
1 **A. Appendix A: Review of Air Emissions Studies**

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

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

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

34 **A.1 Trial Burns**

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

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

3 Following is ATSDR's technical review of the trial burns that DOE has conducted at the TSCA
4 Incinerator.4 Tables A-1 and A-2 summarize the main findings from the trial burns. Overall, the
5 trial burns demonstrated that the TSCA Incinerator is capable of destroying organic material in
6 waste streams, including PCBs, without creating hazardous residuals or unsafe air emissions.

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

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

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

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

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

23 As Table A-1 shows, PCBs were measured in the stack gases to determine how efficiently the
24 incinerator destroyed the waste material. In all six tests, PCBs were detected in the stack gases,
25 but the detected amounts indicated that the incinerator's DRE was 99.99997% for both types of
26 wastes. Thus, the trial burn demonstrated that the incinerator's DRE met the minimum
27 requirement of TSCA regulations (99.9999%). Other key findings during the trial burn were that
28 stack gas concentrations of particulate matter and hydrogen chloride removal efficiencies both
29 fell well within limits later set in RCRA permits. Additionally, PCB concentrations in the
30 process residuals met TSCA requirements: the ash generated during the tests contained less than
31 2 ppm PCBs, and the wastewater contained less than 3 ppb PCBs. After this trial burn EPA
32 issued DOE a letter that approved use of the TSCA Incinerator to treat wastes containing PCBs
33 (EPA 1989).

34

4 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.

1 **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 >99.999996%
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.

2
3 Notes: Sources of data: Engineering-Science 1988a; TRC 2001.

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

1 **Table A-2. Summary of RCRA Trial Burn Data**

<i>Parameter</i>	<i>RCRA Requirement</i>	<i>Results from RCRA Trial Burns</i>		
		<i>June 1988 Test</i>	<i>June 1989 Test</i>	<i>May 2001 Test</i>
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%

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 3 Notes: Sources of data: Engineering-Science 1988b; IT Corporation 1989; TRC 2001.
 4 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,
 5 (2) trichlorofluoromethane, and (3) hexachloroethane. In the May 2001 test, the POHCs were (1) carbon tetrachloride and (2) 1,2,4-trichlorobenzene.
 6 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
 7 where emissions exceed this level, that HCl removal efficiencies are at least 99%.

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

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

10 Table A-2 summarizes the results from this initial RCRA trial burn. In general, the incinerator's
11 performance exceeded the minimum requirements EPA established for DREs of organics, stack
12 gas concentrations of particulates, and emission rates of hydrogen chloride. While this testing
13 strongly suggested that the TSCA Incinerator complied with RCRA requirements, an additional
14 trial burn was conducted one year later. The additional trial burn was conducted to better
15 establish permitting limits on key operating conditions (e.g., combustion temperature, waste feed
16 rates) before routine waste treatment operations began. The next item reviews the findings of the
17 follow-up RCRA trial burn.

18 June 1989 RCRA Trial Burn Retest (IT Corporation 1989)

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

30 Over the 3-day test, three different stack tests were conducted for the operating parameters
31 specified in the trial burn. These tests, both individually and combined, all showed that the
32 TSCA Incinerator destroyed organic waste constituents without causing elevated emission rates
33 for particulate matter or hydrogen chloride. Of the three POHCs selected, only
34 trichlorofluoromethane was detected in the stack exhaust. These detections suggested that the
35 DRE was at least 99.998%, which surpasses the minimum required DRE of 99.99%. Further, the
36 highest particulate concentration in the stack gases was 0.0327 grains/dscf, which meets the
37 permit restriction of particulate concentrations being no higher than 0.08 grains/dscf. Finally, the
38 air pollution controls were found to remove at least 99.912% of the hydrogen chloride generated
39 during combustion, while the required removal efficiency is only 99%. In short, this trial burn
40 found that the TSCA Incinerator met the main permit restrictions outlined in RCRA waste
41 management regulations.

1 June 1997 RCRA Metals Trial Burn.

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

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

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

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

25 *Compliance with TSCA requirements*

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

34 *Compliance with RCRA requirements*

35 To evaluate compliance with RCRA, the DOE contractors selected two POHCs (1,2,4-
36 trichlorobenzene and carbon tetrachloride) for the trial burn. Because these contaminants rank
37 among the most difficult to incinerate, it can be inferred that the waste destruction efficiencies
38 for most other organic compounds are at least as high as those observed for the POHCs. In all of
39 the tests conducted, neither POHC was detected in the stack gases. Using the detection limits for
40 these contaminants, the DRE was reported to be at least 99.9993%, far surpassing the minimum

1 DRE (99.99%) that RCRA requires. The highest hydrogen chloride emission rate measured was
2 0.11 pounds/hour — nearly 40 times lower than the maximum level allowed by RCRA (4.0
3 pounds/hour).

4 *Other emissions data (metals and organic compounds).* Though designed to characterize
5 compliance with the aforementioned TSCA and RCRA requirements, the 2001 trial burn also
6 measured emission rates of many additional contaminants. For instance, the stack tests included
7 12 metals: antimony, arsenic, beryllium, mercury, selenium, silver, and thallium were not
8 detected in any of the samples; barium, cadmium, chromium, lead, and nickel were detected. The
9 lead levels measured were safely below the emission limits specified in the incinerator's
10 operating permit. The lack of air permit emission limits for the other metals is not a data gap, as
11 this PHA's conclusions for metals rest largely on the dispersion modeling data and ambient air
12 monitoring data documented in Appendixes B and C, respectively.

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

19 *Notice of violation for particulate emissions*

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

37 **A.2 Performance Tests**

38 DOE and its contractors have conducted four performance tests to obtain and renew the TSCA
39 Incinerator's operating permit with the state of Tennessee. This permit sets maximum emission
40 rates for the following contaminants: particulates, sulfur dioxide, nitrogen oxides, hydrogen
41 fluoride, hydrogen chloride, volatile organic compounds, lead, mercury, and beryllium (TDEC

1 1991). The permit requires DOE to conduct stack tests every 5 years, starting in 1990, to verify
2 compliance with the permitted emission rates. It is important to note that waste feed rates and
3 other operating parameters during performance tests tend to be more representative of actual
4 operating conditions, while those in trial burns are usually set to challenge incinerator
5 performance. Accordingly, air emissions measured during the performance tests are likely more
6 representative of incinerator's typical emission rates.

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

14 **November 1988 Performance Test (Martin Marietta 1988)**

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

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

1 **Table A-3. Summary of TSCA Incinerator Performance Tests**

<i>Parameter</i>	<i>TDEC Permitted Emissions Limit</i>	<i>Emission Rates Measured During Performance Tests</i>			
		<i>November 1988 Test</i>	<i>June 1990 Test</i>	<i>June 1995 Test</i>	<i>November 2000 Test</i>
Particulate	3.0 lb/hour	Not tested	Not tested	0.18 lb/hour	0.385 lb/hour
Beryllium	0.002 lb/day	<i>0.0348 lb/day</i>	< 0.00017 lb/day	0.00016 lb/day	0.0012 lb/day
Lead	3.15 lb/day	<i>4.61 lb/day</i>	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.				

2 Notes: Each performance test involved at least three separate emissions measurements for two different operating scenarios (i.e., liquid waste only and a
 3 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
 4 average emission rates.
 5 In the November 1988 test, DOE was required to measure emissions of only beryllium, fluorine, and lead. TDEC did not require measurement of particulates,
 6 mercury, chlorine, or sulfur, because an earlier trial burn had adequately demonstrated compliance these permit requirements.
 7 Emissions data in italics exceed TDEC emission limits.

1 June 1990 Performance Test (IT Corporation 1990).

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

7 The performance test considered waste streams, both liquid and solid, comparable to those
8 considered in the test done in November 1988. Table A-3 summarizes this test's results. In short,
9 beryllium was not detected in any of the stack gas samples, which indicated that the emission
10 rate was less than 0.00017 pounds/day and the system removal efficiency was at least 99.4%.
11 Lead, on the other hand, was detected in stack gases at levels suggesting an emission rate of
12 0.048 pounds/day — more than 50 times lower than the current permitted limit. The test found
13 that 99.2% of lead in the input waste stream was removed, mostly into the ash. Having
14 successfully demonstrated that beryllium and lead emissions comply with permitted limits, DOE
15 was allowed to begin routine operations of the TSCA Incinerator in 1991.

16 June 1995 Performance Test (Martin Marietta 1995)

17 DOE contractors conducted the required performance test on 6 days, between June 26 and July 1,
18 1995. All testing followed a sampling plan that DOE submitted to TDEC for review and
19 approval. A TDEC representative observed operations and sampling activities on several days of
20 the performance test. All tests were performed using sampling and analytical methods published
21 by EPA and following specifications of a Quality Assurance Project Plan. Multiple quality
22 assurance measures were used, such as analyzing field blanks and method blanks, running
23 laboratory control samples, and analyzing matrix spike samples. The laboratory successfully
24 analyzed all samples collected during the program.

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

37 November 2000 Performance Test (IT Corporation 2001)

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

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

4 The performance test evaluated two scenarios using feed rates, combustion temperatures, and
5 other parameters that are typical of routine operating conditions. The first scenario involved
6 treating liquid wastes. The feed rates, on average, were 342 pounds/hour of organic waste and
7 312 pounds/hour of aqueous waste. The second scenario involved treating a combination of solid
8 and liquid wastes, and the average feed rates were 235 pounds/hour of solid waste, 317
9 pounds/hour of organic waste, and 323 pounds/hour of aqueous waste.

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

21 **A.3 Continuous Emissions Monitoring and Continuous Emissions Sampling**

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

30 **Carbon monoxide, carbon dioxide, and oxygen**

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

40

1 *Carbon monoxide*

2 According to the RCRA permit, 1-hour average concentrations of carbon monoxide (corrected to
3 7% oxygen) must remain below 100 ppm, as higher levels would indicate poor combustion
4 efficiency. Thus, automatic waste feed cutoffs occur whenever stack carbon monoxide levels
5 exceed permitted limits.

6 *Carbon dioxide*

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

11 *Oxygen*

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

17 **Metals and particulate matter**

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

22 *Metals (other than mercury)*

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

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

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

5 Table A-4 summarizes the continuous emissions sampling results collected during 2000 and
 6 2001. Overall, these data show that emission rates of beryllium, lead, and mercury complied with
 7 TDEC permit limits in every sample that was analyzed. Similarly, every stack gas concentration
 8 of low volatile metals (arsenic, beryllium, and chromium) and all but one of the stack gas
 9 concentrations of particulates were below the corresponding “maximum achievable control
 10 technology” (MACT) standards that EPA had proposed at the time. On the other hand, in 8 out
 11 of the 48 valid samples collected outside the trial burn period, the stack gas concentration of
 12 semi-volatile metals (lead and cadmium) exceeded concentration limits that EPA would *later*
 13 *establish* in the technology-based MACT standard. This statement is not intended to imply that
 14 the incinerator operated out of compliance, especially considering that EPA enacted the MACT
 15 standards more than 2 years after these emissions data were collected. Readers should refer to
 16 Appendix C and Section III of the PHA for a more complete evaluation of the air quality issues
 17 for lead and cadmium, given that ambient air has been monitored for these metals in the vicinity
 18 of the TSCA Incinerator for more than 10 years.

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

<i>Parameter</i>	<i>Regulatory Limit***</i>	<i>Source of Regulatory Limit</i>	<i>Number of Measured Values Found Below Regulatory Limit (Maximum = 48)</i>
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%)

21 Notes: The regulatory limits in this table include both stack concentrations (i.e., those expressed in µg/dscm and
 22 grains/dscf) and emission rates (i.e., those expressed in lb/day).

23 Low-volatile metals include concentrations of arsenic, beryllium, and chromium.

24 Semi-volatile metals include concentrations of cadmium and lead.

25 Emissions data collected during the May 2001 trial burn are not included in this tally.

26 ***The MACT limits represent “maximum achievable control technology” among hazardous waste incinerators.

27 Thus, these values are technology-based and not necessarily health-based. Moreover, these standards came into
 28 effect on September 30, 2003 — more than 2 years after the air sampling results summarized above were collected.

29 Comparisons to the MACT standards are presented merely to identify the metals that warrant closer inspection in the
 30 ambient air monitoring data.

1 *Mercury.*

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

11 *Particulate matter*

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

23 *Radionuclides*

24 While continuous emissions monitoring data for radionuclides is clearly desirable, ATSDR is not
25 aware of any technology that can provide such measurements accurately and precisely. On the
26 other hand, continuous emissions sampling for radionuclides is not only feasible, but a required
27 element in one of DOE's environmental permits for the TSCA Incinerator. Accordingly, from
28 1991 to the present, DOE has operated a continuous emissions sampling system on the TSCA
29 Incinerator's main exhaust.

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

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

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

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

<i>Radionuclide</i>	<i>Highest Measured Annual Emission Rate (Ci)</i>
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

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

1 **B. Appendix B: Review of Fate and Transport Modeling Studies**

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

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

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

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

35 **Emissions estimation approach**

36 Emission rates are arguably one of the most critical inputs to air dispersion models. For total
37 PCBs, each metal, and each VOC, the independent panel estimated emission rates by multiplying
38 an annual waste feed quantity and the estimated DRE. The waste feed rates used in these
39 calculations were the highest contaminant-specific rates observed in calendar years 1994, 1995,
40 and 1996. The following DREs were used: 99.9999% for PCBs, between 95% and 98.5% for
41 metals (except for mercury, which was assumed to have a DRE of 0%), and 99.99% for VOCs.

1 ATSDR believes this calculation approach is sound, given that trial burns demonstrated that the
2 TSCA Incinerator achieves the aforementioned efficiencies even under operating conditions that
3 do not favor complete combustion. For particulate matter, the modeling analysis assumed an
4 annual emission rate of 1.32 tons/year. No supporting data are provided for selecting this
5 emission rate; however, the number appears to significantly overstate actual emissions, given
6 that DOE reported particulate matter emission rates from the TSCA Incinerator to be no higher
7 than 0.096 tons/year between 1994 and 1996 (DOE 1991–2002). Overall, ATSDR believes the
8 independent panel used reasonable emissions data in the modeling analysis for the time frame
9 under consideration.

10 **Air dispersion modeling approach**

11 The independent panel used the Industrial Source Complex Short Term (ISCST) model, version
12 3, to simulate how contaminants move from the TSCA Incinerator stack through the air to
13 locations where people might be exposed. ISCST is listed among EPA’s regulatory guideline
14 models for evaluating emissions from industrial sources. Modeling options were generally
15 consistent with regulatory defaults: building downwash effects were considered, deposition was
16 not considered (causing the analysis to overstate potential air quality impacts), and urban
17 dispersion coefficients were used to reflect the industrial nature of the ETTP site. ATSDR
18 believes that all of these options, plus others not specified here, were appropriate for this
19 modeling application.

20 The independent panel’s modeling analysis was based on meteorological data collected at ETTP
21 in 1989, 1991, 1992, 1994, and 1995. At the time the modeling analysis was conducted, these
22 were the five most recent and complete years of meteorological data. Wind roses for these years
23 are similar to the one depicted in Figure 6 of this PHA. The modeling analysis predicted the air
24 quality impacts at hundreds of locations over an area that extends 3 miles in all directions from
25 the TSCA Incinerator. Elevations at each of the receptors were programmed into the dispersion
26 model to account for potential plume impaction at locations in elevated terrain.

27 **Results**

28 The independent panel’s modeling analysis revealed several notable findings. Not surprisingly,
29 the greatest air quality impacts were predicted to occur in the main downwind directions, both
30 northeast and southwest of the TSCA Incinerator. The location with the highest estimated
31 ground-level impacts was 640 meters (0.4 miles) southwest of the main stack. Results for the
32 point of maximum impact are reviewed here, even though this location is within the ETTP
33 property line. The model predicted considerably lower ambient air concentrations at locations
34 further downwind. At the point of maximum impact, the modeling found, the estimated annual
35 average concentration is $1.75 \mu\text{g}/\text{m}^3$ for every gram/second of contaminant emitted — a result
36 that ATSDR incorporated into a separate modeling analysis (see Appendix B.3).

37 Table B-1 summarizes the independent panel’s modeling results. Specifically, the table presents
38 the estimated annual average concentrations at the point of maximum impact alongside health-
39 based comparison values. With one exception, every estimated concentration was safely below
40 the comparison values. For many contaminants, including all of the organic compounds, the

1 estimated concentrations at the point of maximum impact are more than 1,000 times lower than
2 health-based comparison values.

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

8 **Limitations and uncertainties**

9 Like all air quality modeling analyses, the independent panel's study has limitations and
10 uncertainties. The entire study is, for example, based on waste treatment data for just 3 years.
11 ATSDR does not view this as a critical limitation, given that the modeling considers years
12 (1994–1996) when incinerator operations were near their highest. To ensure that focusing on this
13 narrow time frame did not cause the modeling analysis to overlook key issues, ATSDR's
14 modeling evaluation (see Appendix B.3) builds upon the independent panel's study by
15 considering a longer time frame and a broader range of contaminants.

16 The independent panel's modeling analysis has multiple sources of uncertainty, due both to the
17 inherent limitations of atmospheric dispersion models and the incomplete characterization of all
18 inputs. ATSDR has, however, several reasons to believe that the independent panel's modeling
19 analysis tends to overstate, and not understate, the actual exposure concentrations that residents
20 have experienced. First, the independent panel calculated emissions based on the lowest allowed
21 DREs, even though the trial burns have shown that the TSCA Incinerator is typically much more
22 efficient. Second, the emissions data also are based on some of the highest waste feed rates
23 (1994–1996). For comparison, total annual waste feed rates in the past 3 years have been
24 approximately 4 times lower than those observed in the mid-1990s. Finally, the conclusions of
25 the modeling study are based on estimated concentrations for an on-site location. Estimated
26 concentrations at off-site locations were considerably lower than the levels shown in Table B-1.
27 Taken together, these observations suggest that the modeling may have overstated actual
28 exposures. ATSDR is further comforted by the fact that most of the estimated concentrations in
29 Table B-1 are multiple orders of magnitude lower than health-based comparison values. That the
30 modeling analysis understated exposures by such large margins is extremely unlikely.

31 Overall, ATSDR finds the independent panel's modeling analysis to be a reasonable account of
32 the TSCA Incinerator's air quality impacts between 1994 and 1996. ATSDR concurs with the
33 independent panel's conclusion that none of the pollutants evaluated had estimated ambient air
34 concentrations at levels of public health concern.

35

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

<i>Contaminant</i>	<i>Estimated Annual Average Concentration ($\mu\text{g}/\text{m}^3$) at Point of Maximum Impact</i>	<i>Health-Based Comparison Value ($\mu\text{g}/\text{m}^3$)</i>	<i>Type of Comparison Value</i>
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

2 Notes: Modeling results taken from the independent panel's report (Iglar et al. 1998).

3 Refer to Appendix D for more information on the comparison values used and definitions for the abbreviations. The
4 comparison value for uranium is the exposure concentration that would result in an annual radiation dose of 10
5 mrem, assuming that all of the uranium found is uranium-238 (Iglar et al. 1998).

6 Chromium is the only contaminant with an estimated concentration greater than its comparison value. The estimated
7 concentration is for total chromium and the comparison value is for hexavalent chromium, which is a subset of total
8 chromium. Section IV of the PHA discusses this issue further.

9

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

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

9 *Emissions estimation approach*

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

18 *Air dispersion modeling approach*

19 Air dispersion and dose modeling was conducted using EPA's Clean Air Assessment (CAP-88)
20 software, which is a set of computer programs designed to estimate dose and risk from air
21 emissions of radionuclides. The main inputs to the model are source-specific emission rates and
22 local meteorological data, from which the model estimates environmental concentrations of
23 radionuclides. The model assesses both external and internal radiation exposure, not only from
24 inhaling and otherwise contacting airborne radionuclides but also from ingesting radionuclides
25 that might be taken up into the food chain. DOE runs the model using typical default parameters
26 and assumptions, some of which likely overstate potential exposures. For instance, the modeling
27 analysis assumes that 70% of the vegetables and 44% of the meat in residents' diets come from
28 local farms.

29 *Results*

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

38 Table B-2 also identifies which radionuclides accounted for the majority of off-site radiation
39 exposures. Between 1991 and 2002, uranium isotopes accounted for approximately 80% of the

1 off-site radiation exposures attributed specifically to the TSCA Incinerator. The remaining
 2 incinerator-related doses resulted primarily from exposures to tritium and isotopes of neptunium,
 3 plutonium, potassium, technetium, and thorium.

4 *Limitations and uncertainties*

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

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

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

<i>Year</i>	<i>Estimated Effective Dose Equivalent to the Off-site Maximally Exposed Individual (Regulatory Limit = 10 mrem/year)</i>	<i>Radionuclides that Account for the Majority of the Effective Dose Equivalent Associated with ETP Releases</i>
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%)

21 Notes: Source of data: DOE 1991–2002.

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

8 **B.3 ATSDR's Modeling Evaluation**

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

21 ATSDR's modeling analysis focuses on five groups of contaminants: VOCs, PCBs, PAHs,
22 acidic gases, and dioxins and furans. These groups were selected because they have relatively
23 few, if any, ambient air monitoring data available. ATSDR did not consider air emissions for the
24 remaining three groups of contaminants (i.e., particulate matter, radionuclides, and metals),
25 because ambient air concentrations of these contaminants have been measured at multiple
26 locations around the TSCA Incinerator for more than 10 years. Following are detailed
27 descriptions of the contaminant-specific modeling approaches and results:

28 **VOCs and PCBs**

29 The independent panel's modeling results for VOCs and PCBs are based on the amounts of these
30 contaminants found in the waste feed between 1994 and 1996. ATSDR built upon these findings
31 by considering waste treatment quantities reported through 2003. For PCBs and every VOC
32 listed in Table B-1, the highest annual waste treatment quantity actually occurred between 1994
33 and 1996. One can infer from this trend that the air quality impacts for PCBs and VOCs between
34 1997 and the present have not exceeded the estimated concentrations shown in Table B-1,
35 assuming that the TSCA Incinerator continues to meet the required DREs.

36 To build further upon the independent panel's modeling analysis, ATSDR considered potential
37 air quality impacts for a much broader range of VOCs. In addition to considering the 13 VOCs
38 shown in Table B-1, DOE now characterizes waste treatment quantities for more than 150 other
39 organic compounds, mostly volatile. After reviewing the entire history of VOCs and other
40 organic compounds fed to the incinerator, ATSDR found that the maximum annual waste feed
41 for all compounds (except for those shown in Table B-1) was less than 10,000 pounds per year.
42 Using this waste feed rate, an assumed DRE of 99.99%, and the dispersion factor, the annual

1 average concentration at the point of maximum impact for all other VOCs likely does not exceed
2 0.00003 $\mu\text{g}/\text{m}^3$. This annual average concentration is well below corresponding health-based
3 comparison values for the many other VOCs that the incinerator treats. Although published
4 comparison values are not available for all VOCs, ATSDR is reassured by the fact the estimated
5 annual average concentration is almost immeasurably small at the point of maximum impact; in
6 residential areas, the TSCA Incinerator's air quality impacts for VOCs are undoubtedly lower.

7 **PAHs**

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

15 Using the highest measured emissions rate and the independent panel's dispersion factor,
16 ATSDR calculated a maximum annual average concentration of total PAHs to be 0.000005
17 $\mu\text{g}/\text{m}^3$. Even if one assumes that the total PAHs are composed entirely of the most potent
18 individual compound, the estimated concentration is more than 150 times lower than the
19 corresponding risk-based concentration.

20 **Acidic gases**

21 The independent panel's modeling analysis estimated air emissions of hydrogen chloride and
22 hydrogen fluoride from the amounts of chlorine and fluorine in the waste feed and an assumed
23 removal efficiency of the air pollution control devices. While such an approach is reasonable,
24 ATSDR built upon it by evaluating air quality impacts for these compounds using measured
25 emission rates. Specifically, among all performance tests and trial burns (see Appendix A)
26 conducted to date, the maximum measured emission rates for hydrogen chloride and hydrogen
27 fluoride are 0.214 pounds/hour and 0.054 pounds/hour, respectively. Given these emission rates
28 and the independent panel's dispersion factor, the estimated annual average concentrations of
29 hydrogen chloride and hydrogen fluoride at the point of maximum impact are 0.047 $\mu\text{g}/\text{m}^3$ and
30 0.012 $\mu\text{g}/\text{m}^3$, respectively. Both of these estimated concentrations are more than 400 times lower
31 than the chemicals' lowest health-based comparison values.

32 **Dioxins and furans**

33 Neither modeling study reviewed above evaluated potential air quality impacts of dioxins and
34 furans, which arguably are the air contaminants of greatest concern for incineration facilities. To
35 fill this data gap, ATSDR considered the dioxin and furan emissions data recently measured
36 during the 2001 trial burn. Like the PAHs, dioxins and furans were measured in six separate
37 stack tests over the course of the trial burn. During three tests, the incinerator was treating liquid
38 wastes; during the other three tests, the incinerator treated a combination of liquid and solid
39 wastes. Across all six tests, the highest total emission rate of dioxins and furans was 0.214

1 ng/second, expressed on a toxic equivalency (TEQ) basis.⁵ This emission rate is the sum of
2 emissions of all dioxin and furan congeners. In cases where congeners were not detected, the
3 detection limit was used in the emission rate calculation, which is an approach taken to be
4 health-protective.

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

14 **Limitations and uncertainties**

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

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

5 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-tetrachlorodibenzo-p-dioxin) is assigned a TEF of 1, and all other congeners have lower factors.

1 gives ATSDR greater confidence that the modeling results form an adequate basis for reaching
2 conclusions.

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