingly, from 1991 to the present, DOE has operated a continuous emissions sampling system on the TSCA Incinerator's main exhaust.

The system includes a filter sampling mechanism to collect particle-bound contaminants and impingers to collect gaseous contaminants. At the end of every week, DOE archives both sampling media. Then, at the end of every month, DOE composites the month's individual samples and sends this composite to a laboratory for analysis using appropriate methodologies. Annual emissions data are eventually reported in DOE's Annual Site Environmental Reports (DOE 1991–2002).

ATSDR reviewed the emissions data that DOE has collected over the entire time during which the TSCA Incinerator operated. Table A-5 lists the highest annual emission rates reported for the radionuclides that were detected most frequently. The modeling and monitoring studies reviewed in Appendixes B and C, respectively, document estimated radiation doses and measured ambient

air concentrations of radionuclides, which ATSDR used to reach conclusions regarding these contaminants.

Table A-5. Summary of Continuous Emissions Sampling Data for Selected Radionuclides

Radionuclide	*Highest Measured Annual Emission Rate (Ci)*
Cesium-137	0.0050
Neptunium-237	0.00081
Plutonium-238	0.00085
Plutonium-239	0.000050
Technetium-99	0.11
Thorium-228	0.0027
Thorium-230	0.00047
Thorium-232	0.00070
Thorium-234	0.047
Uranium-234	0.023
Uranium-235	0.00092
Uranium-238	0.036

Notes: Source of emission rate data: DOE 1991–2003. Data are presented for the radionuclides that were reported in at least 10 years of the TSCA Incinerator's operational history.

Appendix B: Review of Fate and Transport Modeling Studies

ATSDR views ambient air monitoring data and ambient air sampling data as critical inputs to the public health assessment process for air pathway evaluations. As evidence of this, ATSDR strongly recommends the use of validated sampling data, where available, as the basis for public health decisions. In some circumstances, however, air quality measurements are not sufficient to characterize all site-specific exposures. For instance, ambient air monitoring and ambient air sampling may not have been conducted over all time frames, at all locations of interest, or for all contaminants of concern. In such cases, air dispersion models are arguably the best tools available to evaluate the nature and extent of contamination. ATSDR emphasizes that models are only capable of *estimating* exposure concentrations, based on a scientific understanding of how contaminants move in the environment. All models have assumptions and uncertainties and may not accurately represent actual environmental or topographic conditions. Therefore, ATSDR carefully reviews all modeling applications to determine whether they provide meaningful estimates of environmental contamination and whether they can be used in the public health assessment process.

ATSDR identified two major air dispersion modeling studies for the TSCA Incinerator. The independent panel previously chartered by the Governor of Tennessee conducted one study (see Appendix B.1), and DOE conducted the other (see Appendix B.2). To supplement these studies, ATSDR performed an additional brief modeling evaluation that builds upon the independent panel's study (see Appendix B.3). Combined, all three modeling efforts estimate ambient air concentrations at ground level for all eight groups of contaminants that this PHA considers, thus leaving no major data gaps. It should be noted that dispersion modeling results have been documented in other studies (e.g., DOE's past trial burn plans). While this appendix focuses on the major studies identified above, ATSDR factored the findings from all available modeling studies into the conclusions of this PHA. Refer to Section III.E of this PHA for a discussion of how the air dispersion modeling results support ATSDR's overall environmental health conclusions for this site.

B.1. Independent Panel's Modeling Study (Iglar et al. 1998)

The independent panel chartered by the Governor of Tennessee to evaluate the TSCA Incinerator's air quality impacts conducted a dispersion modeling analysis of PCBs, particulate matter, acidic gases, selected metals, and selected VOCs. The study considered waste treatment data for calendar years 1994, 1995, and 1996 — three of the four years with the highest process throughputs at the TSCA Incinerator. Annual average air concentrations at ground level were estimated for the most toxic contaminants that were processed in greatest quantities. A detailed review of the modeling study follows:

Emissions estimation approach

Emission rates are arguably one of the most critical inputs to air dispersion models. For total PCBs, each metal, and each VOC, the independent panel estimated emission rates by multiplying an annual waste feed quantity and the estimated DRE. The waste feed rates used in these calculations were the highest contaminant-specific rates observed in calendar years 1994, 1995,

and 1996. The following DREs were used: 99.9999% for PCBs, between 95% and 98.5% for metals (except for mercury, which was assumed to have a DRE of 0%), and 99.99% for VOCs. ATSDR believes this calculation approach is sound, given that trial burns demonstrated that the TSCA Incinerator achieves the aforementioned efficiencies even under operating conditions that do not favor complete combustion. For particulate matter, the modeling analysis assumed an annual emission rate of 1.32 tons/year. No supporting data are provided for selecting this emission rate; however, the number appears to significantly overstate actual emissions, given that DOE reported particulate matter emission rates from the TSCA Incinerator to be no higher than 0.096 tons/year between 1994 and 1996 (DOE 1991–2002). Overall, ATSDR believes the independent panel used reasonable emissions data in the modeling analysis for the time frame under consideration.

Air dispersion modeling approach

The independent panel used the Industrial Source Complex Short Term (ISCST) model, version 3, to simulate how contaminants move from the TSCA Incinerator stack through the air to locations where people might be exposed. ISCST is listed among EPA's regulatory guideline models for evaluating emissions from industrial sources. Modeling options were generally consistent with regulatory defaults: building downwash effects were considered, deposition was not considered (causing the analysis to overstate potential air quality impacts), and urban dispersion coefficients were used to reflect the industrial nature of the ETTP site. ATSDR believes that all of these options, plus others not specified here, were appropriate for this modeling application.

The independent panel's modeling analysis was based on meteorological data collected at ETTP in 1989, 1991, 1992, 1994, and 1995. At the time the modeling analysis was conducted, these were the five most recent and complete years of meteorological data. Wind roses for these years are similar to the one depicted in Figure 6 of this PHA. The modeling analysis predicted the air quality impacts at hundreds of locations over an area that extends 3 miles in all directions from the TSCA Incinerator. Elevations at each of the receptors were programmed into the dispersion model to account for potential plume impaction at locations in elevated terrain. This approach is commonly referred to as assessing terrain effects using "flagpole receptors." While this approach may not be as rigorous as using dispersion models developed specifically for complex terrain applications, the approach does provide reasonable insights on the higher air quality impacts that might occur when plumes reach terrain features.

Readers interested in a detailed account of the modeling inputs should refer to pages 67 to 82 of the Independent Panel's summary report (Iglar et al. 1998), a copy of which should be available from the record repositories. Information on the ISCST model can be found in the User Manual (EPA 1995), also available at http://www.epa.gov/ttn/scram/userg/regmod/isc3v2.pdf.

Results

The independent panel's modeling analysis revealed several notable findings. Not surprisingly, the greatest air quality impacts were predicted to occur in the main downwind directions, both northeast and southwest of the TSCA Incinerator. The location with the highest estimated ground-level impacts was 640 meters (0.4 miles) southwest of the main stack. Results for the

point of maximum impact are reviewed here, even though this location is within the ETTP property line. The model predicted considerably lower ambient air concentrations at locations further downwind. At the point of maximum impact, the modeling found, the estimated annual average concentration is 1.75 $\mu g/m^3$ for every gram/second of contaminant emitted — a result that ATSDR incorporated into a separate modeling analysis (see Appendix B.3).

Table B-1 summarizes the independent panel's modeling results. Specifically, the table presents the estimated annual average concentrations at the point of maximum impact alongside health-based comparison values. With one exception, every estimated concentration was safely below the comparison values. For many contaminants, including all of the organic compounds, the estimated concentrations at the point of maximum impact are more than 1,000 times lower than health-based comparison values.

The estimated concentration of total chromium, however, exceeded the comparison value for hexavalent chromium. This is not an ideal comparison, given that the amounts of hexavalent chromium within the total chromium are not known. Nonetheless, ATSDR selected chromium as a contaminant of concern that requires a more detailed health evaluation, which is presented in Section IV of this PHA.

Limitations and uncertainties

Like all air quality modeling analyses, the independent panel's study has limitations and uncertainties. The entire study is, for example, based on waste treatment data for just 3 years. ATSDR does not view this as a critical limitation, given that the modeling considers years (1994–1996) when incinerator operations were near their highest. To ensure that focusing on this narrow time frame did not cause the modeling analysis to overlook key issues, ATSDR's modeling evaluation (see Appendix B.3) builds upon the independent panel's study by considering a longer time frame and a broader range of contaminants.

The independent panel's modeling analysis has multiple sources of uncertainty, due both to the inherent limitations of atmospheric dispersion models and the incomplete characterization of all inputs. ATSDR has, however, several reasons to believe that the independent panel's modeling analysis tends to overstate, and not understate, the actual exposure concentrations that residents have experienced. First, the independent panel calculated emissions based on the lowest allowed DREs, even though the trial burns have shown that the TSCA Incinerator is typically much more efficient. Second, the emissions data also are based on some of the highest waste feed rates (1994–1996). For comparison, total annual waste feed rates in the past 3 years have been approximately 4 times lower than those observed in the mid-1990s. Finally, the conclusions of the modeling study are based on estimated concentrations for an on-site location. Estimated concentrations at off-site locations were considerably lower than the levels shown in Table B-1. Taken together, these observations suggest that the modeling may have overstated actual exposures. ATSDR is further comforted by the fact that most of the estimated concentrations in Table B-1 are multiple orders of magnitude lower than health-based comparison values. That the modeling analysis understated exposures by such large margins is extremely unlikely.

Overall, ATSDR finds the independent panel's modeling analysis to be a reasonable account of the TSCA Incinerator's air quality impacts between 1994 and 1996. ATSDR concurs with the

independent panel's conclusion that none of the pollutants evaluated had estimated ambient air concentrations at levels of public health concern.

Table B-1. Evaluation of Independent Panel's Air Dispersion Modeling Results

Contaminant	*Estimated Annual Average Concentration ($\mu g/m^3$) at Point of Maximum Impact*	*Health-Based Comparison Value ($\mu g/m^3$)*	*Type of Comparison Value*
Modeling results for metals			
Antimony	0.00222	1.5	RBC-N
Arsenic	0.000148	0.0002	CREG
Barium	0.00104	0.51	RBC-N
Beryllium	0.000001	0.0004	CREG
Cadmium	0.000129	0.0006	CREG
Chromium (total)	0.000153	0.00008	CREG (see notes)
Lead	0.000333	1.5	NAAQS
Mercury	0.000215	0.2	EMEG-chronic
Nickel	0.00107	0.09	EMEG-chronic
Silver	0.000014	18	RBC-N
Thallium	0.000012	0.26	RBC-N
Modeling results for particulate matter			
Particulate matter	0.067	50	NAAQS
Modeling results for organic compounds			
Acetone	0.000027	31,000	EMEG-chronic
Acetonitrile	0.000009	60	RfC
Acrolein	0.000009	0.02	RfC
Acrylonitrile	0.000009	0.01	CREG
Benzene	0.000001	0.1	CREG
Carbon tetrachloride	0.000025	0.07	CREG
Chloroform	0.000004	0.04	CREG
Hexachloroethane	0.000005	0.3	CREG
Methylene chloride	0.000031	3	CREG
PCBs	0.000003	0.01	CREG
Tetrachloroethylene	0.000158	270	EMEG-chronic
Toluene	0.000021	300	EMEG-chronic
Trichloroethylene	0.000091	540	EMEG-intermediate
Xylenes	0.000018	0.1	RfC
Modeling results for radionuclides			
Uranium (total)	0.002	0.017	See notes below

Notes: Modeling results taken from the independent panel's report (Iglar et al. 1998).
Refer to Appendix D for more information on the comparison values used and definitions for the abbreviations. The comparison value for uranium is the exposure concentration that would result in an annual radiation dose of 10 mrem, assuming that all of the uranium found is uranium-238 (Iglar et al. 1998).
Chromium is the only contaminant with an estimated concentration greater than its comparison value. The estimated concentration is for total chromium and the comparison value is for hexavalent chromium, which is a subset of total chromium. Section IV of the PHA discusses this issue further.

B.2. DOE's Modeling for NESHAPs (DOE 1997–2002, 1991–2002)

EPA's National Emissions Standards for Hazardous Air Pollutants (NESHAPs) require selected facilities to demonstrate that their air emissions of radionuclides do not cause members of the public to have effective dose equivalents greater than 10 mrem/year. To fulfill its regulatory requirements, DOE characterizes air emissions of radionuclides across all its facilities and uses models to estimate radiation doses that might result. Findings are documented in annual reports that DOE submits to EPA (DOE 1997–2002). The following paragraphs review the scope and findings of the modeling analyses conducted at ORR:

Emissions estimation approach

The NESHAP modeling evaluates radionuclide emissions from selected stack sources at all three major ORR facilities: ETTP, Y-12, and Oak Ridge National Laboratory (ORNL). Included in this modeling are radionuclide emissions data from the TSCA Incinerator, as derived from the continuous emissions sampling system (see Appendix A.3). Thus, the NESHAP air dispersion modeling efforts are based primarily on measured emissions data, not on estimated emissions data. DOE did estimate radionuclide releases that occurred during TRV openings. Therefore, the modeled air quality impacts consider contributions from both non-routine releases through the TRV and routine releases through the main process stack.

Air dispersion modeling approach

Air dispersion and dose modeling was conducted using EPA's Clean Air Assessment (CAP-88) software, which is a set of computer programs designed to estimate dose and risk from air emissions of radionuclides. The main inputs to the model are source-specific emission rates and local meteorological data, from which the model estimates environmental concentrations of radionuclides. The model assesses both external and internal radiation exposure, not only from inhaling and otherwise contacting airborne radionuclides but also from ingesting radionuclides that might be taken up into the food chain. DOE runs the model using typical default parameters and assumptions, some of which likely overstate potential exposures. For instance, the modeling analysis assumes that 70% of the vegetables and 44% of the meat in residents' diets come from local farms. More information on the CAP-88 model can be found from an EPA website describing the model (http://www.epa.gov/radiation/assessment/CAP88/) or in the model User Guide (Trinity Engineering Associates 2002).

Results

DOE has conducted radionuclide modeling for every year that the TSCA Incinerator has operated. Table B-2 summarizes the main findings from these modeling analyses and shows that the estimated effective dose equivalent to the off-site maximally exposed individual has been no more than 1.7 mrem/year from 1991 to 2002. This dose equivalent reflects contributions from all radionuclide emissions sources at ORR, not just the TSCA Incinerator. The estimated effective dose equivalent resulting from ORR operations (<1.7 mrem/year) not only complies with NESHAP requirements, but also amounts to less than 1% of the radiation dose that U.S. citizens receive, on average, from natural sources.

Table B-2 also identifies which radionuclides accounted for the majority of off-site radiation exposures. Between 1991 and 2002, uranium isotopes accounted for approximately 80% of the off-site radiation exposures attributed specifically to the TSCA Incinerator. The remaining incinerator-related doses resulted primarily from exposures to tritium and isotopes of neptunium, plutonium, potassium, technetium, and thorium.

Limitations and uncertainties

DOE's radionuclide modeling for the NESHAP regulations has inherent uncertainties and limitations. The significance of the modeling uncertainties on ATSDR's public health evaluation is, however, limited because an extremely large set of validated ambient air monitoring data are available to support the modeling predictions. As Section III.E of this PHA explains, ATSDR's conclusions for the TSCA Incinerator are based on the combined findings of emissions studies, fate and transport modeling analyses, and ambient air monitoring data — all three of which are reasonably consistent in suggesting that the incinerator's emissions of radionuclides do not cause unhealthful environmental exposures among nearby residents.

In summary, DOE's annual modeling studies for radionuclides suggest that air emissions from the TSCA Incinerator (and, more generally, from all of the ORR facilities) have consistently complied with the health-protective NESHAP regulations. These studies are notable in that they evaluate environmental contamination for radionuclides, a group of contaminants that the other modeling studies did not consider in detail. ATSDR believes DOE's modeling studies, combined with the extensive ambient air monitoring results, provide an adequate basis for public health conclusions about exposures to radionuclides from the TSCA Incinerator.

Table B-2. Results of DOE's Modeling of Radionuclide Emissions

Year	*Estimated Effective Dose Equivalent to the Off-site Maximally Exposed Individual (Regulatory Limit = 10 mrem/year)*	*Radionuclides that Account for the Majority of the Effective Dose Equivalent Associated with ETTP Releases*
1991	1.7 mrem/year	Uranium (75%), thorium (17%), and neptunium (7%)
1992	1.4 mrem/year	Uranium (89%), thorium (7%), and plutonium (3%)
1993	1.4 mrem/year	Uranium (77%), neptunium (10%), and thorium (8%)
1994	1.7 mrem/year	Uranium (80%), neptunium (9%), and thorium (6%)
1995	0.5 mrem/year	Uranium (93%), potassium (6%), and technetium (1%)
1996	0.45 mrem/year	Uranium (95%), thorium (2%), and plutonium (1%)
1997	0.41 mrem/year	Uranium (87%), thorium (9%), and plutonium (1%)
1998	0.73 mrem/year	Uranium (74%), thorium (9%), and plutonium (2%)
1999	0.7 mrem/year	Tritium (50%), uranium (36%), thorium (12%), and plutonium (2%)
2000	0.4 mrem/year	Uranium (93%), thorium (6%), and tritium (1%)
2001	0.78 mrem/year	Uranium (72%), tritium (14%), and thorium (13%)
2002	0.29 mrem/year	Uranium (90%), thorium (5%), tritium (2%), and plutonium (2%)

Notes: Source of data: DOE 1991–2002.
The estimated effective dose equivalents were calculated from air emissions of radionuclides from point sources at all three main ORR facilities (ETTP, ORNL, and Y-12), not just from the TSCA Incinerator. Each dose in the table is for the residential location most impacted by releases from the ORR facilities.
The NESHAP regulations require industrial facilities' incremental increase to off-site radiation doses to be no more than 10 mrem/year. On average, United States residents receive a dose of 300 mrem/year from natural sources of radiation.

B.3. ATSDR's Modeling Evaluation

ATSDR conducted a separate air dispersion modeling evaluation that addresses two key limitations in the independent panel's analysis: ATSDR's evaluation considers a broader range of air contaminants and is based on waste treatment data for the entire history of the TSCA Incinerator's operation, not just the data available at the time the independent panel evaluated the site. ATSDR estimated ambient air concentrations by multiplying an emission rate (either measured or estimated, as described below) by the dispersion factor that the independent panel derived. That factor indicates that, at the point of maximum impact, the estimated ambient air concentration is 1.75 $\mu g/m^3$ for every gram per second of contaminant emitted. Because the point of maximum impact is actually within the ETTP property boundary, use of this dispersion factor very likely overstates exposure concentrations that off-site residents might have experienced. Thus, use of the dispersion factor should be considered a health-protective approach, in that ATSDR has chosen to err on the side of overestimating exposure concentrations.

ATSDR's modeling evaluation applies a single dispersion factor to all groups of contaminants considered. This single dispersion factor was derived assuming that all emitted contaminants

remain airborne and are not consumed by chemical reactions or removed from the plume by wet or dry deposition. By not accounting for these removal mechanisms, the dispersion factor actually overstates the amount of contaminants that remain in the air. Therefore, ATSDR's approach of applying this single dispersion factor to all groups of contaminants likely overstates actual air quality impacts. Furthermore, the dispersion behavior of gaseous pollutants in the ISC model is almost entirely driven by meteorological conditions, not physical or chemical parameters of the individual pollutants.

ATSDR's modeling analysis focuses on five groups of contaminants: VOCs, PCBs, PAHs, acidic gases, and dioxins and furans. These groups were selected because they have relatively few, if any, ambient air monitoring data available. ATSDR did not consider air emissions for the remaining three groups of contaminants (i.e., particulate matter, radionuclides, and metals), because an extremely large volume of information — emissions data, modeling results from the Independent Panel, and air sampling and monitoring data — already suggest that even the highest air quality impacts from the TSCA Incinerator are below levels of health concern. Thus, ATSDR decided to allocate its resources on the groups of pollutants for which notable information gaps remained, after careful consideration of all other data sources. Following are detailed descriptions of the contaminant-specific modeling approaches and results:

VOCs and PCBs

The independent panel's modeling results for VOCs and PCBs are based on the amounts of these contaminants found in the waste feed between 1994 and 1996. ATSDR built upon these findings by considering waste treatment quantities reported through 2003. For PCBs and every VOC listed in Table B-1, the highest annual waste treatment quantity actually occurred between 1994 and 1996. One can infer from this trend that the air quality impacts for PCBs and VOCs between 1997 and the present have not exceeded the estimated concentrations shown in Table B-1, assuming that the TSCA Incinerator continues to meet the required DREs.

To build further upon the independent panel's modeling analysis, ATSDR considered potential air quality impacts for a much broader range of VOCs. In addition to considering the 13 VOCs shown in Table B-1, DOE now characterizes waste treatment quantities for more than 150 other organic compounds, mostly volatile. After reviewing the entire history of VOCs and other organic compounds fed to the incinerator, ATSDR found that the maximum annual waste feed for all compounds (except for those shown in Table B-1) was less than 10,000 pounds per year. Using this waste feed rate, an assumed DRE of 99.99%, and the dispersion factor, the annual average concentration at the point of maximum impact for all other VOCs likely does not exceed 0.00003 $\mu g/m^3$. This annual average concentration is well below corresponding health-based comparison values for the many other VOCs that the incinerator treats. Although published comparison values are not available for all VOCs, ATSDR is reassured by the fact that the estimated annual average concentration is almost immeasurably small at the point of maximum impact; in residential areas, the TSCA Incinerator's air quality impacts for VOCs are undoubtedly lower.

PAHs

In the 2001 trial burn, DOE measured air emission rates of PAHs during six different stack tests. Three of these six tests were performed using waste feeds composed entirely of liquid wastes, in quantities that averaged 1,370 pounds/hour. The other three tests were conducted with a combined waste feed of solid wastes (average feed rate of 863 pounds/hour) and liquid wastes (average feed rate of 2,000 pounds/hour). Emission rates were measured for 20 individual PAHs, from which DOE calculated emission rates for total PAHs. Across all six tests, the highest emission rate for total PAHs was 0.00000312 grams/second.

Using the highest measured emissions rate and the independent panel's dispersion factor, ATSDR calculated a maximum annual average concentration of total PAHs to be 0.000005 $\mu g/m^3$. Even if one assumes that the total PAHs are composed entirely of the most potent individual compound, the estimated concentration is more than 150 times lower than the corresponding risk-based concentration.

Acidic gases

The independent panel's modeling analysis estimated air emissions of hydrogen chloride and hydrogen fluoride from the amounts of chlorine and fluorine in the waste feed and an assumed removal efficiency of the air pollution control devices. While such an approach is reasonable, ATSDR built upon it by evaluating air quality impacts for these compounds using measured emission rates. Specifically, among all performance tests and trial burns (see Appendix A) conducted to date, the maximum measured emission rates for hydrogen chloride and hydrogen fluoride are 0.214 pounds/hour and 0.054 pounds/hour, respectively. Given these emission rates and the independent panel's dispersion factor, the estimated annual average concentrations of hydrogen chloride and hydrogen fluoride at the point of maximum impact are 0.047 $\mu g/m^3$ and 0.012 $\mu g/m^3$, respectively. Both of these estimated concentrations are more than 400 times lower than the chemicals' lowest health-based comparison values.

Dioxins and furans

Neither modeling study reviewed above evaluated potential air quality impacts of dioxins and furans. To fill this data gap, ATSDR considered the dioxin and furan emissions data recently measured during the 2001 trial burn. Like the PAHs, dioxins and furans were measured in six separate stack tests over the course of the trial burn. During three tests, the incinerator was treating liquid wastes; during the other three tests, the incinerator treated a combination of liquid and solid wastes. Across all six tests, the highest total emission rate of dioxins and furans was 0.214 ng/second, expressed on a toxic equivalency (TEQ) basis.7 This emission rate is the sum of emissions of all dioxin and furan congeners. In cases where congeners were not detected, the detection limit was used in the emission rate calculation, which is an approach taken to be health-protective.

7 The TEQ basis allows for evaluating mixtures of numerous dioxin and furan congeners using a single exposure concentration. Rather than evaluating the health implications of each congener individually, one can compute a TEQ concentration that characterizes the toxicity of the entire mixture. TEQs are calculated by weighing the individual dioxin and furan congeners by toxic equivalency factors (TEFs). The most toxic congener (2,3,7,8-tetrachlodibenzo-p-dioxin) is assigned a TEF of 1, and all other congeners have lower factors.

Multiplying the emission rate by the independent panel's dispersion factor and assuming that the TSCA Incinerator routinely operates under conditions similar to those used during the trial burn, ATSDR estimates that the annual average concentration of total dioxins and furans at the point of maximum impact is 3.75×10^{-10} μg/m^3 on a TEQ basis. Besides being immeasurably small, this estimated concentration is more than 100 times lower than the risk-based concentration for the most toxic dioxin congener. Moreover, calculations based on proposed EPA methodologies (EPA 1998) and the estimated concentrations suggest that dioxins and furans released by the TSCA Incinerator present theoretical cancer risks of approximately 1 in 100,000,000 — far below levels that typically cause environmental regulatory agencies to take action.

Limitations and uncertainties

ATSDR's modeling evaluation builds upon the modeling conducted by the independent panel by considering measured emissions data and waste treatment amounts over the entire history of the TSCA Incinerator operations. While this analysis is therefore more extensive than the early modeling efforts, ATSDR's modeling evaluation has limitations and uncertainties. For instance, ATSDR's evaluation considers only routine releases through the main process stack, without considering contributions from TRV openings. This is a notable limitation, but one that is accounted for by the ambient air sampling that has occurred during these events (see Section III.D.2). Further, emissions data used in ATSDR's modeling are collected during discrete tests and might not represent emissions trends over the long term. Still, most emissions data used in the modeling were collected during trial burns, which typically challenge incinerator performance and lead to higher emissions than might be observed otherwise. Further, when using trial burn data, ATSDR always selected the highest measured emission rate across all individual stack tests, rather than selecting the average emission rate. This approach, which likely overstates the incinerator's potential air quality impacts, was taken to make the modeling analysis more protective of public health.

While none of the previous observations quantify the impact of uncertainty in the modeling analysis, ATSDR notes that the estimated ambient air concentrations for acidic gases, PAHs, dioxins, and furans are all at least 100 times lower than levels that might warrant more detailed evaluations. Thus, even if measured emission rates understate actual releases, perhaps by a factor of 100, estimated ambient air concentrations for these contaminants would still be lower than the most conservative health-based comparison values. ATSDR has no reason to believe that the emissions data would be this inaccurate. Therefore, the considerable margin between the estimated ambient air concentrations and their corresponding health-based comparison values gives ATSDR greater confidence that the modeling results form an adequate basis for reaching conclusions.

The purpose of ATSDR's modeling analysis was to account for limitations in the independent panel's modeling study. Section III.C of this PHA brings together the conclusions from all three modeling studies reviewed in this appendix, and Section III.E integrates the modeling results with findings from the emissions data and ambient air monitoring data.

Appendix C: Review of Ambient Air Monitoring and Ambient Air Sampling Studies

Ambient air monitoring data and ambient air sampling data are measurements of the levels of air contamination that people might actually breathe. These are critical elements of this PHA, because they are direct measures of exposure point concentrations and do not involve the inherent uncertainties of modeling studies. ATSDR invested considerable effort in obtaining all ambient air monitoring data and ambient air sampling data that might be relevant to air quality issues associated with the TSCA Incinerator.

The main difference between ambient air monitoring and ambient air sampling is that "ambient air *monitoring*" typically implies periodic measurement of air contamination levels, such as measurements being made once per week; "ambient air *sampling*," on the other hand, generally refers to air quality measurements of discrete events, such as a TRV opening. Therefore, *monitoring* data are most useful for characterizing routine releases from a source, while *sampling* data are most useful for evaluating non-routine or episodic releases.

This appendix presents ATSDR's review of all relevant ambient air sampling studies identified for the TSCA Incinerator. The reviews present key information on the studies, such as number and locations of sampling stations, sampling frequencies, number of samples collected, pollutants measured, and comparisons of measured concentrations to health-based comparison values. Sections III.D and III.E of this PHA indicate how ATSDR interpreted the ambient air monitoring and ambient air sampling data when reaching conclusions for this site.

Note: Throughout this appendix, the units of measurement shown are the same as those reported in the original studies. In the main body of this PHA, ATSDR converts readings for the same parameters into a single set of units to allow better comparison across studies.

C.1. DOE Data (DOE 1991–2002)

For several decades, DOE has operated a routine environmental surveillance program at ORR. This program has been fully functional the entire time that the TSCA Incinerator has processed wastes. DOE's ambient air monitoring and ambient air sampling follow general procedures specified in the ORR site-wide environmental monitoring plan (DOE 2003c), which outlines extensive quality assurance and quality control procedures. Much of DOE's sampling activities are conducted under TDEC oversight (see Appendix C.3).

The scope of DOE's monitoring efforts has changed over the years. For instance, many changes occurred in 1992, when DOE conducted a systematic review of the monitoring locations, siting requirements, quality assurance measures, and standard operating procedures. Deficiencies identified during this review were promptly corrected. While some contaminants have been removed from the monitoring program over the years (typically after multiple years of data demonstrate that contamination levels are safely below levels of public health concern), other contaminants have been added to the program.

ATSDR's review of DOE's routine monitoring and sampling results follow, organized by groups of contaminants. Refer to Section III.D.2 for a summary of DOE's air quality measurements made during TRV events.

Particulate matter

From 1991 to 2000, DOE routinely monitored ambient air concentrations of two size fractions of particulate matter: PM10 and TSP. All measurements were made using EPA reference method devices that have been shown to measure particulate matter concentrations both accurately and precisely. With few exceptions, the monitoring involved collection of 24-hour integrated samples every 6 days. Such a schedule, which ensures that sampling results will be available for all 7 days of the week, is widely used for particulate matter monitoring applications. Data trends for both sets of measurements follow.

From 1991 to 1995, DOE measured TSP concentrations at seven different monitoring stations. Figure C-1 shows the locations of these stations, and Table C-1 reviews the monitoring results. As the figure indicates, monitoring occurred at locations surrounding the incinerator, including at locations where modeling results predicted elevated ground-level impacts would occur. Over this 5-year time frame, DOE collected more than 1,200 valid TSP samples. The data summary in Table C-1 shows that none of the measurements, individually or averaged over a year, exceeded EPA's health-based standards for TSP.

Starting in 1991, DOE included PM10 monitoring as part of its routine environmental surveillance network. Figure C-2 shows where DOE installed three PM10 monitoring stations between 1991 and 2000, and Table C-1 summarizes the measurement results. To date, DOE has collected more than 775 samples from these three stations, not one of which has exceeded EPA's health-based air quality standard. Further, the annual average concentrations of PM10 have all been below EPA's corresponding annual average standard.

Overall, more than 2,000 particulate matter samples have been collected at or near ETTP since the TSCA Incinerator began operating, and every measured concentration has been well below corresponding health-based air quality standards. Further, the particulate matter levels detected at these stations are little different from the nationwide average levels that EPA has recently reported (EPA 2003). With 10 years of monitoring data showing particulate matter levels below levels of health concern, DOE stopped conducting these measurements at the end of calendar year 2000.

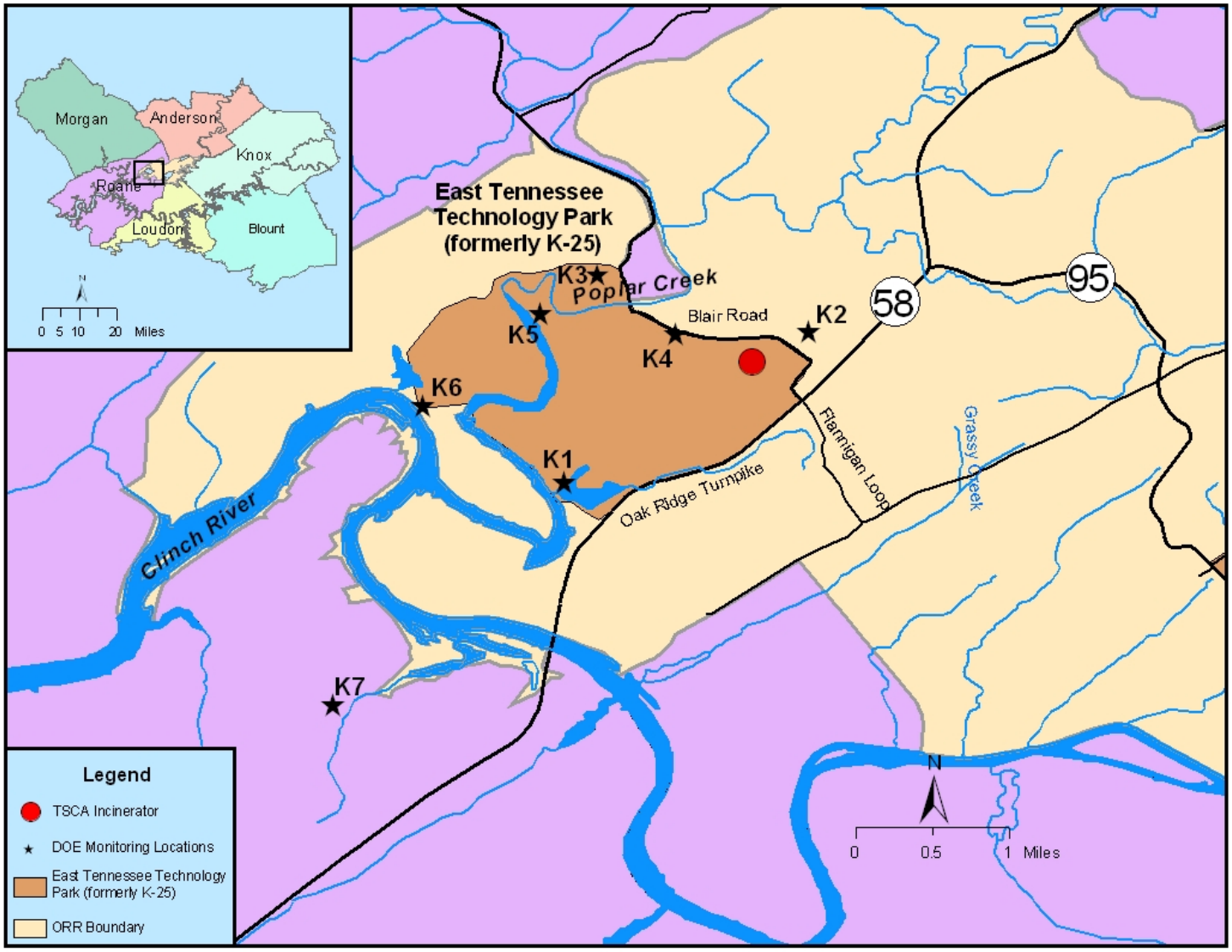

Figure C-1. DOE's TSP Monitoring Locations

Table C-1. DOE's Monitoring Data for Particulate Matter (1991–2000)

Station	*Years of Operation*	*Number of Samples*	*Highest Annual Average Concentration ($\mu g/m^3$)*	*EPA's Annual NAAQS*	*Highest 24-Hour Average Concentration ($\mu g/m^3$)*	*EPA's 24-Hour NAAQS*
Monitoring results for TSP						
K1	1991–1995	>229	27.6		88.4	
K2	1991–1995	>225	24.3		106.5	
K3	1991–1995	>227	26.4		86.4	
K4	1991–1995	>222	34.7	75 µg/m^3	157.5	260 µg/m^3
K5	1991–1995	>222	32.4		93.8	
K6	1994–1995	59	25.2		71.9	
K7	1995	37	47.7		99.4	
Monitoring results for PM10						
K2	1999–2000	117	23.2		69.9	
K4	1991–1998	>378	24.3	50 µg/m^3	89.6	150 µg/m^3
K6	1996–2000	278	21.4		60.2	

Notes: Source of data: DOE 1991–2002.
The numbers of samples for every station were taken from DOE's annual site environmental reports. However, the 1993 report did not specify the numbers of samples that were collected that year. Therefore, the exact number of samples for stations that operated during 1993 is not known.
The table presents EPA's former health-based standards for TSP. The annual TSP standard was actually based on an annual geometric mean concentration, not an annual average (or arithmetic mean). This distinction has no bearing on the conclusion, given the substantial difference between the measured concentrations and the standard.

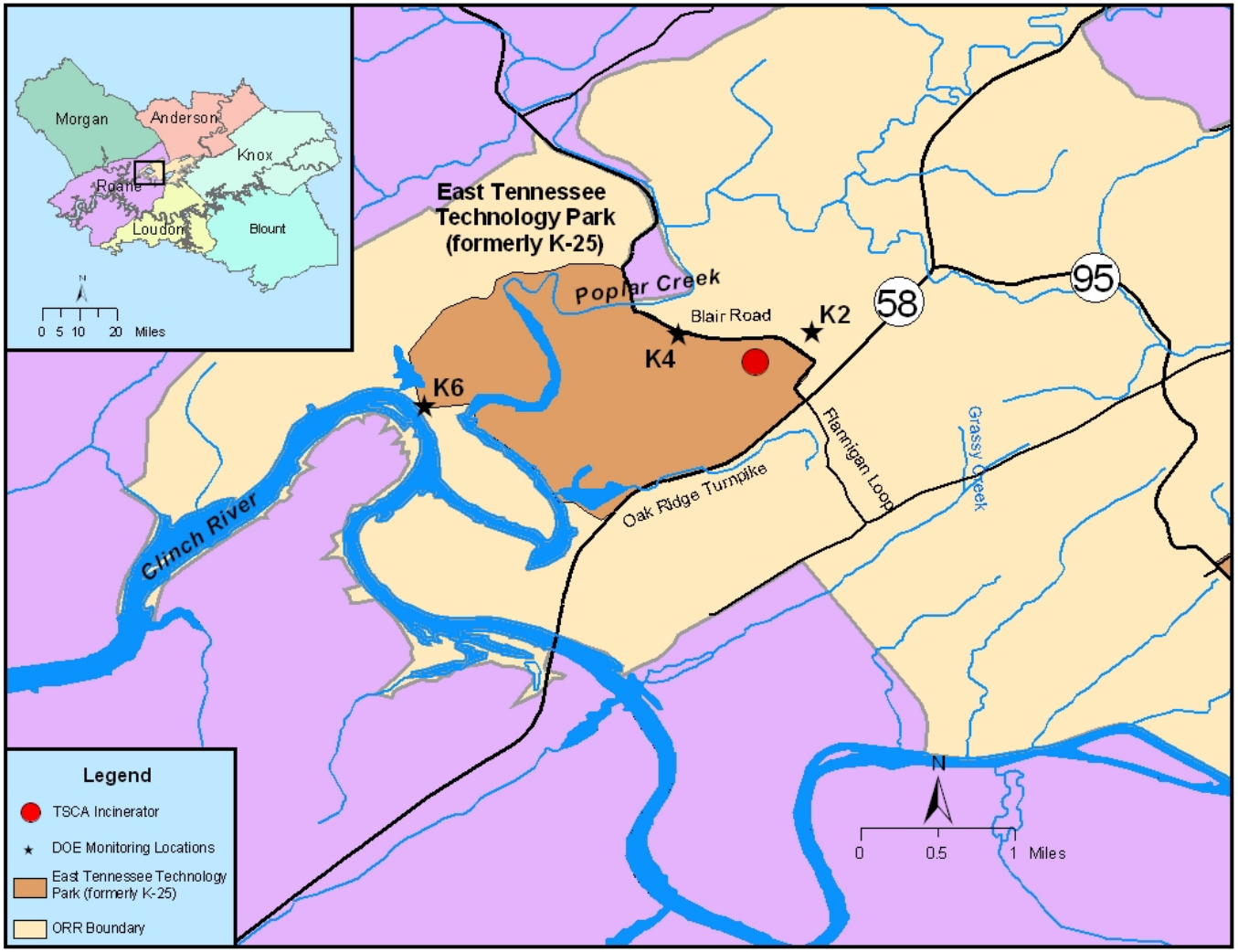

Figure C-2. DOE's PM10 Monitoring Locations

Metals

Since 1991, DOE has measured ambient air concentrations of metals at 14 different locations within and near ETTP (see Figure C-3). The monitoring locations were chosen for various reasons: to characterize maximum impacts from the TSCA Incinerator; to assess upwind-downwind differences in air quality; and to evaluate air contamination at locations where winds blow off ORR property. Between 1991 and 2001, DOE measured ambient air concentrations of seven different metals, including four known human carcinogens.

DOE sent PM10 and TSP filters to an analytical laboratory to determine the composition of the collected airborne particles. The laboratory created composite monthly samples for every monitoring station from the individual filters that DOE collected on the 6-day rotating schedule. Filter analyses were performed using inductively coupled plasma/mass spectrometry, which is consistent with analytical methodologies EPA has published for such chemical speciation work.

Table C-2 summarizes DOE's metals monitoring data. The highest annual average air concentrations of four of the metals — beryllium, lead, nickel, and uranium — did not exceed their corresponding health-based comparison values. In fact, the measured concentrations were considerably lower than these screening numbers. For instance, the highest annual average concentration for uranium (0.001373 $\mu g/m^3$) was more than 200 times lower than uranium's comparison value (0.3 $\mu g/m^3$). On the other hand, measured levels for arsenic, cadmium, and chromium all exceeded their corresponding Cancer Risk Evaluation Guides (CREGs). Accordingly, ATSDR selected these three metals as contaminants of concern and used more detailed evaluations to understand the public health implications of inhaling them (see Section IV).

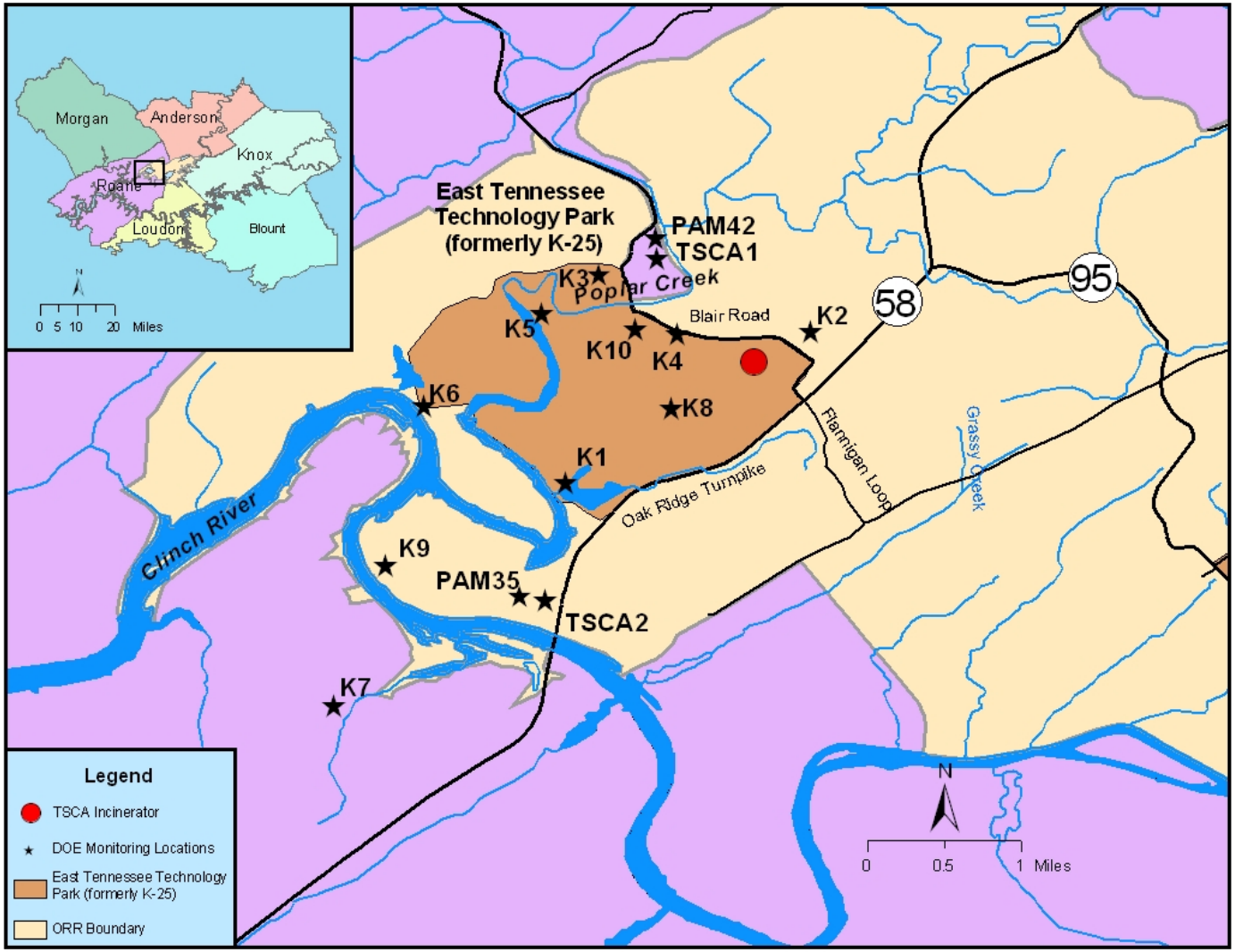

Figure C-3. DOE's Metals Monitoring Locations

Table C-2. DOE's Monitoring Data for Metals (1991–2001)

Metal	*Time Frame of Monitoring*	*Highest Annual Average Concentration ($\mu g/m^3$)*	*Health-Based Comparison Value ($\mu g/m^3$)*	*Type of Comparison Value*
Arsenic	1994–2001	0.000809	0.0002	CREG
Beryllium	1994–2001	0.000024	0.0004	CREG
Cadmium	1994–2001	0.001963	0.0006	CREG
Chromium (total)	1991–2001	<0.0064	0.00008	CREG (see notes)
Lead	1991–2001	<0.0543	1.5	NAAQS
Nickel	1991–1993	<0.0104	0.09	EMEG-chronic
Uranium	1991–2001	0.001373	0.3	EMEG-chronic (see notes)

Notes: Source of data: DOE 1991–2002.
The highest annual average concentration is the highest average value reported for any of the monitoring stations for any of the years on record. This highest value was selected as the first step in the screening process. In cases where a metal was not detected in every sample, DOE used the detection limit to compute arithmetic means and reported the annual average as being "less than" the computed value.
DOE measured ambient air concentrations of total chromium. The comparison value is for hexavalent chromium, which is a subset of total chromium. Refer to Section IV.B for ATSDR's detailed evaluation of chromium exposures.
The comparison value for uranium is ATSDR's EMEG for chronic exposure to highly soluble uranium salts. This comparison value is suitable for evaluating the chemical toxicity of uranium. Refer to Tables C-3 and C-4 for ATSDR's evaluation of exposures to radioactivity associated with uranium.

Radiation and radionuclides

For several years before the TSCA Incinerator first operated, DOE's environmental surveillance network at ORR included external gamma radiation monitoring. This monitoring helps determine whether releases from ORR facilities are causing increases in external gamma radiation above background levels. The measurements are collected using external gross gamma radiation monitors that are equipped with dual-range, high-pressure ion chamber sensors and digital electronic count-rate meters. The external gamma readings are recorded weekly, including at station PAM-42, which is in close proximity to ETTP (see Figure C-4). Between 1991 and 2002, the average external gamma radiation levels at this location were 5.9 μR/hr. These levels not only were consistent with measurements at designated background monitoring stations (i.e., Fort Loudon Dam, Norris Dam), but also fell within the range of gamma radiation levels in urban and suburban locations around the country (DOE 1991–2002).

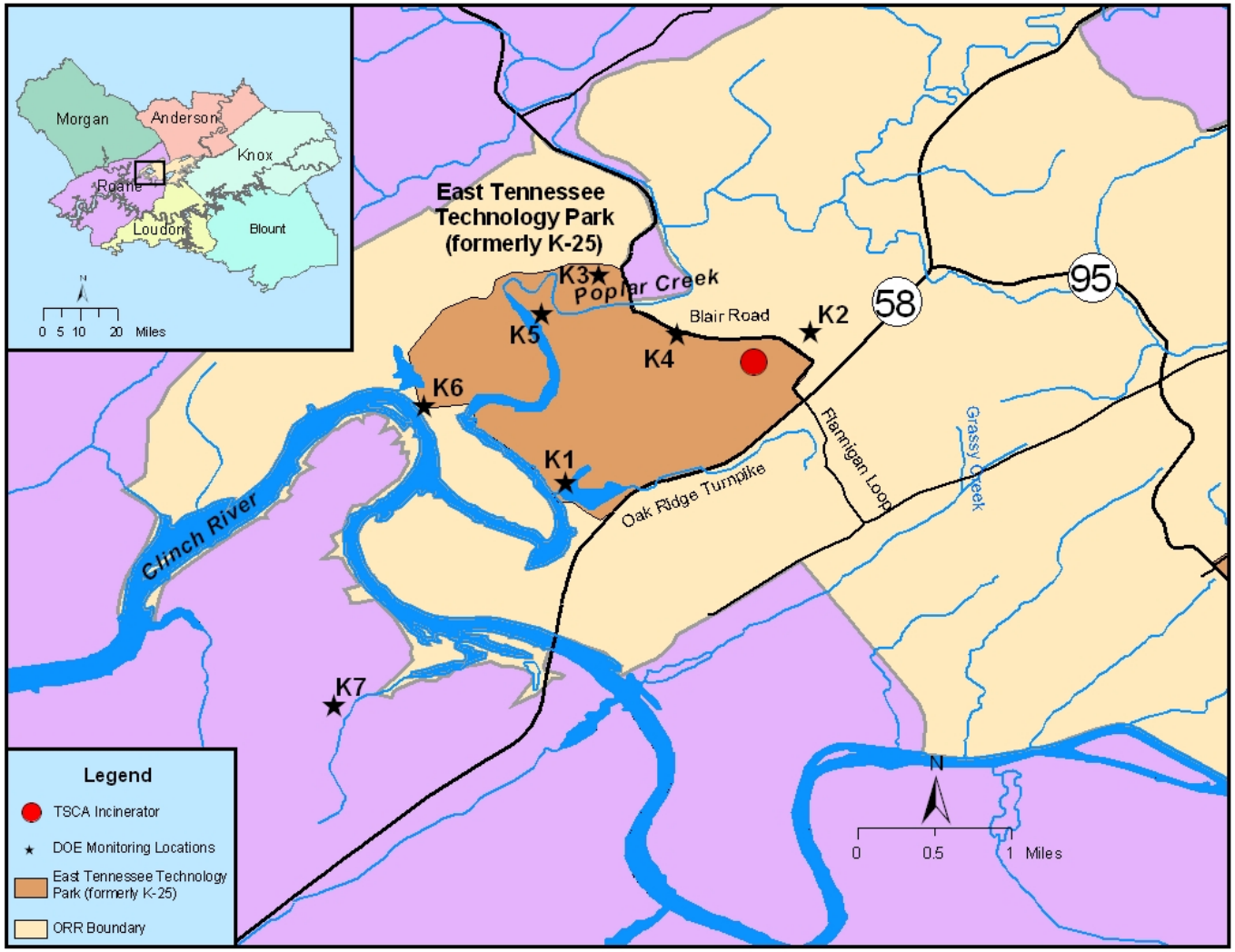

Figure C-4. DOE's Radionuclide Monitoring Locations

To supplement the gamma radiation measurements, DOE also measures concentrations of radionuclides around the perimeter of the main ORR facilities. ATSDR reviewed the history of sampling results for stations PAM35 and PAM42, as documented in the annual site environmental reports (DOE 1991–2002). At both of these stations, two sampling devices operate. The first device continuously collects particulate matter on filters, which are removed biweekly and analyzed as quarterly composites.8 The second device collects water vapor to measure concentrations of tritium. An analytical laboratory then conducts all isotopic analyses of the sampling media. TDEC's state radiochemistry laboratory has performed much of the filter analyses for the radionuclide samples.

Table C-3 summarizes DOE's monitoring data for radionuclides and compares the highest annual average concentration measured to DOE's Derived Concentration Guides (DCGs) for inhalation exposure (see Appendix D). As the table shows, all of the radionuclides documented in DOE's annual site environmental reports were found at concentrations at least 100 times lower than their corresponding DCGs.

Table C-3. DOE's Monitoring Data for Radionuclides (1991–2001)

Radionuclide	***Highest Annual Concentration Measured*** *(µCi/mL)*	***DOE's Derived Concentration Guide*** *(µCi/mL)*	***Margin of Safety*** *(See Notes)*
Beryllium-7	1.6×10^{-13}	4.0×10^{-8}	250,000
Cesium-137	1.6×10^{-16}	4.0×10^{-10}	2,500,000
Cobalt-60	1.5×10^{-16}	4.0×10^{-10}	2,700,000
Potassium-40	3.8×10^{-15}	9.0×10^{-10}	240,000
Thorium-228	7.0×10^{-18}	4.0×10^{-14}	5,700
Thorium-230	3.8×10^{-16}	4.0×10^{-14}	110
Thorium-232	8.3×10^{-18}	7.0×10^{-15}	840
Tritium	1.1×10^{-11}	1.0×10^{-7}	9,100
Uranium-234	7.2×10^{-17}	9.0×10^{-14}	1,300
Uranium-235	1.1×10^{-17}	1.0×10^{-13}	9,100
Uranium-238	4.6×10^{-17}	1.0×10^{-13}	2,200

Notes: Source of data: DOE 1991–2002.
Concentrations for radionuclides are the highest annual averages reported in DOE's annual site environmental reports for the two perimeter monitoring stations at ETTP. The table lists those radionuclides for which measurement data were reported in at least three annual site environmental reports.
DOE's Derived Concentration Guides (DCGs) represent exposure levels that would deliver annual effective dose equivalents of 100 mrem/year to an individual who is continuously exposed to the measured amounts, 24 hours per day, 365 days per year.
Margin of safety in this table is calculated as the quotient of the DCG and the highest activity measured. Margins of safety greater than 1 imply that measured levels are safely below the relevant DCGs.

In summary, DOE's environmental surveillance network offers extensive insights into the air contamination levels of particulate matter, metals, and radionuclides. These data are particularly useful due to their extensive temporal and spatial coverage: monitoring for most contaminants has occurred the entire time the TSCA Incinerator has operated, and monitoring stations are located in and near the areas expected to have the greatest air quality impacts from the

8 Note that the averaging time and compositing frequency for this and other sampling efforts have changed over the years.

incinerator's emissions. The monitoring data suggest that ambient air concentrations of many pollutants do not reach levels of potential health concern; however, ambient air concentrations of arsenic, cadmium, and chromium require additional evaluation (see Section IV). Section III.D.1 of this PHA reviews DOE's monitoring data in light of air quality measurements made by other parties; that section also lists several recommendations for improving the reporting of the monitoring results. Section III.D.2 summarizes ambient air concentrations DOE measured during TRV events.

C.2. EPA Data (EPA 1996–2003)

In 1973, EPA established the Environmental Radiation Ambient Monitoring System (ERAMS) to identify nationwide trends in radionuclide levels in multiple environmental media. One station EPA installed (see Figure 10) is located immediately downwind from the TSCA Incinerator, where the agency has continuously collected airborne particulates on sampling filters since July 1996. Twice weekly, TDEC employees remove the filters, which are then surveyed in the field for gross beta activity and sent to an EPA laboratory for a more accurate and precise measurement of gross beta activity. Composites of the semi-weekly sampling filters are then analyzed, either quarterly or annually, for activity levels of selected uranium and plutonium isotopes. The sampling and analytical procedures at all monitoring stations are consistent with specifications in the ERAMS Quality Assurance Project Plan. EPA publishes the sampling results in quarterly reports (EPA 1996–2003) and has posted them on a project Web site (EPA 2004e). According to EPA, all ERAMS data posted on the Web site have undergone thorough quality assurance and quality control checks.

Table C-4 summarizes data trends for three ERAMS stations: the K-25 station, which is located immediately downwind from the TSCA Incinerator, and stations in Knoxville and Nashville, which are included for comparison purposes. The table presents average activity levels for gross beta, two plutonium isotopes, and three uranium isotopes. These summary statistics indicate that the annual average levels of the two plutonium isotopes at K-25 are lower than the levels observed in Knoxville and Nashville, while the opposite trend exists for the three uranium isotopes. More importantly, the activity levels for all five isotopes shown in Table C-4 are safely below health-protective comparison values developed by EPA.

Table C-4. EPA's ERAMS Data (1996–2000)

Radionuclide	*Monitoring Station*	*Highest Annual Average Air Activity*	*Health-Based Comparison Value or Screening Value (See Notes)*
Gross Beta	K-25	0.012 pCi/m^3	1 pCi/m^3
	Knoxville	0.018 pCi/m^3	
	Nashville	0.015 pCi/m^3	
Plutonium-238	K-25	0.46 aCi/m^3	140 aCi/m^3
	Knoxville	0.83 aCi/m^3	
	Nashville	0.64 aCi/m^3	
Plutonium-239	K-25	0.37 aCi/m^3	140 aCi/m^3
	Knoxville	18.3 aCi/m^3	
	Nashville	0.21 aCi/m^3	
Uranium-234	K-25	59.1 aCi/m^3	420 aCi/m^3
	Knoxville	31.8 aCi/m^3	
	Nashville	20.7 aCi/m^3	
Uranium-235	K-25	4.23 aCi/m^3	470 aCi/m^3
	Knoxville	3.63 aCi/m^3	
	Nashville	2.58 aCi/m^3	
Uranium-238	K-25	69.7 aCi/m^3	510 aCi/m^3
	Knoxville	29.8 aCi/m^3	
	Nashville	19.6 aCi/m^3	

Notes: Data source: EPA 1996–2003.
Health-based comparison values for plutonium and uranium isotopes are taken from EPA's ERAMS Web site (EPA 2004e). Specifically, the values selected represent exposure levels that would present theoretical cancer risks of less than 1 in 1,000,000 for the majority of the exposed population.
A screening value of 1 pCi/m^3 is used to evaluate gross beta radiation. When levels exceeded this amount, EPA performed a gamma analysis of the sampling filters. The data for gross beta are average activities from 1996 to 2003, not the highest annual average.
Data from monitoring stations in Knoxville and Nashville are presented for comparison purposes.
1 aCi = 10^{-18} Ci = 10^{-6} pCi

C.3. TDEC Data (TDEC 1996–2002)

To assist ATSDR with the public health assessment process, TDEC provided copies of its annual Environmental Monitoring Reports from calendar years 1996 to 2002 (TDEC 1996–2002). ATSDR thoroughly reviewed these documents, which present environmental sampling data for multiple media throughout ORR. The following paragraphs describe TDEC's ambient air sampling efforts, as those relate most directly to the issues evaluated in this PHA.

Ambient radiation monitoring using environmental dosimetry

Since 1995, TDEC has operated an extensive network of thermoluminescent dosimeters (TLDs) to continuously measure gamma radiation levels at numerous locations throughout ORR. Currently, TDEC's network includes nearly 65 monitoring locations, though the number and placement of TLDs has changed over the years. The overwhelming majority of these monitoring locations are in on-site areas that the public cannot access. Both aluminum oxide TLDs and lithium fluoride TLDs are used in this network. TDEC collects the TLDs quarterly and returns them to the manufacturer (Landauer, Inc.) for analysis.

When evaluating the gamma radiation data, ATSDR considered the monitoring locations nearest ETTP where the public might have routine access. Based on these criteria, ATSDR focused its evaluation on gamma radiation levels measured at the "K-25 Visitor Center," which is located along the Oak Ridge Turnpike (Route 58), just south of the main entrance to ETTP. According to measurements documented in TDEC's annual monitoring reports, annual average radiation doses at this location have ranged from 8.9 to 22.5 mrem/year (above background), with an 8-year average of 15.7 mrem/year (above background). These levels are considerably lower than 100 mrem/year, which is both ATSDR's MRL for ionizing radiation and TDEC's primary dose limit for protecting members of the public.

Monitoring for metals

From 1997 to the present, TDEC conducted ambient air monitoring for metals at multiple locations around ETTP, but primarily at stations where DOE also monitors metals. These measurements occur at stations K2, PAM35, and PAM42 (see Figure C-3). A stated purpose of the TDEC monitoring is "to provide an independent verification of monitoring results as reported by the DOE" (TDEC 1996–2002). The program has focused on a core group of metals: arsenic, beryllium, cadmium, chromium, lead, nickel, and uranium. In the first years this monitoring was conducted, TDEC operated a single particulate sampling device at a fixed location for a set time frame (roughly 1 month), after which the device would be moved to another location for a set time frame, and so on. The program changed in 2002, with TDEC operating three separate sampling devices at three different locations.

Table C-5 summarizes TDEC's monitoring data for metals. Of the analytes considered, only arsenic and chromium had at least one measured concentration greater than their health-based comparison values. This finding is somewhat consistent with trends among DOE's monitoring data for metals from the same time frame. According to TDEC's monitoring data, ambient air concentrations of the remaining metals (beryllium, cadmium, lead, nickel, and uranium) did not exceed health-based comparison values. Based on trends among both DOE's and TDEC's

monitoring data, ATSDR selected arsenic, cadmium, and chromium as contaminants warranting further evaluation, as documented in Section IV of this PHA. As noted elsewhere in this PHA, the detection of the metals in ambient air near ETTP does not mean the metals originate from the TSCA Incinerator. Rather, multiple air emissions sources — some not associated with ORR operations (e.g., mobile sources) — contribute to the airborne levels of metals summarized below.

Table C-5. TDEC's Monitoring Data for Metals (1997–2002)

Metal	*Time Frame of Monitoring*	*Highest Average Concentration ($\mu g/m^3$)*	*Health-Based Comparison Value ($\mu g/m^3$)*	*Type of Comparison Value*
Arsenic	1997–2002	0.003	0.0002	CREG
Beryllium	1997–2002	0.0004	0.0004	CREG
Cadmium	1997–2002	0.0004	0.0006	CREG
Chromium (total)	1997–2002	0.002	0.00008	CREG (see notes)
Lead	1997–2002	0.05	1.5	NAAQS
Nickel	1999–2002	0.000128	0.09	EMEG-chronic
Uranium	1999–2002	<0.01	0.3	EMEG-chronic (see notes)

Notes: Source of data: TDEC 1996–2002.
The highest average concentrations are the highest values in TDEC's annual reports that did not have a "<" before the concentration. In the case of uranium, every measurement was either reported as "not detected" or as "<0.01."
The averaging period for the concentrations shown in this table varies, because TDEC moved its sampling equipment from location to location during the first several years this program operated.
TDEC measured ambient air concentrations of total chromium. The comparison value is for hexavalent chromium, which is a subset of total chromium. Refer to Section IV.B for ATSDR's detailed evaluation of chromium exposures.
The comparison value for uranium is ATSDR's EMEG for chronic exposure to highly soluble uranium salts. This comparison value is suitable for evaluating the chemical toxicity of uranium. Refer to Tables C-3 and C-4 for ATSDR's evaluation of exposures to radioactivity associated with uranium.

Additional monitoring and sampling activities

ATSDR acknowledges that TDEC conducts numerous additional activities related to environmental surveillance. For instance, TDEC takes the lead in providing oversight of DOE's emissions and ambient air sampling programs. The oversight activities involve observing sampling efforts, reviewing equipment operation, evaluating sampling results, conducting independent sampling events, and analyzing some samples collected by DOE. For instance, TDEC's state radiochemistry laboratory analyzes particulate filters collected at DOE's perimeter monitoring stations (see Appendix C.1). Finally, TDEC conducts many other monitoring and surveillance activities aimed at characterizing releases and exposure levels within ETTP property, where the public cannot access. These activities include monitoring fugitive radiological emissions, real-time ambient monitoring for gamma radiation, and various special studies that focus on specific issues.

Section III.D.1 describes how TDEC's monitoring results factored into ATSDR's analysis and recommends how TDEC can improve its documentation of monitoring data in future annual reports.

C.4. TVA Data (EPA 2004d)

Early in the Oak Ridge TSCA Incinerator public health assessment process, a community member recommended that ATSDR consult with TVA to determine whether that agency collected any ambient air monitoring data from locations near the TSCA Incinerator. ATSDR contacted TVA and received a listing of that agency's ambient air monitoring stations, only one of which is located within 5 miles of this site. As Figure 10 depicts, that TVA station is located approximately 3 miles south of the site along a bend in the Clinch River, where TVA continuously measured ambient air concentrations of nitrogen dioxide, ozone, and sulfur dioxide for nearly 2 years, between 1999 and 2000. Measurements were made with EPA-approved monitoring methodologies and were validated before submission to a centralized database of monitoring results maintained by EPA. Table C-6 summarizes TVA's monitoring data from this station, which are reviewed below for the three main contaminants:

Nitrogen dioxide

TVA collected 10,940 1-hour average observations of ambient air concentrations of nitrogen dioxide. The annual average concentrations computed from these measurements were safely below EPA's health-based air quality standards.

Ozone

Between 1999 and 2000, TVA's monitoring station south of the TSCA Incinerator collected valid ozone data on approximately 380 days. A single 1-hour average measurement (0.131 ppm) exceeded EPA's previous health-based standard for ozone. During this same time, 8-hour average ozone concentrations exceeded EPA's current health-based standard for ozone on 22 days, or roughly 6% of the days on which ozone monitoring occurred. As multiple sections of this PHA describe, the elevated ozone levels observed in the Knoxville metropolitan area should be viewed as a regional air quality issue caused by an extremely wide range of emissions, both

local and distant. Air emissions from the TSCA Incinerator likely have an insignificant effect on the ozone concentrations previously measured by TVA.

Sulfur dioxide

TVA collected 12,206 1-hour average observations of ambient air concentrations of sulfur dioxide. Every 3-hour average, 24-hour average, and annual average concentration computed from these values was safely below EPA's corresponding health-based air quality standards.

Trends from the TVA monitoring data provide very limited insights into the TSCA Incinerator's potential air quality impacts, given the pollutants that were measured. Nonetheless, other sections of this PHA refer to the TVA monitoring data when considering general air quality issues for the Knoxville metropolitan area.

Table C-6. TVA's Monitoring Data for Criteria Pollutants (1999–2000)

Pollutant	*Averaging Time*	*Highest Concentration Measured*	*Comparison Value (See Notes)*
Nitrogen dioxide	Annual average	0.0084 ppm	0.053 ppm
Ozone	1-hour average	0.131 ppm	0.12 ppm
	8-hour average	0.108 ppm	0.08 ppm
Sulfur dioxide	Annual average	0.0031 ppm	0.03 ppm
	24-hour average	0.014 ppm	0.14 ppm
	3-hour average	0.049 ppm	0.5 ppm

Notes: Data source: EPA 2004d.
The comparison values are all EPA National Ambient Air Quality Standards (NAAQS). For nitrogen dioxide, ozone, and the annual average and 24-hour average concentrations of sulfur dioxide, the comparison values are health-based. For the 3-hour average concentration of sulfur dioxide, the comparison value is a secondary standard, which is designed to protect things people value, other than their health (e.g., visibility, vegetation, building surfaces).

Appendix D: Definitions of Comparison Values

Following are definitions of the various health-based comparison values that ATSDR used in this PHA to put the measured and modeled levels of environmental contamination into perspective:

CREG: Cancer Risk Evaluation Guide, a highly conservative and theoretical value that is believed to cause no more than one excess cancer in a million persons exposed over time.

DCG: Derived Concentration Guide, radionuclide exposure level reported by DOE that would deliver (for inhalation pathways) an annual effective dose equivalent of 100 millirem/year to an individual who is continuously exposed 24 hours per day, 365 days per year. DOE has also calculated DCGs for ingestion exposures.

EMEG: Environmental Media Evaluation Guide, a media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse noncarcinogenic health effects. These have been developed for acute exposure scenarios, intermediate exposure scenarios, and chronic exposure scenarios.

MRL: Minimal Risk Level, an estimate of daily human exposure to a dose of a chemical that is likely to be without an appreciable risk of adverse non-cancerous effects over a specified duration of exposure.

NAAQS: National Ambient Air Quality Standard, an ambient air concentration that EPA has established to characterize air quality. The standards are health-based and were designed to be protective of many sensitive populations, such as people with asthma and children. The standards have been developed only for a small subset of pollutants, and their averaging times and statistical interpretations vary among the regulated pollutants.

RBC: Risk-Based Concentration, a contaminant concentration that is not expected to cause adverse health effects over long-term exposure. These have been developed for both cancer outcomes (RBC-C) and non-cancer outcomes (RBC-N).

RfC: Reference Concentration, an ambient air concentration developed by EPA that people, including sensitive subpopulations, likely can be exposed to continuously over a lifetime without developing adverse non-cancer health effects. RfCs typically have uncertainty factors built into them to account for any perceived limitations in the data on which they are based.

Appendix E: ATSDR Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in this PHA. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Acute
Occurring over a short time [compare with **chronic**].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate-duration exposure** and **chronic exposure**].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Ambient
Surrounding (for example, *ambient* air).

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Background radiation
The amount of radiation to which a member of the general population is exposed from natural sources, such as terrestrial radiation from naturally occurring radionuclides in the soil, cosmic radiation originating from outer space, and naturally occurring radionuclides deposited in the human body.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CERCLA
[See **Comprehensive Environmental Response, Compensation, and Liability Act of 1980.**]

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate-duration exposure**].

Committed Effective Dose Equivalent (CEDE)
The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to the organs or tissues. The *committed effective dose equivalent* is used in radiation safety because it implicitly includes the relative carcinogenic sensitivity of the various tissues. The unit of dose for the CEDE is the rem (or, in SI units, the sievert — 1 sievert equals 100 rem.)

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway
[See **exposure pathway.**]

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as **Superfund,** is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by *CERCLA,* is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other medium.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Curie (Ci)
A unit of radioactivity. One *curie* equals that quantity of radioactive material in which there are 3.7×10^{10} nuclear transformations per second. The activity of 1 gram of radium is approximately 1 Ci; the activity of 1.46 million grams of natural uranium is approximately 1 Ci.

Dermal
Referring to the skin. For example, *dermal* absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. *Dose* is a measurement of exposure. *Dose* is often expressed as milligrams (a measure of quantity) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the *dose,* the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually gets into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation *dose* is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). *Transport mechanisms* move contaminants from the source to points where human exposure can occur. The *environmental media and transport mechanism* is the second part of an exposure pathway.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. *Exposure* can be short-term [see **acute exposure**], of intermediate duration [see **intermediate-duration exposure**], or long-term [see **chronic exposure**].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An *exposure pathway* has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through **groundwater**); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the *exposure pathway* is termed a **completed exposure pathway.**

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. *Health consultations* are focused on a specific exposure issue. They are therefore more limited than public health assessments, which review the exposure potential of each pathway and chemical [compare with **public health assessment**].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A *health statistics review* is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with **prevalence**].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate-duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

Isotopes
Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Identical chemical properties exist in *isotopes* of a particular element. The term should not be used as a synonym for "nuclide," because "isotopes" refers specifically to different nuclei of the same element.

Migration
Moving from one location to another.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The *NPL* is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but is not expected to cause any harmful health effects.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL
[See National Priorities List for Uncontrolled Hazardous Waste Sites.]

Plume
A volume of a substance that moves from its source to places farther away from the source. *Plumes* can be described by the volume of air or water they occupy and the direction in which they move. For example, a *plume* can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with **incidence**].

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action plan
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed by coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **health consultation**].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or **radionuclides** that could result in harmful health effects.

Public health hazard categories
Statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five *public health hazard categories* are **no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard,** and **urgent public health hazard.**

Radiation
The emission and propagation of energy through space or through a material medium in the form of waves (e.g., the emission and propagation of electromagnetic waves, or of sound and elastic waves). The term "radiation" (or "radiant energy"), when unqualified, usually refers to electromagnetic *radiation.* Such *radiation* commonly is classified according to frequency, as microwaves, infrared, visible (light), ultraviolet, and x and gamma rays and, by extension, corpuscular emission, such as alpha and beta *radiation,* neutrons, or rays of mixed or unknown type, such as cosmic *radiation.*

Radioactive material
Material containing radioactive atoms.

Radioactivity
Spontaneous nuclear transformations that result in the formation of new elements. These transformations are accomplished by emission of alpha or beta particles from the nucleus or by the capture of an orbital electron. Each of these reactions may or may not be accompanied by a gamma photon.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA
[See **Resource Conservation and Recovery Act (1976, 1984).**]

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Rem
A unit of dose equivalent that is used in the regulatory, administrative, and engineering design aspects of radiation safety practice. The dose equivalent in *rem* is numerically equal to the absorbed dose in rad multiplied by the quality factor (1 *rem* is equal to 0.01 sievert).

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three *routes of exposure* are breathing [**inhalation**], eating or drinking [**ingestion**], and contact with the skin [**dermal contact**].

Sample
A portion or piece of a whole; a selected subset of a population or subset of whatever is being studied. For example, in a study of people the *sample* is a number of people chosen from a larger population [see **population**]. An environmental *sample* (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A *source of contamination* is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered *special populations.*

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Surveillance
[see epidemiologic surveillance]

Survey
A systematic collection of information or data. A *survey* can be conducted to collect information from a group of people or from the environment. *Surveys* of a group of people can be conducted by telephone, by mail, or in person. Some *surveys* are done by interviewing a group of people.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A *toxicological profile* also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Uncertainty factor
A mathematical adjustment for reasons of safety when knowledge is incomplete — for example, a factor used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). *Uncertainty factors* are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use *uncertainty factors* when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people.

Units, radiological

Units	*Equivalents*
Becquerel* (Bq)	1 disintegration per second = 2.7×10^{-11} Ci
Curie (Ci)	3.7×10^{10} disintegrations per second = 3.7×10^{10} Bq
Gray* (Gy)	1 J/kg = 100 rad
Rad (rad)	100 erg/g = 0.01 Gy
Rem (rem)	0.01 sievert
Sievert* (Sv)	100 rem

*International Units, designated (SI)

Urgent public health hazard

A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Other Glossaries and Dictionaries

Environmental Protection Agency http://www.epa.gov/OCEPAterms/

National Center for Environmental Health (CDC) http://www.cdc.gov/nceh/dls/report/glossary.htm

National Library of Medicine http://www.nlm.nih.gov/medlineplus/mplusdictionary.html

Appendix F: Units of Measurement Used in this PHA

Throughout this document, ATSDR reported observations in many different units of measurement. While ATSDR can appreciate a desire to use consistent units when measuring a given phenomenon (e.g., an air concentration), the reality is that many different types of units are widely used by scientists, often due to conventions that have been followed for many years. Some of these reporting conventions vary from one type of pollutant to the next.

This appendix defines the different units of measurement used throughout this PHA and presents unit conversion information, where appropriate. This appendix should not be viewed as an exhaustive account of units of measurement. Rather, it provides perspective on the units presented throughout this PHA.

Units used when reporting concentrations of radioactive contaminants

aCi/m^3 = attocuries per cubic meter

pCi/m^3 = picocuries per cubic meter

μCi/ml = microcurie per milliliter

Note: The following information may be useful for appreciating the terminology used in these units of measurements and for converting between the units:

1,000,000 μCi = 1 Ci

1,000,000 pCi = 1 μCi

1,000,000 aCi = 1 pCi

1,000,000 ml = 1 m^3

Units used when reporting concentrations of non-radioactive contaminants

$\mu g/m^3$ = micrograms per cubic meter

ppm = parts per million

Notes: Scientists typically report ambient air concentrations of particulate matter and metals in units of micrograms per cubic meter.

There is no widely used convention for reporting ambient air concentrations of organics and inorganic compounds. Some scientists use mass concentrations (e.g., micrograms per cubic meter and variations upon this unit); other scientists use volume concentrations (e.g., parts per million and variations upon this unit).

Units used when reporting stack gas concentrations

grains/dscf = grains per dry standard cubic foot

ng/dscm = nanograms per dry standard cubic meter

µg/dscm = micrograms per dry standard cubic meter

Notes: Grains are a mass measurement commonly used when reporting stack gas concentrations of particulate matter. There are 7,000 grains in a pound.

"Nanograms" and "micrograms" are commonly used when reporting stack gas concentrations of trace gases, such as PCBs and dioxins. There are 1,000,000 micrograms in a gram, and there are 1,000,000,000 nanograms in a gram.

Units used when reporting mass emission rates

lb/hour = pounds per hour

lb/day = pounds per day

µg/second = micrograms per second

ng/second = nanograms per second

Note: The most appropriate unit of measurement for mass emission rates is often based on reporting convention and regulatory requirements. Some regulations, for instance, require facility operators to report maximum hourly emission rates; in such cases, pounds per hour might be an acceptable unit of measurement. The pollutants also determine what units are most appropriate. Pollutants present in very trace amounts (e.g., dioxins) often are reported in terms of micrograms or nanograms.

Appendix G: Responses to Public Comments

On March 1, 2005, the Agency for Toxic Substances and Disease Registry (ATSDR) issued the Public Comment Release of the public health assessment for the TSCA Incinerator. The Public Comment Release was distributed directly to numerous individuals and local organizations. Additionally, ATSDR issued a press release announcing the availability of the Public Comment Release at local records repositories. The public comment period lasted nearly 12 weeks and ended on May 20, 2005. During the public comment period, ATSDR also coordinated a peer review of the public health assessment, which was conducted by four independent scientists.

This appendix presents the comments that the public, local organizations, and peer reviewers submitted during the public comment period, along with ATSDR's responses to those comments. Note that all page numbers cited in this appendix refer to page numbers in the Public Comment Release draft. The list of comments below does not include editorial comments, such as suggested word changes and spelling corrections.

	Public or Peer Reviewer Comment	ATSDR's Response
General Comments		
1	The document is well written and, in large measure, should be comprehendible to the lay public. This is partly borne out by the sparse amount of comments that have been made by members of the Exposure Evaluation Work Group and the ORRHES.	ATSDR appreciates receiving these comments. No changes were made in the PHA in response to these comments.
2	The report was very well prepared; the sources of information, reliability of data, and assumptions were well documented.	
3	This is a very comprehensive and well-prepared document. This reviewer has rarely seen such accurate and clear communications of the health threats. Comments that are offered are of minor significance.	
4	The report is unusually thorough and well written.	
5	Overall a very well written report.	
Comments on Specific Topics or Minor Clarifications		
6	As can be noted in the acknowledgments of the Environmental Radiation Ambient Monitoring System (ERAMS) quarterly data reports, (http://www.epa.gov/nare1/ERD11.pdf), U.S. Environmental Protection Agency (EPA) doesn't actually perform the sampling at the ERAMS stations, but relies on other agencies and volunteers to perform the sampling. On the reservation, TDEC employees collect the samples and maintain the equipment. The U.S. Department of Energy (DOE) provides the power necessary to run the equipment. For the Oak Ridge program, EPA agreed to provide multiple air stations (five), which were placed at locations submitted by TDEC for EPA approval. Samples are collected from these stations by TDEC staff twice weekly (or at the request of EPA), scanned using a GM scaler, and then mailed to EPA's National Air and Radiation Environmental Laboratory (NAREL) for analysis.	ATSDR revised the description of the ERAMS monitoring program (see Appendix C.2) to clarify that TDEC employees collect the samples which are then analyzed in an EPA laboratory.

	Public or Peer Reviewer Comment	ATSDR's Response
7	Page 52, Lines 35-38 (also Page 53, Lines 1-2, Page 58, Lines 20-22, Appendix C): In addition to DOE's monitoring efforts, EPA has continuously sampled air for radionuclides at ETTP, but this sampling did not commence until 1996. EPA's sampling device is installed at DOE's K-2 station (see Figure 10), approximately ¾-mile from one of DOE's perimeter monitoring stations.	ATSDR revised these passages to clarify that TDEC collected the samples in the ERAMS network, and EPA analyzed the samples.
8	Amount of waste treated (see Figure 5), pages 14-16 - This section implies that the incinerator is operating much below its capacity. Please revise the section to clarify that other permit conditions for specific contaminants and parameters in the feed would cause the allowable waste feed rate to be lower than just the limit on liquid and solid mass throughput.	This clarification has been added to "amount of waste treated" in Section II.B.
9	Page 17, line 1; see also page 45, line 1 and page 54, line 5 – The description of thermal relief vent (TRV) opening events is not complete; please expand so it is clear that they have an insignificant effect on air emissions.	None of the reports that ATSDR reviewed present measured or estimated emission rates from the TRV events. Therefore, ATSDR has no basis for concluding that these events have an "insignificant effect" on air emissions. However, ATSDR revised several passages in the PHA to emphasize that the TRV events are extremely short-lived, as are their associated air quality impacts. ATSDR made additional revisions to the text on TRV events in response to Comment #40.
10	The context of "other local emissions" (page 24 line 39 and page 29, line 9) should be brought forward into the Summary as a context statement.	This context has been added under the header "Air emissions from the TSCA Incinerator" in Section I.
11	June 1988 Resource Conservation and Recovery Act (RCRA) Trial Burn (Engineering-Science 1988b), Page A-5, Lines 14-16 - The report states that an additional trial burn was conducted one year later to better establish permitting limits on key operating conditions. The retest was in fact required after TDEC ruled the initial test report inconclusive. The reasons that the test report was ruled inconclusive were because some samples were broken in transit to the laboratory and others were not analyzed properly or exceeded the allowed holding time before being analyzed. All samples that were correctly analyzed were within the required performance standards.	ATSDR has received conflicting accounts for why the 1988 test report was ruled inconclusive. We have included both accounts in Appendix A-1. These conflicting accounts do not affect the overall interpretations of the 1988 test report, because regulators required a subsequent trial burn to demonstrate the incinerator's effectiveness before routine operations could commence.
12	Performance Tests, Section A-2 - A new permit issued January 25, 2005, revises the TDEC Permitted Emission Limits. Most of the revised limits reflect application of Maximum Achievable Control Technology standards for pollutants with limits under that regulation. Sulfur dioxide and hydrogen fluoride are unchanged. Beryllium is increased from 0.002 lb/day to 0.02 lb/day.	ATSDR added information to Table A-2 about the changes to permitted emission limits that are identified in this comment.

	Public or Peer Reviewer Comment	ATSDR's Response
13	P. 10. This section should give some description of the composition of the feedstock (instead of on p. 14), what happens chemically in the incinerator, and the composition of the incinerator effluents (e.g., water, carbon and nitrogen oxides, chloro compounds, etc.). Also, the fate of the noxious effluents should be addressed more completely here (it is partially covered on p.12).	ATSDR has made several minor changes to Section II.A.2 in response to this comment. First, under "Waste Handling," the section now gives further detail on the composition of the feedstock, as characterized by annual incinerator "rolling totals" reports. Second, under "Incineration," there is additional text explaining what happens to different substances after they enter the incinerator. Third, under "Air Pollution Controls" and "Residuals Management," further information is included on the fate of different effluents.
14	P. 10. State that the ventilated table on which repackaging occurs is ventilated through a filtration system that prevents particulates and noxious gases from entering the atmosphere (if this is indeed correct).	ATSDR added this information under "Waste Handling" in Section II.A.2.
15	P. 12 (and P. 22). The stack of the TSCA incinerator is 100 feet high. The parallel, bounding ridges are 200 feet high, twice as high as the incinerator stack. Has this been considered in the dispersion calculations? How does this affect dispersion?	Terrain features are significant because they influence surface-level prevailing wind patterns. This information has been added to Section II.D. ATSDR has updated Appendix B to explain that the dispersion modeling analyses represented complex terrain features using a technique called "flagpole receptors." For various reasons specified in Appendix B, ATSDR still believes the dispersion modeling analyses reviewed in the PHA tend to overstate, and not understate, the actual exposure concentrations that residents might have experienced.
16	P. 22 (and Fig. 6). Describe the Wind Rose in greater detail and clarity. For example, note that the circular grid lines represent the percent of time that the wind blows in a particular direction, and that the wind direction is from the end of the bar towards the center of the Wind Rose. Also, reword the sentence on p. 22 to something like "As Fig. 6 depicts, the prevailing wind patterns near the TSCA incinerator are from the *general* southwest *direction (i.e., WSW, SW, and SSW) toward* the northeast and, to a lesser extent, from the *general* northeast *direction toward* the southwest."	ATSDR added this information under "Climate and prevailing wind patters" in Section II.D and in Figure 6.

	Public or Peer Reviewer Comment	ATSDR's Response
17	P. 30. Have you sought input from the Knox County Health Department in your presentation of the air quality of the Greater Knoxville area? This certainly would demonstrate a desire to work openly with a broad range of stakeholders.	The Knox County Air Quality Management Division conducts various activities to characterize general air quality in the Greater Knoxville Area. ATSDR has provided the Air Quality Management Division a copy of the PHA. TDEC has informed ATSDR that it, in coordination with the Air Quality Management Division, would continue to issue warnings about poor air quality, as needed. ATSDR will provide the Knox County Health Department a copy of the PHA as well.
18	P. 31. Have incinerator campaigns been conducted during periods of high pollen concentration? If so, what effect would this have on the dispersion of airborne material?	ATSDR's findings in this PHA are based largely on ambient air sampling data and ambient air monitoring data that are collected throughout the year. Thus, any influences of seasonal effects, whether due to temperature, higher pollen counts, or other factors, were implicitly considered when evaluating these monitoring data.
19	P. 39. Refer the reader to the definition of "Comparison Value" on p. E-2 in the appropriate paragraph. Also, the definition of CV needs to be more specific. Is it wrong to state that the CV is intended to be lower than the lowest value known to be associated with adverse health effects by at least (a stated factor) of safety?	ATSDR revised a paragraph in Section III.A to refer to the Glossary (as requested) and to include the additional perspective on comparison values noted in the comment.
20	P. 52 (and P. C-14). Despite the difference in the limits of detection of the analytical methods used by TDEC and DOE, the TDEC monitoring data should be considered when selecting contaminants for further consideration. For beryllium, for example, the TDEC value is equal to the comparison value. Also, is limit of detection actually intended, as opposed to precision (i.e., the number of significant figures to which the results may be determined)?	ATSDR considered all ambient air sampling data and ambient air monitoring data when selecting contaminants for further consideration. Any contaminant with a concentration *greater than* its corresponding comparison value was selected. The highest concentration of beryllium was not *greater than* its comparison value. More precise wording has been used in Section V.A (Question 5) in response to this comment. More detailed evaluation of beryllium is not warranted by the fact that a single measured concentration was equal to the highly protective comparison value.

	Public or Peer Reviewer Comment	ATSDR's Response
21	P. 52 (and Pp. 53 and 58). There appear to be several instances in which the terms "sampling" and "monitoring" are used interchangeably. "Sampling" implies selecting a portion of the whole for analysis, whereas "monitoring" implies continuously measuring the whole. Also, the terms "continuous sampling" and "sampling continuously" are misleading, and should be replaced with "frequent sampling" or "samples taken at regular intervals."	ATSDR was sensitive to the differences between "sampling" and "monitoring" when preparing this PHA (e.g., see the text box in Section III.D). A difficulty in distinguishing these terms is that various parties have different concepts of "monitoring." For instance, EPA would typically consider a program that collects particulate samples every 7 days to be an "ambient air monitoring program," while the comment implies that such a program is better classified as "sampling." ATSDR reviewed the text on the pages noted and revised wording, as appropriate.
22	P. 54. If possible, indicate wind speed and direction at the times of the TRV events.	ATSDR does not have information on the wind speed and direction during every TRV event. However, it is important to note that DOE collects air samples at the two locations that separate the TSCA Incinerator from the nearest residents. Thus, the samples collected during these events likely provide an upper-bound estimate of the short-term exposures that might have occurred at the nearest residential locations. ATSDR has added this observation to Section III.D.2.
23	P.59 (and Pp. 61, 62, and 64). Attributing a difference between calculated and measured concentrations to one or more causes requires explicit consideration of the accuracy of the calculations. This is particularly true of air-dispersion calculations, so that the perceived five-fold difference may very well be within the uncertainty of the calculation, although the occurrence of sources other than the TSCA incinerator is also a plausible contributing factor.	ATSDR revised the text on arsenic to acknowledge the possible explanations for why model predictions differed from air quality measurements. In the case of cadmium and chromium, uncertainty in the modeling alone likely does not account for the more than 15-fold difference between the measured and modeled concentrations.
24	P. 66. Lines 21 – 26 indicate that several reports that are identified are available for reading in the ATSDR Oak Ridge Field Office. Is this correct?	The Oak Ridge Field Office is no longer open, but complete references are included in the text for the specific documents of concern.

	Public or Peer Reviewer Comment	ATSDR's Response
25	Pp. B-2 to B-3. It would be helpful to list the quantities required as input to the ISCST code, and to discuss the uncertainties associated with each one. Also, it would be helpful to cite the EPA User Manual for the ISCST code for those who might wish to pursue this facet further. The EPA User Manual is available on line at http://www.epa.gov/ttn/scram/userg/regmod/isc3v2.pdf.	Information on the inputs and assumptions inherent in the Independent Panel's modeling analysis is documented on pages 67 to 82 of the panel's summary report (Iglar et al. 1998). ATSDR added text to Appendix B.1 that refers readers to those specific pages, as well as the ISCST User Manual, should any reader want to look further into the modeling analyses.
26	P. B-2. Consider providing a set of maps depicting contours of calculated ground level concentrations of contaminants of concern. This might help in providing a visual description of the effects of wind-rose data, stack height, and topography.	The maps suggested in the comment are included on pages 74 to 78 of the independent panel's summary report (Iglar et al. 1998). These maps clearly show maximum ground level air quality impacts consistent with the prevailing wind patterns. What is more important, in ATSDR's opinion, is that the estimated air quality impacts are all safely below levels expected to cause adverse health effects — a message that is more appropriately and easily reported in the text.
27	P. B-5. The EPA Clean Air Assessment (CAP-88) document does not appear to be cited in the list of references. It is available on-line at www.epa.gov/radiation/assessment/CAP88/.	A reference to the CAP-88 User's Guide and the website included in the comment have been added to Appendix B.2.
28	The magnitude of emissions was clearly stated. The PHA provides a detailed account of the emissions from the TSCA Incinerator. The PHA clearly describes the wastes being handled, the incineration system used for its disposal, the pathways for release of emissions, the topography and wind patterns, the surrounding population density, alternative pollution sources in the area, and the methodologies used in the PHA. This information is utilized to determine the nature and extent of contamination using both dispersion modeling and monitoring networks.	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.
29	P. B-9. Is the report (EPA 1998) available at the DOE Information Center?	The particular reference of concern mentioned in this comment is available online from EPA's web page. That link has been added to the list of References in Section XII.

	Public or Peer Reviewer Comment	ATSDR's Response
30	The PHA provided two approaches to the assessment of exposure: (1) By the use of dispersion modeling to calculate the concentration at the position of maximum exposure. The calculations provide a conservative estimate of exposure. The position of maximum concentration is within the ETTP so that local populations at off-site locations will be exposed to lower concentrations. The calculations were based on the maximum allowed feed rate, even though average waste treatment rates are much lower. (2) From ambient monitors. These ambient monitors provide a conservative estimate of the contributions to exposure by the TSCA Incinerator since other sources contribute to the ambient concentrations of pollutants. The concentrations of pollutants were found to be, with few exceptions, well below those necessary to safeguard public health.	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.
31	P. B-7. Knowing that air dispersion calculations do not yield precise values because of theoretical and empirical limitations on the calculations as well as uncertainties associated with the input parameters, it would nonetheless be instructive to compare the calculated ground-level concentrations with reliable measured values for particulate matter, radionuclides, and metals, where the latter are available, instead of dismissing the calculations completely.	ATSDR conducted its modeling evaluation to fill important information gaps left by the other available studies. ATSDR judged that the available data on emissions, dispersion modeling, and ambient air sampling were more than sufficient for reaching conclusions on particulate matter, radionuclides, and metals. Therefore, ATSDR decided not to devote additional resources to modeling these groups of contaminants. ATSDR has added text to Appendix B.3 to clarify its justification for not doing this additional modeling.
32	P. B-7. It is not obvious that the same dispersion factor can be used for all of the contaminants that have been examined. Justification of this assumption is required.	Use of a single dispersion factor in ATSDR's calculations essentially assumes that all pollutants remain airborne and do not have decaying concentrations due to mechanisms or deposition or reaction. By not accounting for these mechanisms, the dispersion factor actually leads to an upper-bound estimate of actual ambient air concentrations for all pollutants. ATSDR added a paragraph in Appendix B.3 to justify the use of a single dispersion factor for multiple pollutants.
33	P. B-8 (and C-6). The statement that dioxins and furans are the air contaminants of greatest concern for incineration facilities seems to contradict the statement on P. C-6, based on Table C-2, that the maximum annual measured air concentrations at ground level of arsenic, cadmium, and chromium exceeded their respective comparison values.	On page B-8 of the Public Comment Release, ATSDR refers to dioxins and furans as "arguably" being the contaminants of greatest concern for incineration facilities. While this statement is supported by prominent reviews of incineration facilities (e.g., NRC 2000), ATSDR removed the statement from page B-8 to respond to concerns raised in this comment.

	Public or Peer Reviewer Comment	ATSDR's Response
34	The lead emissions from prior tests are noted (on page A-13) to have been in some cases higher than the MACT standards. Therefore, I would suggest that statements be made regarding whether this incinerator will be subject to the MACT standards in the future, and, if so, what will be done differently to ensure that lead emissions are within the MACT standards.	The TSCA Incinerator is subject to EPA's MACT standards. However, one cannot infer from Table A-4 that emissions of lead exceeded these standards. Rather, looking more broadly at Appendix A, the emissions data for lead quite clearly were routinely lower than permitted emission limits. Also, considering Appendixes B and C, all modeled and measured ambient air concentrations of lead near the TSCA Incinerator were considerably lower than EPA's health-based air quality standards. For these reasons, ATSDR does not believe any revisions to the PHA are needed to clarify the conclusions for lead.
35	The PHA evaluates exposures to "eight groups of contaminants" measured in various stack tests and trial burns conducted on the ORR TSCA Incinerator (page 3, lines 4 to 11). Three of the eight groups of contaminants represent semi-volatile organic compound groups. While the three semi-volatile groups included in the PHA are likely to represent those semi-volatile compounds of greatest concern with respect to toxicity and/or carcinogenicity, the PHA would benefit in terms of completeness from a brief discussion of which other semi-volatile compounds are present in the facility emissions and to what extent those compounds contribute to the overall risk.	ATSDR agrees with the statement in the comment that the PHA focuses on the semi-volatile compounds of greatest concern with respect to toxicity and carcinogenicity. ATSDR has added a note to Table 6 acknowledging that other semi-volatile organic compounds are also emitted, but waste composition data suggest that the quantities emitted are likely immeasurably small.
36	One additional point of some confusion may be the comparison of TRI reported data. As TRI data is not limited to air emissions via dedicated point sources, the lay reader may not fully appreciate the relevance of the extreme differences represented in the table of Answer B-2 (page 68).	ATSDR included the TRI data in response to a public comment. Aware of the many limitations associated with TRI data, ATSDR included several cautionary statements in the PHA to avoid potential misinterpretations. The text in question was revised slightly to emphasize the importance of interpreting TRI data in proper context.

	Public or Peer Reviewer Comment	ATSDR's Response
37	To the extent the PHA relies on the limited ISCST3 modeling by the Independent Panel for the assessment of direct exposures, ATSDR provides appropriate qualifications and limitations for its conclusions (Page B-2 and B-3). However, at such time ATSDR begins its assessment of indirect risk, the air dispersion modeling should incorporate wet and dry deposition effects, mass versus area particulate partitioning (for metals and semi-volatile organics), and plume depletion.	Given the considerable uncertainties associated with modeling atmospheric deposition and subsequent accumulation of contaminants in food chains, ATSDR has no plans for conducting any further dispersion modeling. Rather, the extent to which emissions from the TSCA Incinerator might be found in environmental media besides air is being addressed in ATSDR's Public Health Assessment of Current and Future Chemical Exposures in the Vicinity of the Oak Ridge Reservation (see responses to Comments #49, 50, and 51).
38	It is well known that emission from rotary kilns are prone to occur in puffs, during upset conditions and during the periodic feed of solids. The solids are fed in combustible containers. Other industries and EPA have found the amount of solids that can be fed in such containers is limited by the rate of volatile release. Insufficient information was provided to determine if the volatile release after the container was injected could exceed the air supply providing a transient release (puff).	While it is possible that certain feed conditions could lead to "puffs" of volatile compounds passing through the rotary kiln, the incinerator permit requires that gases take at least 2 seconds to pass through the afterburner. This requirement, which must be continuously monitored, along with other waste handling requirements for solids is expected to dramatically dampen any transient increases in emission rates.
39	Oxygen combustion is very different from air combustion. Oxygen on page 7 and Figure 3 (page 9) should be replaced with air to avoid any confusion.	ATSDR revised the text accordingly.
40	The discussion of the TRV releases is not up to the quality of the rest of the report. It should be noted that the changes in emission rate will vary greatly with pollutant category. The extremes are: (1) There is no change in Hg emissions when the TRV is open (all the Hg is emitted with or without the TRV open). (2) There is an increase by over a factor of 1,000 in HCl when the TRV opens [from a capture efficiency of 99.912% see page A-5 to 0% capture with the TRV open]. Others pollutants fall in between. The discussion on page 57 implies that the measurements of PCBs when the TRV was open is representative of changes for other pollutants but the ratio of emissions for PCBs is not a good measure of those of other contaminants. The ratio of emissions also provides only a measure of acute effects. For chronic effects the duration of the openings of the TRV are needed in order to compare the cumulative emissions during the 18 episodes relative to the aggregated during normal operation. (Note that although the waste feed is cut off the contents of the kiln will continue to burn during such incidents). The data on the radionuclides are aggregate values that include the TRV events and provide the best measure of the aggregate emissions. Note, however, extrapolation to other pollutants must be qualified for the change in the emission rates discussed above.	ATSDR revised text in Section III.D.2 to provide additional information on how air emissions during TRV events differ from air emissions during routine operations. The comment does not question ATSDR's findings for dioxins, furans, PCBs, or radionuclides. The main issue raised is whether the TRV events might cause elevated air quality impacts for pollutants largely removed by the air pollution controls, namely hydrochloric acid. ATSDR has added a paragraph to Section III.D.2 acknowledging the limitations of the existing data and providing arguments why anticipated exposure levels to hydrochloric acid during TRV events are not expected to reach levels of health concern.

	Public or Peer Reviewer Comment	ATSDR's Response
41	Page 45, Lines 19 to 27: The fact that samples are collected during all TRV events needs qualification based on analysis decision criteria.	ATSDR clarified in this particular section, as was qualified elsewhere in the PHA, that only a subset of samples collected during TRV events are currently being analyzed.
42	P. 60 (and P. B-4). ATSDR should employ a consistent terminology for health effect concentration limits. In the PHA for uranium releases from Y-12, the term "lowest observed adverse effect level" (LOAEL) is used. The non-cancer LOAEL is approximately 0.7 micrograms per cubic meter, and the cancer-related LOAEL is 50 micrograms per cubic meter. In Table B-1 on p. B-4, the comparison value for arsenic is given as $2x10^{-4}$ micrograms per cubic meter. This value is lower than the non-cancer LOAEL by a factor of 250,000. The definition of LOAEL should be given, as well as the relationship between LOAEL and CV, if only for the sake of consistency.	In the initial screening for contaminants requiring further evaluation, ATSDR uses comparison values. Some comparison values have been established for non-cancer effects (e.g., EMEGs); others have been established for cancer effects (e.g., CREGs). For all contaminants having concentrations greater than health-based comparison values, regardless of the type of comparison value, ATSDR examined exposures more thoroughly. For non-cancer effects, exposure concentrations are compared against lowest observed adverse effect levels (LOAELs); and for cancer effects, exposure concentrations are compared against cancer effect levels (CELs). This approach is consistent with ATSDR guidance for conducting PHAs. ATSDR has added the definition of LOAEL to Section IV, as requested.
43	Pp. 60 – 63 (and Pp. B-4 and D-1). The comparison values for arsenic, cadmium, and chromium are 1,250 to 500,000-times smaller than the corresponding LOAEL values. Why are the differences so large, and so variable? And what is the relationship of both the LOAEL and the CV to the CREG, that is defined on P. D-1?	As Table B-1 notes, the comparison values for arsenic, cadmium, and chromium are Cancer Risk Evaluation Guides. These comparison values are derived from Unit Risk Factors that EPA has published in its Integrated Risk Information System (IRIS); they are not computed directly from LOAELs for non-cancer effects, as the comment suggests.

	Public or Peer Reviewer Comment	ATSDR's Response
44	P. C-13. The statement that only arsenic and chromium had at least one measured concentration greater than their health-based comparison values is not exactly correct, as Table C-5 indicates that the highest measured value of beryllium was equal to its CV. Also, it would be helpful to include the uncertainties associated with these measured values.	The statement noted is correct. As the comment itself notes, beryllium did not have any concentrations *greater than* its corresponding health-based comparison value; rather, the highest concentration was equal to the health-based comparison value. More detailed evaluation of beryllium is not warranted by the fact that a single measured concentration was equal to the highly protective comparison value. ATSDR agrees that information on the uncertainty associated with measurements would be helpful, but such information is not presented in any of the original reports. ATSDR notes that the laboratory analytical methods commonly used for identifying metals on particulate filters can usually achieve a measurement precision of better than 10% (EPA 1999).
45	There are four sets of parameters that are pertinent to this report for arsenic, cadmium, chromium, and beryllium. They are the CV numbers, calculated concentrations, LOAEL values, and measured maximum and long-term concentrations. A table that allows a comparison to be made of the four sets of values would be most instructive. [A handwritten table was provided as an example.]	ATSDR appreciates the desire to conduct data evaluations in a uniform manner. The Public Comment Release draft tried to achieve this as follows: (1) for every contaminant, the highest concentration was first compared to the most protective comparison value (whether derived for non-cancer or cancer effects); and (2) for the three contaminants selected for further evaluation, detailed evaluations were presented first for non-cancer effects and then for cancer effects. ATSDR has revised the opening statements in Section IV to emphasize that separate evaluations are presented for non-cancer effects and cancer effects. ATSDR is not including a single table as the comment suggests, because the proposed table mixed information on the non-cancer and cancer evaluations, which are routinely conducted separately for contaminants requiring further assessment.

	Public or Peer Reviewer Comment	ATSDR's Response
46	The communication of the risks posed by the incinerator is the area of greatest concern in this report; in particular, the frequent use of the term "contamination," "contaminants," "harm," etc. "Contamination" undeniably conveys the notion of real, not potential, harm. This problem may have its origin in the somewhat contradictory definition of contaminant included in the glossary: "A substance that is either present in the environment where it does not belong, or is present at levels that might cause harmful (adverse) health effects." If you were a lay audience member reading this report, which definition would *you* believe? How would you distinguish between the two? I would respectfully suggest a lay audience should not be asked to do so, which is why this double-meaning is confusing. A reader would be understandably confused by hearing mixed messages of "contaminants" being released that cause no harm, and this confusion hinders public understanding and acceptance of the findings. This could be clarified by finding two different words or phrases that accurately describe each concept, rather than relying on one emotive word such as "contamination" to fill several roles. Is there a term that more accurately conveys the concept of potential risk, such as compounds of concern? Compounds of interest? It would be advisable to find a term that more accurately conveys the level of risk (not harm) posed by these compounds and use that term throughout the report. See also this very question #4 [in the charge to the peer reviewers], referring to the "health threat posed by the site." If the conclusion of the report is that there is no health threat, is there a more accurate way to phrase this question that does not somehow imply that there is a health threat? Given the conclusion of lack of any threat to health from this incinerator, the report should be worded in a way that accurately conveys that conclusion without increasing perception of risk simply by choice of words.	The comment questions the use of the term "contaminant" throughout the PHA. The comment states that using the term "contaminant" might give the impression that harmful exposures are occurring, even in cases when they are not. ATSDR is quite sensitive to the connotations of terms used in its documents. However, one can just as well argue that using "less threatening" terminology (like "substance" or "compound of interest") might give the impression that ATSDR is downplaying the potential dangers of some highly toxic chemicals (e.g., arsenic, dioxin). After carefully considering this comment and noting that none of the many other reviewers of this document have raised similar concerns, ATSDR will not be replacing the term "contaminant" as suggested.
Comments on Methodologies Used in the PHA		
47	ATSDR's ORR TSCA Incinerator PHA employs current and appropriate methodologies to adequately describe the nature and extent of potential risks associated with direct exposure (via inhalation) to facility emissions.	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.
48	This Peer Review question appears to conflate data (the information available for assessment) with methods (the manner in which information is assessed). Notwithstanding this possible point of confusion, this review is unable to address the appropriateness of data use absent a presentation of such data and any methodological manipulations. However, the document does present a reasonably detailed description of assessment methods. The assessment methods described appear to have been properly used in arriving at the conclusions presented.	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.
49	ATSDR's ORR TSCA Incinerator PHA description of potential pathways of human exposure would benefit from a more thorough explanation of the different pathways of human exposure and that this PHA focuses on the direct exposure route. This expanded discussion should be highlighted in the Summary section to provide readers a clear and early indication of the PHA's focus and limitations.	ATSDR added two sentences to the Summary (Section I) to indicate that the primary focus of the PHA is indeed on direct inhalation exposures and to acknowledge that indirect exposures will be considered further in a future PHA.

	Public or Peer Reviewer Comment	ATSDR's Response
50	Some may question why additional pathways were not addressed in more detail, but understanding that airborne exposure poses the greatest risk at this site, I am not concerned by the lack of additional analysis of secondary pathways as you have shown the airborne risks to be quite low.	ATSDR has more prominently acknowledged in the Summary that the PHA focuses almost entirely on direct (inhalation) exposures. The possibility of indirect exposures is being considered in a subsequent PHA, though all indications from the air monitoring data suggest that such indirect exposures are likely insignificant — a finding echoed by two of the peer reviewers (see Comments #50 and 51).
51	Only air emissions are of concern since water and solid discharge passes through ORR's waste treatment and disposal systems which are monitored to ensure that they do not lead to public exposure. Air emissions are used to evaluate air exposure. However, air emissions can enter the food chain through soil deposition and transport to aqueous media. This was clearly recognized in the treatment of the radionuclides discussed on page B-5 and in the response to Question B-3 on page 69. Alternative exposure pathways clearly cannot be excluded a priori. However, if the TSCA Incinerator contributes a negligible fraction of the air concentration, it follows that air emissions would similarly contribute a small fraction of the exposure through alternative pathways that result from deposition of air emissions. This issue should have been addressed up front and not in a response to a question on page 69.	ATSDR's revision to the Summary (see responses to the two previous comments) addresses the issue raised in this comment. As this comment and the previous comment note, the available data suggest that indirect exposure pathways are likely insignificant for the TSCA Incinerator.
52	The data and methods were correctly applied. However, in the "Overall Findings" in Table 8, metals, it would not be correct to conclude "chromium was selected as a contaminant of concern" or in Table 9 and page 57 that "arsenic, cadmium and chromium require more detailed evaluation." If they required more detailed evaluation or were of concern beyond initial evaluation, it is only because they were not correctly evaluated at the outset (i.e., they were evaluated assuming 100% of each metal was emitted in its most toxic form without justification for assuming so based on speciation of emitted metals, as noted for chromium on page B-4 and C-8) and/or that other sources of exposure to these metals were included in the evaluation of the incinerator (as noted on page 59) instead of quantifying the exposure to the incinerator relative to other sources. As a result, Section IV on Public Health Implications goes into considerably more additional detailed evaluation than warranted by the data.	The comment addresses the methodology ATSDR used to select contaminants requiring further evaluation and suggests that ATSDR should have selected fewer (rather than more) contaminants requiring further evaluation. During chemical screening, ATSDR first compares the highest concentrations to conservative health-based comparison values. In some instances (e.g., chromium), assumptions must be made regarding the form of the contaminant present. All such assumptions were fully documented in this PHA. The net result is that this screening process intentionally errs on the side of being more health-protective, which ATSDR believes is entirely appropriate for a screening procedure. Accordingly, no changes were made in response to this comment.

	Public or Peer Reviewer Comment	ATSDR's Response
53	You may want to check the source of the DOE data presented in Table C-2 on page C-8 to be sure the data are being presented accurately. It does not seem likely that CREGs would be exceeded for arsenic, cadmium and chromium unless some significant assumptions were made about the form of each metal present when it was compared to the CREG, such as assuming each metal was present in 100% carcinogenic form which is highly unlikely. If such assumptions were made, those should be stated here and the justifications for them, as they seem to form the entire basis of the additional evaluation for those three metals (according to page C-6, line 20). The same thought applies to TDEC monitoring data in Table C-5 on page C-14. Any assumptions with regard to the original speciation of the monitored data that were compared to CREGs should be clearly stated and the justification for doing so before submitting these compounds to further evaluation that may not warrant it.	The comment asks ATSDR to double-check the data summaries presented throughout Appendix C. ATSDR has verified that the data tables are indeed correct. The comment suggests that ATSDR made "significant assumptions" when finding that ambient air concentrations exceeded the CREG. While this is true for chromium (and the assumption that the chromium is present entirely as the hexavalent form is documented in the PHA), no such assumptions were made for arsenic or cadmium. The fact that the ambient air concentrations exceeded the CREG primarily reflects the very conservative nature of the comparison values for cancer outcomes. More importantly, however, the detailed evaluations in Section IV of the PHA showed (1) that ambient air concentrations of arsenic, cadmium, and chromium near the TSCA Incinerator are reasonably consistent with those measured in rural and suburban areas around the country and (2) that measured concentrations are at levels well below those observed to be associated with adverse health effects.
54	Much of the health assessment is based on ambient monitoring data. However, the report does not provide a basis for estimating the fraction of the concentrations at the monitoring sites that are contributed by the TSCA Incinerator. Determination of the fraction is possible, in principle, using source apportionment techniques, taking advantage of the fact that radionuclides can serve as a source signature for the TSCA incinerator. There may be other contributors of the radionuclides at ORR but the radionuclides should provide a basis for eliminating the background contaminants that are from off-site sources. The ratio of contaminants such as cadmium to the radionuclides in the filters from the stack of the TSCA Incinerator compared to those from ambient samples should provide a means of eliminating the grossly conservative assumption that the ambient concentration is due to emissions from only the TSCA Incinerator. An opportunity seems to have been missed to use the unique signatures present in the wastes to better resolve the air monitoring results. It is particularly important to provide this fraction as the potential health consequences of cadmium, arsenic, and chromium.	ATSDR entirely agrees that conducting sophisticated source apportionment studies would provide even greater insights into the ambient air monitoring data collected near the TSCA Incinerator. When conducting this PHA, however, ATSDR's initial goal was to evaluate the public health implications of the measured concentrations, regardless of their origin. Given that the measured concentrations were found to be safely below levels associated with adverse health effects, ATSDR does not feel compelled to invest additional resources in source apportionment studies, though such studies might generate interesting and informative results. Accordingly, no changes to the PHA are needed in response to this comment.

	Public or Peer Reviewer Comment	ATSDR's Response
55	With the reindustrialization of portions of East Tennessee Technology Park (ETTP) and leasing of buildings to private businesses, there has been an influx of workers employed by businesses not directly associated with DOE operations. As a consequence, it would appear that employees of the lessees would be the most exposed members of the public. Were the exposures to these workers given consideration in Agency for Toxic Substances and Disease Registry (ATSDR) evaluations?	When preparing this PHA, ATSDR did consider exposure to workers not directly associated with DOE operations. This was done in two ways. First, ATSDR noted that the highest concentrations predicted in the Independent Panel's modeling study occurred at locations within and immediately adjacent to ETTP, where occupational exposures could potentially be occurring for the workers noted in this comment. Given that the estimated concentrations from the Independent Panel study were below levels of health concern, under the assumption of continuous residential exposure scenario, it follows that the estimated concentrations are also safe for an occupational exposure scenario. Second, several of the ambient air monitoring stations considered in this PHA (e.g., see Figures C-2 through C-4) were placed either within the ETTP site boundary or in locations believed to experience the greatest air quality impacts. None of the measurements ATSDR reviewed reached levels of health concern, including measurements collected at locations that only workers might frequently access.

	Public or Peer Reviewer Comment	ATSDR's Response
56	ATSDR has identified that ambient air concentrations of arsenic, cadmium, and chromium are present at concentrations above their health-based comparison values. Is there any indication that these air contaminants are due to the TSCA Incinerator? If not, is this discussion relevant to this PHA? The same ambient air monitoring results are reported annually by DOE and TDEC; however they have not come to the same conclusions because these agencies use different guidelines (e.g., risk-specific doses from 40 CFR Part 266). DOE, TDEC, and ATSDR should resolve the appropriate comparison standard for the data. The lead sentences discussing the results for arsenic (page 59, line 41-44), cadmium (page 61, line 2-5) and chromium (page 62, line 26-29) should be reworded so that they cannot be quoted out of context to give a meaning opposite that intended by ATSDR. These statements (without context) give the impression that the metals were of concern to public health. The paragraphs containing these statements should also cite references to the comparison values used and describe their nature, i.e. conservative or otherwise. The new statements should make the reader immediately aware of any assumptions leading to different conclusions. The discussion should clearly distinguish between the use of screening values and final decision values.	The comment raises several issues. First, the comment asks the extent to which ambient air concentrations of arsenic, cadmium, and chromium result from the TSCA Incinerator's air emissions. In Section IV.D of the PHA, ATSDR addressed this issue in a general fashion by noting that: "For all three metals, the available sampling and modeling data suggest that emissions from multiple local sources, and not just the TSCA Incinerator, contribute to the measured airborne concentrations." Second, the comment questions why the PHA discusses these contaminants if the ambient air concentrations are not "due to the TSCA Incinerator." When evaluating air quality issues, ATSDR routinely presents ambient air sampling and ambient air monitoring data collected at locations near the source of interest. Omitting these data from the PHA would be a very serious oversight. Third, the comment requests further information in Sections IV.A, IV.B, and IV.C to ensure that certain statements cannot be taken out of context. ATSDR has revised the specific passages mentioned in the comment in attempt to help ensure that the data summaries cannot be misinterpreted. Finally, the comment correctly notes that different agencies use different guidelines to evaluate ambient air monitoring data. Although this reality might be somewhat confusing, ATSDR encourages readers to appreciate the consistency of the overall message. While the agencies involved in this site use various and different guidelines to evaluate ambient air monitoring data, the different agencies' interpretations converge on the same conclusion: the air emissions from the TSCA Incinerator do not cause exposures at levels of health concern.
Comments on the PHA's Conclusions and Recommendations		
57	The CAP concurs that the most appropriate category for the TSCA Incinerator emissions is "limited public exposures in amounts that are not expected to result in public health effects."	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.

	Public or Peer Reviewer Comment	ATSDR's Response
58	The PHA conclusions that the TSCA Incinerator destroys organic waste with high efficiencies and that the emissions of trace contaminants do not pose a public hazard are strongly supported by the data and reinforcing arguments.	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.
59	Mindful of the specific qualifications found within the PHA, the document's conclusions and recommendations appear appropriate.	ATSDR appreciates receiving this comment. No changes to the PHA are needed in response.
60	With the exception of providing an earlier and more complete context for the PHA's direct exposure pathway focus [see Comment #51], the document generally communicates in clear and accurate terms the estimated risks posed by the facility's emissions.	ATSDR appreciates receiving this comment. Refer to responses to Comments #49 to 51 for how ATSDR addressed the issue of providing "earlier and more complete context" of the PHA's focus.
61	A suggestion for future monitoring: collect more specific information on the types of these metals present (e.g., page 64, line 15, "…the relative amounts of trivalent chromium and hexavalent chromium in ambient air near ETTP are not known). They should be. Having these data would likely also obviate the need for "additional evaluation" beyond preliminary screening. This would be included in public health recommendations, page 81, first paragraph (and also recommendation for further action, page 82), and preclude the need for the fourth paragraph in the public health recommendations on page 81 and 82. Having lower detection limits of metals will not help characterize risk more accurately if the metals are all assumed to be present in 100% of their most toxic form for the health assessment.	The comment suggests that ATSDR include a new recommendation for conducting speciated sampling of airborne metals. While such sampling results would certainly provide improved insights for chromium, the analyses in the PHA show that realistic estimates of inhalation exposures using the existing data are below levels of health concern. ATSDR believes that conducting the additional sampling mentioned would probably do no more than confirm the main conclusion, but at a considerable cost. Refer to ATSDR's response to Comment #64 on the recommendation specific to TDEC's ambient air sampling of metals.
62	The recommendations are thoughtful and sound. This reviewer notes that the second objective of the PHA on page 1 is to respond to specific community concerns about the TSCA Incinerator. Recommendations are made on page 81 on how the community should heed air quality warnings by the TDEC. Given that the TSCA Incinerator is operating at a small fraction of its capacity [see page 2 (5% of its permitted limit) or Fig 5 on page 16], it would make for good community relations if, on the days of air quality warning, the waste feed was cut off to the TSCA Incinerator and the Incinerator kept ready for restart by firing with the clean back up fuel. Even though the TSCA Incinerator contributes very small increments to the PM and ozone, given the excess capacity of the Incinerator there is no need to contribute any incremental emissions when there are air quality warnings.	The comment suggests that ATSDR should consider recommending that the TSCA Incinerator cease operating on days with air quality warnings, even though the comment also acknowledges that the TSCA Incinerator's emissions contribute little to the measured concentrations of pollutants that trigger these warnings. While ATSDR can certainly appreciate the argument presented in this comment, ATSDR defers to the state and local environmental agencies for the most appropriate actions to take during the air quality warnings.

	Public or Peer Reviewer Comment	ATSDR's Response
63	The report represents an excellent consolidation of voluminous information compiled to educate the public about the history, operation, and environmental impacts of the facility. The factual accuracy, conclusions, and recommendations in the report need to be reviewed in the future against any new information from performance tests and risk assessments associated with ongoing permit renewal requirements. Continuous stack sampling for metals and continuous emission monitoring of particulate matter should be maintained using equipment already installed at the facility and the results used to provide continuing assurance of anticipated performance of emission controls. This may provide for better detection of changed conditions at the incinerator than ambient air sampling and monitoring.	The PHA includes a Public Health Action Plan to ensure that ongoing operation of the TSCA Incinerator will not cause harmful health effects in the future. Specific recommendations in the Public Health Action Plan are consistent with suggestions in this comment (e.g., continued ambient air monitoring, preparation of annual fact sheets). Additionally, the existing regulatory framework requires some of the suggested measurements identified in the comment (e.g., continuous emissions monitoring for certain pollutants). ATSDR is willing to review relevant data that become available in the future, as appropriate.
64	The CAP does not accept Agency for Toxic Substances and Disease Registry's (ATSDR) recommendation that Tennessee Department of Environment and Conservation (TDEC) should achieve lower detection limits in its air-emissions metals monitoring network. The current limits do not make any difference in the PHA results. The monitoring data presented by U.S. Department of Energy (DOE) are supported by various lines of evidence that all indicate the data are accurate. In lieu of expensive instrumental and analytical improvements, the CAP recommends that TDEC perform critical technical oversight of DOE's procedures and review any proposed changes. Improvements in TDEC's monitoring capability eventually may be needed to obtain measurements for purposes other than direct comparison to DOE's data and to allow for continuation of data collection if DOE's monitoring should be discontinued. In the best of all worlds, the TDEC and DOE sampling and analytical procedures should be designed to reinforce one another. However, in a state already short of health related funds, it is not clear that monies should be expended to prove what is indicated to be true by several other methods.	The comment questions the need for ATSDR's recommendation that TDEC achieve lower detection limits in its analysis of metals samples. ATSDR made that recommendation such that TDEC would independently verify the quality of DOE's ambient air monitoring data for metals. ATSDR still believes it is important to verify the accuracy of these data, but agrees that this verification can be achieved in various ways (some being more cost-effective than others). In response to this comment, ATSDR has revised its recommendations to TDEC. The revised recommendations still emphasize the need to independently verify the accuracy of DOE's metals data, but acknowledge different approaches that TDEC can take to do so (e.g., increased oversight of DOE's sampling and analytical procedures, analysis of "split samples" from the filters collected by the sampling devices).
65	Regarding ATSDR's recommendation that TDEC should achieve lower detection limits in its metals monitoring network and, after lowering detection limits, compare its data to DOE's metals monitoring data, the Board is uncertain whether value is added beyond that which could be achieved by critical technical oversight of DOE's procedures and review of any proposed changes. The Board, however, recognizes that improvements in TDEC's monitoring capability may be needed to obtain measurements for purposes other than direct comparison to DOE's data and to allow for continuation of data collection if DOE's monitoring should be discontinued.	As the response to the previous comment notes, ATSDR has revised the recommendation that this comment addresses.

	Public or Peer Reviewer Comment	ATSDR's Response
66	TDEC will maintain its commitment of ambient air-monitoring activities at ETTP for metals and radionuclides. TDEC intends to achieve this technical recommendation [to achieve lower detection limits in its metals analysis]. TDEC will issue an annual fact sheet on the environmental status of the TSCA incinerator. TDEC will always seek ways to improve on its annual reporting of its environmental activities. TDEC will, in coordination wit the Knox County Department of Air Quality Management, continue to issue the air quality warnings for the Knoxville area.	ATSDR appreciates receiving these assurances. No changes to the PHA are needed in response.
67	TRV openings (See Table 2), Page 17 - The rationale for not analyzing any samples since 1996 would appear to need basis from additional criteria other than a management decision that feed and operating conditions were bracketed by previous events. Periodic analysis may be needed more frequently to identify changes in ambient background concentrations and to assure quality of sampling and analytical procedures. Regarding episodic releases following TRV openings (page 45, lines 19-27): qualify the statement that samples are collected during all TRV events but are no longer analyzed. The recommendation on page 81 regarding continuous ambient air monitoring is not a TRV issue. ATSDR's recommendation for continuing ambient monitoring during TRV events should be stated.	When preparing this PHA, ATSDR considered the need for DOE to analyze a greater fraction of the ambient air samples collected during TRV events. ATSDR determined that its conclusion regarding TRV events would change only if the ambient air concentrations of dioxins, furans, and PCBs were found to be consistently and dramatically higher than those that have been measured to date. ATSDR has no reason to expect that such elevated concentrations will occur. A sensible way of verifying this is to analyze only those samples collected during TRV events associated with high waste feed rates or PCB inputs. In other words, the criteria that DOE currently uses when deciding whether to analyze samples should provide sufficient insights on whether air quality impacts during TRV events are unusually higher than the concentrations that have already been measured. Based on this analysis, ATSDR is not recommending any change to the current ambient air sampling and analysis framework for TRV events.