IV. PUBLIC HEALTH IMPLICATIONS

Summary of Public Health Implications

ATSDR evaluated past and current off-site exposures to uranium releases from the Y-12 plant for both chemical and radiation health effects. Uranium from the Y-12 plant was released into the air from vents and stacks; uranium was also released into the surface water via East Fork Poplar Creek (EFPC) (ChemRisk 1999).

The Scarboro community represents an established community surrounding ORR where residents resided during the years of uranium releases. The Scarboro community was selected as the reference population after air dispersion modeling indicated that its residents were expected to have received the highest uranium exposures (ChemRisk 1999). The Task 6 report stated that "while other potentially exposed communities were considered in the selection process, the reference locations [Scarboro] represent residents who lived closest to the ORR facilities and would have received the highest exposures from past uranium releases…Scarboro is the most suitable for screening both a maximally and typically exposed individual" (ChemRisk 1999).

As shown in Table 25, all of the exposure pathways evaluated by ATSDR for both radiation and chemical health effects resulted in uranium exposures that were too low to be of health concern. Therefore, the residents living in Scarboro were not exposed to harmful levels of uranium from the Y-12 plant in the past, and they are not currently being exposed to harmful levels of uranium from the Y-12 plant. **Consequently, if the Scarboro community—the population likely to have received the highest uranium exposures from the Y-12 plant—was not in the past and is not currently being exposed to harmful levels of uranium from the Y-12 plant, then other residents living near the Y-12 plant, including those within the city of Oak Ridge, are also not being exposed to harmful levels of uranium.** For more details about each of the pathways evaluated, see Section III.B. Public Health Evaluation.

Table 25. Summary of Public Health Implications from ATSDR's Evaluation of Past and Current Uranium Exposure to Off-Site Populations

Exposure	Effects	Pathway	Notes	Is there a public health concern?
Past	Radiation	Total	The total radiation dose from exposure to uranium via all air, surface water, and soil exposure pathways was estimated to be 155 mrem over 70 years (see Table 4 and Figure 9). This dose is well below (32 times less than) the ATSDR radiogenic cancer comparison value of 5,000 mrem over 70 years. Also, the total radiation dose approximation value of 2.2 mrem per year (based on the 155 mrem over 70 years) is well below (45 times less than) the ATSDR chronic-duration MRL of 100 mrem/year for ionizing radiation.	No
	Chemical	Inhalation	Yearly estimated air concentrations of uranium ranged from 2.1×10^{-8} to 6.0×10^{-5} mg/m^3 (see Figure 16 and Table 12). All concentrations were less than 1% of the intermediate-duration inhalation MRL of 8×10^{-3} mg/m^3 for insoluble forms of uranium.	No
		Ingestion	Yearly estimated uranium doses via all soil and surface water exposure pathways ranged from 2.7×10^{-5} to 1.3×10^{-2} mg/kg/day (See Figure 17 and Table 13). All doses are less than the dose (5×10^{-2} mg/kg/day) at which health effects (renal toxicity) have been observed in rabbits, the mammalian species most sensitive to uranium kidney toxicity.	No
Current	Radiation	Ingestion and Inhalation	The uranium radiation dose from exposure via ingestion of soil and vegetables and inhalation of air is 0.216 mrem over 70 years (see Table 14 and Figure 9). This dose is well below (23,000 times less than) the radiogenic cancer comparison value of 5,000 mrem over 70 years. Also, the approximation value of current radiation dose of 0.003 mrem per year (based on 0.216 mrem over 70 years) is well below (33,000 times less than) the ATSDR chronic-duration MRL of 100 mrem/year for ionizing radiation.	No
	Chemical	Inhalation	Average uranium air concentrations (5.4×10^{-11} mg/m^3 in Scarboro and 1.4×10^{-10} mg/m^3 in the city of Oak Ridge) are well below (more than a million times less than) the intermediate-duration MRL of 8×10^{-3} mg/m^3 for insoluble forms of uranium (see Figure 24).	No
		Ingestion	The estimated uranium doses from ingestion of Scarboro soil (ranging from 2.0×10^{-6} to 1.4×10^{-5} mg/kg/day) were well below (more than 140 times less than) the ATSDR oral MRL of 2×10^{-3} mg/kg/day for uranium (see Table 23). The estimated uranium doses from ingestion of vegetables grown in private gardens in Scarboro are 3.0×10^{-5} and 3.9×10^{-5} mg/kg/day which are more than 50 times less than the oral MRL of 2×10^{-3} mg/kg/day for uranium.	No

ATSDR's evaluations of off-site exposures to uranium released from the Y-12 plant indicate that past exposures are not of health concern and are unlikely to result in adverse health effects. For every exposure pathway evaluated, the doses were too low to be of health concern for both radiation and chemical health effects.

Past Radiation Exposure

For the evaluation of carcinogenic effects of past radiation exposure to uranium releases from the Y-12 plant, ATSDR compared the estimated total radiation dose over 70 years from exposure to uranium in the air, surface water, and soil pathways (presented in the Task 6 report)[18] to the ATSDR radiogenic cancer comparison value of 5,000 mrem over 70 years. The radiation dose expected to be received in the reference community, the Scarboro population, was 155 mrem over 70 years (see Table 4), and accounts for multiple routes of exposure. This radiation dose of 155 mrem is 32 times less than the radiogenic cancer comparison value of 5,000 mrem which ATSDR believes is protective of human health (see Figure 9). Therefore, ATSDR does not expect carcinogenic health effects to have occurred from past off-site exposures to radiation doses received from Y-12 uranium releases. This committed effective dose equivalent (CEDE) value of 5,000 mrem over 70 years was derived by ATSDR after reviewing the peer-reviewed literature and other documents developed to review the health effects of ionizing radiation (see Appendix D for more information about ATSDR's derivation of the radiogenic cancer comparison value of 5,000 mrem over 70 years).

To evaluate noncancer health effect from the total past uranium radiation dose (CEDE of 155 mrem over 70 years) received by the Scarboro community, an approximation can be made to compare the CEDE of 155 mrem, which is based on 70 years of exposure, to the ATSDR chronic exposure minimal risk level (MRL) for ionizing radiation (100 mrem/year), which is based on one year of exposure. The CEDE of 155 mrem over 70 years could be divided by 70 years to approximate a value of 2.2 mrem as the radiation dose for the first year, which is well below (45 times less than) the 100 mrem/year ATSDR chronic exposure MRL for ionizing radiation (see Figures 7 and 9).

[18] The Task 6 values (based on 52 years of exposure) were multiplied by 1.35 (70 years/52 years) for comparison with ATSDR's MRL, which is based on a 70-year exposure.

The ATSDR MRLs are based on noncancer health effects only and are not based on a consideration of cancer effects. MRLs are estimates of daily human exposure to a substance that are unlikely to result in noncancer effects over a specified duration. MRLs are intended to serve only as a screening tool to assist in determining which contaminants should be more closely evaluated in the public health assessment process. Exposure to estimated doses less than the MRL is not considered to be of health concern, and exposure to estimated doses above the MRL does not necessarily mean that adverse health effects will occur—values above require additional evaluation.

- ATSDR derived the chronic-duration, noncancer MRL of 100 mrem/year for ionizing radiation by dividing the average annual effective dose to the U.S. population (360 mrem/year) by three to account for human variability (that is, ATSDR applied an uncertainty factor of 3) (ATSDR 1999b). This annual effective dose to the U.S. population is obtained mainly from naturally occurring radioactive material, medical uses of radiation, and radiation from consumer products (BEIR V 1990 as cited in ATSDR 1999b). The annual effective dose of 360 mrem/year has not been associated with adverse health effects in humans or animals.

ATSDR believes the chronic ionizing radiation MRLs of 100 mrem/year is below levels that might cause adverse health effects in people most sensitive to such effects: therefore, ATSDR does not expect noncancer health effects to have occurred from past off-site exposures to radiation doses received from past Y-12 uranium releases.

Past Chemical Exposure

To evaluate past chemical exposure to uranium releases from the Y-12 plant, ATSDR compared the estimated average annual air concentrations of uranium in Scarboro (generated during the Task 6 evaluation) to ATSDR's intermediate-duration inhalation MRL for insoluble forms of uranium. All the estimated average air concentrations of uranium for each year were less than 1% of the inhalation MRL of 0.008 mg/m^3 (see Figure 16 and Table 12).

- ATSDR derived this MRL from a study in which no adverse health effects were observed in dogs exposed to 1.1 mg/m^3 of uranium dioxide dust (an insoluble form of uranium) (Rothstein 1949b as cited in ATSDR 1999a). Because this no-observed-adverse-effect level (NOAEL) was derived from an intermittent exposure and ATSDR derives inhalation MRLs for continuous exposure, the NOAEL was adjusted to continuous exposure. In addition, because the NOAEL was derived from an animal study, ATSDR converted it to a human equivalency concentration. Then, ATSDR divided the NOAEL of 1.1 mg/m^3 by an uncertainty factor of 30 (3 for extrapolation from animals to humans and 10 for human variability) to calculate the intermediate-duration inhalation MRL.

ATSDR also compared the estimated total uranium dose from ingestion via both the surface water and soil exposure pathways (also generated during the Task 6 evaluation), to ATSDR's intermediate-duration oral MRL for uranium. Remember that MRLs are used only as a screening tool and have built-in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. Even though some of the doses were higher than the MRL, it does not necessarily follow that harmful health effects will occur—values above the MRL indicate that the contaminant should be evaluated further. Because some of the estimated doses were above the MRL, ATSDR further investigated the toxicologic literature to find doses associated with known health effects. The minimum lowest-observed-adverse-effect level (LOAEL) for oral exposure to uranium that has caused the most sensitive harmful health effects considered to be of relevance to humans was 0.05 mg/kg/day, which caused renal (kidney) toxicity in rabbits (Gilman et al 1998b as cited in ATSDR 1999a). The rabbit is the mammalian species most sensitive to uranium kidney toxicity and is likely to be even more sensitive that humans (ATSDR 1999a). Therefore, ATSDR is comfortable with extrapolating the

results from this animal toxicity study to humans. All of the estimated total ingestion doses were less than the LOAEL of 0.05 mg/kg/day at which health effects (renal toxicity) have been observed in rabbits; therefore, past exposure via all the surface water and soil exposure pathways is not a health concern (see Figure 17 and Table 13).

- ATSDR derived this intermediate-duration oral MRL from a study in which an increased incidence of renal toxicity (specifically, anisokaryosis and nuclear vesiculation) was observed in New Zealand rabbits exposed to 0.05 mg/kg/day of uranium as uranyl nitrate (Gilman et al. as cited in ATSDR 1999a). ATSDR applied a total uncertainty factor of 30 (3 for use of a minimal LOAEL and 10 for human variability) to calculate the MRL. No adjustment was made for interspecies variation because the rabbit is the mammalian species most sensitive to uranium toxicity and is likely to be even more sensitive than humans. This MRL for intermediate-duration oral exposure is also protective for chronic-duration oral exposure. This is because the renal effects of uranium exposure are more dependent on the dose than on the duration of the exposure.

Additionally, it should be noted that several levels of conservatism were built into this evaluation of past exposures. As mentioned previously, the values that ATSDR relied on to evaluate past exposures (those from the Task 6 report) came from a screening evaluation that routinely and appropriately used conservative and overly protective assumptions and approaches, which led to an overestimation of concentrations and doses. Even using these conservative overestimations of concentrations and doses, the estimated levels of uranium that persons in the reference community, Scarboro, were exposed to were below levels of health concern. Following is a list of conservative aspects in this evaluation.

1. The majority of the total uranium dose (54% of the total U 234/235 dose and 78% of the total U 238 dose) is attributed to frequently eating fish from the EFPC and eating vegetables grown in contaminated soil over several years (see Tables 9 and 10). If a person did not regularly eat fish from the creek or homegrown vegetables over a prolonged period of time (which is very probable), then that person's uranium dose

would likely have been substantially lower than the estimated doses reported in this public health assessment.

2. The Task 6 report noted that late in the project it was ascertained that the Y-12 uranium releases for some of the years used to develop the empirical χ/Q value may have been understated due to omission of some unmonitored release estimates. This would cause the empirical χ/Q values to be overestimated and in turn would cause the air concentrations to be overestimated.

3. According to ATSDR's regression analysis, the method that the Task 6 team used to estimate historical uranium air concentrations overestimated uranium 234/235 concentrations by as much as a factor of 5. Consequently, airborne uranium 234/235 doses based on this method were most likely overestimated (see Figure 12 and Appendix E).

4. Using the ICRP dose conversion factors tends to overestimate the actual radiation doses due to the built-in conservative assumptions (i.e., selecting variables that typically overestimate the true, but uncertain physical and biological interactions associated with radiation exposure) (for examples, see Harrison et al. 2001; Leggett 2001).

5. In evaluating the soil exposure pathway, the Task 6 team used EFPC floodplain soil data to calculate doses. Actual measured uranium concentrations in Scarboro soil are much lower than the uranium concentrations in the floodplain soil. Consequently, the uranium doses that were estimated for the residents were overestimated because of the use of the higher EFPC floodplain uranium concentrations. The estimated doses would be much lower if they were based on actual measured concentrations in Scarboro.

ATSDR's evaluations of off-site exposures to uranium released from the Y-12 plant indicate that current exposures are not of health concern and unlikely to result in adverse health effects. For every exposure pathway evaluated, the doses were too low to be of health concern for both radiation and chemical health effects.

Current Radiation Exposure

To evaluate carcinogenic effects of current radiation exposure to uranium releases from the Y-12 plant, ATSDR calculated the radiation dose (see Table 14) from the following pathways: (1) inhalation of air, (2) ingestion of soils, and (3) ingestion of foods. ATSDR then compared the dose to the radiogenic cancer comparison value. The radiation dose received by the reference population, the Scarboro community, is 0.216 mrem, which is well below (more than 23,000 times less than) the radiogenic cancer comparison value of 5,000 mrem over 70 years (see Figure 9). ATSDR derived this CEDE after reviewing the peer-reviewed literature and other documents developed to review the health effects of ionizing radiation (see Appendix D for more information about ATSDR's derivation of the radiogenic cancer comparison value of 5,000 mrem over 70 years). The CEDE assumes that from the intake of uranium, the entire dose (a 70-year dose, in this case) is received in the first year following the intake. ATSDR believes this value to be protective of human health and, therefore, does not expect that harmful radiation effects from exposure to uranium are occurring currently.

As noted previously, to evaluate noncancer health effects from the current radiation dose (CEDE of 0.216 mrem over 70 years), an approximation can be make to compare the CEDE of 0.216 mrem, which is based on 70 years of exposure, to the ATSDR chronic exposure MRL of 100 mrem/year, which is based on one year of exposure. The CEDE of 0.216 mrem over 70 years could be divided by 70 years to approximate a value of 0.003 mrem as the radiation dose for the first year, which is well below (33,000 times less than) the 100 mrem/year ATSDR chronic exposure MRL for ionizing radiation (see Figures 7 and 9). ATSDR MRLs are based on noncancer adverse health effects only and are not based on a consideration of cancer effects. ATSDR believes the chronic ionizing radiation MRL of 100 mrem/year is below levels that might cause noncancer adverse health effects in persons most sensitive to such effects. ATSDR,

therefore, does not expect noncancer health effects to have occurred from radiation doses received from current off-site uranium exposure.

- As noted previously, ATSDR derived the chronic-duration, noncancer MRL for ionizing radiation by dividing the average annual effective dose to the U.S. population (360 mrem/year) by 3 to account for human variability (i.e., ATSDR applied an uncertainty factor of 3) (ATSDR 1999b). This annual effective dose to the U.S. population is obtained mainly from naturally occurring radioactive material, medical uses of radiation, and radiation from consumer products (BEIR V 1990 as cited in ATSDR 1999b). The annual effective dose of 360 mrem/year has not been associated with adverse health effects in humans or animals.

ATSDR compared off-site surface water concentrations of uranium to the EMEG of 20 μg/L. The average uranium concentrations found in surface water from Scarboro ditches (0.197 μg/L) and in surface water of Lower EFPC (12.8 μg/L) are below ATSDR's EMEG and, therefore, not of health concern (see Table 16).

ATSDR also compared Scarboro soil concentrations to natural background concentrations and to background concentrations collected at uncontaminated areas on and around the ORR (see Tables 17,18 and Figures 18, 21, 22). The soil concentrations found in Scarboro are indistinguishable from natural background concentrations.

Therefore, the level of radiation a person receives from current off-site exposures to uranium the air, surface water, and soil (including ingestion of soil and vegetables) would not cause harmful health effects.

Current Chemical Exposure

To evaluate current chemical exposure to uranium releases from the Y-12 plant, ATSDR compared the average air concentrations from several monitoring stations, including ones in Scarboro and the city of Oak Ridge, to the intermediate-duration inhalation MRL for insoluble

forms of uranium. The average uranium air concentrations from all of the monitoring stations evaluated, including the ones in Scarboro and the city of Oak Ridge, were well below (more than a million times less than) ATSDR's intermediate-duration inhalation MRL of 0.008 mg/m^3 for insoluble forms of uranium (see Figure 24). The average uranium air concentrations, therefore, are well below levels that would be expected to cause harmful chemical effects.

- As noted previously, ATSDR derived the inhalation MRL from a study in which no adverse health effects were observed in dogs exposed to 1.1 mg/m^3 of uranium dioxide dust (an insoluble form of uranium) (Rothstein 1949b as cited in ATSDR 1999a). Because this NOAEL was derived from an intermittent exposure, and ATSDR derives inhalation MRLs for continuous exposure, the NOAEL was adjusted to continuous exposure. In addition, because the NOAEL derived from an animal study, ATSDR converted it to a human equivalency concentration. Then, ATSDR divided the NOAEL of 1.1 mg/m^3 by an uncertainty factor of 30 (3 for extrapolation from animals to humans and 10 for human variability) to calculate the intermediate-duration inhalation MRL.

ATSDR also compared the doses from ingestion of uranium through the soil pathway (see Table 23 and Figure 25), including ingestion of soil and vegetables from the reference location, Scarboro (see Table 24 and Figure 26), to the oral intermediate-duration MRL of 0.002 mg/kg/day for insoluble forms of uranium. The maximum uranium dose from ingestion of Scarboro soil is approximately 140 times less than the MRL, and the uranium dose from ingestion of vegetables grown in the private gardens in Scarboro are more than 50 times less than the MRL. Therefore, the uranium doses are well below the MRL and not of health concern.

- As noted previously, ATSDR derived this intermediate-duration oral MRL from a study in which an increased incidence of renal toxicity (specifically, anisokaryosis and nuclear vesiculation) was observed in New Zealand rabbits exposed to 0.05 mg/kg/day of uranium as uranyl nitrate (Gilman et al. as cited in ATSDR 1999a). ATSDR applied a total uncertainty factor of 30 (3 for use of a minimal LOAEL and 10 for human variability) to calculate the MRL. No adjustment was made for interspecies variation because the rabbit is the mammalian species most sensitive to uranium toxicity and is

likely to be even more sensitive than humans. This MRL for intermediate-duration oral exposure is also protective for chronic-duration oral exposure. This is because the renal effects of uranium exposure are more dependent on the dose than on the duration of the exposure.

EFPC is not used as a drinking water source. The city of Oak Ridge, including Scarboro, is served by municipal water, which must meet specific drinking water quality standards set by EPA. Regardless, the total uranium mean concentrations in surface water collected from Scarboro ditches and in water collected from Lower EFPC are below EPA's maximum contaminant level (MCL) for uranium (30 μg/L). In addition, Table 16 shows that the mean total uranium concentrations for surface water samples collected from Scarboro and Lower EFPC are below ATSDR's environmental media evaluation guide (EMEG) of 20 μg/L. Therefore, the concentrations of uranium that people might be exposed to in surface water are not of health concern.

V. Community Health Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. ATSDR actively gathers comments and other information from the people who live or work near the ORR. ATSDR is particularly interested in hearing from residents of the area, civic leaders, health professionals, and community groups. ATSDR will be addressing these community health concerns in the ORR public health assessments that are related to those concerns.

To improve the documentation and organization of community health concerns at the ORR, ATSDR developed a **Community Health Concerns Database** specifically designed to compile and track community health concerns related to the site. The database allows ATSDR to record, to track, and to respond appropriately to all community concerns and to document ATSDR's responses to these concerns.

In 2001 and 2002, ATSDR compiled more than 1,800 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 workgroup meetings), and surveys conducted by other agencies and organizations. These concerns were organized in a consistent and uniform format and imported into the database.

The community health concerns addressed in this public health assessment are those concerns in the ATSDR Community Health Concerns Database that are related to issues associated with uranium releases from the Y-12 plant. The following table contains summarized comments, actual comments, and ATSDR's responses. These concerns and responses are sorted by category (health concerns/general, cancer health effects, noncancer health effects, and health concerns/procedural).

Community Health Concerns From the Oak Ridge Reservation Community Health Concerns Database

	Summarized Comment	Actual Comment	ATSDR's Response
Health Concerns/General			
1	A commenter believes that Scarboro is significantly contaminated by U 235.	The U 235 contamination is significant.	ATSDR evaluated past and current exposure to uranium contamination released from the Y-12 plant and determined that in every exposure pathway, the levels of uranium were too low to be of public health concern for both radiation and chemical health effects. ATSDR evaluated whether the levels of U 235 in the soil in Scarboro were significant by comparing the radioactivity concentrations detected in Scarboro by FAMU (1998) and EPA (2002b) to average background levels in the area around Oak Ridge and to background concentrations typically found in nature. ATSDR found that the levels of U 235 that were detected were indistinguishable from background levels when considering the uncertainty associated with the analysis of the uranium measurements. Please see Section *II.B.2.a. Radiation Effects*, Soil, and Figures 18, 21, and 22 for more details about this evaluation. ATSDR also evaluated whether the radioactivity concentrations of uranium detected in the air in Scarboro were higher than those detected at background air monitoring stations. The data indicate that the concentrations in Scarboro are about 60% higher than the remote background locations; however, all of the air concentrations, including those from Scarboro, were well below levels of health concern. Please see Section *III.B.2.b Chemical Effects,* Inhalation, and Figure 24 for additional details.

	Summarized Comment	Actual Comment	ATSDR's Response
2	A commenter believes that facilities on ORR produced plutonium.	ORR facilities were engaged in plutonium production.	A pilot-scale plutonium production plant was built at the X-10 site in 1943 and was operated until November 1963. For more details, please see Section 2.1.1 The Original Mission in the Oak Ridge Health Studies Phase 1 Report, Volume II, Part A: Dose Reconstruction Feasibility Study, Tasks 1 & 2 (ChemRisk 1993a). During Phase 1 of the Oak Ridge Health Studies, the quantity of plutonium released was estimated and determined to not warrant further health study. Plutonium was low in the preliminary ranking of potential hazards. Please see Section 5.4, Relative Importance of Releases from the ORR, and Table 5-11 in the Oak Ridge Health Studies Phase 1 Report, Volume II, Part B: Dose Reconstruction Feasibility Study, Tasks 3&4 (ChemRisk 1993b). These reports are available at the DOE Information Center located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee. You can also obtain documents from the Information Center at http://www.oakridge.doe.gov/Foia/DOE_Public_Reading_Room.htm or by calling 865-241-4780.

	Summarized Comment	Actual Comment	ATSDR's Response
3	Three commenters requested a careful comparison of Scarboro's contaminant levels with those of other regions of Oak Ridge. Another commenter said that the media perceived Scarboro as a contaminated community. The commenter questioned why the media did not portray as contaminated other parts of Oak Ridge where contaminants have been found.	We would like for environmental tests to be performed on other neighborhoods in Oak Ridge so that it can be determined if the trace levels of uranium contaminants detected in our neighborhood are significantly different from Oak Ridge in general. Do you have any statistics comparing illness in Scarboro and other sections of Oak Ridge? There are no other residential data to compare to Scarboro. It is generally believed by most people who live in Tennessee and perhaps the nation that the Scarboro neighborhood in Oak Ridge, Tennessee, is contaminated with mercury.... The data showed very high levels of mercury contamination in several areas of Oak Ridge; however, the media primarily focused attention on mercury contamination in the Scarboro neighborhood (where no significant mercury was ever found). We would like for those interested in helping our neighborhood with health and contamination issues to be mindful of the psychological, sociological, and economic consequences that result whether contamination issues are real or imaginary.	During this evaluation of Y-12 uranium releases, ATSDR attempted to locate uranium soil sampling data from other areas in Oak Ridge (for example, data from the Atomic City Auto Parts remediation, the CSX Railroad remediation, and sampling data collected in the Woodland area of Oak Ridge), but as of this writing was unsuccessful. ATSDR evaluated whether the levels of uranium in the soil were significantly different in Scarboro by comparing the levels detected in Scarboro by FAMU (1998) and EPA (2002b) to the average background levels in the area around Oak Ridge and to background concentrations typically found in nature. ATSDR found that the levels of uranium that were detected were indistinguishable from background, when considering the uncertainty associated with the analysis of the uranium measurements. Please see Section *II.B.2.a. Radiation Effects*, Soil, and Figures 18, 21, and 22 for more details about this evaluation. ATSDR also evaluated whether the radioactivity concentrations of U 235 detected in the air in Scarboro were higher than those detected at background stations. The data indicate that the concentrations in Scarboro are about 60% higher than the background locations; however, all of the air concentrations, including those from Scarboro, were well below levels of health concern. Please see Section *III.B.2.b Chemical Effects,* Inhalation, and Figure 24 for additional details. ATSDR evaluated past and current exposure to uranium contamination released from the Y-12 plant and determined that in every exposure pathway, the levels of uranium were too low to be of public health concern for both radiation and chemical health effects. ATSDR will be conducting a public health assessment on mercury releases from Y-12, which will evaluate the mercury concentrations in Scarboro.

	Summarized Comment	Actual Comment	ATSDR's Response
4	Three commenters are already certain that Scarboro is seriously contaminated.	We know the soil is contaminated and want someone to prove it. (Just tell us the truth.) There must be something wrong if the government does so many studies, and the newspaper gives it so much attention. Scarboro is the most contaminated residential area.	The Scarboro community was selected as the reference population after air dispersion modeling indicated that its residents were expected to have received the highest exposures (ChemRisk 1999). However, when ATSDR compared the levels of uranium in the soil in Scarboro (FAMU 1998 and EPA 2002b) to levels of uranium naturally occurring in the soil and to average background levels in the Oak Ridge area, it was determined that the uranium radioactivity concentrations in Scarboro were indistinguishable from levels occurring naturally. Please see Section *II.B.2.a. Radiation Effects*, Soil, and Figures 18, 21, and 22 for more details about this evaluation.
5	One commenter believes sirens signify nuclear emergencies at ORR.	The sirens in Y-12 are all nuclear alarms.	The following Web site provides information on warning sirens, the latest news, and other information in case of an emergency at the ORR: http://www.oakridge.doe.gov/emercomm/. The Web site also provides general information about the DOE Emergency Preparedness Program. If you have questions about this program, please visit the Web site or call the DOE Public Affairs Office at 865-576-0885. The sirens are tested at noon eastern time on the first Wednesday of each month. Any other tests and exercises are announced in advance through area newspapers, radio, and television.
6	Three commenters suspect that radioactive wastes are or were secretly dumped around Scarboro.	The SED/AEC dumped "hot" waste from Y-12 in/near Scarboro. Scarboro is a part of ORR, is owned by the government, is leased to the residents, and can be used as a DOE dump at any time. Concerned about the locations of actual and alleged "dumps."	A municipal landfill (on Tuskegee Drive across from Scarboro) and a building material dump site (at the corner of Tuskegee Drive and Tulsa) were present in Oak Ridge in the past. Both sites are currently closed. Neither area was identified as having radioactive wastes during the aerial radiological surveys conducted in the Scarboro area in 1959, 1973, 1980, 1989, 1992, and 1997. Every flyover of Scarboro showed only natural background levels (Carden and Joseph 1998). While this does not preclude the presence of deeply buried wastes in these areas, if present, they most likely are not impacting public health in the Scarboro community because people do not have contact with deeply buried wastes. Designated landfills on the ORR were used for disposal of hazardous wastes and radioactive materials.

	Summarized Comment	Actual Comment	ATSDR's Response
7	Several commenters were concerned about the appearance of their water and whether the water presents a threat to their health.	The drinking water changes color and is sometimes cloudy. Something in water; water was white; how much exposure can an individual have to the water before they are affected by it; things in the water; water not drinkable; problems with water; water quality (thick, milky appearance).	Oak Ridge is supplied with public water from a water treatment plant that draws surface water from Melton Hill Lake. The intake at the lake is located approximately one mile upstream of the ORR. Until May 2000, DOE owned and operated the water treatment plant at its Y-12 facility and sold drinking water to the city of Oak Ridge for distribution to residents and businesses. The city of Oak Ridge now owns and operates the water distribution system (City of Oak Ridge 2002). Under the Safe Drinking Water Act, EPA sets health-based standards for hundreds of substances in drinking water and specifies treatments for providing safe drinking water (EPA 1999). The public water supply for Oak Ridge is continually monitored for these regulated substances. TDEC receives a copy of the monitoring report to ensure that people are receiving clean drinking water. More information about the quality of the Oak Ridge public water supply system is available at the following Web site: http://www.cortn.org/PW-html/2001WaterQualityReport.htm. To ask specific questions related to your drinking water, please call Mr. Bruce Giles, Water and Wastewater Manager, at 865-425-1875 or call EPA's Safe Drinking Water Hotline at 800-426-4791.

	Summarized Comment	Actual Comment	ATSDR's Response
8	Several commenters discussed the Joint Center for Political and Economic Studies' role in the Scarboro community. Two commenters stated that the Joint Center should obtain money for the Scarboro community.	If the Joint Center cannot supply Scarboro with money they should go home. The Joint Center should help Scarboro to write and find grant money. The Joint Center agreement does not require them to explain any past data before 1998. The purpose of Joint Center's Scarboro Community Environmental Study is to address community concerns about environmental monitoring in the Scarboro neighborhood.	Please contact DOE with your concerns about the Joint Center's funding as these comments are not applicable to ATSDR. More information about the Joint Center for Political and Economic Studies can be found at www.jointcenter.org or by calling 202-789-3500.

	Summarized Comment	Actual Comment	ATSDR's Response
9	One commenter asked who will make the official decision about whether or not Scarboro is a contaminated community.	Who makes the official health call?	ATSDR is the principal federal public health agency charged with the responsibility of evaluating the human health effects of exposure to hazardous substances. The agency works in close collaboration with local, state, and other federal agencies, with tribal governments, and with communities and local health care providers. The goal of the agency is to help prevent or reduce harmful human health effects from exposure to hazardous substances. In 1980, the U.S. Congress created ATSDR to implement the health-related sections of the laws that protect the public from hazardous waste and environmental spills of hazardous substances. CERCLA, commonly known as the "Superfund" Act, provided a congressional mandate to clean up abandoned and inactive hazardous waste sites and to provide federal assistance in emergencies involving toxic substances. As the lead agency in the Public Health Service for implementing the health-related provisions of CERCLA, ATSDR is charged under the Superfund Act to assess the presence and nature of health hazards at specific Superfund sites, help reduce or prevent further exposure, and expand the knowledge base about health effects related to exposure to hazardous substances. Under this purview, ATSDR is determining whether hazardous substances in Scarboro represent a public health hazard. For additional information about ATSDR, please visit our Web site at: http://www.atsdr.cdc.gov/. ORRHES was established in 1999, as a subcommittee of the Citizens Advisory Committee on Public Health Service Activities and Research at DOE Sites. The ORRHES provides advice and recommendations to ATSDR and Centers for Disease Control and Prevention (CDC) concerning public health activities and research conducted by ATSDR and CDC at the ORR.

	Summarized Comment	Actual Comment	ATSDR's Response
10	Six commenters questioned the way in which the environmental sampling of Scarboro has been conducted. One commenter suggested that DOE let the citizens of Scarboro determine exactly where sampling is to take place.	Scarboro has a "high" background. The monitor is in the wrong place. They didn't sample the pond where the dump was. They sampled my neighbor's yard, but not my yard. The number of surface water and sediment samples taken should be increased. Our objections in the Scarboro sampling issue include: DOE's shameless refusal to investigate particular areas suggested by Scarboro residents familiar with the DOE's legacy of contamination in their neighborhood. Our objections in the Scarboro sampling issue include: The use of Y-12 as a control against which Scarboro soil was measured to compare contamination levels. Our objections in the Scarboro sampling issue include: The use of the top two inches of soil as a valid sample for soil analysis; the use of only three soil samples sets for analysis.	In 2001, EPA validated the environmental sampling conducted within the Scarboro community by FAMU in 1998 (EPA 2002b; FAMU 1998). ATSDR reviewed the methods and results of the environmental sampling conducted by FAMU and EPA, and found that the procedures were adequate for making public health decisions. Both EPA's and FAMU's reports are available in the DOE Information Center located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee. You can obtain documents from the Information Center at http://www.oakridge.doe.gov/Foia/DOE_Public_Reading_Room.htm or by calling 865-241-4780. ATSDR evaluated whether the levels of uranium in the soil were significantly different in Scarboro (FAMU 1998 and EPA 2002b) by comparing the levels detected in the soil in Scarboro to levels of uranium naturally occurring in the soil and to average background levels in the Oak Ridge area. ATSDR determined that the uranium concentrations in Scarboro were indistinguishable from levels occurring naturally. Please see Section II.B.2.a. *Radiation Effects*, Soil, and Figures 18, 21, and 22 for more details about this evaluation. When conducting sampling at hazardous waste sites, ATSDR recommends that the initial evaluation of the site include an assessment of probable routes of public exposure/contaminant migration off site, and that the sampling begin at the public exposure points to determine if interim actions are needed to reduce or eliminate public exposure. Contaminated soils may expose individuals who live, play, or work near the site to contaminants at levels of health concern. Ingestion of contaminated surface soil, particularly by children, is a primary concern. Inhalation of contaminated dust and direct dermal contact with contaminated soils also can lead to adverse health effects. Generally, the public is exposed to only the top few inches of soil; therefore, ATSDR has defined surface soil as the top 3 inches. For a public health evaluation, ATSDR needs concentrations of contaminants found in surface soil reported separately from those found in subsurface soil.

	Summarized Comment	Actual Comment	ATSDR's Response
11	Several commenters are concerned about ash and debris settling from the air. Some fear airborne contaminants are related to respiratory health problems.	Scarboro is adjacent to the "incinerator." Fly ash from Y-12 settled over my car. Contamination in air; lots of dust, air stays very smoky, smoggy. Things in air; respiratory problems; respiratory problems in children caused by air pollution from ORR; black air on mother's car after she washed it had to be from the plant; at times the air has a peculiar smell; chest pain during excitation; air pollutants building in the soils nearby; gasoline type fumes.	In 1997 and 1998, CDC, TDOH, and the Scarboro Community Environmental Justice Council conducted a study to determine whether rates of pediatric respiratory illnesses were higher in Scarboro than elsewhere in the United States and to assess whether exposure to various factors increased residents' risk for health problems. The researchers concluded the following: No unusual pattern of illnesses emerged among the children receiving medical exams. The illnesses that were detected were not more severe than would be expected in any community. The findings of the medical exams were consistent with the findings of the community survey. The reported prevalence rate of asthma among children in Scarboro (13%) was higher than the estimated national rate (7% in all children and 9% in black children). However, few studies have been conducted on communities similar to Scarboro, and without asthma prevalence information from these communities, it was not possible to determine whether the prevalence of asthma was higher than would be expected. The Scarboro rate was, however, within the range of rates reported in similar studies throughout the United States and internationally. The reported rate of wheezing among children in Scarboro (35%) was also higher than most national and international estimated rates (which range from 1.6% to 36.8%). The prevalence rates of hay fever and sinus infections in children were comparable to national estimated rates. Because the investigation was not designed to detect associations, and a relatively small group of children was studied, it was not possible to identify causes of the respiratory illnesses. Copies of the report on this study, *An Analysis of Respiratory Illnesses Among Children in the Scarboro Community,* are available in the ATSDR Oak Ridge field office at 1975 Tulane Avenue, Oak Ridge, Tennessee (telephone: 865-220-0295).

	Summarized Comment	Actual Comment	ATSDR's Response
12	Two commenters are concerned about health problems and contamination stemming from employment with DOE.	What did my husband bring home from the plant? Activities at DOE plants have led to worker health problems.	Federal regulations establish requirements for a radiological protection program. Included in the law are requirements for monitoring personnel and the workplace to ensure that contaminants are not taken outside of radiological areas. A DOE Order delineates requirements to ensure worker protection in all environment, safety, and health disciplines. The Atomic Energy Commission established worker health and safety plans through a series of orders. Worker health issues at the plants are a concern to ATSDR; however, those issues are under the purview of NIOSH. For information on NIOSH's occupational energy research program see NIOSH's Web site at www.cdc.gov/niosh/2001-133.html or telephone 513-841-4400.
13	One commenter noted that people have lived along Scarboro Road.	People have lived along Scarboro Road.	To address this comment, ATSDR reviewed available historical U.S. Geological Survey (USGS) maps from 1941, 1953, 1968, 1980, and 1990 to identify buildings located along Scarboro Road. In 1941, prior to ORR being established, eight unidentified buildings (potentially houses) were located along Scarboro Road. By 1953, all but one of these buildings (located at a Y intersection about 1,200 feet north of Bear Creek Road) were removed and one additional structure was added about 1,500 feet south of Bear Creek Road. Both were located west of Scarboro Road on DOE property. In 1968, the structure south of Bear Creek Road was removed, but the one at the Y intersection remained. In addition, a gas station was added north of the intersection of Scarboro Road and Bear Creek Road. No changes along Scarboro Road were noted from the 1968 map to the 1980 and 1990 maps. In addition, ATSDR reviewed a 1945 map of the city of Oak Ridge that shows that Scarboro Road used to run north to the Oak Ridge Turnpike prior to the construction of South Illinois Avenue. According to the USGS map from 1936, seven buildings were located on this portion of Scarboro Road that no longer exists. In 1946, an additional building is shown.
14	One commenter asserted that DOE should buy back any land they have contaminated.	If DOE has contaminated Scarboro land, they must buy it back.	Please contact DOE with your concerns about buying back contaminated land in Scarboro as this comment is not applicable to ATSDR.

	Summarized Comment	Actual Comment	ATSDR's Response
15	Several commenters are concerned about whether Scarboro's creeks, springs, and drainage ditches are contaminated.	The city should cover the contaminated ditches. The springs along the north side of Pine Ridge are contaminated. Groundwater flows from the Y-12 plant to Scarboro. LEFPC flows through the Scarboro community; so does Scarboro Creek. Kids play around the EFPC, when it rains water runs from the EFPC into the yards in community; son swam in the creek as a child; mercury in creek; concerned about water that flows across property; open ditches; children play in water; test the water running through the community; more frequent testing of water; lots of creeks used for drinking water when young; water glows in dark; storm water drains from reservation onto property.	Using the surface water and sediment radioactivity concentrations estimated during Task 6 of the Oak Ridge Dose Reconstruction (ChemRisk 1999), ATSDR evaluated whether past exposure to uranium in the surface water and sediment from EFPC and the floodplain would cause harmful health effects. The estimated doses were below levels of health concern for both radiation and chemical effects. Please see Section ***III.B.1 Past Exposure (1944-1995),*** *Radiation Effects:* Surface Water and Soil; and *Chemical Effects:* Ingestion, for more details about this evaluation. In 1998 and 2001, FAMU and EPA, respectively, sampled surface water and sediment from Scarboro ditches (EPA 2002b; FAMU 1998). In addition, DOE takes bi-monthly surface water samples in EFPC (DOE 1995b). ATSDR evaluated the current surface water data as it pertains to uranium contamination in Section ***III.B.2 Current Exposure***, *Radiation Effects*, Surface Water and Soil. As shown in Table 16, the mean total uranium concentrations in surface water in Scarboro and Lower EFPC are below ATSDR's EMEG and are therefore not of health concern. ATSDR evaluated sediment data with the soil data (see Tables 17 and 18 and Figures 18, 21, and 22). The uranium content of soils/sediment in Scarboro is indistinguishable from natural background levels and is not at a level of health concern.

	Summarized Comment	Actual Comment	ATSDR's Response
16	Several commenters believe that local soil, vegetation, and fish are contaminated. One is concerned because he had been eating these fish before learning that they were contaminated. Two commenters noted that Scarboro's vegetation has an unusual color.	Not allowed to eat fish or touch the water; like to fish; ate fish only to learn later they were contaminated. Vegetables grown in Scarboro are not safe to eat and changed color. What is in the soil? How does it get inside people's body; grass is purplish gold in color, color of flowers has changed; no information on soil testing; soil and water should be tested.	ATSDR received data on vegetable samples collected from gardens from two Scarboro residents. ATSDR calculated radiation and chemical doses following ingestion of vegetables from these gardens. As shown in Tables 21 and 24, the resulting doses are below levels of health concern—it is safe to eat vegetables from private gardens in Scarboro. Please see Section *II.B.2.a Radiation Effects*, Soil*, Ingestion of foods grown in Scarboro,* for more details about ATSDR's evaluation. ATSDR compared the levels of uranium detected in Scarboro soil (EPA 2002b; FAMU 1998) to the average background levels in the area around Oak Ridge and to background concentrations typically found in nature. ATSDR found that the levels of uranium that were detected were indistinguishable from background and are not at levels of health concern. Please see Section *II.B.2.a. Radiation Effects*, Soil, and Figures 18, 21, and 22 for more details about this evaluation. Fish fillet samples collected from EFPC contain mercury and PCBs. However, it is ATSDR's understanding that EFPC is not a very productive fishing location and very few people actually eat fish from the creek. Regardless, in 1993, ATSDR evaluated eating fish from EFPC in a health consultation (ATSDR 1993b). ATSDR concluded that there is no acute health threat to people who eat the fish. However, if people frequently ingest contaminated fish from the creek over a prolonged period, there is a moderate increased risk of adverse effects to the central nervous system and kidneys, and of developing cancer. Copies of the health consultation, entitled *Y-12 Weapons Plant Chemical Releases Into East Fork Poplar Creek,* are available at the ATSDR Oak Ridge field office at 1975 Tulane Avenue, Oak Ridge, Tennessee (telephone: 865-220-0295).

	Summarized Comment	Actual Comment	ATSDR's Response
17	Several commenters want radiation levels to be monitored in Scarboro.	Check for radiation from the plant; radiation spills; radiation levels in Scarboro; should check homes for radon; a lot of people have died; skin allergy; allergies 65% have it; skin rashes on children.	DOE conducts ambient air monitoring in the environment surrounding ORR facilities, including around the Y-12 plant, to measure radiological and other parameters (DOE 1995b). One monitoring station (Station 46) is located in Scarboro, west of the Mount Zion Church on Tuskegee Drive, about 140 meters west of the Scarboro Community Center. This continuous monitoring station has been providing quarterly and annual measurements of uranium in the air since 1986 (ChemRisk 1999).
18	One commenter asked what kinds of health effects would be produced by strontium 90 (Sr-90) exposure.	If Sr 90 were to produce health effects, how would those present themselves?	Because Sr 90 is chemically similar to calcium, it tends to deposit in bone and bone marrow (it is called a "bone seeker"). Internal exposure to Sr 90 is linked to bone cancer, cancer of the soft tissue near the bone, and leukemia (EPA 2002d). Risk of cancer increases with increased exposure to Sr 90. However, Sr 90 was not released from the Y-12 plant in high enough quantities to be a health issue.

	Summarized Comment	Actual Comment	ATSDR's Response
19	Several commenters discussed the scope of substances being investigated in Scarboro. Some requested that scope of environmental sampling be expanded.	Uranium and mercury are the obvious contaminants to detect. What about other radionuclides such as beryllium? Wasn't it used at Y-12? Is the Y-12 nuke slow cooker at Chestnut Ridge security pits included in health effects? I also agree with attendees that the proposed surveillance, in its present proposed form, does not go far enough. Lead, thorium, beryllium, cyanide, acetonitrile, tungsten, and other materials worked at the Y-12 site have been historically "misplaced." At the meeting it was stated by someone in the audience that Strontium-90 and Cesium-137 and other relevant radionuclides should also be measured. The concentration of mercury in the air should be measured, so air samples should be taken also. The concentration of mercury in plants should be measured. Uranium, mercury, iodine, and PCBs have been detected in Scarboro.	ATSDR will continue to evaluate contaminants and pathways of concern to the community surrounding ORR. In addition to this evaluation of uranium from the Y-12 plant, ATSDR is evaluating uranium from the K-25 facility, iodine 131, mercury, White Oak Creek releases in the 1950s, PCBs, fluorides, the TSCA incinerator, and groundwater. ATSDR will also screen data from 1990 to the present to determine whether additional contaminants of concern need to be addressed. While beryllium was used at the Y-12 plant, the form used was not radioactive. In 1998, FAMU collected soil and sediment from Scarboro and analyzed 10% of the samples for 150 organic and inorganic chemicals (FAMU 1998). ATSDR evaluated these data and determined that none of the chemicals that were detected (more than 100 chemicals were not detected) were at concentrations that would cause harmful health effects from exposure to the soil or sediment. ATSDR also evaluated the gamma spectroscopy data collected by EPA in their soil sampling effort in Scarboro (EPA 2002b) and concluded that other radionuclides are not of public health concern. Uranium and thorium are naturally occurring; during their decay, they produce a number of progeny that are gamma emitters. The results indicate that the progeny of uranium 238 and thorium 232 are present in the expected concentrations based on the amount of U 238 reported by EPA and FAMU (EPA 2002b; FAMU 1998). Furthermore, no cobalt 60 (Co 60) was detected, and the concentration of cesium 137 (Cs 137) detected at the sampling locations averaged less than 0.3 pCi/g. In DOE's Background Soil Characterization Project (DOE 1993), the reported concentration of Cs 137 was 2 to 3 times higher than the Scarboro value. This concentration of Cs 137 is not considered to be a public health concern as the resulting radiation dose (estimated from Federal Guidance Report 13 electronic data) following the ingestion of 100 mg of soil, is orders of magnitude below the typical background dose in the Oak Ridge area.

	Summarized Comment	Actual Comment	ATSDR's Response
20	Several commenters suggested that the people of Scarboro need more direct control over environmental sampling activities that go on in their community.	The community, via SCEJOC, should be able to identify and select a contractor to accomplish the tasks needed for the characterization of pollution in the community. Establish clearly that other affected communities in Oak Ridge are invited to sit at the table and collaborate on coordinating activities. The community needs funding to secure its own technical assistance to ensure adequate input into this project.	DOE has primary responsibility for environmental sampling at the ORR.
21	One commenter requested additional information about environmental sampling in the community.	This community needs a Sentinel Health Event evaluation performed immediately. The community needs the data from the secret well monitoring done since the 1980s. The community needs the data from the surface and groundwater studies at Y-12 and K-25, and this data directly impacts the surrounding residents.	This public health assessment evaluates exposure to uranium released from the Y-12 plant. All of the data that ATSDR knows of that pertains the community is included in this report. ATSDR will evaluate uranium from the K-25 facility and the groundwater pathway in the future.

	Summarized Comment	Actual Comment	ATSDR's Response
22	One commenter questioned the value of aerial studies.	As the aerial studies will only reveal large releases (i.e., rare events) why is DOE spending large amounts of funding on this project?	Since the 1950s, aerial radiological surveys have been conducted at DOE facilities to provide data on the total gamma radiation emission rate found on and around its facilities (Carden and Joseph 1998). Not only do these surveys allow for the relatively rapid characterization of large land areas to determine the background levels of radiation, they are also a proven method for identifying areas where the radiation levels significantly exceed background levels of radiation. Because many of the radioactive materials used at Oak Ridge are gamma-emitting elements or decay into gamma-emitting elements, the elevated levels could be associated with Cs 137, Co 60, decay products of SR 90, and decay products of uranium isotopes. In the case of uranium isotopes, if the soil concentrations are not significantly elevated above background levels, then the aerial survey data will be inconclusive; that is, the computer-generated results would not show the presence of elevated levels of uranium. ATSDR has reviewed the existing flyover data for the Scarboro community and the soil survey data. While these aerial radiological surveys aid in identifying contaminated areas, ATSDR does not find the surveys extremely useful in estimating doses or in making health decisions.

	Summarized Comment	Actual Comment	ATSDR's Response
23	Several commenters stated that the people of Scarboro have not been adequately informed about ongoing environmental studies.	DOE has not done an adequate job of informing Scarboro, Oak Ridge, and surrounding communities of these meetings. Our demand is that all policy debates and decisions made on the issues of environmental contamination and its effects include citizens affected by DOE-ORO operations. Should not the result of past studies of past contaminants be more widely made available to the people of Scarboro?	ATSDR is committed to engaging the Oak Ridge community as partners in conceptualizing, planning, and implementing public health activities at ORR, in communicating and discussing results, and in determining appropriate follow-up actions. Throughout the public health assessment process, ATSDR staff have worked with the local community to identify and understand health concerns and to provide opportunities for public involvement. Please see Section ***II.F.1. Summary of ATSDR Activities*** for additional information about ATSDR's community involvement activities. The Oak Ridge Reservation Health Effects Subcommittee (ORRHES) was established in 1999, by ATSDR and CDC to provide advice and recommendations concerning public health activities and research conducted at the ORR. The subcommittee consists of 21 individuals with different backgrounds, interests, and expertise, as well as liaison members from state and federal agencies. The Subcommittee meets periodically in Oak Ridge—community members are always welcome to attend the meetings. To promote collaboration between ATSDR and the communities surrounding the ORR, ATSDR opened a field office in Oak Ridge (located at 1975 Tulane Avenue) in 2001. This field office provides even more opportunities for community members to become involved in ATSDR's public health activities at the ORR. Please contact the ATSDR Oak Ridge field office at 865-220-0295 if you would like to be involved.

	Summarized Comment	Actual Comment	ATSDR's Response
24	Two commenters stated that some people in Scarboro do not participate in meetings because they fear retaliation if they do so.	DOE MUST remember that many people don't attend these meetings because of fear of retaliation on their jobs. Scarboro residents and other Afro-Americans do not participate for fear of retaliation.	All community members are encouraged to talk to any of the ORRHES members about their concerns. Perhaps it would help to know that one of the members is a Scarboro resident and a number of other members are active in the Scarboro community. Please visit the following Web site for more information about the ORRHES and its members: http://www.atsdr.cdc.gov/HAC/oakridge/index.html. Additionally, community members can fill out an *anonymous* Community Health Concerns sheet in ATSDR's field office, located at 1975 Tulane Avenue in Oak Ridge (telephone: 865-220-0295). All concerns are entered into the ATSDR Community Health Concerns Database to ensure that all health concerns are brought to ATSDR's attention and are included in ATSDR's evaluation of potential public health impacts from exposures related to the ORR.
25	One commenter was concerned about ozone levels in Scarboro.	Is ozone concentration monitored? What health effects from ozone?	ATSDR is unaware of any ozone monitoring in Scarboro or the city of Oak Ridge. EPA's Clean Air Act Web site may provide some useful information: http://www.epa.gov/air/oaq_caa.html.
Cancer Health Effects			
26	Several commenters believe that the rate of cancer in Scarboro is unusually high. Some of these people are worried that living near or working at ORR may cause some cancers.	There is a high rate of cancer deaths in Scarboro. Over 80% of people die from cancer; grandfather has spot on lung; husband passed of leukemia; cancer from the plant or the water; husband died of cancer in 1996, worked 39 years at ORR: Everybody around here dies with cancer; Did living here have anything to do with it? Cancer killed 2 brothers, mother, and husband; high rate of breast cancer; cancer possibly due to vegetable garden.	The Public Health Assessment Work Group, as part of the ORRHES, is currently evaluating cancer issues with the TDOH Cancer Registry. This issue will be addressed in the future.

	Summarized Comment	Actual Comment	ATSDR's Response
Noncancer Health Effects			
27	One commenter was concerned about deformed and retarded babies born in Scarboro.	A lot of deformed and retarded babies were born in Oak Ridge.	Uranium is not known to cause these kinds of health effects. However, ATSDR will also be evaluating the effects from exposure to iodine 131, mercury, White Oak Creek releases in the 1950s, PCBs, fluorides, the TSCA incinerator, and groundwater. Please contact the TDOH with your concerns about a high rate of deformed and retarded babies being born in Oak Ridge.

	Summarized Comment	Actual Comment	ATSDR's Response
28	Several commenters were concerned about the prevalence of asthma among children in Scarboro.	Scarboro children suffer from too much asthma. Asthma; Check people with respiratory problems; 65% of residents have asthma, child up the street has trouble breathing; man had to leave Scarboro because his two boys had trouble breathing.	In 1997 and 1998, CDC, TDOH, and the Scarboro Community Environmental Justice Council conducted a study to determine whether rates of pediatric respiratory illnesses were higher in Scarboro than elsewhere in the United States, and whether exposure to various factors increased residents' risk for health problems. The researchers concluded the following: No unusual pattern of illnesses emerged among the children receiving medical exams. The illnesses that were detected were not more severe than would be expected in any community. The findings of the medical exams were consistent with the findings of the community survey. The reported prevalence rate of asthma among children in Scarboro (13%) was higher than the estimated national rate (7% in all children and 9% in black children). However, few studies have been conducted on communities similar to Scarboro, and without asthma prevalence information from these communities, it was not possible to determine whether the prevalence of asthma was higher than would be expected. The Scarboro rate was, however, within the range of rates reported in similar studies throughout the United States and internationally. The reported rate of wheezing among children in Scarboro (35%) was also higher than most national and international estimated rates (which range from 1.6% to 36.8%). The prevalence rates of hay fever and sinus infections in children were comparable to national estimated rates. Because the investigation was not designed to detect associations, and a relatively small group of children was studied, it was not possible to identify causes of the respiratory illnesses. Copies of the report on this study, *An Analysis of Respiratory Illnesses Among Children in the Scarboro Community,* are available in the ATSDR Oak Ridge field office at 1975 Tulane Avenue, Oak Ridge, Tennessee (telephone: 865-220-0295).

	Summarized Comment	Actual Comment	ATSDR's Response
Health Concerns/Procedural			
29	One commenter suggested that Scarboro was deliberately left out of aerial flyovers for fear of revealing contamination.	Scarboro was left out of the flyovers because it is contaminated.	DOE conducted eight aerial radiological surveys of the ORR between 1959 and 1997. Such flyovers are performed at major DOE facilities nationwide and follow specific procedures. "Broad Area" flyovers cover the entire ORR, while "Focused Area" flyovers cover the three plants, and specific areas of interest due to DOE activities in the area, such as White Oak Creek remediation. Areas off the plant site that show only natural background levels of radiation are not surveyed in "Focused Area" flyovers. The community of Scarboro was included in five "Broad Area" flyovers, and because every flyover showed only background readings, it was not included in two "Focused Area" flyovers. About a third of the Scarboro Community was included in the "Focused Area" flyover of White Oak Creek only because it was on the flight-path for the White Oak Creek survey. Scarboro was not included in "Focused Area" flyovers because it was "not contaminated." Copies of the full report of all radiological flyovers, entitled *Aerial Radiological Surveys of the Scarboro Community,* are available from the Information Center by visiting the following Web site http://www.oakridge.doe.gov/Foia/DOE_Public_Reading_Room.htm or by calling 865-241-4780. Because of this concern, FAMU and EPA performed independent soil sampling of Scarboro. The results of both sampling campaigns confirmed that the levels of uranium would not result in harmful health effects for the people living in Scarboro. For every exposure pathway evaluated, the levels were too low to be of health concern for both radiation and chemical health effects.

	Summarized Comment	Actual Comment	ATSDR's Response
30	One commenter challenged the validity of DOE's Background Soil Study.	The DOE Background Soil Study was done on contaminated soils.	During this evaluation of uranium from the Y-12 plant, ATSDR reviewed Scarboro soil data (EPA 2002b; FAMU 1998), the Background Soil Characterization Project (DOE 1993), and natural background levels. As shown in Figures 18, 21, and 22, there was no significant difference between them. Please see Section *II.B.2.a. Radiation Effects,* Soil for more details about this evaluation. Furthermore, ATSDR compared the results of the Scarboro sampling and the DOE Background Characterization Project to values typically found throughout the country and found no significant difference among the values reported.
31	One commenter challenged the completeness of the Scarboro cancer data.	The Scarboro cancer data supplied by the state is incomplete.	The Public Health Assessment Work Group, as part of ORRHES, is currently evaluating cancer data in counties surrounding the ORR. For more information about the work group's efforts, contact members of ORRHES or the ATSDR Oak Ridge field office (located at 1975 Tulane Avenue, Oak Ridge, Tennessee; telephone: 865-220-0295).

	Summarized Comment	Actual Comment	ATSDR's Response
32	Three commenters expressed their lack of trust in DOE.	What experiments were run on us? What secrets are still being kept? Any DOE-controlled study will lack credibility.	For several decades, DOE and its predecessor agencies have conducted research and production activities at a number of sites across the country, including ORR. These activities involved development and production of nuclear weapons and materials, as well as other nuclear energy-related research. People in communities near and downwind from these sites became increasingly concerned about whether site activities might be affecting their health. In response to these concerns, DOE asked the U.S. Department of Health and Human Services (DHHS) to *independently* investigate the public health implications of its nuclear energy-related activities. DOE formally delegated responsibility for this work to DHHS in two memorandums of understanding issued in 1990. Under a memorandum of understanding between DOE and DHHS, CDC became responsible for analytic epidemiologic research concerning the potential impacts of DOE's energy-related activities. This memorandum of understanding also recognized that ATSDR would be responsible for all public health activities mandated by Superfund. These activities include conducting public health assessments at DOE sites, in addition to other follow-up activities, as appropriate. The ORRHES was established in 1999, as a subcommittee of the Citizens Advisory Committee on Public Health Service Activities and Research at DOE Sites. ORRHES provides advice and recommendations to ATSDR and CDC concerning public health activities and research conducted at ORR. The subcommittee consists of 21 individuals with different backgrounds, interests, and expertise, as well as liaison members from state and federal agencies.
33	One commenter requested greater community control over the selection of environmental contractors.	The Scarboro community should influence the choice of the contractor that will perform the sample collections.	Because ATSDR did not perform environmental sampling in the Scarboro community, this comment is not applicable to ATSDR.

	Summarized Comment	Actual Comment	ATSDR's Response
34	One commenter requested independent analysis and research on mercury from both minority and majority universities.	ORHASP has recognized that mercury speciation is still a problem, but is not going to address it. We must have independent analysis and research performed by both minority and majority universities.	ATSDR will evaluate exposures to mercury during a separate public health assessment, expected to be conducted during 2003.

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VI. CHILDREN'S HEALTH CONSIDERATIONS

ATSDR recognizes that infants and children can be more sensitive to environmental exposure than adults in communities faced with contamination of their water, soil, air, or food. This sensitivity is a result of the following factors: (1) children are more likely to be exposed to certain media (for example, soil or surface water) because they play and eat outdoors; (2) children are shorter than adults, which means that they can breathe dust, soil, and vapors close to the ground; and (3) children are smaller; therefore, childhood exposure results in higher doses of chemical exposure per body weight. Children can sustain permanent damage if these factors lead to toxic exposure during critical growth stages. As part of the ATSDR Child Health Initiative, ATSDR is committed to evaluating the special interests of children at sites such as the ORR.

Children living near the ORR are exposed to small amounts of uranium in the air they breathe, in the food they eat, and in the water they play in. However, no cases have been reported where exposure to uranium is known to have caused health effects in children (ATSDR 1999a). It is possible that if children were exposed to very high amounts of uranium, they might have damage to their kidneys, similar to what is seen in adults. However, the levels of uranium in the environment surrounding ORR are too low to cause these kinds of health effects. At this time, the scientific community does not know whether children differ from adults in their susceptibility to health effects from uranium exposure. It is also not known if exposure to uranium has effects on the development of the human fetus. Very high doses of uranium in drinking water can affect the development of the fetus in laboratory animals (one study reported birth defects and another reported an increase in fetal deaths). However, health scientists do not believe that uranium can cause these problems in pregnant women who take in normal amounts of uranium from food and water, or women who breathe the air around a hazardous waste site that contains uranium (ATSDR 1999a).

VII. CONCLUSIONS

Based on a thorough evaluation of past public health activities and available current environmental information, ATSDR has reached the following conclusions:

- ATSDR concludes that the levels of **uranium released from the Y-12 plant in the past and currently would not result in harmful health effects** for either adults or children living near the Y-12 plant, including the city of Oak Ridge and the Scarboro community. ATSDR has categorized this site as having *no apparent public health hazard* from exposure to uranium. ATSDR's category of no apparent public health hazard means that people could be or were exposed, but the level of exposure would not likely result in adverse health effects (definitions of ATSDR's public health categories are included in the glossary in Appendix A).

- Using the results of the Task 6 report, ATSDR evaluated **past uranium exposures** (1944 to 1995) to communities near the Y-12 plant. Despite several conservative parameters, exposure to uranium through both the inhalation and ingestion pathways would result in doses below levels of health concern for radiation and chemical health effects. Therefore, past exposure to uranium poses *no apparent public health hazard*.

    - The total past radiation dose from exposure to uranium via air, surface water, and soil pathways was estimated to be 155 mrem over 70 years, which is well below (32 times less than) the radiogenic cancer comparison value of 5,000 mrem over 70 years. The approximated radiation dose of 2.2 mrem for the first year dose is well below (45 times less than) the ATSDR minimal risk level (MRL) of 100 mrem/year for ionizing radiation.

    - Yearly estimated past air concentrations of uranium ranged from 2.1×10^{-8} to 6.0×10^{-5} mg/m^3, which are less than 1% of the intermediate-duration inhalation MRL of 8×10^{-3} mg/m^3 for insoluble forms of uranium.

- Yearly estimated past doses from exposure to uranium via all soil and surface water exposure pathways ranged from 2.7×10^{-5} to 1.3×10^{-2} mg/kg/day, which are less than the dose (5×10^{-2} mg/kg/day) at which health effects (renal toxicity) have been observed in rabbits, the mammalian species most sensitive to uranium kidney toxicity.

▪ Using available environmental data, ATSDR evaluated **current uranium exposures** (1995 to 2002) to residents living near the Y-12 plant. Exposure to uranium through both the inhalation and ingestion pathways would result in doses below levels of health concern for radiation and chemical health effects. Therefore, current exposure to uranium poses *no apparent public health hazard*.

- The current radiation dose from exposure to uranium through ingestion of soil and vegetables and inhalation of air is 0.216 millirem (mrem), which is well below (more than 23,000 times less than) the radiogenic cancer comparison value of 5,000 mrem over 70 years. The approximated radiation dose of 0.003 mrem for the first year dose is also well below (33,000 times less than) the ATSDR MRL of 100 mrem/year for ionizing radiation.

- Average current uranium air concentrations were 5.4×10^{-11} mg/m^3 in Scarboro and 1.4×10^{-10} mg/m^3 in the city of Oak Ridge, well below (more than a million times less than) the ATSDR intermediate-duration MRL of 8×10^{-3} mg/m^3 for insoluble forms of uranium.

- The estimated uranium doses from ingestion of Scarboro soil (ranging from 2.0×10^{-6} to 1.4×10^{-5} mg/kg/day) are well below (140 times less than) the ATSDR intermediate-duration oral MRL of 2×10^{-3} mg/kg/day.

- The estimated current uranium dose from ingestion of vegetables grown in private gardens in Scarboro (3.0×10^{-5} and 3.9×10^{-5} mg/kg/day) are well below (more than 50 times less than) the oral MRL of 2×10^{-3} mg/kg/day.

- The total uranium mean concentrations in surface water from Scarboro ditches (0.197µg/L) and from off-site areas of Lower East Fork Poplar Creek (12.8 µg/L) are well below ATSDR's health-based comparison value, the environmental media evaluation guide, of 20 µg/L.

VIII. RECOMMENDATIONS

On the basis of the evaluation of past public health activities and the available environmental information, ATSDR recommends the following:

1. ATSDR recommends that the community be informed that ATSDR has evaluated uranium releases from the Y-12 plant on the Oak Ridge Reservation and has concluded that there is no public health hazard associated with past and current releases. ATSDR will work with the Oak Ridge Reservation Health Effects Subcommittee to determine the best way to communicate the results of the evaluation to the people in the community.

IX. PUBLIC HEALTH ACTION PLAN

The public health action plan for the Oak Ridge Reservation (ORR) contains a description of actions taken at the site and those to be taken at the site following the completion of this public health assessment. The purpose of the public health action plan is to ensure that this public health assessment not only identifies potential and ongoing public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to harmful substances in the environment. The following public health actions at the ORR are completed, ongoing, or planned:

Completed Actions

- In 1991, the Tennessee Department of Health (TDOH) began a two-phase research project to determine whether environmental releases from ORR harmed people who lived nearby. Phase I focused on assessing the feasibility of doing historical dose reconstruction and identifying contaminants that were most likely to have effects on public health. Phase II efforts included full dose reconstruction analyses of iodine 131, mercury, polychlorinated biphenyls (PCBs), and radionuclides, as well as a more detailed health effects screening analysis for releases of uranium and other toxic substances (a summary can be found in the *Oak Ridge Dose Reconstruction Project Summary Report, Volume 7*).

- In 1992, the U.S. Department of Energy (DOE) conducted a Background Soil Characterization Project in the area around Oak Ridge (DOE 1993).

- In 1993, an ATSDR health consultation, Y-12 Weapons Plant Chemical Releases Into East Fork Poplar Creek, evaluated public health issues related to past and present releases into the creek from the Y-12 plant (ATSDR 1993).

- In 1996, an ATSDR health consultation on the Lower Watts Bar Reservoir evaluated the current public health issues related to the past and present releases into the reservoir from the ORR (ATSDR 1996).

- In 1997, the Centers for Disease Control and Prevention (CDC), the National Center for Environmental Health (NCEH), TDOH, and the Scarboro Community Environmental Justice Council conducted a study to determine whether rates of pediatric respiratory illnesses were higher in Scarboro than elsewhere in the United States, and whether exposure to various factors increased residents' risk for health problems (CDC et al. 1998).

- In 1998, the Environmental Sciences Institute at Florida Agricultural and Mechanical University (FAMU), along with its contractual partners at the Environmental Radioactivity Measurement Facility at Florida State University, and the Bureau of Laboratories of the Florida Department of Environmental Protections, as well as DOE subcontractors in the Neutron Activation Analysis Group at Oak Ridge National Laboratory and the Jacobs Engineering Environmental Management Team, sampled soil, sediment, and surface water from Scarboro to address community concerns about environmental monitoring in the neighborhood (FAMU 1998).

- In 2001, the U.S. Environmental Protection Agency (EPA) collected samples of soil, sediment, and surface water from the Scarboro community to address community concerns and verify the results of the 1998 sampling conducted by FAMU (EPA 2002b).

Ongoing Actions

- ATSDR will continue to evaluate contaminants and pathways of concern to the community surrounding the reservation. In addition to this evaluation of uranium from the Y-12 plant, ATSDR is evaluating uranium from the K-25 facility,

iodine 131, mercury, White Oak Creek releases in the 1950s, PCBs, fluorides, the TSCA incinerator, and groundwater. ATSDR will also screen data from 1990 to the present to determine whether additional contaminants of concern need to be addressed.

- In 1986, DOE installed a continuous air monitoring station (Station 46) in the Scarboro community to provide quarterly and annual air measurements of uranium 234, uranium 235, and uranium 238 (ChemRisk 1999). The station is operated by the Oak Ridge National Laboratory as part of the DOE ORR air monitoring network.

- In 1999, the Oak Ridge Reservation Health Effects Subcommittee (ORRHES) was created under the guidelines and rules of the Federal Advisory Committee Act to provide a forum for communication and collaboration between citizens and the agencies that are evaluating public health issues and conducting public health activities at the ORR. The ORRHES serves as a citizen advisory group to CDC and ATSDR and provides recommendations on matters related to public health activities and research at the reservation. It also provides an opportunity for citizens to collaborate with agency staff members, to learn more about the public health assessment process and other public health activities, and to help prioritize public health issues and community concerns to be evaluated by ATSDR.

Planned Actions

- In 2003, ATSDR will conduct community involvement activities, such as health education, to provide the public with the results of the public health assessment on uranium releases from the Y-12 Plant. Past releases were not a public health hazard to people living near the reservation, and current releases are not a public health hazard to people living near the reservation.

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APPENDICES

APPENDIX A

ATSDR Glossary of Environmental Health Terms

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ATSDR Glossary of Environmental Health 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 communications with the public. 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).

Absorption
The process of taking in. For a person or animal, *absorption* is the process through which a substance gets into the body through the eyes, skin, stomach, intestines, or lungs.

Activity
The number of radioactive nuclear transformations occurring in a material per unit time. The term for *activity* per unit mass is specific activity.

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).

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

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.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

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.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

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.

Decay product/daughter product/progeny
A new nuclide formed as a result of radioactive decay: from the radioactive transformation of a radionuclide, either directly or as the result of successive transformations in a radioactive series. A *decay product* can be either radioactive or stable.

Depleted uranium (DU)
Uranium having a percentage of U 235 smaller than the 0.7% found in natural uranium. It is obtained as a byproduct of U 235 enrichment.

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**].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

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.

DOE
The United States Department of Energy.

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.

Dose-response relationship
The relationship between the amount of exposure [**dose**] to a substance and the resulting changes in body function or health (response).

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.

Enriched uranium
Uranium in which the abundance of the U 235 isotope is increased above normal.

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.**

EPA
The United States Environmental Protection Agency.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

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.

Equilibrium, radioactive
In a radioactive series, the state that prevails when the ratios between the activities of two or more successive members of the series remain constant.

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-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biological tests (when appropriate) to determine whether people have been exposed to hazardous substances.

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.**

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

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

Half-life ($t_{½}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the *half-life* is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the *half-life* is the time it takes for half the original amount of the substance to disappear either by being changed to another substance or by leaving the body. In the case of radioactive material, the *half-life* is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into other atoms (normally not radioactive). After two *half-lives,* 25% of the original number of radioactive atoms remain.

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**].

Ionizing radiation
Any radiation capable of knocking electrons out of atoms and producing ions. Examples: alpha, beta, gamma and x rays, and neutrons.

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.

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

mg/kg
Milligrams per kilogram.

mg/m^3
Milligrams per cubic meter: a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. *MRLs* are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). *MRLs* should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes **mutations** (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

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-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

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.**]

Parent
A radionuclide which, upon disintegration, yields a new nuclide, either directly or as a later member of a radioactive series.

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).

ppb
Parts per billion.

ppm
Parts per million.

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.**

Public health statement
The first chapter of an ATSDR **toxicological profile.** The *public health statement* is a summary written in words that are easy to understand. It explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Quality factor (radiation weighting factor)
The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses - on a common scale for all ionizing radiation - the approximate biological effectiveness of the absorbed dose.

Rad
The unit of absorbed dose equal to 100 ergs per gram, or 0.01 joules per kilogram (0.01 gray) in any medium [see **dose**].

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.

RBC
Risk-based Concentration, a contaminant concentration that is not expected to cause adverse health effects over long-term exposure.

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

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

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

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).

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

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.

RfD
[See **reference dose.**]

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**].

Safety factor
[See **uncertainty factor**.]

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.

Sievert (Sv)
The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose, in gray, multiplied by the quality factor (1 sievert equals 100 rem).

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.*

Specific activity
Radioactivity per unit mass of material containing a radionuclide, expressed, for example, as Ci/gram or Bq/gram.

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

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

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 [also sometimes called a **safety factor**].

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/dictionaries.html

APPENDIX B

Summary of Other Public Health Activities

1

Appendix B

Summary of Other Public Health Activities

Summary of ATSDR Activities

Exposure Investigations, Health Consultations, and Other Scientific Evaluations. ATSDR health scientists have addressed current public health issues and community health concerns related to two areas affected by ORR operations—the EFPC area and the Watts Bar Reservoir area.

Following are summaries of other ATSDR public health activities involving EFPC.

- *Health Consultation on Proposed Mercury Clean Up Levels, January 1996*. In response to a request from community members and the city of Oak Ridge, ATSDR evaluated the public health impact of DOE's clean-up levels of 180 milligrams per kilogram (mg/kg) and 400 mg/kg of mercury in the EFPC floodplain soil. ATSDR concluded that the clean-up levels of 180 mg/kg and 400 mg/kg of mercury in the soil of the EFPC floodplain would be protective of public health and pose no health threat to adults or children.

- *ATSDR Science Panel Meeting on the Bioavailability of Mercury in Soil, August 1995*. The purpose of the science panel was to identify methods and strategies that would enable health assessors to develop data-supported, site-specific estimates of the bioavailability of inorganic mercury and other metals (arsenic and lead) from soils. The panel consisted of private consultants and academicians internationally known for their metal bioavailability research along with experts from ATSDR, the Centers for Disease Control and Prevention (CDC), EPA, and the National Institute for Environmental Health Science. ATSDR used information obtained from the panel meeting to evaluate the EFPC clean-up level. ATSDR also used the findings to characterize and evaluate soil containing mercury at other waste sites. Three technical papers and an ATSDR overview paper on the findings of the panel meeting were published in the International Journal of Risk Analysis in 1997 (Volume 17:5).

Following are summaries of other ATSDR public health activities involving Watts Bar Reservoir:

- *Community and Physician Education, September 1996*. To follow up on the recommendations in the ATSDR Lower Watts Bar Reservoir Health Consultation, ATSDR developed community and physician education programs on PCBs in the Watts Bar Reservoir. Daniel Hryhorczuk, MD, MPH, ABMT, of the Great Lakes Center, University of Illinois at Chicago, made presentations on the health risk associated with PCBs in fish at a community health education meeting in Spring City, TN on September 11, 1996. In addition, a physician and health professional education meeting for health care providers in the vicinity of the lower Watts Bar Reservoir was held at the Methodist Medical Center in Oak Ridge on September 12, 1996. ATSDR, in collaboration with local citizens, organizations, and state officials, developed an instructive brochure on the TDEC's fish consumption advisories for the Watts Bar Reservoir.

- *Watts Bar Reservoir Exposure Investigation*. In following up on the findings of previous studies and investigations of the Watts Bar Reservoir, including Feasibility of Epidemiologic Studies by the TDOH, ATSDR conducted the exposure investigation with cooperation from the Tennessee Department of Health and the Roane County Health Department. The 1996 exposure investigation was conducted to measure actual PCB and mercury levels in people consuming moderate to large amounts of fish and turtles from the Watts Bar Reservoir, and to determine whether these people are being exposed to high levels of PCBs and mercury. ATSDR published the following three major findings:

    - The exposure investigation participants' serum PCB levels and blood mercury levels are very similar to levels found in the general population.

    - Only 5 of the 116 people tested (4%) had PCB levels that were higher than 20 micrograms per liter (µg/L) or parts per billion (ppb), which is considered to be an elevated level of total PCBs. Of the five participants who exceeded 20 µg/L,

four had levels of 20–30 µg/L. Only one participant had a serum PCB level of 103.8 µg/L, which is higher than the general population distribution.

- Only one participant in the exposure investigation had a total blood mercury level higher than 10 µg/L, which is considered to be elevated. The remaining participants had mercury blood levels that ranged up to 10 µg/L, as might be expected to be found in the general population.

Clinical Laboratory Analysis. In June 1992, an Oak Ridge physician reported to the TDOH and the Oak Ridge Health Agreement Steering Panel (ORHASP) that approximately 60 of his patients may have been exposed, either occupationally or from the environment, to several heavy metals. The physician felt that these exposures had resulted in a number of adverse health outcomes (for example, increased incidence of cancer, chronic fatigue syndrome, neurological diseases, autoimmune disease, and bone marrow damage). In 1992 and 1993, ATSDR and the Centers for Disease Control and Prevention's (CDC's) National Center for Environmental Health (NCEH) facilitated clinical laboratory support by the NCEH Environmental Health Laboratory for patients referred by an Oak Ridge physician to the Howard Frumkin, M.D., Dr.PH., Emory University School of Public Health.

Because of patient-to-physician and physician-to-physician confidentiality, results of the clinical analysis have not been released to public health agencies. However, Dr. Frumkin recommended (in an April 26, 1995 letter to the Commissioner of the Tennessee Department of Health) that one should "not evaluate the patients seen at Emory as if they were a cohort for whom group statistics would be meaningful. This was a self-selected group of patients, most with difficult to answer medical questions (hence their trips to Emory), and cannot in any way be taken to typify the population at Oak Ridge. For that reason, I have consistently urged Dr. Reid, each of the patients, and officials of the CDC and the Tennessee Health Department, not to attempt group analyses of these patients."

Review of Clinical Information on Persons Living In or Near Oak Ridge. In addition to the above Clinical Laboratory Analysis, an ATSDR physician reviewed the clinical data and medical

histories provide by the Oak Ridge physician on 45 of his patients. The purpose of this review was to evaluate clinical information on persons tested for heavy metals and to determine whether exposure to metals was related to these patients' illnesses. ATSDR concluded that this case series did not provide sufficient evidence to associate low levels of metals with these diseases. The TDOH came to the same conclusion. ATSDR sent a copy of its review to the Oak Ridge physician in September 1992.

Health education. Another essential part of the public health assessment process is designing and implementing activities that promote health and provide information about hazardous substances in the environment.

- *Health Professional Education on Cyanide.* A physician education program was conducted in 1996, to provide information regarding the health impacts of possible cyanide intoxication. The program was intended to assist community health care providers in responding to health concerns expressed by employees working at the East Tennessee Technology Park (formerly the K-25 facility). ATSDR provided the local physicians with copies of the ATSDR Case Studies in Environmental Medicine publication "Cyanide Toxicity," the National Institute for Occupational Safety and Health (NIOSH) final health hazard evaluation, and the ATSDR public health statement for cyanide. Further, ATSDR instituted a system through which local physicians could make patient referrals to the Association of Occupational and Environmental Clinics (AOEC). Finally, ATSDR conducted an environmental health education session for physicians at the Methodist Medical Center in Oak Ridge, Tennessee. The medical staff grand rounds provided the venue for conducting this session. The workshop focused on providing local physicians and other health care providers with information to help them diagnose chronic and acute cyanide intoxication and to answer patients' questions.

- *Workshops on Epidemiology.* At the request of members of the Oak Ridge Reservation Health Effects Subcommittee (ORRHES), ATSDR held two workshops on epidemiology for the subcommittee. The first epidemiology workshop was presented at the June 2001 ORRHES meeting. Ms. Sherri Berger and Dr. Lucy Peipins of ATSDR's Division of

Health Studies provided an overview of the science of epidemiology. The second epidemiology workshop was presented at the December 2001 ORRHES meeting and was designed to help subcommittee members develop the skills needed to review and evaluate scientific reports. In addition, at the August 28, 2001, meeting of the Public Health Assessment Work Group (PHAWG), Dr. Peipins guided the work group and community members through a systematic scientific approach as they critiqued a report by J. Mangano, "Cancer Mortality Near Oak Ridge, Tennessee" (Int. J. of Health Services, V. 24 #3, 1994, p. 521). Based on the PHAWG critique, the ORRHES made the following conclusions and recommendation to ATSDR.

1. The Mangano paper is not an adequate, science-based explanation of any alleged anomalies in cancer mortality rates of the off-site public.
2. The Mangano paper fails to establish that radiation exposure from the ORR are the cause of any such alleged anomalies of cancer mortality rates in the general public.
3. The ORRHES recommends to the ATSDR that the Mangano paper be excluded from consideration in the ORR public health assessment process.

- *Health Education Needs Assessment.* Throughout the public health assessment process, ATSDR staff members have gathered concerns from people in the communities around the ORR. Through a cooperative agreement with ATSDR, AOEC began a community health education needs assessment in 2000 to aid in developing a community health education action plan. George Washington University and MCP Hahnemann University are conducting the assessment for the AOEC. The needs assessment will help in planning, implementing, and evaluating the health education program for the site. It will also help health educators identify key people, cultural norms, attitudes, beliefs, behaviors, and practices in the community, which is information that will aid in developing effective health education activities. Information on the needs assessment was presented at several ORRHES meetings.

Coordination with other parties. Since 1992 and continuing to the present, ATSDR has consulted regularly with representatives of other parties involved with the ORR. Specifically, ATSDR has coordinated efforts with TDOH, TDEC, NCEH, NIOSH, and DOE. This effort led to the establishment of the Public Health Working Group in 1999, which led to the establishment of ORRHES. In addition, ATSDR provided some assistance to TDOH in its study of past public health issues. ATSDR has also obtained and interpreted studies prepared by academic institutions, consulting firms, community groups, and other parties.

Establishment of the ORR Public Health Working Group and the ORRHES. In 1998, in collaboration with the DOE Office of Health Studies, ATSDR and CDC embarked on a process of developing credible, coherent, and coordinated agendas of public health activities and health studies for each DOE site. In February 1999, ATSDR was given the responsibility to lead the interagency group's efforts to improve communication at ORR. In cooperation with other agencies, ATSDR established the ORR Public Health Working Group to gather input from local organizations and individuals regarding the creation of a public health forum. After careful consideration of the input gathered from community members, ATSDR and CDC determined that the most appropriate way to meet the needs of the community would be to establish the ORRHES.

Site visits. To better understand site-specific exposure conditions, ATSDR scientists have conducted site visits to the ORR and visited surrounding areas numerous times since 1992. The site visits included guided tours of the ORR operation areas, as well as tours of the local communities to identify how community members might come into contact with environmental contamination.

Summary of TDOH Activities

Pilot Survey. In the fall of 1983, TDOH developed an interim soil mercury level for use in environmental management decisions. CDC reviewed the methodology for the interim mercury level in soil and recommended that a pilot survey be conducted to determine whether populations with the highest risk for mercury exposure had elevated body burdens of mercury. In June and

July 1984, a pilot survey was conducted to document human body levels of inorganic mercury for residents of Oak Ridge with the highest potential for mercury exposure from contaminated soil and fish. The survey also examined whether exposure to mercury-contaminated soil and fish constituted an immediate health risk to the Oak Ridge population. The results of the pilot survey, released in October 1985, suggested that residents and workers in Oak Ridge, Tennessee, are not likely to be at increased risk for having significantly high mercury levels. Mercury concentrations in hair and urine samples were below levels associated with known health effects.

Health Statistics Review. In June 1992, an Oak Ridge physician reported to the Tennessee Department of Health (TDOH) and the Oak Ridge Health Agreement Steering Panel (ORHASP) that he believed approximately 60 of his patients had experienced occupational and environmental exposures to several heavy metals. The physician felt that these exposures had resulted in increased cancer, immunosuppression, chronic fatigue syndrome, neurologic diseases, autoimmune disease, bone marrow damage, and hypercoagulable state including early myocardial infarctions and stroke. In 1992, The TDOH conducted a health statistics review to compare cancer incidence rates for the period of 1988 to 1990 for counties surrounding the Oak Ridge Reservation to rates from the rest of the state. Findings of the review are in a TDOH memorandum dated October 19, 1992, from Mary Layne Van Cleave to Dr. Mary Yarbrough. The memorandum details an Oak Ridge physician's concerns about the health status in the Oak Ridge area. Also available from the TDOH are the minutes and handouts from a presentation given by Ms. Van Cleave at the ORHASP meeting on December 14, 1994.

Health Statistics Review. In 1994 local residents reported that there were many community members with amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS). The Tennessee Department of Health in consultation with Peru Thapa, MD, MPH, from the Vanderbilt University School of Medicine conducted a health statistics review of mortality rates for amyotrophic lateral sclerosis (ALS), multiple sclerosis (MS), and other selected health outcomes.

TDOH found that because ALS and MS are not reportable diseases, it is impossible to calculate reliable incidence rates. Mortality rates for the period of 1980 to 1992 were reviewed for the 10 counties surrounding the ORR and compared with mortality rates for the state of Tennessee. The

following results were reported by the TDOH at the ORHASP public meeting on August 18, 1994.

- There were no significant differences in ALS mortality in any of the counties in comparison to the rest of the state.

- For Anderson County, the rate of age-adjusted deaths from chronic obstructive pulmonary disease (COPD) was significantly higher than rates in the rest of the state, but rates for total deaths, deaths from stroke, deaths from congenital anomalies, and deaths from heart disease were significantly lower for the period from 1979 to 1988. There were no significant differences in the rates of deaths due to cancer, for all sites, in comparison to rates in the rest of state. Rates of deaths from uterine and ovarian cancer were significantly higher than the rates in the rest of the state. The rate of deaths from liver cancer was significantly lower in comparison to the rest of the state.

- For Roane County, the rates of total deaths and deaths from heart disease were significantly lower than the rates in the rest of the state for the period from 1979 to 1988. Although the total cancer death rate was significantly lower than the rate in the rest of the state, the rate of deaths from lung cancer was significantly higher than the rate in the rest of the state. Rates of deaths from colon cancer, female breast cancer, and prostate cancer were also significantly lower than the rates in the rest of the state.

- For Knox County, the rates for total deaths and deaths from heart disease were significantly lower than the rates in the rest of the state. There was no significant difference in the total cancer death rate in comparison to the rest of the state.

- There were no significant exceedances for any cause of mortality studied in Knox, Loudon, Rhea, and Union counties in comparison to the rest of the state.

- Rates of total deaths were significantly higher in Campbell, Claiborne, and Morgan counties in comparison to the rest of the state.

- Cancer mortality was significantly higher in Campbell County in comparison to the rest of the state. The excess in number of deaths from cancer appeared to be attributed to the earlier part of the time period (1980 to 1985); the rate of deaths from cancer was not higher in Campbell County in comparison to the rest of the state for the time periods from 1986 to 1988 and 1989 to 1992.

- Cancer mortality was significantly higher in Meigs County in comparison to the rest of the state from 1980 to 1982. This excess in cancer deaths did not persist from 1983 to 1992.

Knowledge, Attitude, and Beliefs Study. A study, coordinated by TDOH, was conducted in an eight-county area surrounding Oak Ridge, Tennessee. The purpose of the study was to (1) investigate public perceptions and attitudes about environmental contamination and public health problems related to the ORR, (2) ascertain the public's level of awareness and assessment of the ORHASP, and (3) make recommendations for improving public outreach programs. The report was released in August 1994. Following is a summary of the findings.

- A majority of the respondents regard their local environmental quality as better than the national environmental quality. Most rate the quality of the air and their drinking water as good or excellent. Almost half rate the local groundwater as good or excellent.

- A majority of the respondents think that activities at the ORR created some health problems for people living nearby and most think that activities at ORR created health problems for people who work at the site. Most feel that researchers should examine the actual occurrence of disease among Oak Ridge residents. Twenty-fine percent know of a specific local environmental condition that they believe has adversely affected public health, but many of these appear to be unrelated to ORR. Less than 0.1% have personally experienced a health problem that they attribute to the ORR.

- About 25% have heard of the Oak Ridge Health Study and newspapers are the primary source of information about the study. Roughly 33% rate the performance of the study as

good or excellent and 40% think the study will improve public health. Also, 25% feel that communication about the study has been good or excellent.

Health Assessment. A health assessment of the East Tennessee region was conducted by TDOH's East Tennessee Region to evaluate the health status of the population, assess the availability and utilization of health services, and develop priorities in planning to use resources. In December 1991, the East Tennessee Region released the first edition of "A Health Assessment of the East Tennessee Region," which included data generally from 1986 to 1990. The second edition, released in 1996, included data generally from 1990 through 1995. A copy of the document is available from the TDOH East Tennessee Region.

Presentation. Dr. Joseph Lyon of the University of Utah gave a presentation to inform the ORHASP and the public of the multiple studies related to the fallout from the Nevada Test Site, including the study of leukemia and thyroid disease. The presentation was sponsored by TDOH and held on February 16, 1995, at the ORHASP public meeting.

Summary of Joint Center for Political and Economic Studies Activities

Scarboro Community Assessment Report. In 1999, the Joint Center for Political and Economic Studies conducted a survey of the Scarboro community to identify environmental and health concerns of the residents. The surveyors attempted to elicit responses from the whole community and achieved an 82% response rate. Additionally, with support from DOE Oak Ridge Operations, the Joint Center has been working with the community since 1998 to help residents articulate their environmental, health, economic, and social needs. Because Scarboro is a small community, the community assessment provided new information about the community that is not available through sources such as the U.S. Census Bureau. It also identified Scarboro's strengths and weaknesses and illustrated the relative unimportance of environmental health issues to other community concerns—environmental and health issues are not a priority for most Scarboro residents; rather the community is more concerned about crime and security, children, and economic development. The Joint Center recommended more active community involvement in city and community planning (Friday and Turner 2001).

APPENDIX C

Toxicologic Implications of Uranium Exposure

APPENDIX C

Toxicologic Implications of Uranium Exposure

ATSDR's toxicological profiles identify and review the key peer-reviewed literature that describes particular hazardous substances' toxicologic properties. They also present other pertinent literature, but describe it in less detail than the key studies. Toxicological profiles are not intended to be exhaustive documents, but they do reference more comprehensive sources of specialty information.

In 1999, ATSDR published an updated toxicological profile for uranium (ATSDR 1999a). This document, like all such profiles, succinctly characterizes the toxicologic and adverse health effects information for the hazardous substance it describes. The discussion below is drawn from the updated profile for uranium, except where otherwise noted.

What Is Uranium?

Uranium, a natural and commonly occurring radioactive element, is found in very small amounts in nature in the form of minerals. Rocks, soil, surface and underground water, air, and plants and animals all contain varying amounts of uranium. Typical concentrations in most materials are a few parts per million (ppm). This corresponds to around 4 tons of uranium in 1 square mile of soil 1 foot deep, or about half a teaspoon of uranium in a typical 8-cubic-yard dump truck load of soil (ATSDR 1999a).

Natural uranium is a mixture of three types (or isotopes) of uranium, written as U 234, U 235, and U 238. By weight, natural uranium is about 0.005% U 234, 0.72% U 235, and 99.27% U 238. For uranium that has been in contact with water, the natural weight and radioactivity percentages can vary slightly from these percentages. All three isotopes behave the same chemically, so any combination of the three would have the same chemical effect on your body. But they are different radioactive materials with different radioactive properties. About 48.9% of

the radioactivity is associated with U 234, 2.2% is associated with U 235, and 48.9% is associated with U 238 (ATSDR 1999a).

Uranium Use at ORR

One of the industrial processes at the Y-12 plant artificially increased (enriched) the amount of U 235 over and above the enrichment from the K-25 plant. This enrichment process is used to increase the amount of U 235 and decrease the amount of U 238 in uranium. Enriched uranium used for nuclear power plants is typically 3% U 235. Uranium enrichment for nuclear weapons and nuclear propulsion can produce uranium that contains as much as, if not more than, 97% U 235. The uranium left over after enrichment is called depleted uranium. Uranium enriched as at Y-12 is more radioactive than natural uranium, and natural uranium is more radioactive than depleted uranium.

Various types and amounts of uranium compound were used and produced at the Y-12 facility and potentially released to the environment. The chemical forms of uranium used at Y-12 included uranium tetrachloride, uranium oxides in the form of UO_2, UO_3, and U_3O_8, and uranium hexafluoride (ChemRisk 1999). Of these forms, U_3O_8 is most commonly found in nature and chemically is the most stable. Uranium dioxide (UO_2) is the form most used in nuclear reactors; over time, it converts to U_3O_8. The following table gives the water solubility and kidney toxicity of the common uranium compounds used at the Y-12 facility.

Table C-1. Relative Water Solubility and Kidney Toxicity of the Uranium Compounds Used at Y-12

Relative Water Solubility	Relative Toxicity to Kidney	Uranium Compound
Most water soluble	Most toxic	Uranium hexafluoride Uranium tetrachloride
Low water solubility	Low to moderate toxicity	Uranium trioxide
Insoluble	Least toxic	Uranium dioxide Triuranium octaoxide

How Can Uranium Enter and Leave My Body?

Plants and animals can take up uranium. Uranium in soil can be taken into plants without entering into the plants' bodies. Root vegetables (like potatoes and radishes) that are grown in soils with high concentrations of uranium may contain more uranium than other vegetables grown in the same conditions. Uranium can also get into livestock through food, water, and soil. Therefore, uranium is taken into our bodies in the food we eat, the water we drink, and the air we breathe. But it does not stay in the body long—it is eliminated quickly in urine and feces.

What we take in from industrial activities is in addition to what we take in from natural sources. When you breathe uranium dust, some is exhaled and some stays in your lungs. The size of the uranium dust particles and how easily they dissolve determines where in the body the uranium goes and how it leaves your body. Uranium dust can consist of small, fine particles and coarse, big particles. The big particles are caught in the nose, the sinuses, and the upper part of your lungs; from there, they are blown out or pushed to the throat and swallowed. The small particles are inhaled down to the lower part of your lungs. If they do not dissolve easily, they stay there for years. (Most of uranium's radiation dose to the lungs comes from these small particles.) Given these solubilities, the International Commission on Radiological Protection has grouped uranium compounds into three classes, as shown in the following table (ICRP 1993, 1995).

Table C-2. Types of Uranium Compound According to Their Solubilities

	Type F	Type M	Type S
Initial Dissolution Rate (per day)	100	10	0.1
Representative Uranium Compounds	Hexafluoride, tetrafluoride; pure trioxide form (UO_3)	Tetrafluoride, trioxide, octoxide (U_3O_8) (dependent on process)	Octoxide, dioxide (UO_2)

Uranium particles can also gradually dissolve and go into your blood. If the particles dissolve easily, they go into your blood more quickly. When you eat foods and drink liquids containing uranium, most of it leaves within a few days in your feces and never enters your blood. A small portion does get into your blood, which carries it throughout your body. Some of the uranium in your blood leaves your body through your urine within a few days, but the rest stays in your

bones, kidneys, or other soft tissues. A small amount of the uranium that goes to your bones can stay there for years. Most people have very small amounts of uranium, about 1/5,000th of the weight of an aspirin tablet, in their bodies, mainly in their bones.

How Can Uranium Affect My Health?

Although uranium is weakly radioactive, most of the radiation it gives off cannot travel far from its source. If the uranium is outside your body (in soil, for example), most of its radiation cannot penetrate your skin and enter your body. To be exposed to radiation from uranium, you have to eat, drink, or breathe it, or get it on your skin (ATSDR 1999a).

Scientists have never detected harmful radiation effects from low levels of natural uranium, although some may be possible. However, scientists have seen chemical effects. A few people have developed signs of kidney disease after taking in large amounts of uranium (e.g., one man ingested 131 milligrams per kilogram of uranyl acetate in a suicide attempt; see Pavlakis et al. 1996 as cited in ATSDR 1999a). Animals have also developed kidney disease after they have been treated with large amounts of uranium. It is possible that intake of a large amount of uranium will damage your kidneys.

There is also a chance of getting cancer from any radioactive material like uranium. Again, natural and depleted uranium are only weakly radioactive, and their radiation is not likely to cause cancer. No human cancer of any type has ever been seen as a result of exposure to natural or depleted uranium (ATSDR 1999a). Although several studies of uranium miners found that they were more likely to die from lung cancer, it is difficult to say whether uranium exposure caused these cancers: while they were being exposed to the uranium, the miners were also being exposed to known cancer-causing agents (tobacco smoke, radon and decay products, silica, and diesel engine exhaust). The studies attributed the cancers to exposure to these agents and not to uranium exposure.

The National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR IV) reported that eating food or drinking water that has normal amounts of uranium will

most likely not cause cancer or other health problems in most people (National Research Council 1988). The Committee used data from animal studies to estimate that a small number of people who steadily eat food or drink water containing larger-than-normal quantities of uranium could get a kind of bone cancer called a sarcoma. The Committee reported calculations showing that if a million people steadily ate food or drink water containing about 1 picocurie of uranium every day of their lives, one or two of them would have developed bone sarcomas after 70 years, based on the radiation dose alone. However, we do not know this for certain because people normally ingest only slightly more than this amount each day, and people who have been exposed to larger amounts have not been found to get cancer. We do not know if exposure to uranium causes reproductive effects in people. Very high doses of uranium have caused reproductive problems (reduced sperm counts) in some experiments with laboratory animals. Most studies show no effects (ATSDR 1999a).

How Can Uranium Affect Children?

Children are also exposed to small amounts of uranium in air, food, and drinking water. However, no cases have been reported in which exposure to uranium was known to have caused health effects in children. Children exposed to very high amounts of uranium might have damage to their kidneys like that seen in adults. We do not know whether children differ from adults in their susceptibility to health effects from uranium exposure. It is not known if exposure to uranium has effects on the development of the human fetus. Very high doses of uranium in drinking water can affect the development of the fetus in laboratory animals. One study reported birth defects and another reported an increase in fetal deaths. However, we do not believe that uranium can cause these problems in pregnant women who take in normal amounts of uranium from food and water, or who breathe the air around a hazardous waste site that contains uranium (ATSDR 1999a).

Is There a Medical Test to Determine Whether I Have Been Exposed to Uranium?

There are medical tests that can determine whether you have been exposed by measuring the amount of uranium in your urine, blood, and hair. Urine analysis is the standard test. If your

body takes in a larger-than-normal amount of uranium over a short period, the amount of uranium in your urine may be increased for a short time. Because most uranium leaves the body within a few days, normally the amount in the urine only shows whether you have been exposed to a larger-than-normal amount within the last week or so. If the intake is large or if higher-than-normal levels are taken in over a long period, the urine levels may be high for a longer period of time. Many factors can affect the detection of uranium after exposure. These factors include the type of uranium you were exposed to, the amount you took into your body, and the sensitivity of the detection method. Also, the amount in your urine does not always accurately show how much uranium you have been exposed to. If you think you have been exposed to elevated levels of uranium and want to have your urine tested, you should do so promptly while the levels may still be high. In addition to uranium, the urine could be tested for evidence of kidney damage, through tests for protein, glucose, and nonprotein nitrogen, which are some of the chemicals that can appear in your urine because of kidney damage. Though such tests could determine whether you have kidney damage, they would not tell you if uranium in your body caused that damage: several common diseases, such as diabetes, also damage the kidneys (ATSDR 1999a).

What Recommendations Has the Federal Government Made to Protect Human Health?

Federal agencies have set limits for uranium in the environment and workplace. In 1991, the U.S. Environmental Protection Agency established a maximum contaminant level for uranium in drinking water of 20 micrograms per liter (μg/L). In December 2003, the maximum contaminant level for uranium will increase to 30 μg/L. The National Institute of Occupational Safety and Health and the Occupational Safety and Health Organization have established a recommended exposure limit and a permissible exposure limit of 0.05 milligrams per cubic meter for water-soluble uranium dust in the workplace. The Nuclear Regulatory Commission has set uranium release limits of 0.06 picocuries per cubic meter in air and 300 picocuries per liter in water (or approximately 438 μg/L).

APPENDIX D

ATSDR's Derivation of the Radiogenic Cancer Comparison Value

APPENDIX D

ATSDR's Derivation of the Radiogenic Cancer Comparison Value

For the evaluation of radiation doses at Oak Ridge, ATSDR used the concept of committed effective dose equivalent (CEDE). The CEDE is a calculated dose arising from the one-time intake of radiological uranium, with the assumption that the entire dose (a 70-year dose, in this case)[19] is received in the first year following the intake. The value used by ATSDR for the radiogenic cancer comparison value is 5,000 millirem (mrem) over 70 years. ATSDR derived this value after reviewing the peer-reviewed literature and other documents developed to review the health effects of ionizing radiation.

In 1994, the General Accounting Office (GAO) released a report reviewing the U.S. radiation standards and radiation protection issues (GAO 1994). The GAO further refined their results in 2000 (GAO 2000). According to the later report, "conclusive evidence of radiation effects is lacking below a total of about 5,000 to 10,000 mrem, according to the scientific literature," which was also the consensus of experts they interviewed (GAO 2000).[20] The GAO then developed the following figure from their analysis. The figure shows the representative knowledge base of radiation effects in relation to radiation dose. Besides the four possible dose response curves indicated on the figure, it also shows that at a dose of 10,000 mrem (which is equal to 10 rems or 0.1 sieverts; "rems" is abbreviated as "rem" and "sieverts" is abbreviated as "Sv") or more, the data are conclusive with respect to health effects from radiation exposure. Between 10 rem and 5 rem, the data are not clear as to the health effects. Below 5 rem the effects are not observed, only assumed to occur. Therefore, the risk associated with a dose that approaches background, 0.36 rem/year (360 mrem or 3.6 millisieverts [mSv]) is essentially impossible to measure.

[19] In this case, the entire dose is the dose a person would receive over 70 years of exposure. ATSDR chose a 70-year period of exposure under the assumption that a member of the public would be exposed over an entire lifetime.
[20]Expert organizations estimate risks associated with radiation doses at these levels using complex models of existing data. Here, for example, is an estimate from a 1990 study by a National Academy of Sciences committee called BEIR V: at the 90% statistical confidence interval, out of 100,000 adults exposed to 100 mrem a year of radiation over a lifetime, anywhere from 410 to 980 men and 500 to 930 women might die of cancer caused by the exposure. This confidence interval assumes the validity of the linear model and reflects the uncertainty of inputs to the model.

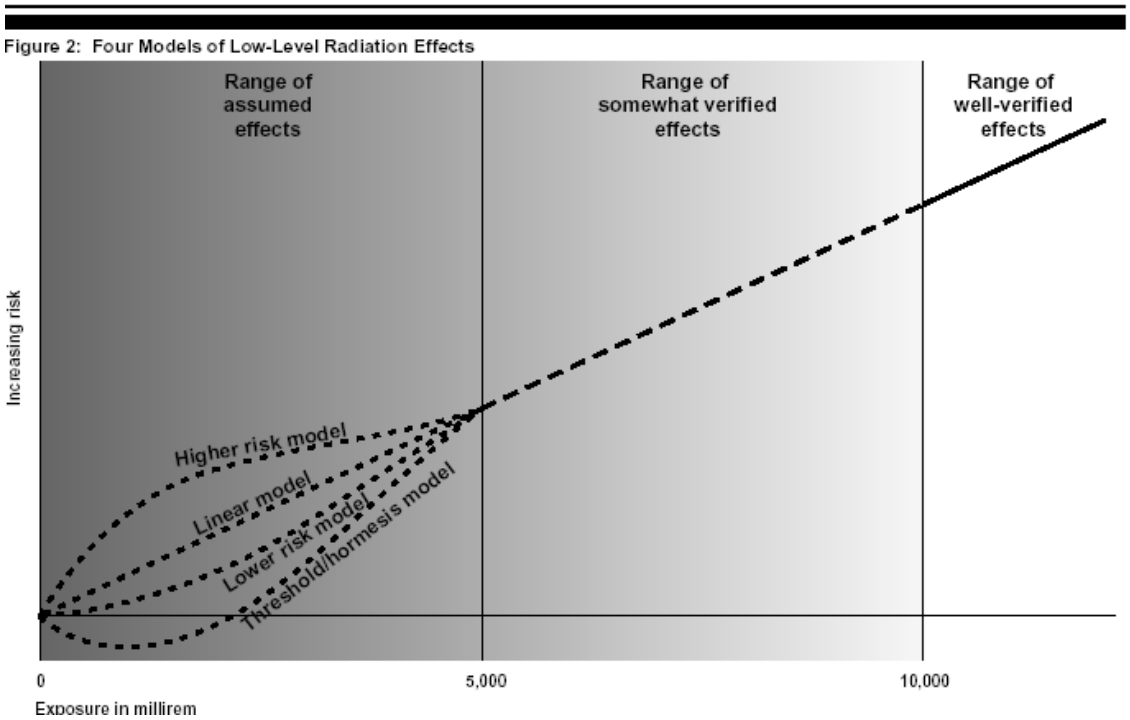


Figure 2: Four Models of Low-Level Radiation Effects

The National Council on Radiation Protection and Measurement (NCRP), in their Report 136 on linear non-threshold issues, reevaluated the existing data on the dose-response of ionizing radiation and the health effects associated with exposures to ionizing radiation (NCRP 2001). Their evaluation focused on "the mutagenic, clastogenic (chromosome-damaging), and carcinogenic effects of radiation." As in other reviews, the NCRP found no conclusive evidence to reject the linear no-threshold model for radiation dose response. One result of these reviews, however, is that the NCRP stated that for cell systems receiving "low-LET [Linear Energy Transfer] radiations the lowest dose at which a statistically significant increase of transformation over background has been demonstrated is 10 mGy." (10 mGy, or milligrays, are equivalent to a radiation dose of 1 rad.) Animal studies, meanwhile, show variation in the dose-response curves. Accordingly, page 210 of the NCRP report states that "the available information does not suffice to define the dose-response curve unambiguously for any neoplasm in the dose range below 0.5 Sv." Note that the NCRP also stated that other data on induction of neoplasms and life shortening in mice were not inconsistent with a linear response. Thus, there is uncertainty in the

response to the types of radiation, the endpoint under investigation, and the animal system being studied.

According to the NCRP, similar dose responses occur in humans, as evidenced by many studies. However, many of these studies were atomic bomb survivor studies—the doses and dose rates involved were very different from the doses and rates typically observed at hazardous waste sites. The NCRP states that in the bomb survivors, induction of leukemia appears to be linear-quadratic; however, the studies on which that statement is based began at least 5 years after the bombing, so they may have missed the initial wave of leukemia. Overall, the induction of solid cancers has a linear nonthreshold (LNT) component as low as 50 mSv (5,000 mrem). Other radiation studies show a possible increase in fetal cancer following an exposure of 10 mGy and increased thyroid cancer following irradiation during childhood following a dose of 100 mSv (10,000 mrem).

The adverse health effects from acute exposures to radiation have been well defined through studies of atomic bomb survivors, medical accidents, and industrial accidents. But this document is concerned with health effects associated with low-dose chronic exposures to ionizing radiation. These health effects are more difficult to define, characterize, and discuss. ATSDR's experience at sites contaminated with radioactive materials shows that chronic exposures are incremental in comparison to background. In the United States, background consists of naturally occurring radon (54%), terrestrial and cosmic radiation (8% each), and radiation from natural internal sources (11%). The remainder (19%) is associated with medical exposures and consumer products (ATSDR 1999b). The typical average background radiation in the United States is 3.6 mSv (360 mrem) per year. Excluding medical and consumer products, the average background is about 300 mrem (3 mSv).

Exposures Associated with Background Radiation

ATSDR could not identify any peer-reviewed studies that show that background-level radiation is harmful. In fact, there are portions of the globe where the background is higher than in the typical area in the United States. According to the United Nations, the world's background

radiation can vary from below 1 mSv (100 mrem) to above 6.4 mSv (640 mrem), or higher, per year. For example, in an area in China where elevated levels of natural background radiation are found, studies have shown a significant increase in chromosomal aberrations; however, no increases in adverse health effects have been observed in the 20 or more years this area has been studied. Other areas in the world where there are high background radiation levels are India, Brazil, and Iran. An area in Iran called Ramsar has verified doses as high as 130 mSv per year (1,300 mrem).[21]

Incremental Exposures Above Background Radiation

Many studies have attempted to show a cause and effect from low-level chronic radiation exposure. In these studies, low dose can be defined as doses in excess of 10 mSv (1,000 mrem). No studies exist for exposures or doses below this limit. For many of these low-dose epidemiological studies, researchers used the standardized mortality ratio (SMR). The Society for Risk Analysis defines the SMR as "the ratio of observed deaths in a population to the expected number of deaths as derived from rates in a standard population with adjustment of age and possibly other factors such as sex or race."

An English study of over 95,000 radiation workers whose collective dose from external radiation was about 3,200 man Sv (3,200/95,000 = 34 mSv or 3,400 mrem) only took into account external radiation exposure and dose. The results showed that the SMR for all cancers was less than 1 (Kendall et al. 1992).

A later study by Cardis and coworkers included 95,000 nuclear industry workers in the United States, Canada, and the United Kingdom. The study participants were monitored for external radiation exposure (mostly gamma) and were employed for at least 6 months. In all, there were 15,825 deaths, of which 3,976 were from cancer. The authors found no evidence of a dose response and mortality association from all causes or from all cancers. Of the cancer types,

[21] ATSDR used several data sources in developing this section: Internet searches, the *Health Physics* journal, and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reports.

leukemia (except for chronic lymphocytic leukemia and multiple myeloma) showed a significant association with cumulative external radiation dose (Cardis et al. 1995).

In a cohort study to determine if radiation workers' children were at risk of developing leukemia or other cancers before they reached 25 years of age, Roman and coworkers included 39,557 children of male workers and 8,883 children of female workers. The study suggested that the incidence of cancer and leukemia among children of nuclear industry employees is similar to that in the general population. The SMR for all cancers and leukemias for each sex of the worker was less than 1 (Roman et al. 1999).

In conclusion, ATSDR believes that its reasoning in using a radiogenic cancer comparison value of 5,000 mrem over 70 years is protective of human health at Oak Ridge.

APPENDIX E

Measured vs. Estimated Average Annual Uranium Air Radioactivity Concentrations at ORR Air Monitoring Station 46 in Scarboro

Appendix E

Measured vs. Estimated Average Annual Uranium Air Radioactivity Concentrations at ORR Air Monitoring Station 46 in Scarboro

Task 6 of the Oak Ridge Health Studies Phase II (ChemRisk 1999) included an extensive assessment of uranium air emissions from the Y-12 facility and an attempt to estimate historic uranium air radioactivity concentrations in Scarboro from 1944 to 1995 based on the annual airborne uranium release estimates for Y-12 from 1944 to 1995. This section of the public health assessment compares the estimated uranium air radioactivity concentrations (1985 to 1995) in Scarboro to the uranium air radioactivity concentrations measured in Scarboro between 1986 and 1995.

The DOE perimeter air monitoring station 46 in Scarboro has been in operation since 1986. The Task 6 report evaluated the environmental monitoring procedures and methods used for that sampling. The Task 6 report concluded that the "procedures and methods that have been used to collect and analyze air samples for uranium concentrations at the Scarboro location were deemed by the project team to be of adequate quality for use in the Scarboro χ/Q [chi/Q] evaluation presented below. The methods employed by ORNL are consistent with industry standards and are capable of producing reliable estimates of uranium concentrations in Scarboro."

Given the Task 6 conclusion about air sampling at station 46, ATSDR assumes that the measured uranium air concentrations at Scarboro, beginning in 1986, are a reliable basis for calculating uranium air exposures and doses to the Scarboro community. Uranium air concentrations at Scarboro from 1944 to 1985 are unknown and must be estimated. If the 1986 to 1995 annual airborne release estimates for Y-12 and the 1986 to 1995 measured air concentrations in Scarboro are correlated, the correlation will provide a quantitative basis for estimating historic annual average air radioactivity concentrations (1944 to 1995) at Scarboro from the annual airborne uranium release estimated for Y-12 between 1944 and 1995.

The Task 6 study used the correlation between the measured Scarboro air concentrations (1986 to 1995) and the estimated Y-12 airborne uranium emissions (1986 to 1995) to create a multiplying factor (termed "an empirical χ/Q"). This χ/Q is simply the ratio of an observed (measured) annual average uranium air concentration in Scarboro to the estimated airborne uranium releases from Y-12 for the same year.[22] As there were 10 years (1986 to 1995) of observed annual average air concentrations in Scarboro and Y-12 airborne emission rates at the time of the Task 6 report, the χ/Q multiplier corresponding to the 95th upper confidence limit of the mean was used.

Figure E-1 shows the annual average U 234/235 air concentrations calculated using the Task 6 χ/Q multiplier relative to the measured Scarboro air concentrations for 1986 to 1995. The figure shows that the χ/Q estimation of Scarboro air concentrations overestimates the measured air concentrations by up to a factor of 5. Consequently, airborne uranium doses to Scarboro residents calculated from χ/Q concentration estimates were probably also overestimated by a factor of up to 5.

Figure E-1 also shows Scarboro air concentrations estimated using linear regression of Y-12 airborne emissions and measured air concentrations. This is a different method of estimating Scarboro air concentrations from Y-12 emissions data. As the air concentrations estimated using linear regression directly overlie the measured air concentrations in Figure E-1, this method appears to be a better estimator of historic Scarboro air concentrations than the χ/Q method.

The linear regression relationship is illustrated in Figure E-2. This method plots the measured air radioactivity concentrations (in femtocuries per cubic meter, or fCi/m^3; 1 femtocurie equals 1×10^{-15} curies) with the Y-12 uranium airborne emissions and draws a best fit straight line through the plotted points. The linear regression is the equation of the best fit line. The correlation coefficient (shown as R^2 in Figure E-2) is a measure of the strength of association between the air concentrations and emissions. The perfect correlation between factors would be 1. The

[22] χ represents the average annual Scarboro uranium concentration; Q represents the annual Y-12 uranium emissions. Multiplying the historic Y-12 emissions (Q) by the χ/Q term results in an estimate of the historic Scarboro air concentration, or χ.

coefficient of 0.9657 between Scarboro air concentrations and Y-12 U 234/235 emissions indicates that the linear regression is a very reliable estimator of historic Scarboro air radioactivity concentrations.

The regression equation (Figure E-2) for estimating historic Scarboro air radioactivity concentrations from Y-12 emissions is:

$$y = 1.7059x + 0.0784$$

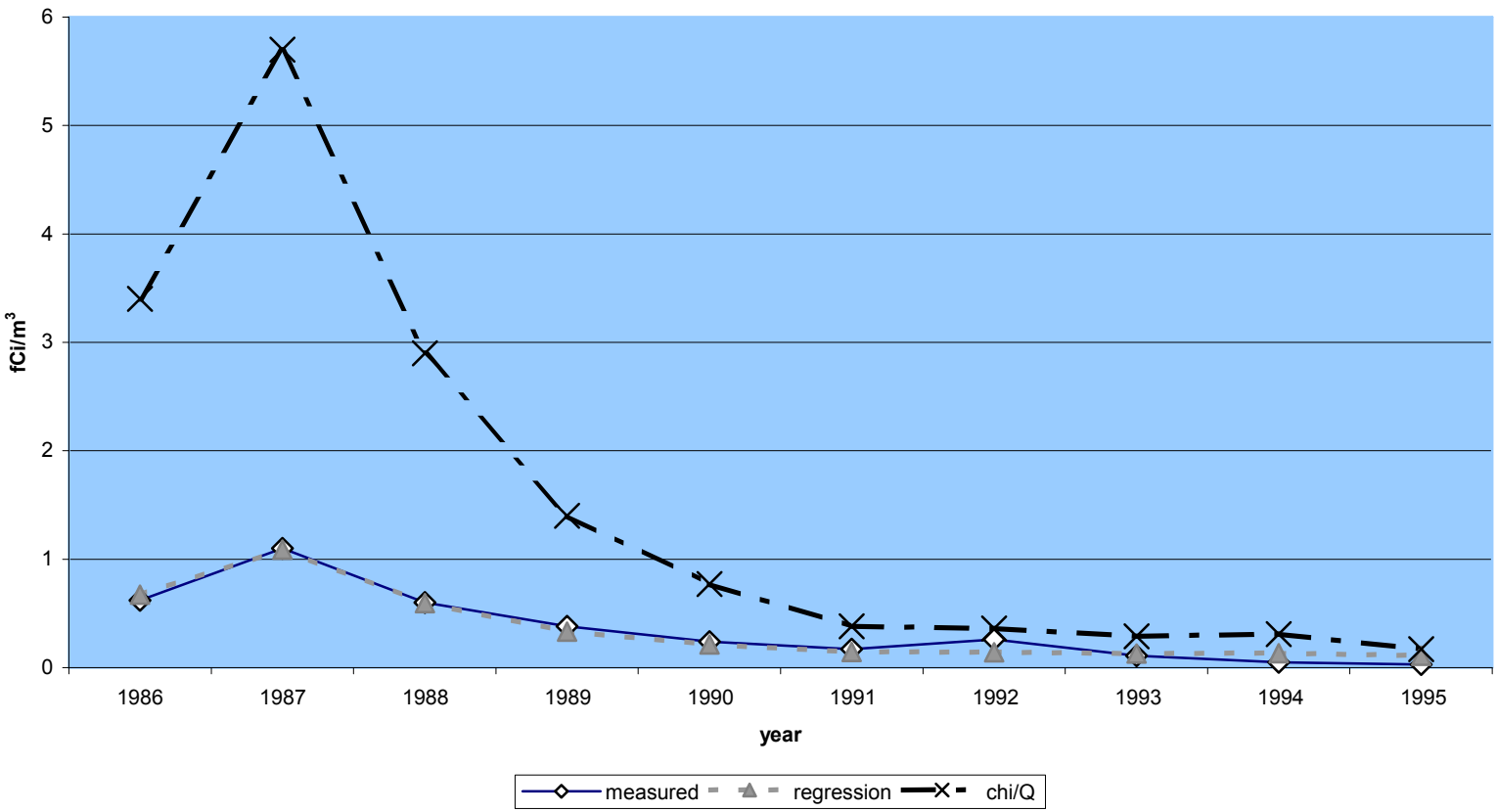
Where: y = the estimated Scarboro air radioactivity concentration in fCi/m^3
x = the Y-12 uranium emission rate in curies

The equation above is based on correlation of U 234/235 release rates (Y-12 emissions) and measured U 234/235 air concentrations.

Figure E-3 shows the relationship between U 238 airborne emissions and measured air concentrations. Although this relationship also shows a positive correlation, it is a much weaker association: the correlation coefficient (R^2) is only 0.6377 and there is much greater scatter of the plotted points relative to the best fit regression line. Consequently, the regression equation based on U 238 emissions and measured Scarboro air concentrations is not considered a reliable estimator of historic air concentrations.

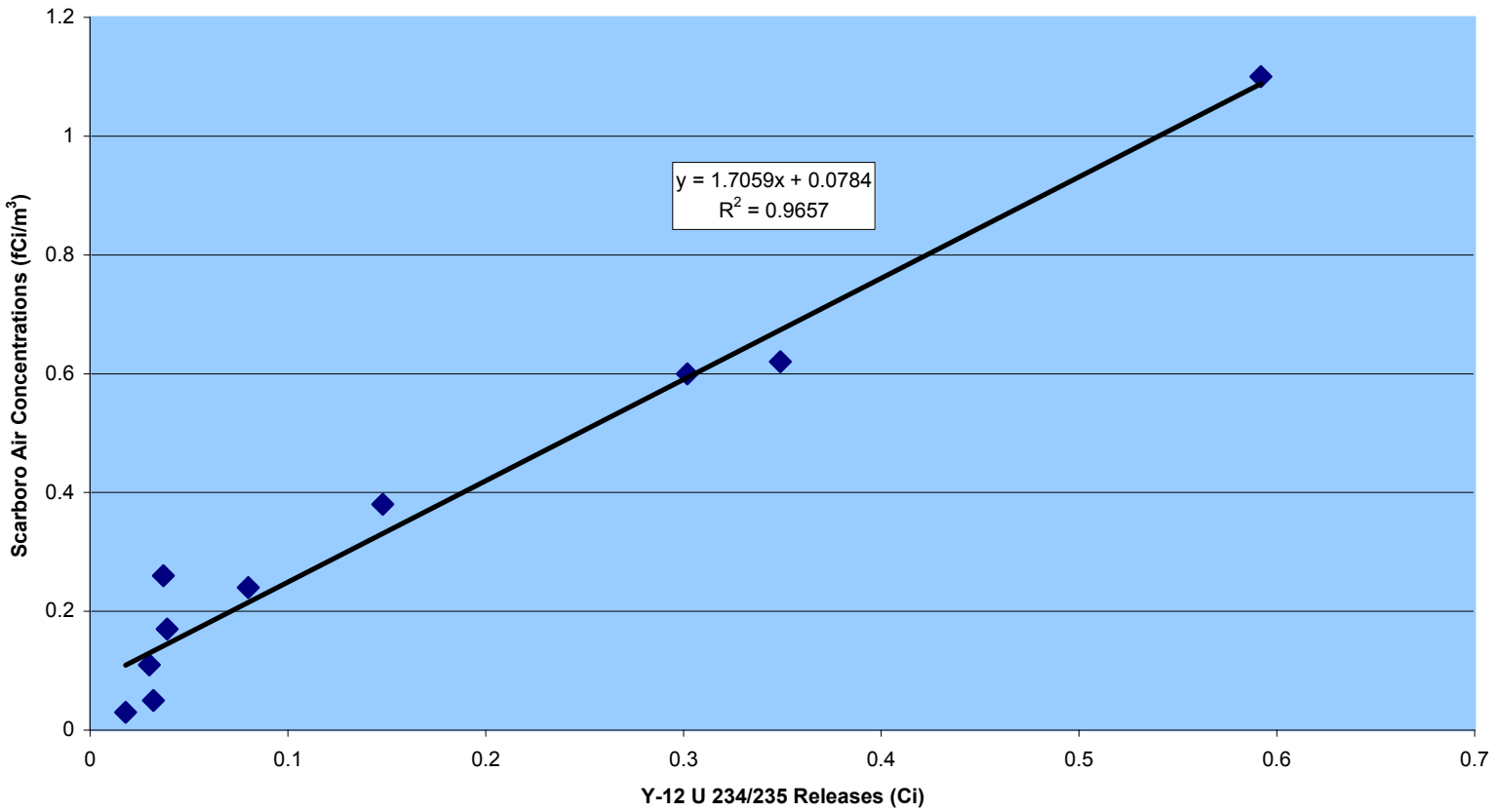
Figure E-4 shows measured and estimated U 238 air concentrations in Scarboro based on the χ/Q and linear regression methods. In this case, the U 238 concentrations are estimated using the U 234/235 regression equation (Figure E-2). The χ/Q estimates show little correspondence with the measured concentrations and either greatly overestimate or underestimate the measured U 238 concentrations. The concentrations estimated using the linear regression method correspond much more closely to the measured U 238 concentrations and never underestimate the measured values. Consequently, airborne U 238 doses to Scarboro residents based on the historic χ/Q concentrations will most likely overestimate, and in some cases underestimate, actual doses.

Figure E-1. Measured vs. Estimated U 234/235 Air Concentrations for Scarboro



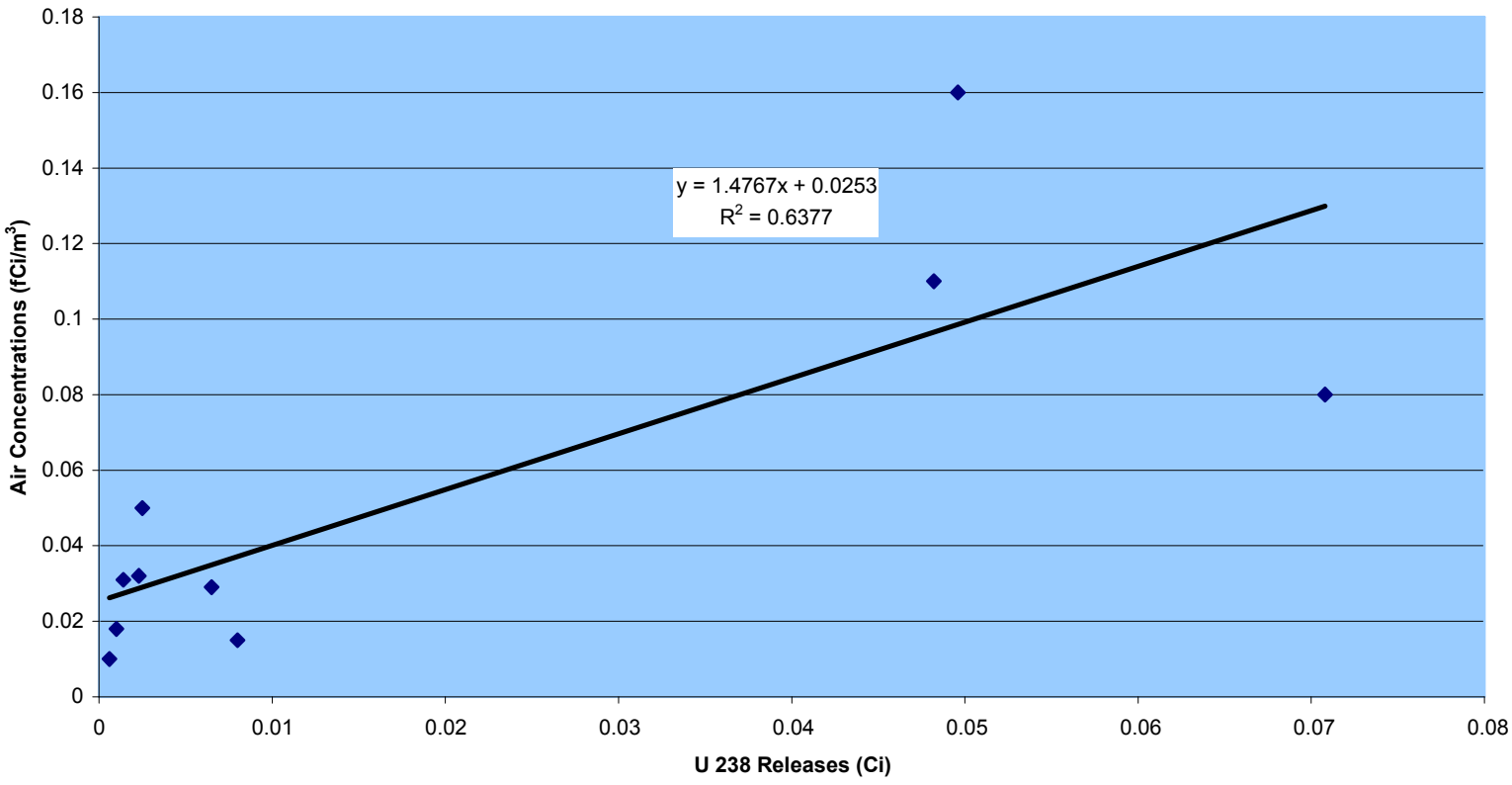
Concentrations estimated using the Task 6 χ/Q method overestimate measured concentrations in Scarboro by a factor of up to 5. Air concentrations estimated using linear regression of measured U 234/235 air concentrations in Scarboro and Y-12 airborne U 234/235 emissions have a much closer agreement with measured air concentrations.

Figure E-2. Airborne U 234/235 Releases Estimates for Y-12 vs. Measured Uranium Air Concentrations in Scarboro



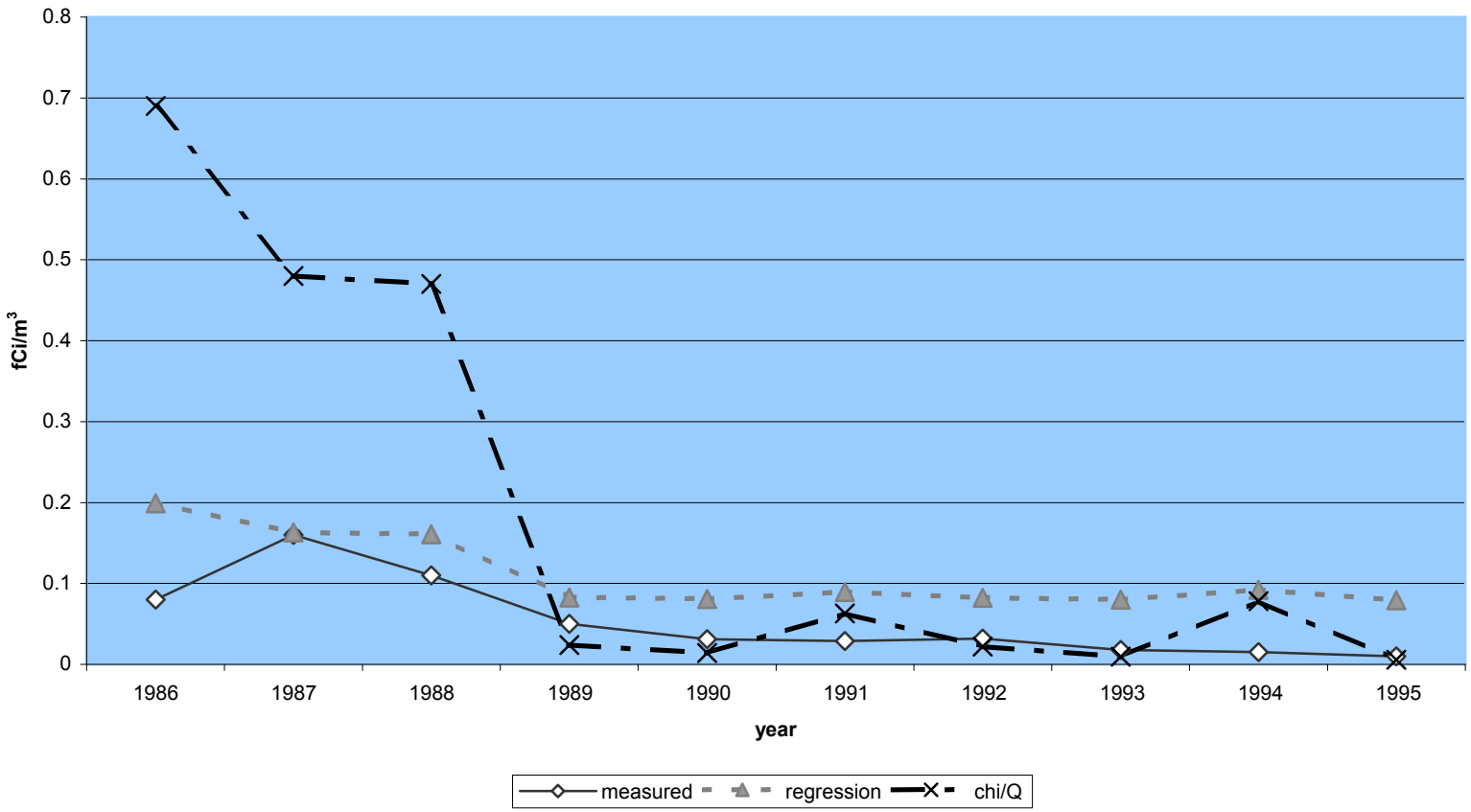
Linear regression between measured Scarboro U 234/235 air concentrations (annual average in fCi/m^3) and Y-12 U 234/235 airborne emissions (in curies) for the years 1986 to 1995. The correlation coefficient (R^2) of 0.9657 indicates a strong positive relationship and the regression equation (y = 1.7059x + 0.0784) is a reliable estimator of historic Scarboro air concentrations.

Figure E-3. Airborne U 238 Releases Estimates for Y-12 vs. Measured Uranium Air Concentrations in Scarboro



Linear regression between measured Scarboro U 238 air concentrations (annual average in fCi/m^3) and Y-12 airborne U 238 releases (in curies) for the years 1986 to 1995. The correlation coefficient (R^2) of 0.6377 indicates a weak positive relationship and that the regression equation (y = 1.4767x + 0.0253) is a poor estimator of historic Scarboro air concentrations.

Figure E-4. Measured vs. Estimated U 238 Air Concentrations for Scarboro



Concentrations estimated using the Task 6 χ/Q method overestimate or underestimate measured concentrations in Scarboro. Air concentrations estimated using linear regression of measured U 234/235 air concentrations in Scarboro and Y-12 airborne emissions of U 234/235 have a much closer agreement with measured air concentrations in Scarboro.

APPENDIX F

A Conservative Approach in Radiation Dose Assessment
Issues Associated with Being Protective or Overestimating Radiation Doses

APPENDIX F

A Conservative Approach in Radiation Dose Assessment
Issues Associated with Being Protective or Overestimating Radiation Doses

Research has shown there is little evidence of harm associated with exposure to ionizing radiation at or below the limits recommended by the International Commission on Radiological Protection (ICRP).

Most of the observed data showing adverse health effects related to radiation exposure come from high-dose, high-dose-rate exposures. Therefore, the ICRP's initial goal in setting dose limits was to prevent the directly observable, nonmalignant, not necessarily cancerous effects of such exposures. As the science of radiation protection advanced, the ICRP modified its dose limits to reduce the incidence of cancer and detrimental heredity effects resulting from exposure to radiation (ICRP 1991).

Estimation of Radiation Dose

Radiation dose is a function of the energy from radiation, the amount of radiation absorbed, and the mass of the material absorbing the radiation. The energy of radiation is well known, being derived from first principles of physics. The amount of radiation absorbed is based either on estimated measurements of energy transfer or, in the case of human exposures, on models called phantoms that are used to estimate the shapes, sizes, and masses of organs. Using mathematical models called transport models, one estimates the amount of radiation absorbed by these phantoms. These data are then applied to realistic human data. The ICRP has reviewed and prepared publications discussing tissue masses, ethnicity issues, composition, age, and sex from medically derived information. The masses of human organs used, therefore, are best estimates. Because of these variabilities, the ICRP established a standardized human, the "reference man."

ICRP Dose Coefficients

In its earlier publications, the ICRP only concerned itself with radiation exposure to workers. Following the events associated with the nuclear reactor accident at Chernobyl, the ICRP expanded its role to include members of the public. To characterize exposure to members of the public, ICRP Publication 56 (ICRP 1990) stated, one must have a good understanding of age dependency, biokinetics, anatomical, and physiological data.

The ICRP has developed factors called dose coefficients, dose conversion factors (DCF), which can be used for the purposes of dose assessment. These DCF values are a combination of factors containing much uncertainty. To compensate for this uncertainty, the ICRP added conservative assumptions to the DCF values; accordingly, they may overestimate radiation doses. As radioactive materials decay and emit particles and/or waves, the energy emitted can interact with matter. This interaction has been assigned a weighting factor (called the radiation weighting factor, W_R). The ICRP selected the W_R to be representative of values that are broadly compatible with the dosimetric quantity of Linear Energy Transfer, or LET. The LET estimates the number of ionizations produced by radioactive emissions along their paths as they traverse matter. Although based on the energy of the particular particle, the ICRP selected one specific value (1) for beta particles and gamma radiation and another value (20) for alpha particles based on the energy distribution curves.

For radiation effects on tissues, the ICRP also established a tissue weighting factor (W_T), which is based on the organ and tissue contribution to overall health and incidence of cancers, also based on the "reference man" concept and rates of disease in the population. The weighting factors range from 1% for bone surfaces and skin to 20% for the gonads. Except in the case of radiation effects to the breast, the sexes differ little in response to ionizing radiation. The factors are also used to establish probabilities, based on latency periods, of fatal cancers and non-fatal or hereditary effects in the whole population and in workers. This is a concept of detriment that the ICRP defines as a "measure of the total harm that would eventually be experienced by an exposed group and its descendants as a result of the group's exposure to a radiation source."

Accordingly, the ICRP established coefficients for detriment following exposure to ionizing radiation as shown in Table F-1.

Table F-1. ICRP Detriment Coefficients

	Fatal Cancers	Non-Fatal	Hereditary Effects	Total
Adult Workers	0.0004 per rem	0.00008 per rem	0.00008 per rem	0.00056 per rem
Population	0.0005 per rem	0.0001 per rem	0.00013 per rem	0.00073 per rem

Biokinetic Models

After radioactive materials are ingested or inhaled, they are absorbed and distributed throughout the body. The degree of absorption depends on the chemical form of the material; the ICRP has grouped the compounds into general categories based on solubilities in water or body fluids. Furthermore, the ICRP divided the human body into compartments into or out of which the materials are transported, or where they are stored for extended time periods. The models explaining radioactive materials' movement relative to compartments are based on autopsy studies, human volunteers, and animal studies, with adjustments for the "reference man" incorporated. After reviewing these studies, the ICRP selected coefficients for rates of absorption, transit times, and storage times in the organs of interest. In many cases, the variables selected are an overestimation of the true but uncertain biological function.

Summary

The establishment of a series of dose coefficients or dose conversion factors involves much uncertainty in the parameters leading to the calculation of the coefficient. Because of human variability, a standardized human commonly called a "reference man" is used to estimate the radiation dose.

Typical dose assessments use dose coefficients to estimate the radiation dose to a given population. Many of these assessments do not use site-specific information such as demographics or inhalation and ingestion rates. ATSDR, in its evaluation of the radiation doses associated with the Oak Ridge Reservation, has used site-specific parameters and variables more related to the Southern life style than to the human population.

APPENDIX G

Summary of Technical Review Comments

on the

Oak Ridge Health Studies
Oak Ridge Dose Reconstruction—Task 6 Report

Volume 5: Uranium Releases from the Oak Ridge Reservation—a Review of the Quality of Historical Effluent Monitoring Data and a Screening Evaluation of Potential Off-Site Exposures

FOREWORD

As provided for by the 1991 Tennessee Oversight Agreement between the state of Tennessee and the U.S. Department of Energy (DOE), the Tennessee Department of Health conducted the Oak Ridge Health Studies. The Oak Ridge Health Studies are independent state evaluations of hazardous substances released from the DOE Oak Ridge Reservation (ORR) since its creation. The purpose of the studies is to evaluate whether off-site populations were exposed to chemical and radiological releases from ORR and to assess the risk posed by off-site exposures. The Oak Ridge Health Studies include six dose reconstruction reports: one each on iodine, mercury, polychlorinated biphenyls (PCBs), uranium, and radiological releases into the White Oak Creek, and a screening-level evaluation of additional potential materials of concern. The Oak Ridge Health Agreement Steering Panel provided technical oversight of work performed by contractors (i.e., ChemRisk Division, McLaren/Hart Environmental Services, Inc.; SENES Oak Ridge, Inc.; and Shonka Research Associates) to conduct the Oak Ridge Health Studies.

The Agency for Toxic Substances and Disease Registry (ATSDR) is having each of the Phase II Oak Ridge Health Studies documents reviewed by a group of technical experts to evaluate the quality and completeness of the studies and to determine if the studies provide a foundation for follow-up public health actions or studies. ATSDR will use the information from the Oak Ridge Health Studies, as well as data from the technical reviews and other studies, to develop public health assessments for the ORR. The public health assessments will assess the overall public health impact on off-site populations and determine which follow-up public health actions or studies are indicated.

PURPOSE OF TECHNICAL REVIEW

Introduction

Using the findings of the September 1993 Oak Ridge Health Studies Phase I Report—Dose Reconstruction Feasibility Study, the Tennessee Department of Health developed six dose reconstruction reports in July 1999. The subject of this technical review is the report entitled *Uranium Releases from the Oak Ridge Reservation—a Review of the Quality of Historical Effluent Monitoring Data and a Screening Evaluation of Potential Off-Site Exposures*; hereafter referred to as "the report" or "the uranium report." Some reviewers also refer to the report as the "Task 6 document." The report focuses entirely on uranium dose reconstruction and risk assessment. The main text of the report contains the overall approach, an extensive source term analysis, and an estimation of uranium concentrations in the environment. It concludes by considering the health implications (expressed as screening indices) of these concentrations. The appendices to the report contain supporting data and documents, including detailed discussions, calculations, and analyses concerning uranium present in the areas surrounding Oak Ridge Reservation (ORR).

The December 1999 report of the Oak Ridge Health Agreement Steering Panel (ORHASP), entitled *Releases of Contaminants from Oak Ridge Facilities and Risks to Public Health,* hereafter referred to as the "steering panel document," was also reviewed. ORHASP prepared the steering panel document to compile, in a condensed format accessible to the general public, the results of the uranium report with those of a series of analogous reports that reconstruct the release of other contaminants from the ORR: iodine 131, mercury, PCBs, and other radionuclides.

Finally, reviewers considered two recently released documents dealing with uranium contamination near ORR. The conclusions of these documents were not available until after the uranium document was finalized. The first document, *Scarboro Community Environmental Study,* is a collection of sampling data obtained by scientists from the Florida Agricultural and Mechanical University (FAMU) during a site visit to the town of Scarboro (a small community

neighboring on ORR). It will be referred to hereafter as the "FAMU study." The second document, *Scarboro Community Sampling Results: Implications for Task 6 Environmental Projections and Assumptions,* is a report developed by Auxier & Associates that analyzes the results of FAMU's study. It will be referred to hereafter as the "Auxier report." Reviewers were asked to comment on what effect the FAMU study and the Auxier report may have on the conclusions of the uranium document.

Review Process

The purpose of this technical review was to determine if the uranium report provides a foundation on which the Agency for Toxic Substances and Disease Registry (ATSDR) can base follow-up public health actions or studies. ATSDR contracted with Eastern Research Group, Inc., (ERG) to select four expert reviewers to technically review the uranium report: Melvin Carter, Nolan Hertel, Ronald Kathren, and Fritz Seiler. The four reviewers read the entire dose reconstruction document on uranium releases, including appendices and the appropriate sections of the steering panel document ("Summary," "Screening Analysis for Uranium and Other Contaminants" [pp. 51–55], "Technical Issues," "Procedural Issues," and "Recommendations and Discussions"). The reviewers also read and considered both the FAMU study and the Auxier report in preparation for commenting on the uranium report.

Appendices A through D of the full report contain reviewer comments in their entirety, listed alphabetically by author. The appendices are not included in this public health assessment, however, copies of the full report can be obtained by calling ATSDR at 1-888-42-ATSDR or writing to:

ATSDR
Division of Health Assessment and Consultation
Attn: Chief, Program Evaluation, Records, and Information Services Branch, E-60
1600 Clifton Road, N.E., Atlanta, Georgia 30333

Charge to Reviewers

ATSDR charged the technical reviewers to comment on whether the study results were scientifically valid and applicable to public health decision-making and to provide recommendations necessary to strengthen the report's study analyses. Reviewers considered and commented on the report's study design and scientific approaches; its methods of data acquisition, analyses, and statistical reliability; and the scientific interpretations made by the study authors. Reviewers evaluated whether the conclusions and recommendations of the uranium report were substantiated and developed on the sole basis of the information in the documents. ATSDR specifically asked reviewers to critique:

- Study design and scientific approaches
- Methods of data acquisition, analyses, and statistical reliability
- Completeness of data and analyses
- Model validation
- Conformance with current scientific consensuses; internal consistency of methodologies
- Dose validation
- Data gaps
- Bias
- Clarity and thoroughness (e.g., is there enough information to draw conclusions and make public health decisions?)

ATSDR asked reviewers to comment on any and all technical aspects of the dose reconstruction study and how the report might be improved. Each reviewer assessed the dose reconstruction by responding to the study outline below.

1. Source Term and Environmental Concentration Estimates

a. Comment on the quality, completeness, and reasonableness of the estimates of the source terms (releases to air and water) and environmental concentrations (air, water, and soil).

b. In the absence of soil data from the Y-12 reference location (Scarboro community), the authors used uranium concentrations in sediments from the East Fork Poplar Creek floodplain to evaluate the soil exposure pathways. However, in 1998, the Environmental Sciences Institute at FAMU and its contractual partners conducted the Scarboro Community Environmental Study, in which soil, sediment, and surface water samples from the Scarboro community were analyzed for uranium.

Please review the radiological analyses in the *Scarboro Community Environmental Study* by FAMU and the *Scarboro Community Sampling Results: Implications for Task 6 Environmental Projections and Assumptions* by Auxier & Associates, Inc. Comment on whether the 1998 uranium concentrations from Scarboro soil could be used to estimate committed effective dose equivalents, annual average intake, and kidney burdens for the period 1944–1990 in Scarboro. Reviewers may benefit from an on-line bibliography on Cs 137 soil studies available at http://hydrolab.arsusda.gov/cesium137bib.htm.

2. Uncertainty and Sensitivity Analysis

a. Comment on the quality and completeness of the statistical approaches, uncertainty analysis, and sensitivity analysis.

b. Comment on the appropriateness and reasonableness of parameters, assumptions, distribution functions, and qualifiers used to estimate the Level II screening indices, committed effective dose equivalents, annual average intakes, uranium kidney burdens, and hazard index. Do the authors provide sufficient details and justification for independent evaluation and verification?

c. Do the distribution functions appropriately describe the variability of the parameters?

d. Comment on the quality of available data and identify where important data are unreliable, incomplete, or absent.

e. Comment on the degree of reliability and statistical uncertainty in the estimates of committed effective dose equivalents, annual average intakes, uranium kidney burdens, and hazard index.

f. Comment on the limitations of interpreting these estimates.

3. Health Effects/Public Health

a. Comment on quality and completeness of the screening indices, committed effective dose equivalents, annual average intakes, uranium kidney burdens, and the hazard index.

b. Are the screening indices, committed effective dose equivalents, annual average intakes, uranium kidney burdens, and the hazard index appropriately determined?

c. Are the appropriate decision guide (1×10^{-4} cancer risk), the oral reference dose (RfD), and toxicity threshold criteria for uranium kidney burdens used to estimate the potential health impact from uranium exposures?

d. Given the uncertainties, are the committed effective dose equivalents, annual average intakes, and uranium kidney burdens at sufficient levels to be a significant human health problem? If so, explain. Which reference populations might be at significant risk? What are the potential or likely health consequences?

e. Are adverse health effects likely to be statistically detectable?

f. Is the hazard index an appropriate indicator of possible health effects?

g. Are the screening decision tree and criterion appropriate to determine the need for further study?

h. Given the uncertainties, is there a need for a more detailed study with full uncertainty analysis to estimate the potential health impact from uranium exposures? Explain.

i. Is there sufficient information to identify and carefully define by one or more distinguished characteristics a population at significant increased risk? Such distinguishing characteristics might be for example age, sex, ethnicity, geographic area, time period, dietary habits, or lifestyle characteristics.

j. Is the dosimetric and exposed population information appropriate for epidemiologic planning and decisions?

SUMMARY OF REVIEWER COMMENTS

I. Executive Summary

Three of the four reviewers commented on the overall quality of the uranium report. These three reviewers agreed that the report met basic methodological standards and that, while it was not a complete analysis of possible uranium exposure near ORR, it was "a good first pass." Reviewers praised the report in terms such as these: "technically sound and applicable to decision-making," "supported by and developed on the basis of information in the reports," and "no major or significant problems with respect to the study design or the scientific approaches used." One reviewer affirmed that most of the work described in the study conformed with "established and generally accepted techniques." One reviewer applauded the efforts of the Oak Ridge Health Assessment Steering Panel (ORHASP) in developing the report, calling it logically constructed and "state-of-the-art." Overall, the reviewers agreed that the screening assessment is adequate for public health decision-making. However, they felt that additional modifications are required for an adequate past dose reconstruction to be completed.

Two of the four reviewers commented that the report is somewhat lacking in uncertainty or sensitivity analysis. One reviewer indicated that the study did conduct some uncertainty analyses, but they were limited in scope and non-quantitative. The consequence of this lack is that the report does not characterize the error ranges of its quantitative estimates as fully as reviewers would have liked. Two reviewers pointed out that the estimates made in the report tend to be on the conservative side—one expects, therefore, that (when in error) the report would tend to *overestimate* the extent to which exposure to uranium is a problem in the Oak Ridge area. Further refinements to the study are likely to reveal that uranium exposures are actually *lower* than those currently estimated.

Two reviewers noted that the large difference between the new source term estimates and the earlier estimates provided by DOE raise concerns about the underlying reliability of either estimate. One reviewer was surprised that the study authors, after having determined that actual release levels for 1987 and 1988 were 30% greater than those DOE had reported, were willing to

accept DOE's release estimates for the years between 1989 and 1995 at face value. The reviewers indicated that their concerns about the source terms estimates would probably be resolved if a full uncertainty analysis were performed for the relevant calculations.

One reviewer was somewhat skeptical of the reported mass distribution for emitted airborne uranium particles. The reviewer suspected that the actual mass distribution of emissions contained a higher percentage of higher-mass particles than that which was recorded by the monitoring equipment. This issue is important to evaluating the public health consequences of the uranium release because higher-mass particles are less likely to be absorbed in the lung than lower-mass particles are.

One of the reviewers noted that the study makes no effort to differentiate between anthropogenic and background concentrations of airborne uranium, while conceding that background levels would probably prove to be insignificant. Another reviewer, however, encouraged further work to quantify the contribution of radioisotopes originating from coal-burning power plants in the area.

Two reviewers considered the basic appropriateness of the report's use of χ/Q calculations to correlate historical uranium releases from the Y-12 facility and historical air concentrations in the Scarboro area. Both reviewers agreed that, at a basic level, this kind of calculation was appropriate for estimating past airborne uranium concentrations in Scarboro. One of these reviewers cautioned, however, that the usefulness of the χ/Q calculations depends on the assumption that there has been no significant change in the sizes of emitted uranium particles between the times when χ/Q data were collected and the times when the χ/Q ratio is being used to estimate airborne uranium concentrations.

Two reviewers disagreed about whether or not the tracer dispersion study suggested in Recommendation #4 of the Steering Panel Report was warranted. One reviewer suggested that this experiment *was* warranted, citing the sparse distribution of air monitoring stations in the Oak Ridge area (which leave many gaps in coverage) and the continuing uncertainty about how effectively Pine Ridge acts as a barrier between the air around ORR and the air around Scarboro.

The other reviewer thought that tracer release studies seemed somewhat excessive and suggested that, as an alternative, the existing χ/Q calculations be re-worked, making use of additional historical weather data, where available.

The reviewers, as a whole, found the treatment of waterborne uranium transport somewhat cursory, and had a range of unanswered questions and concerns in regard to it.

Two reviewers felt that the uranium report's use of sediment samples as a surrogate for uranium soil sampling data was unacceptable. A third reviewer stated that the analogy between soil and sediment data *might* be acceptable but nevertheless praised the actual soil data collected by FAMU as clearly preferable to this analogy. Other reviewers called for further soil sampling in the Oak Ridge area, particularly subsurface soil core sampling.

All four reviewers expressed confidence in the soil sampling data collected by researchers from FAMU. One reviewer considered them clearly superior to the uranium report's sediment data for use in public health decision-making. Three reviewers called for additional uranium monitoring in strategic locations where one might expect past releases of uranium to have accumulated: in sediments behind dams, on flood plains, and around lakes and swamps. Two reviewers also called for soil core samples at depths of up to 1 meter, noting that one would not expect to find significant uranium accumulation near the soil surface (where FAMU collected its samples).

One reviewer concluded that the reference locations selected seemed appropriate but another questioned the report's degree of emphasis on the town of Scarboro as an area of primary public health concern. The reviewer indicated that Scarboro seems to have been chosen as a primary public health concern for the Y-12 uranium releases simply because it is the closest community to the facility. This conclusion, the reviewer stated, is premature and might be modified by further analysis of population distribution, wind patterns, and surface water features in the Oak Ridge area. The reviewer noted that, even if it were determined that uranium exposure was higher in Scarboro than in any other community, overall risk to the public health might still be greater in another town with lower exposure levels but a larger population.

Three reviewers agreed that epidemiological investigation of the Scarboro community was unlikely to produce a statistically significant finding, given the limited screening results of the "likely magnitude of the risk." One reviewer cautioned, however, that the uranium report did not contain enough information about Scarboro to answer questions about the value of further epidemiological study or the possible existence of vulnerable subpopulations.

One reviewer noted that the report, despite its lack of uncertainty analysis, does support the conclusion that ORR uranium exposure has had no *detectable* health effect on persons living in Scarboro. This is not the same as saying that there has been no health effect—the same reviewer said there was a reasonable likelihood that a few cases of cancer in Scarboro were caused by uranium exposure. Even if this were the case, however, there would probably be no statistically valid way to distinguish those cases caused by ORR emissions from those which were not.

II. Review of Documents' Overall Quality

Uranium Report

Three of the four reviewers commented on the overall quality of the uranium report. These three reviewers agreed that the report met basic methodological standards and that, while it was not a complete analysis of possible uranium exposure near ORR, it was "a good first pass." Reviewers praised the report in terms such as these: "technically sound and applicable to decision-making," "supported by and developed on the basis of information in the reports," "no major or significant problems with respect to the study design or the scientific approaches used." One reviewer affirmed that most of the work described in the study conformed with "established and generally accepted techniques." One reviewer applauded the efforts of the Oak Ridge Health Assessment Steering Panel (ORHASP) in developing the report, calling it logically constructed and "state-of-the-art."

Two of the four reviewers commented that the report is somewhat lacking in uncertainty or sensitivity analysis. One reviewer indicated that the study did conduct some uncertainty analyses, but they were limited in scope and non-quantitative. The consequence of this lack is that the

report does not characterize the error ranges of its quantitative estimates as fully as reviewers would have liked. Two reviewers pointed out that the estimates made in the report tend to be on the conservative side—one expects, therefore, that, (when in error) the report would tend to *overestimate* the extent to which exposure to uranium is a problem in the Oak Ridge area. Further refinements to the study are likely to reveal that uranium exposures are actually *lower* than those currently estimated.

Other general limitations of the report, as asserted by the reviewers, are that:

- The evaluation of uranium concentrations in soil was not covered in depth; one reviewer noted that it almost seemed incidental to the rest of the report.

- The report lacked background information on how operations data from ORR were obtained, evaluated, and interpreted.

- The report's data were limited to effluent monitoring and included no environmental monitoring data.

- The report fails to adequately differentiate natural and anthropogenic uranium levels in the Oak Ridge area. One reviewer emphasized the importance of this distinction, stating that natural background concentrations must not be mixed in with anthropogenic concentrations for the purposes of risk assessment.

- The report is overly weighted toward gauging the radiological effects of uranium exposure. It should have placed more focus on the chemical toxicity of uranium.

FAMU Study

All four reviewers expressed confidence in the soil sampling data collected by researchers from Florida Agricultural and Mechanical University. One reviewer considered them clearly superior to the uranium report's sediment data for use in public health decision-making. Another stated

that the new measurements have "changed the picture completely." Although they applauded FAMU's research efforts, the reviewers were cautious about using the FAMU data to estimate past exposure without additional research into the environmental distribution of uranium in the Oak Ridge area. Three reviewers called for additional uranium monitoring in strategic locations where one might expect past releases of uranium to have accumulated: in sediments behind dams, on flood plains, and around lakes and swamps. Two reviewers also called for soil core samples at depths of up to 1 meter, noting that one would not expect to find significant uranium accumulation near the soil surface (where FAMU collected its samples).

Auxier Report

Three reviewers commented on the Auxier report, describing its analysis and overall conclusions as compelling. Two reviewers stated that it presented convincing evidence that the FAMU soil sampling data are superior to the sediment samples used as surrogates for soil data in the uranium report. One reviewer indicated that the Auxier report convinced him that uranium soil concentrations are 10 to 100 times lower than the values listed in the ORHASP uranium report. Another reviewer praised the Auxier report's study of U 235/U 238 activity ratios in soil samples, which indicated to him that at least *some* anthropogenic uranium is present in Scarboro's soil (probably originating from the Y-12 facility). The reviewer described the Auxier report as "valuable work" that will "add the kind of information which will be needed for a risk assessment."

Steering Panel Report

Two reviewers commented briefly on the overall quality of the steering panel report. One reviewer praised its clarity and thoroughness and stated that it "reached reasonable conclusions and made sound and useful recommendations." The other reviewer noted that, in general, it seemed overly pessimistic in its summary of the uranium report's results.

III. Review of Source Term Estimates

Two reviewers approved of the basic methods used to estimate uranium releases from ORR, calling them reasonable. A broad concern surrounding the estimates, however, was a lack of statistical information about the uncertainties associated with the monitoring data (or lack of such data). One reviewer emphasized that he did not fault the research team for not finding more data, as he recognized that they were constrained by the limits of their archival records. His concern was rather that the team had not adequately expressed the limits of their knowledge in statistical terms.

In particular, reviewers sought more information about the assumptions and justifications used in the source term estimates than was available to them in the text of the uranium report. One reviewer stated that he was unable to evaluate the appropriateness and reasonableness of the source term estimates (and hence of derivative dose estimates) because of this lack of information.

Two reviewers expressed disappointment that no quantitative information is available on over a third of the reported releases of uranium from the K-25 facility. One of these reviewers was puzzled that the study authors chose to treat these data gaps as periods of zero release rather than develop a probability distribution function (PDF) to address their uncertainty. The second reviewer was troubled by this understatement of K-25 releases, given that the report did not attempt to estimate the extent of that understatement. A third reviewer cautioned, however, that it is in fact proper to assign zero values to periods with data gaps if there is truly no information upon which a PDF could be developed.

Two reviewers noted that the large difference between the new source term estimates and the earlier estimates provided by DOE raises concerns about the underlying reliability of interpreting ORR operations and monitoring data. For example, one reviewer wanted additional assurance that uranium releases have not been "double counted" (i.e., counted once in the release reports and again in the monitoring data).

One reviewer was surprised that the study authors, after having determined that actual release levels for 1987 and 1988 were 30% greater than those DOE had reported, were willing to accept DOE's release estimates for the years between 1989 and 1995 at face value.

One reviewer was somewhat skeptical of the reported mass distribution for emitted airborne uranium particles. After considering the configuration of the monitoring equipment used in ORR's stacks, the reviewer suspected that monitoring results may have been erroneously skewed in favor of recording smaller particles. The reviewer suspected that the actual mass distribution of emissions contained a higher percentage of higher-mass particles than that which was recorded by the monitoring equipment. This issue is important to evaluating the public health consequences of the uranium release because higher-mass particles are less likely to be absorbed in the lung than lower-mass particles are.

One reviewer was of the opinion that release estimates of depleted and natural uranium (as opposed to enriched uranium) were particularly uncertain. This uncertainty, the reviewer believed, could affect the *chemical* (as opposed to radiological) health consequences of Oak Ridge residents' uranium exposure.

One reviewer noted that there was very little data available about the release of uranium to surface water from the S-50 facility (in comparison to amount of information available on the Y-12 and K-25 releases). The reviewer qualified the significance of this lack of data, also noting that the overall magnitude of the S-50 release was low, so it would not have much effect on the overall uranium source term.

IV. Review of the Estimation and Measurement of Environmental Uranium Concentrations

Airborne Transport of Uranium

Two reviewers considered the basic appropriateness of the report's use of χ/Q calculations to correlate historical uranium releases from the Y-12 facility and historical air concentrations in

the Scarboro area. Both reviewers agreed that, at a basic level, this kind of calculation was appropriate for estimating past airborne uranium concentrations in Scarboro. One of these reviewers cautioned, however, that the usefulness of the χ/Q calculations depends on the assumption that there has been no significant change in the sizes of emitted uranium particles between the times when χ/Q data were collected and the times when the χ/Q ratio is being used to estimate airborne uranium concentrations. The reviewer suggested that further studies ascertain the validity of this assumption.

Two reviewers disagreed about whether or not the tracer dispersion study suggested in Recommendation #4 of the Steering Panel Report was warranted. One reviewer suggested that this experiment *was* warranted, citing the sparse distribution of air monitoring stations in the Oak Ridge area (which leave many gaps of coverage) and the continuing uncertainty about how effectively Pine Ridge acts as a barrier between the air around ORR and the air around Scarboro. The other reviewer thought that tracer release studies seemed somewhat excessive and suggested that, as an alternative, the existing χ/Q calculations be re-worked along the following lines:

- *Use historical wind rose information, when available.* This reviewer noted that days of peak release from Y-12 do not always match days of peak uranium concentrations around Scarboro. The reviewers attributed this occasional lack of correlation to wind conditions that did not favor transport of particulate uranium from ORR to Scarboro. With this in mind, the reviewer suggested that future research efforts might attempt to evaluate Oak Ridge–area uranium concentrations as a function of both ORR release levels *and* specific wind conditions. The reviewer suggested that this might be a particularly worthwhile exercise for periods of known high releases, such as the five days in 1965 when uranium hexafluoride was released from K-25 as part of a fire test.

- *When historical wind rose information is not available, use 5-year average data.* The reviewer was somewhat puzzled by the report's use of meteorological conditions from 1987 to represent "average" weather. The reviewer suggested the report could be improved if 5-year meteorological averages were used instead.

- *Characterize uncertainty of uranium releases for years upon which χ/Q is based.* The reviewer pointed out that if ORR's uranium releases were underestimated in the years upon which χ/Q was based, the χ/Q value would itself be overestimated. Therefore, further information about the reliability of release estimates during those years will shed light on the reliability of χ/Q.

One of the reviewers noted that the study makes no effort to differentiate between anthropogenic and background concentrations of airborne uranium. That reviewer conceded that background levels would probably prove to be insignificant, but another reviewer encouraged further work to quantify the contribution of radioisotopes originating from coal-burning power plants in the area.

The one reviewer who considered the study's use of an ISCST3 dispersion model to estimate the transport of uranium from the K-25/S-50 and X-10 facilities confirmed that the study's methods were appropriate.

Waterborne Transport of Uranium

Three reviewers provided comments pertaining to the concentration of uranium in the East Fork Poplar Creek and Clinch River. Two of these reviewers noted that the results presented are derived from flow rates and concentrations at discharge points. One reviewer wondered if the report's analysis took into account the partitioning of uranium from water into sediment. Another reviewer noted that the absence of the raw data (i.e., the actual flow and concentration data at discharge points) upon which the results were based hampered his evaluation of those results. In particular, the reviewer noted that the reported uranium discharges to the East Fork Poplar Creek seemed "unreasonably high"; he required additional data and analysis before he would vouch for their accuracy.

The reviewers, as a group, found the treatment of waterborne uranium transport somewhat cursory. They had a range of unanswered questions and concerns in regard to it:

- Why did the report use a single annual volume for East Fork Poplar Creek instead of taking seasonable variation into account?

- Why was it assumed that waterborne uranium is at a natural level of enrichment?

- How likely is it that significant quantities of enriched uranium entered local water bodies via soil runoff?

- What is the background level of uranium in the Clinch River and East Fork Poplar Creek?

Concentration of Uranium in Soil and Sediment

Two reviewers agreed that the uranium report's use of sediment samples as a surrogate for uranium soil sampling data was unacceptable. A third reviewer stated that the analogy between soil and sediment data *might* be acceptable, but nevertheless praised the actual soil data collected by FAMU as clearly preferable to this analogy. Other reviewers called for further soil sampling in the Oak Ridge area, particularly subsurface soil core sampling. One reviewer argued that uranium levels in sediment should not be used as an indication of uranium levels in soil because uranium's provenance differs depending on its location:

- The level of uranium present in soil is a function of:

    — The natural prevalence of uranium ore (background uranium) in the region.
    — The deposition of airborne uranium particles onto the soil surface.

- The level of uranium present in sediment is a function of:

    — Groundwater leaching uranium out of soil and into rivers and lakes.

- The deposition of airborne uranium particles onto the surface of the covering water body.
- The partitioning of dissolved uranium from water to sediment.

Two reviewers found the FAMU data suggested that contamination of surface soil with uranium in the Oak Ridge area is less serious than previously thought. One reviewer said that the data show that uranium in the soil is close to natural levels of enrichment and concentration. Another said that the data show that the soil exposure pathway for uranium is less significant than previously thought. A third reviewer pointed out that he was not surprised that surface soil concentrations of uranium are near background levels—he expects that if elevated soil concentrations of uranium exist, they would exist further *below* the soil surface.

V. Reviewers' Conclusions and Recommendations for the Use of the Report in Public Health Decision-Making

Exposure and Dose Estimates

Two reviewers considered the methodology used in the uranium study to establish screening indices and compute effective doses. Both reviewers agreed the methodology used was appropriate and consistent with standard practice. Two other reviewers noted that the report was quite conservative in its use of correction factors.

One reviewer noted that although the lack of uncertainty analysis in the uranium report made it difficult to evaluate the reliability of the report's conclusions, he would guess that the report's exposure and dose estimates are accurate to within an order of magnitude. This reviewer also flagged a possible exposure pathway (the transfer of uranium from contaminated water to produce to human consumption) that was excluded from consideration in the report without explanation. Another reviewer held the opinion that the uranium dose estimates were accurate to a factor of 2 and were probably overestimates.

Two reviewers considered the appropriateness of the reference locations chosen to gauge the potential public health consequences of uranium releases from ORR. One reviewer concluded that the reference locations selected seemed appropriate, but the other questioned the report's degree of emphasis on the town of Scarboro as an area of primary public health concern. The reviewer indicated that Scarboro seems to have been chosen as a primary public health concern for the Y-12 uranium releases simply because it is the closest community to the facility. This conclusion, the reviewer stated, is premature and might be modified by further analysis of population distribution, wind patterns, and surface water features in the Oak Ridge area. The reviewer noted that, even if it were determined that uranium exposure was higher in Scarboro than in any other community, overall risk to the public health might still be greater in another town with lower exposure levels but a larger population.

One reviewer referred to the FAMU study's use of the RESRAD model. The reviewer noted that this model is appropriate only if residual soil contamination is the only source of uranium exposure, a situation that may be true at current emissions levels but was not necessarily the case in the past. The reviewer also sought more information about: (1) why the RESRAD model used default parameters instead of site-specific parameters and (2) why certain RESRAD exposure pathways, such as well water and livestock uptake, were eliminated from consideration.

Use of the Report by ATSDR for Public Health Purposes

The three reviewers who spoke to the issue of the uranium report's public health application agreed that the report is adequate for public health decision-making; however, it does not, at present, provide a reliable reconstruction of past uranium doses in the Oak Ridge area. The reviewers, however, affirmed the study's value as a suitable foundation for follow-up studies. One reviewer considered the report useful only as a first-order approximation of actual doses, but suggested that it could be used in cautious preliminary public health work—along with the caveat that it may have underestimated the degree of uncertainty inherent in its estimates.

Three reviewers agreed that epidemiological investigation of the Scarboro community was unlikely to produce a statistically significant finding, given the limited screening results of the

"likely magnitude of the risk." One reviewer cautioned, however, that the uranium report did not contain enough information about Scarboro to answer questions about the value of further epidemiological study or the possible existence of vulnerable subpopulations.

One reviewer noted that the report, despite its lack of uncertainty analysis, does support the conclusion that ORR uranium exposure has had no *detectable* health effect on persons living in Scarboro. This is not the same as saying that there has been no health effect: the same reviewer said there was a reasonable likelihood that a few cases of cancer in Scarboro were caused by uranium exposure. Even if this were the case, however, there would probably be no statistically valid way to distinguish those cases caused by ORR emissions from those which were not.

Directions for Further Work

The reviewers had three principal recommendations for improving the quality of the uranium report in preparation for using it in public health decision-making:

- *Add/improve uncertainty and sensitivity analyses.* Three reviewers indicated that more work needs to be done to characterize the extent and significance of the lack of knowledge pertaining to past uranium exposures in the Oak Ridge area. As a guide, one reviewer suggested that future investigators develop probability distribution functions, develop reasonable estimates to fill in gaps in release data, and perform a sensitivity analysis to evaluate how uncertainty in the study's input data creates uncertainty in the study's output. One reviewer also recommended that uncertainty calculations be done separately for systematic and random errors.

- *Develop dynamic models to further characterize the fate of past uranium releases.* Two reviewers emphasized the need to measure uranium concentrations in *core* samples of soil from the Oak Ridge area. These measurements should be part of a broader research effort aimed at identifying how uranium has moved through the Oak Ridge environment after its release. For example, one reviewer asked future investigators to determine where and by what means past releases of uranium have accumulated. Another reviewer

emphasized that most such analyses would have to make use of *dynamic* (as opposed to equilibrium) models. This is because ORR uranium releases prior to 1974 varied significantly from year to year and cannot be properly modeled with equilibrium models.

- *Continue searching for site-specific historical information.* One reviewer suggested that investigators collect additional site-specific information about the Oak Ridge area, such as information about the agricultural practices common there during the period in question. The reviewer also suggested that investigators continue to attempt to uncover additional archival information relating to uranium releases from ORR.