PUBLIC HEALTH ASSESSMENT

Y-12 Uranium Releases

OAK RIDGE RESERVATION (USDOE)

OAK RIDGE, ANDERSON COUNTY, TENNESSEE

EPA FACILITY ID: TN1890090003

Prepared by:

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

FOREWORD

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

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

Exposure

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

Health Effects

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

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

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

Conclusions

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

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

Community

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

Comments

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

Attention: Chief, Program Evaluation, Records, and Information Services Branch
Agency for Toxic Substances and Disease Registry
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Atlanta, GA 30333

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ACRONYMS

ACAP	Atomic City Auto Parts
ALS	amyotrophic lateral sclerosis
AOEC	Association of Occupational and Environmental Clinics
ATSDR	Agency for Toxic Substances and Disease Registry
BW	body weight
CDC	Centers for Disease Control and Prevention
CEDE	committed effective dose equivalent
CEDR	Comprehensive Epidemiologic Data Resource
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Co 60	cobalt 60
COPD	chronic obstructive pulmonary disease
CR	concentration ratio
Cs 137	cesium 137
CSF	cancer slope factor
CT	computed tomography
DHHS	U.S. Department of Health and Human Services
DOE	U.S. Department of Energy
EFPC	East Fork Poplar Creek
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
FACA	Federal Advisory Committee Act
FAMU	Florida Agricultural and Mechanical University
fCi/m^3	femtocuries per cubic meter
GAO	General Accounting Office
g/kg/day	grams per kilogram per day
ICRP	International Commission on Radiological Protection
IR	ingestion rate
kg	kilogram
LET	Linear Energy Transfer
LNT	linear nonthreshold
LOAEL	lowest-observed-adverse-effect level
m^3/day	cubic meters per day
MCL	maximum contaminant level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
mrem	millirem
mrem/year	millirems per year
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
mg/m^3	milligrams per cubic meter
MRL	minimal risk level
MS	multiple sclerosis

ACRONYMS (continued)

NAACP	National Association for the Advancement of Colored People
NCEH	National Center for Environmental Health
NCRP	National Council on Radiation Protection and Measurements
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
OREIS	Oak Ridge Environmental Information System
ORHASP	Oak Ridge Health Agreement Steering Panel
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
ORRHES	Oak Ridge Reservation Health Effects Subcommittee
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
PDF	probability distribution function
PHA	Public health assessment
PHAWG	Public Health Assessment Work Group
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SMR	standardized mortality ratio
Sr 90	strontium 90
SSAB	Site-Specific Advisory Board
Sv	sievert
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TEDE	term total effective dose
TSCA	Toxic Substances Control Act
U	uranium
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USGS	U.S. Geological Survey
χ	chi

I. SUMMARY

In 1942, the federal government established the Oak Ridge Reservation (ORR) in Anderson and Roane counties in Tennessee as part of the Manhattan Project to research, develop, and produce special nuclear materials for nuclear weapons. Four facilities were built at that time. The Y-12 plant, the K-25 site, and the S-50 site were created to enrich uranium. The X-10 site was created to demonstrate processes for producing and separating plutonium. Since the end of World War II, the role of the ORR (Y-12 plant, K-25 site, and X-10 site) broadened widely to include a variety of nuclear research and production projects vital to national security.

In 1989, the ORR was added to the U.S. Environmental Protection Agency's (EPA's) National Priorities List because, over the years, the ORR operations have generated a variety of radioactive and nonradioactive wastes that are present in old waste sites or have been released into the environment. The U.S. Department of Energy is conducting cleanup activities at the ORR under a Federal Facility Agreement with EPA and the Tennessee Department of Environment and Conservation. These agencies are working together to investigate and take remedial action on hazardous waste from past and present activities at the site.

For the last 10 years, the Agency for Toxic Substances and Disease Registry (ATSDR) has responded to requests and addressed health concerns of community members, civic organizations, and other government agencies by working extensively to determine whether levels of environmental contamination at and near the ORR present a public health hazard to communities surrounding the ORR. During this time, ATSDR has identified and evaluated several public health issues and has worked closely with many parties. ATSDR is the principal federal public health agency charged with evaluating human health effects of exposure to hazardous substances in the environment. While the Tennessee Department of Health (TDOH) conducted the Oak Ridge Health Studies to evaluate whether off-site populations have been exposed in the past, ATSDR's activities focused on current public health issues related to Superfund cleanup activities at the site. Prior to this public health assessment, ATSDR addressed current public health issues related to two off-site areas affected by ORR operations—the East Fork Poplar Creek area and the Watts Bar Reservoir area.

During Phase I and Phase II of the Oak Ridge Health Studies, the TDOH conducted extensive reviews and screening analyses of the available information and identified four hazardous substances that may have been responsible for adverse health effects: radionuclides from White Oak Creek, iodine, mercury, and polychlorinated biphenyls (PCBs). In addition to the dose reconstruction studies on these four substances, the TDOH conducted additional screening analyses for releases of uranium, radionuclides, and several other toxic substances.

To expand upon the efforts of the TDOH—not duplicate them—ATSDR scientists conducted a review and a screening analysis of the department's Phase I and Phase II screening-level evaluation of past exposure (1944–1990) to identify contaminants of concern for further evaluation. Based on this review, ATSDR scientists are conducting public health assessments on the release of iodine 131, Y-12 mercury releases, PCBs, radionuclides from White Oak Creek, Y-12 uranium releases, K-25 uranium and fluoride releases, and other topics such as the Toxic Substances Control Act (TSCA) incinerator and off-site groundwater. In conducting these public

health assessments, ATSDR scientists are evaluating and analyzing the information, data, and findings from previous studies and investigations to assess the public health implications of past and current exposure. The public health assessment is the primary public health process ATSDR uses to:

1. Identify populations off the site who may have been exposed to hazardous substances at levels of health concern.

2. Determine the public health implications of the exposure.

3. Address the health concerns of people in the community.

4. Recommend follow-up public health actions or studies to address the exposure.

ATSDR scientists will also conduct a screening analysis of all available environmental sampling data from 1990 to the present to determine whether additional contaminants of concern need to be addressed.

This public health assessment evaluates the releases of uranium from the Y-12 plant; assesses past and current uranium exposure to residents living near the ORR, including the residents of the Scarboro community (the reference community); addresses the community health concerns and issues associated with the uranium releases from the Y-12 plant; and, where possible, considers health outcome data that measure health effects associated with exposure to uranium or characterize the health status of a group of exposed people. This document does not address the release of other contaminants of concern such as mercury, iodine 131, PCBs, uranium from the K-25 facility, and fluorides, nor does it address exposures to those contaminants. ATSDR will evaluate these contaminants and other topics in separate public health assessments.

The 825-acre Y-12 plant, now called the Y-12 National Security Complex, is located in Bear Creek Valley and is bordered by Chestnut Ridge and Pine Ridge. The Y-12 plant was used in the 1940s to electromagnetically enrich uranium. In 1952, the facility was converted to enrich lithium-6 using a column-exchange process and to fabricate components for thermonuclear weapons using high-precision machining and other specialized processes. In 1992, after the Cold War ended, Y-12's mission was curtailed, and the plant is currently used for weapons disassembly and weapon renovation operations. The National Nuclear Security Administration currently uses the Y-12 National Security Complex as the primary storage site for highly enriched uranium. While operational levels have increased since 1992, the total operations have not approached the levels experienced before the 1990s.

The Y-12 plant is about 2 miles south of downtown Oak Ridge. It is separated from the main residential areas of Oak Ridge by Pine Ridge, a ridge that rises to about 300 feet above the valley floor. In 1942, the city of Oak Ridge was established for the 13,000 persons who were expected to work at the ORR. The population peaked at 75,000 in 1945 and decreased to 30,229 in 1950. Since 1959, when the city of Oak Ridge became self-governing, the Oak Ridge population has been approximately 27,000. The Scarboro community is a residential area within the city of Oak Ridge, about a half mile from the Y-12 plant, and is separated from the Y-12 plant by Pine

Ridge. Scarboro was established in 1950 to provide single-family homes, duplexes, apartments, and an elementary school to African-American Oak Ridge residents. Scarboro remains predominantly African-American and has a population of approximately 300 persons.

The meteorological data indicates that the predominant wind directions at the Y-12 plant are southwest and northeast, generally up and down Bear Creek Valley, between Pine Ridge and Chestnut Ridge, with limited winds crossing over the ridges. Therefore, most of the uranium would deposit up and down Bear Creek Valley and Union Valley. No one lives in these valleys. The city of Oak Ridge is the only established community where people resided during the years of uranium releases that could have been impacted by Y-12 uranium releases. In this public health assessment, the Scarboro community is used as a reference location that represents the city of Oak Ridge.

During Phase II of the Oak Ridge Health Studies, the TDOH identified Scarboro as a reference location using air dispersion modeling to estimate average ground-level air concentrations at locations surrounding the reservation. According to the modeling results, Scarboro was the off-site population likely to receive the highest exposures to past releases from the Y-12 plant. 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."

ATSDR evaluated past and current exposure to uranium released from the Y-12 plant and found that the off-site exposures to uranium were too low to be a health hazard for either radiation or chemical health effects.

Past Exposure

ATSDR evaluated both radiation and chemical aspects of past uranium exposure. ATSDR concluded that past off-site exposure to uranium from Y-12 is not a public health hazard. Neither the total radiation dose nor the chemical ingestion and inhalation doses from off-site exposure to uranium released from the Y-12 plant in the past would have caused harmful health effects.

To evaluate past exposure to uranium releases from the Y-12 plant, ATSDR primarily relied on data generated during Task 6 of the TDOH's Reports of the Oak Ridge Dose Reconstruction, *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* (referred to as the "Task 6 report"). The city of Oak Ridge is the only established community adjacent to ORR that could have been impacted by Y-12 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 exposures. The Scarboro community, located in the city of Oak Ridge, is a representative community; therefore, the conclusions are valid for the people living near the Y-12 Plant, including the city of Oak Ridge.

To evaluate cancer health effects from past radiation exposure, ATSDR adjusted the total uranium radiation doses reported in the Task 6 report to be equivalent to a 70-year exposure.[1] The total radiation dose received by the reference population, the Scarboro community, from all air, surface water, and soil exposure pathways (a committed effective dose [CEDE] of 155 millirem [mrem] over 70 years) is well below (32 times less than) the ATSDR radiogenic cancer comparison value of 5,000 mrem over 70 years. This radiogenic cancer comparison value assumes that the entire radiation dose (a 70-year dose, in this case) from the intake of uranium is received in the first year following the intake. Doses below this value are not expected to result in adverse health effects. Therefore, ATSDR does not expect carcinogenic health effects to have occurred from exposure to uranium in the past.

To evaluate noncancer health effects from the total past uranium radiation dose received by the Scarboro community (a CEDE of 155 mrem over 70 years), ATSDR divided that dose by 70 years to approximate a value of 2.2 mrem as the radiation dose for the first year. This approximate dose is well below (45 times less than) the ATSDR minimum risk level (MRL) of 100 mrem/year for chronic ionizing radiation exposure. ATSDR believes that the MRL itself is below levels that might cause adverse health effects in people most sensitive to such effects, and therefore does not expect noncancer health effects to have occurred from radiation doses received from past Y-12 uranium releases.

MRLs are estimates of daily human exposure to hazardous substances that are likely to be without appreciable risk of adverse noncancer health effects. They are conservative (protective) screening values based on the most sensitive health effect and have built in safety factors. Exposure to levels above the MRL does not mean that adverse health effects will occur. Rather, it is an indication that ATSDR should further examine the harmful effect levels reported in the scientific literature and more fully review exposure potential.

To evaluate potential chemical health effects from past uranium exposure, ATSDR estimated exposure through the air pathway and compared the yearly air concentrations in the Scarboro community to ATSDR's inhalation MRL for uranium. Yearly estimated average air concentrations of uranium in Scarboro ranged from 2.1×10^{-8} to 6.0×10^{-5} milligrams per cubic meter (mg/m^3). These air concentrations are less than 1% of the inhalation MRL for chemical effects (8×10^{-3} mg/m^3). ATSDR also estimated exposure to uranium through the soil and surface water pathways and compared the resulting doses to levels associated with known health effects. Yearly estimated doses from exposure to uranium via all soil ingestion and surface water exposure pathways ranged from 2.7×10^{-5} to 1.3×10^{-2} milligrams per kilogram per day (mg/kg/day). 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. Therefore, ATSDR does not expect that residents were exposed in the past to levels of uranium that would cause harmful chemical effects.

The same value can be presented in different ways:
0.001
1.0E-03
1.0×10^{-3}
1/1,000
one in a thousand

[1] The values from the Task 6 report were multiplied by 1.35 (70 years/52 years) for comparison with ATSDR's comparison values.

Additionally, it should be noted that several levels of conservatism were built into this evaluation of past exposures. 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 protective assumptions and approaches. This led to an overestimation of concentrations and doses. Even using these conservative overestimations of concentrations and doses, persons in the reference community (Scarboro) and other communities near the Y-12 plant were exposed to levels of uranium that are below health concern.

Current Exposure

ATSDR evaluated both radiation and chemical aspects of current uranium exposure. Based on our review of data collected in and around the Scarboro community, and as compared to background and distant areas, ATSDR has determined that exposure to the current levels of uranium would not cause harmful health effects.

To assess current exposure to uranium releases from the Y-12 plant, ATSDR evaluated air data from monitoring stations, surface water sampling from East Fork Poplar Creek and Scarboro, recent soil sampling from the Scarboro community, samples of garden crops from Scarboro, and garden crop samples from outlying areas. Most of the data were supplied by the Oak Ridge Environmental Information System (OREIS), a centralized, standardized, quality-assured, and configuration-controlled environmental data management system that is publicly available. ATSDR also supplemented the evaluation with data from the *Scarboro Community Environmental Study* by the Florida Agricultural and Mechanical University (FAMU) and the *September 2001 Sampling Report for the Scarboro Community* by EPA. ATSDR evaluated the following pathways: ingestion of soil, ingestion of foods, ingestion of water from nearby creeks, inhalation of air, and external exposure from uranium in soils.

To evaluate the cancer effects of current exposure to radiation from uranium, ATSDR assessed the radiation dose received by the reference population—the Scarboro community—through exposure to uranium ingested in soil and vegetables and inhaled in air. That dose (0.216 mrem) is well below (23,000 times less than) the radiogenic cancer comparison value of 5,000 mrem over 70 years. ATSDR derived this CEDE from the intake of uranium, making the assumption that the entire dose (a 70-year dose, in this case) is received in the first year following the intake. Doses below this value are not expected to have adverse health effects. Therefore, ATSDR does not expect harmful radiation effects to occur from the exposure to uranium that is occurring currently.

ATSDR also evaluated noncancer health effects from the total current uranium radiation dose (a CEDE of 0.216 mrem over 70 years) received by the Scarboro community, ATSDR divided the CEDE of 0.216 mrem, which is based on 70 years of exposure, by 70 years to approximate a value of 0.003 mrem as the radiation dose for the first year. This approximate dose of 0.003 mrem is well below (33,000 times lower than) the ATSDR minimum risk level (MRL) of 100 mrem/year for chronic ionizing radiation exposure. ATSDR believes the chronic ionizing radiation received by communities near the Y-12 plant from uranium exposure is below levels that might cause adverse health effects in people most sensitive to such effects, and therefore does not expect noncancer health effects to occur from current radiation doses.

In addition, ATSDR compared the soil radioactivity concentrations in the reference location (Scarboro) with typical concentrations found in nature and from background samples collected from uncontaminated areas around the reservation. This evaluation showed that the soil radioactivity concentrations in Scarboro were indistinguishable from natural and background concentrations.

To evaluate potential chemical health effects, ATSDR estimated exposure through the air pathway and compared the yearly air concentrations in the Scarboro community to ATSDR's inhalation MRL. Average uranium air concentrations from monitoring stations near the ORR (ranging from 3.7×10^{-11} to 1.4×10^{-10} mg/m^3), including station 46 in Scarboro (5.4×10^{-11}), are several orders of magnitude below (over a million times less than) the intermediate-duration MRL of 8×10^{-3} mg/m^3 for insoluble forms of uranium. ATSDR also estimated exposure to uranium through the soil and surface water pathways and compared the resulting doses to ATSDR's screening values: the environmental media evaluation guide (EMEG) and the oral MRL. The concentrations of uranium found in the surface water from off-site areas of East Fork Poplar Creek (0.197 and 12.8 micrograms per liter, or µg/L) are below ATSDR's EMEG of 20 µg/L. Additionally, the estimated doses from ingestion of uranium in soil (ranging from 2.07×10^{-6} to 1.4×10^{-5} mg/kg/day) and food (3.0×10^{-5} and 3.9×10^{-5} mg/kg/day in the Scarboro community) were well below the oral MRL of 2×10^{-3} mg/kg/day. Even if the exposures from the two pathways are combined, the resulting dose is still lower than the MRL. For example, if the highest dose following ingestion of soil is added to the total intake from ingestion of vegetables grown in Scarboro, the total ingestion dose is 5.3×10^{-5} mg/kg/day, which is about two orders of magnitude below the MRL. Therefore, ATSDR believes that residents are currently being exposed to levels of uranium that would not cause harmful chemical effects.

II. BACKGROUND

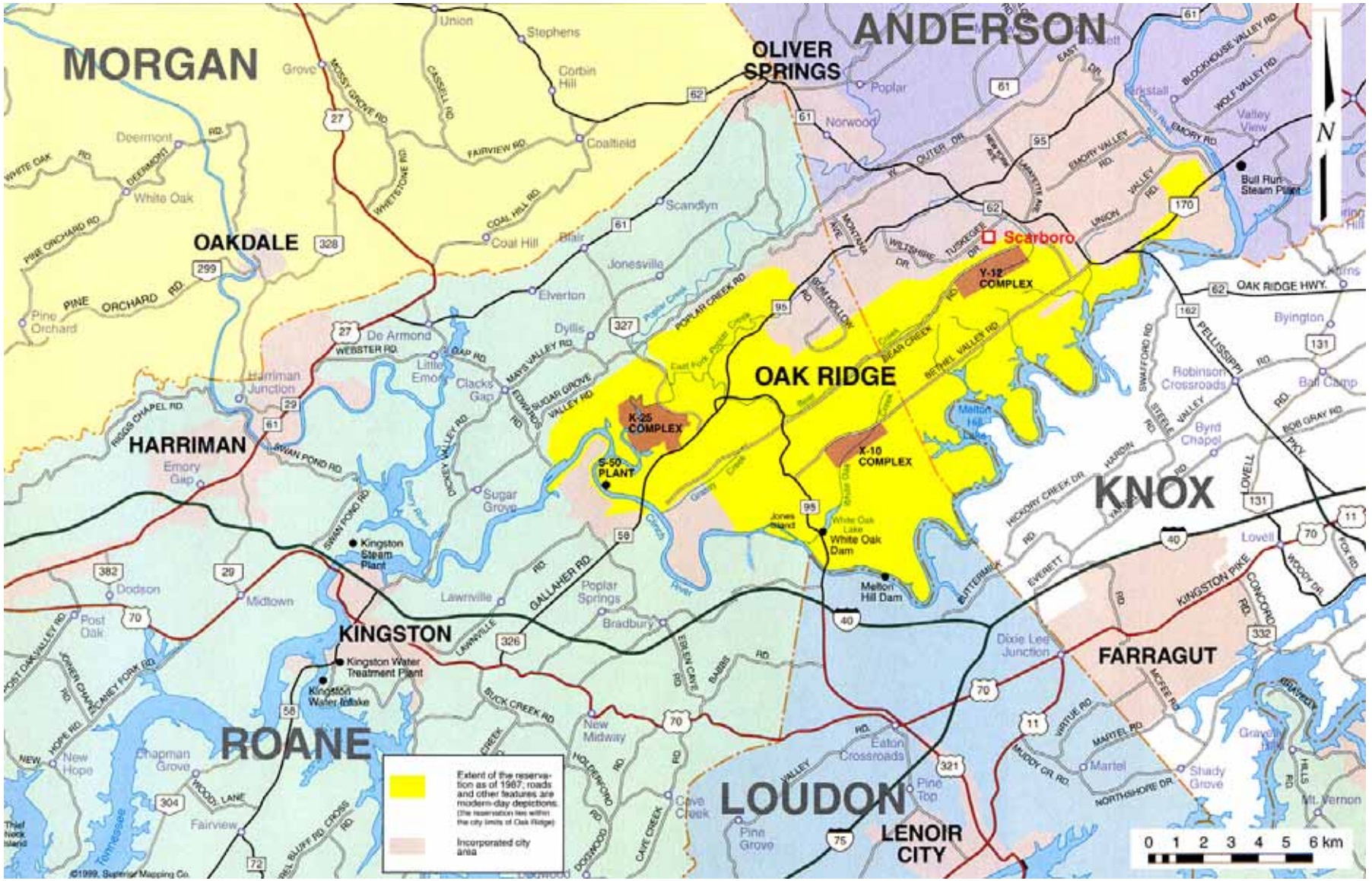
II.A. Site Description

In 1942, the federal government established the 58,000-acre Oak Ridge Reservation (ORR), located in Anderson and Roane counties in Tennessee, as part of the Manhattan Project to research, develop, and produce special nuclear materials for nuclear weapons (ChemRisk 1993a; TDOH 2000). Four facilities were built. The Y-12 plant, the K-25 site, and the S-50 site were created to enrich uranium (U), and the X-10 site was created to demonstrate processes for producing and separating plutonium (TDOH 2000).[2] The Clinch River forms the southern and western boundaries of the reservation, and most of the property is within the Oak Ridge city limits (EUWG 1998). Please see Figure 1 for the location of the ORR.

The Y-12 plant is located in the eastern end of Bear Creek Valley. It is bordered on the south by Chestnut Ridge and on the north by Bear Creek Road and Pine Ridge (ChemRisk 1999). The main Y-12 production area is about 0.6 miles wide and 3.2 miles long; the area contains roughly 240 principal buildings, of which about 18 were directly involved with processing and/or storage of uranium compounds (Patton 1963; UCC-ND 1983 as cited in ChemRisk 1999). The 825-acre Y-12 plant is located within the corporate limits of the city of Oak Ridge, about 2 miles south of downtown (ChemRisk 1999). It is less than a half mile from the Scarboro community, but Pine Ridge (which rises to about 300 feet above the valley floor) separates the Y-12 plant from the main residential areas of Oak Ridge (TDOH 2000).

[2] Because this health assessment focuses on exposure to uranium released from the Y-12 plant, the other main facilities on ORR are not discussed in detail.

Figure 1. Location of Oak Ridge Reservation



II.B. Operational History

Since the early 1940s, the ORR processed large quantities of uranium, enriching it into uranium 235 for the production of nuclear weapon components and for use in commercial nuclear reactors and various research and development projects (ChemRisk 1993a as cited in ChemRisk 1999).

From 1944 to 1947, the Y-12 plant was used to electromagnetically enrich uranium, but in 1952 the facilities were converted to fabricate nuclear weapon components (ChemRisk 1999). During the Cold War, a column-exchange process (Colex) that used large quantities of mercury as an extraction solvent to enrich lithium in lithium 6 was built and operated (TDOH 2000). At the end of the Cold War, the Y-12 missions were curtailed. In 1992 the major focus of the Y-12 plant was the remanufacture of nuclear weapon components and the dismantlement and storage of strategic nuclear materials from retired nuclear weapons systems. In October 2000, oversight of the Y-12 plant was changed from the U.S. Department of Energy (DOE) Oak Ridge Operations to the DOE National Nuclear Security Administration. The National Nuclear Security Administration currently uses the Y-12 National Security Complex as the primary storage site for highly enriched uranium. While operational levels have increased since 1992, the total operations have not approached the levels experienced prior to the 1990s. See Figure 2 for a time line of the major processes at the Y-12 plant.

Task 6 of the reports of the Oak Ridge Dose Reconstruction (ChemRisk 1999) gives greater detail on the operational history of the Y-12 plant. The key processes and activities associated with uranium include (1) feed preparation for enrichment operations (1943–1947), (2) electromagnetic enrichment (1943–1947), (3) uranium recovery and recycling operations (1944–1951), (4) uranium salvage operations (1947–1951), (5) uranium preparation and recycling for weapons component operations (1949–1995), (6) uranium forming and machining for weapon component operations (1949–1995, continuing to the present), and (7) weapons component assembly operations (1952–1995, continuing to the present) (ChemRisk 1999). For more details, please see Section 1.4 and Appendix A of Task 6 of the Reports of the Oak Ridge Dose Reconstruction, *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* (ChemRisk 1999) (referred to as the "Task 6 report") and the *Oak Ridge Health Studies Phase 1 Report: Volume II—Part A—Dose Reconstruction Feasibility Study, Tasks 1 & 2, A Summary of Historical Activities on the Oak Ridge Reservation With Emphasis on Information Concerning Off-Site Emission of Hazardous Material* (ChemRisk 1993a).

Figure 2. Y-12 Plant Time Line

MAJOR PROCESSES

- Electromagnetic Separation of U-235, 1943-48
- Uranium Chemical Processing and Parts Manufacturing, 1943-present
- Disposal in Boneyard/Burnyard, 1944-72
- Electromagnetic Separation of Stable Isotopes, 1947-90
- ELEX & COLEX Separarting Process for Lithium Isotopes (Using Mercury), 1950-63
- Production of Thorium Weapon Components, 1950-75
- Production of Lithium and Beryllium Weapon Components, 1950-present
- Waste Disposal in S-3 Ponds, 1951-82
- Disposal in Bear Creek Burial Ground, 1954-92
- Waste Disposal in New Hope Pond, 1963-88

ORR ENVIRONMENTAL MONITORING DATA

Surface Water

- 1947-48, Radioactivity, Flourine, Uranium in Clinch River, Poplar Creek
- 1950-present, Radioactivity, Mercury in EFPC, Bear Creek
- 1955-57, Mercury, Manganese in Clinch River, Poplar Creek, EFPC
- 1959-present, Radionuclides, Metals in Clinch River
- 1960-64, Radionuclides, Chemicals in Clinch River, Poplar Creek
- 1971-present, Uranium, Radionuclides, Metals in EFPC, Poplar Creek, Bear Creek
- 1971-90, PCBs in Bear Creek
- 1983, Organics, Priority Pollutants in Bear Creek
- 1983, VOCs, PCBs, Metals in Bear Creek
- 1984, Metals, VOCs, Radioactivity, Radionuclides in Clinch River, EFPC
- 1984-86, Mercury, Organics, in Bear Creek
- 1985, Herbicides, Pesticides, PCBs in Bear Creek
- 1986, Cs-137 in Watts Bar Reservoir
- 1989-90, Metals, Organics, Radionuclides, PCBs, SVOCs, Pesticides, Tritium in Clinch River, Poplar Creek
- 1990, Metals, Organics, Radionuclides, in Melton Hill, Norris, and Watts Bar Reservoir
- 1993, EFPC Remedial Investigation
- 1995-96, Clinch River/Watts Bar Remedial Investigations
- 1998, Radionuclides, metals, organics in Scarboro
- 2001, Radionuclides, metals, VOCs, SVOCs, pesticides, & PCBs in Scarboro

Biota

- 1948-49, Radioactivity Radionuclides in Clinch River Fish
- 1961-present, I-131 and SR-90 in Cows' Milk within 50 miles of ORR
- 1967-present, Mercury, PCBs, Radionuclides, in Clinch River Fish
- 1970-82, Mercury in EFPC, Bear Creek Fish
- 1974-77, Mercury in Clinch River and Poplar Creek Fish
- 1977, Metals, PCBs in Clinch River and Poplar Creek Fish
- 1977-present, Radionuclides in ORR Deer
- 1977-present, Radionuclides in Grass from ORR Perimeter and Remote Stations
- 1979, Metals in Melton Hill Reservoir and Clinch River Fish
- 1982, Mercury in Pasture Grass in EFPC Drainage
- 1982, Mercury in Cow and Horse Grazing on EFPC Floodplain
- 1983, Mercury in EFPC and Bear Creek Frogs and Crayfish
- 1983-87, Mercury in Native Vegetation and Garden Vegetables on EFPC Floodplain
- 1984, Mercury in EFPC and Poplar Creek Turtles
- 1984, Metals, PCBs, Radionuclides in Melton Hill Reservoir, EFPC, Bear Creek, and Clinch River Fish, Frogs, Turtles, and Crayfish
- 1985-present, Metals and Organics in EFPC Fish
- mid-80's, Metals in Deer from the EFPC Floodplain
- 1986, Mercury, PCBs in EFPC Fish
- 1986-89, Metals, Pesticides, PCBs, in Melton Hill and Watts Bar Reservoir Fish
- 1987-present, Radioactivity in Geese
- 1989, Metals, PCBs, Pesticides, SVOCs, Radionuclides in Clinch and Tennessee River Fish
- 1993, EFPC Remedial Investigation
- 1995-96, Clinch River/Watts Bar Remedial Investigations

Sediment

- 1951-66, 77, Radionuclides in Clinch River and Tennessee River
- 1960-64, Organics and Radioactivity in Clinch and Tennessee River
- 1970, Mercury in Melton Hill Reservoir, EFPC, Bear Creek
- 1972, Mercury in EFPC, Bear Creek
- 1973-74, 79, PCBs in Clinch River, EFPC, Poplar Creek
- 1973-82, Metals and PCBs in Melton Hill Reservoir
- 1974-75, Mercury in EFPC
- 1975-present, Metals in Clinch River, EFPC
- 1981-82, Metals in Bear Creek and EFPC
- 1984-86, Metals, Organics, and Radionuclides in Bear Creek
- 1985, Herbicides, Pesticides, and PCBs in Bear Creek
- 1985, Metals, PCBs, Organics, and Radionuclides in Clinch River, Poplar Creek, EFPC, Bear Creek
- 1986, Cs-137 in Watts Bar Reservoir
- 1989-90, Metals, VOCs, SVOCs, PCBs, Pesticides, Tritium, Radionuclides in Clinch River, Poplar Creek
- 1990, Metals, Organics, Radionuclides in Melton Hill, Norris, and Watts Bar Reservoir
- 1993, EFPC Remedial Investigation
- 1995-96, Clinch River/Watts Bar Remedial Investigations
- 1998, Radionuclides, metals, organics in Scarboro
- 2001, Radionuclides, metals, VOCs, SVOCs, pesticides, & PCBs in Scarboro

Soil

- 1949-present, External Gamma Radiation Measurements
- 1959-1968, Routine Aerial Background Surveys
- 1971-present, Radionuclides in Soil at Perimeter and Remote Monitoring Stations
- 1973-74, 1980, 1986, 1989, and 1992, Airborne Gamma Radiation Surveys
- 1978-79, Technetium-99 in Soils near K-25
- 1983-87, Metals, PCBs, and Radionuclides in EFPC Floodplain Soils
- 1984, Radiation Survey of the Oak Ridge Sewer Beltway
- 1989-90, Surface Radiation Exposures to Hunters on ORR
- 1993, EFPC Remedial Investigation
- 1998, Radionuclides, metals, organics in Scarboro
- 2001, Radionuclides, metals, VOCs, SVOCs, pesticides, & PCBs in Scarboro

Air

- 1955-present, Particle Number, Fallout Particle Number, Beta Radioactivity, Beta Radioactivity in Rainwater, Uranium, Nickel, Lead, Chromium, Particulates (nickel, lead, chromium no longer sampled)
- 1963-present, I-131
- 1975-present, Particulate Gamma Emitters, SR-90, uranium, thorium
- 1986-present, Mercury
- 1990-present, Uranium Particulates, Flourides, Particulates
- 1993, EFPC Remedial Investigation

Drinking Water

- 1959-present, Radionuclides in Water from Clinch River Water Intakes
- 1981, 83, Radionuclides, Metals in Residential Well Water
- 1985, Radioactivity in Residential Well Water
- 1986, Radioactivity, Radionuclides, Inorganics in Residential Well Water
- 1986, 89-present, Metals, Organics, Radionuclides in Residential Drinking Water

PUBLIC HEALTH ACTIVITIES AT THE ORR

- 1942-93, Oak Ridge Health Studies Phase 1 Report—Dose Reconstruction Feasibility Study (10/93)
- 1942-90, PCBs, Phase II of Oak Ridge Health Studies Dose Reconstruction Reports (7/99)
- 1944-90, Uranium, Phase II of Oak Ridge Health Studies Dose Reconstruction Reports (7/99)
- 1944-56, White Oak Creek Releases, Phase II of Oak Ridge Health Studies Dose Reconstruction Reports (7/99)
- 1944-56, Iodine 131, Phase II of Oak Ridge Health Studies Dose Reconstruction Reports (7/99)
- 1950-63, Mercury, Phase II of Oak Ridge Health Studies Dose Reconstruction Reports (7/99)
- 1959, 1973, 1980, 1989, 1992, 1997, Aerial Radiological Surveys of the Scarboro Community (1998)
- 1980-92, Health Statistics Review of Mortality Rates (1994)
- 1984, Pilot Survey of Mercury Levels in Oak Ridge (10/85)
- 1985-95, Health Consultation on Lower Watts Bar Reservoir (2/96)
- 1988-90, Health Statistics Review to Address Oak Ridge Physician's Concerns (10/19/92)
- 1990-92, Health Consultation on Y-12 Weapons Plant Chemical Releases into East Fork Poplar Creek (3/93)
- 1992, Review of Clinical Information on Persons Living in or near Oak Ridge, Tennessee (9/92)
- 1995, Health Consultation on Proposed Mercury Clean-Up Levels (1/96)
- 1997, Watts Bar Reservoir Exposure Investigation (3/98)
- 1998, Scarboro Community Health Investigation (7/00)

1944 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005

II.C. Remedial and Regulatory History

Because ORR operations have generated a variety of radioactive and nonradioactive wastes, the ORR was added to the National Priorities List (NPL) in 1989 (EPA 2002b). DOE is conducting cleanup activities at the ORR under a Federal Facility Agreement, which is an Interagency Agreement with the U.S. Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC). This agreement allows for input from the public. These parties are working together to investigate and take remedial action on hazardous waste from past and present activities at the site. DOE is integrating required measures from the Resource Conservation and Recovery Act (RCRA) with response actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). See Figure 2 for a time line of surface water, biota, sediment, soil, air, and drinking water environmental monitoring data related to activities at the Y-12 plant.

The Federal Facility Agreement, which was implemented on January 1, 1992, is a legally binding agreement to establish timetables, procedures, and documentation for remediation actions at ORR. The Federal Facility Agreement is available online at http://www.bechteljacobs.com/ettp_ffa.shtml.

Contaminants such as uranium and mercury are present in old waste sites, which occupy 5% to 10% of the ORR. The abundant rainfall (an annual average of 55 inches) and high water tables (for example, 0 to 20 feet below the surface) on the reservation contribute to leaching of these contaminants, resulting in contaminated soil, surface water, sediments, and groundwater (EUWG 1998).

Since 1986 (when initial cleanup activities commenced), DOE has initiated approximately 50 response actions under the Federal Facility Agreement that address contamination and disposal issues on the reservation. In order to consolidate investigation and remediation of environmental contamination, the contaminated areas were divided into five large tracts of land, generally associated with the major hydrologic watersheds (EUWG 1998). The following remedial actions pertain to the Y-12 plant specifically:

- *Upper East Fork Poplar Creek (EFPC)* is located entirely on the site. It originates from a spring beneath the Y-12 plant; initially confined to a manmade channel, it flows through the Y-12 plant along Bear Creek Valley. A Record of Decision (ROD) was negotiated between EPA, TDEC, and DOE that selected a number of different source control remedies to control the influx of mercury from the Y-12 plant into Upper EFPC. The major actions are the hydraulic isolation of contaminated soils in the West End Mercury Area, the treatment of the discharge of groundwater into Upper EFPC at Outfall 51, and the removal of contaminated sediments from Upper EFPC and Lake Reality. The goal is to restore surface water in Upper EFPC to human health recreational risk-based values at Station 17, which is where Upper EFPC flows into Lower EFPC (DOE 2002b; EPA 2002a).

- *Lower East Fork Poplar Creek (EFPC)* flows north from the Y-12 plant off site into the city of Oak Ridge through a gap in Pine Ridge. Lower EFPC flows through residential and business sections of Oak Ridge to join Poplar Creek, which flows to the Clinch

River. Lower EFPC was contaminated by releases of mercury and other contaminants, starting in the early 1950s. The remedial investigation/feasibility study (RI/FS) for Lower EFPC was completed in 1994. The ROD was approved in September 1995, and remediation field activities began in June 1996 (ATSDR et al. 2000). The Remedial Investigation and Proposed Plan ultimately led to the decision to excavate floodplain soils having mercury levels higher than 400 parts per million (ppm), sampling to ensure that all mercury above this level had been removed, and periodic monitoring (DOE 2001). The Agency for Toxic Substances and Disease Registry (ATSDR) evaluated the public health impacts of the 400 ppm cleanup level and concluded that it was protective of public health (ATSDR 1996). During the remediation, several pockets of radiologically contaminated soils (>250 counts per minute gross beta-gamma) were located, excavated, placed in containers, and stored at the East Tennessee Technology Park (DOE 2002a).

- *Bear Creek Valley* is located on the reservation. A remedial decision for part of Bear Creek Valley was recently signed. To prevent further leaching of uranium to groundwater and surface water, approximately 80,000 cubic yards of contaminated soil and debris was removed from the Boneyard/Burnyard and disposed of in an on-site CERCLA waste disposal facility and a capped aboveground disposal area (DOE 2003). In addition, shallow groundwater near the S-3 ponds and the burial grounds will be treated through *in situ* reactive trenches (C.J. Enterprises 2001).

Further detailed information on remedial and regulatory information at the ORR can be found in *Oak Ridge Health Studies Phase 1 Report: Volume II—Part A—Dose Reconstruction Feasibility Study, Tasks 1 & 2, A Summary of Historical Activities on the Oak Ridge Reservation With Emphasis on Information Concerning Off-Site Emission of Hazardous Material* (ChemRisk 1993a); *Public Involvement Plan for CERCLA Activities at the U.S. Department of Energy, Oak Ridge Reservation* (C.J. Enterprises 2001); and *Oak Ridge Reservation Annual Site Reports*.

II.D. Land Use and Natural Resources

The ORR currently has about 35,000 acres. The three major DOE installations—the East Tennessee Technology Park (formerly the K-25 site and the Oak Ridge Gaseous Diffusion Plant), Oak Ridge National Laboratory (formerly the X-10 site), and the Y-12 National Security Complex (formerly the Y-12 plant)—occupy about 30% of that acreage. The remaining 70% was established as a National Environmental Research Park in 1980, to provide protected land for environmental science research and education and to demonstrate that energy technology development can coexist with a quality environment. Large portions of the reservation, much of which had formerly been cleared for farmland, have grown into full forests over the past several decades. Some of this land includes areas known as “deep forest” that contain ecologically significant flora and fauna; portions of ORR are considered to be biologically rich (SAIC 2002).

The ORR also included an area set aside for residential, commercial, and support services. The city of Oak Ridge was created in 1942 to provide housing to the employees of ORR and was originally controlled by the military (Friday and Turner 2001). The self-governing portion of the city of Oak Ridge comprises about 14,000 acres and contains housing, schools, parks, shops, offices, and industrial areas. The urban population of Oak Ridge continued to grow over several

decades, and some residential properties are next to the ORR boundary line. Outside the urban areas, much of the region (about 40%) is still a pattern of farms and small communities, as it was historically (ChemRisk 1993c).

Public access is restricted at the Y-12 plant, which is located entirely within the ORR "229 Boundary." Y-12 is "an active production and special nuclear materials management facility [and so] additional security and access limitations apply" (DOE 2002b). Out of 1,170 acres in the Upper EFPC area, 800 acres are currently used for industrial purposes. This area includes maintenance facilities, office space, training facilities, change houses, facilities that were formerly used by the Oak Ridge National Laboratory Biology Division, waste management facilities, construction contractor support areas, and a high-security portion that supports core National Nuclear Security Administration missions (DOE 2002b).

A number of maps of this area indicate a wide range of land types, including "types of urban or built up land, agricultural land, rangeland, forestland, water, and wetlands," and uses that consist of "residential, commercial, public and semi-public, industrial, transportation, communication and utility, and extractive (e.g., mining)" (ChemRisk 1993c).

Agriculture (beef and dairy cattle) and forestry had been the two predominant land uses in the area around ORR; however, both of these uses are currently declining. For many years, milk was produced, bottled, and distributed locally. Corn, tobacco, wheat, and soybeans were the major crops grown in the area. Small game and waterfowl are hunted in the area continuously, and deer are hunted during certain periods (ChemRisk 1993c). Radiological monitoring is performed during the annual deer hunts to "provide assurance that harvested animals do not contain levels of radionuclides which would result in significant internal exposure to humans consuming meat from the animals" (Teasley 1995).

EFPC originates from within the Y-12 plant boundary, flows through the city of Oak Ridge for about 12 miles, and ultimately converges with Poplar Creek near the K-25 facility (DOE 1989). A number of small tributaries flow into the creek and support some small aquatic life. EFPC is classified by the state of Tennessee as appropriate for fishing, recreation, irrigation, livestock watering, and wildlife use (ATSDR 1993a). While people do not use the streams on the reservation, public access exists downstream from the reservation. The area that Lower EFPC flows through has many uses, which can be grouped into five categories: residential, commercial, agricultural, other, and DOE-owned (DOE 1995a). The creek appears to be too shallow for swimming, although some areas, particularly those near the confluence with Poplar Creek, are suitable for wading and fishing. TDEC issued a fishing advisory for EFPC that warns the public to avoid eating fish from the creek and to avoid contact with the water (ATSDR 1993a).

Groundwater is contaminated throughout much of the on-site Upper EFPC area. No one, however, is currently using the groundwater in the area where a contaminated groundwater plume extends past the ORR boundary (i.e., in Union Valley to the east of ORR) (DOE 2002b). The shallow groundwater along some off-site areas of the Lower EFPC floodplain contains metals at levels of public health concern; however, this off-site shallow groundwater is not used for drinking or other domestic purposes.

II.E. Demographics

II.E.1. Oak Ridge

The city of Oak Ridge, Tennessee, was established in Anderson County in 1942, for the 13,000 persons who were expected to work at the ORR (Friday and Turner 2001). By July 1944, the population of Oak Ridge had increased to 50,000. The population peaked at 75,000 in 1945 and decreased to 30,229 by 1950 (see Table 1) (Oak Ridge Comprehensive Plan 1988). In 1959, about 14,000 acres within the city of Oak Ridge became self-governing (ChemRisk 1993c). Almost since its establishment, the city of Oak Ridge has been the largest population center in the area (ChemRisk 1993c).

Table 1. Population of Oak Ridge From 1942 to 2000

	1942	1944	1945	1950	1960	1970	1980	1990	2000
Oak Ridge	13,000	50,000	75,000	30,229	27,169	28,319	27,662	27,310	27,387

Sources: ChemRisk 1993c; Oak Ridge Comprehensive Plan 1988; U.S. Census Bureau 2000

From 1940 to 1960, the city of Oak Ridge had a higher proportion of working-age people and fewer seniors than the rest of Tennessee (ChemRisk 1993c). However, since 1960, the population of residents over age 35 and over age 55 has increased, while the population of children under age 16 has declined (Oak Ridge Comprehensive Plan 1988). The education level of Oak Ridge citizens is dramatically higher than in surrounding areas; Oak Ridge boasts one of the highest per capita ratios of Doctors of Philosophy (Ph.D.s) of any city in the United States (Oak Ridge Comprehensive Plan 1988).

II.E.2. Scarboro

The Scarboro community is located within the city of Oak Ridge, about a half mile from the Y-12 plant, and is separated from the Y-12 plant by Pine Ridge. Before 1950, the area was known as the Gamble Valley Trailer Camp, and the population was predominantly white. In 1950, Scarboro was established to provide single-family homes, duplexes, apartments, and an elementary school to African-American Oak Ridge residents (Friday and Turner 2001). To this day, Scarboro remains predominantly African-American (94%) (Joint Center Summary Number 4).

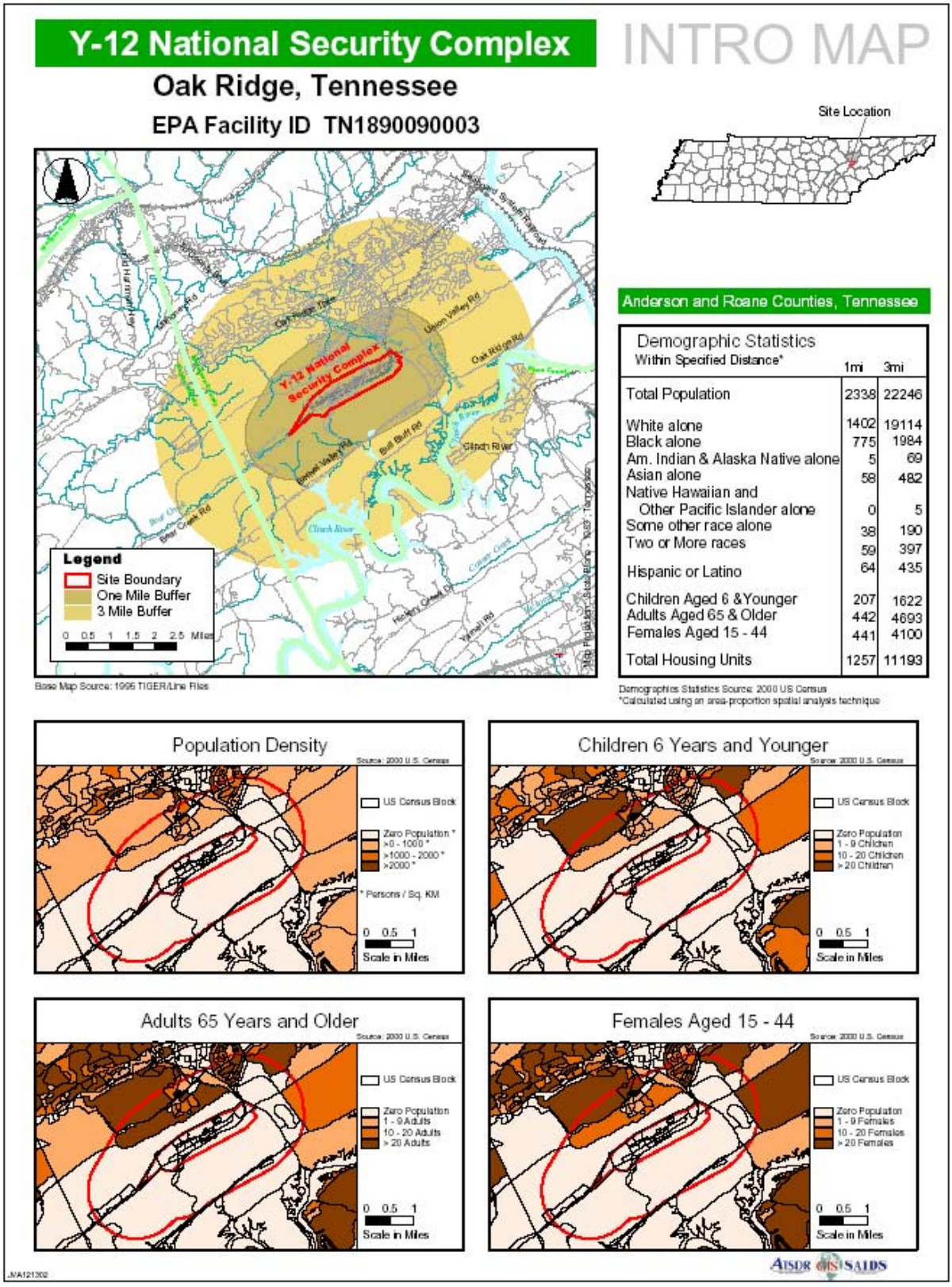
In the fall of 1999, the Joint Center for Political and Economic Studies conducted a survey of the broader Scarboro community (Friday and Turner 2001). The staff identified 380 residences, of which 326 were occupied, and about 266 persons responded to the survey (82%). The report generated from the survey is one of the few sources of detailed information available on the Scarboro community (Friday and Turner 2001). Some of the demographic information resulting from this survey is presented in the following paragraphs. For additional details, please see the *Scarboro Community Assessment Report* (Friday and Turner 2001).

The Scarboro community is aging: the average respondent is almost 53 years old and only 36% of participating households reported having at least one member between the ages of 18 and 34 years old. About half of the households reported having one senior citizen or more, while only

23% of the surveyed households reported having children. Additionally, 39% of respondents were retired. As of 1999, the average length of residence in Scarboro was 29 years. However, many (82%) of the young adult residents (18–30 years old) moved to Scarboro after 1994 (Friday and Turner 2001).

Figure 3 provides the current demographics for a 1-mile and 3-mile radius of the Y-12 plant.

Figure 3. Demographics Within 1 and 3 miles of the Y-12 Plant



II.F. Summary of Public Health Activities Pertaining to Y-12 Uranium Releases

This section describes the public health activities that pertain to Y-12 uranium releases. Several additional public health activities that have been conducted at the ORR by ATSDR, the Tennessee Department of Health (TDOH), and other agencies are described in Appendix B. See Figure 2 for a time line of public health activities related to the Y-12 plant.

II.F.1. ATSDR

For the last 10 years, ATSDR has addressed the health concerns of community members, civic organizations, and other government agencies by working extensively to determine whether levels of environmental contamination at and near the ORR present a public health hazard. During this time, ATSDR has identified and evaluated several public health issues and has worked closely with many parties, including community members, civic organizations, physicians, and several local, state, and federal environmental and health agencies. While the TDOH conducted the Oak Ridge Health Studies to evaluate whether off-site populations have experienced exposures in the *past*, ATSDR's activities focused on *current* public health issues to prevent duplication of the state's efforts. The following paragraphs highlight major public health activities conducted by ATSDR that pertain to Y-12 uranium releases.

- *Exposure Investigations, Health Consultations, and Other Scientific Evaluations.* ATSDR health scientists have addressed current public health issues related to two areas affected by ORR operations—the EFPC area and the Watts Bar Reservoir area. Briefs summarizing both health consultations are provided in Appendix I

    - *Health Consultation on Y-12 Weapons Plant Chemical Releases Into East Fork Poplar Creek, April 1993*. This health consultation provided DOE with advice on current public health issues related to past and present chemical releases into the creek from the Y-12 weapons plant. DOE implemented many of ATSDR's recommendations before finalizing its remedial investigation and feasibility study on EFPC. The EFPC Phase IA data evaluated for this health consultation indicate that the creek's soil, sediment, groundwater, surface water, air, and fish are contaminated with various chemicals. ATSDR made the following public health conclusions:

        1. Soil and sediments in certain locations along the EFPC floodplain are contaminated with levels of mercury that pose a public health concern.

        2. Fish in the creek contain levels of mercury and polychlorinated biphenyls (PCBs) that pose a moderately increased risk of adverse health effects to people who eat fish frequently over long periods of time.

        3. Shallow groundwater in a few areas along the EFPC floodplain contains metals at levels of public health concern; however, this shallow groundwater is not used for drinking or other domestic purposes.

4. Other contaminants, including radionuclides found in soil, sediment, surface water, and fish, were not detected at levels of public health concern.

- *Health Consultation on the Lower Watts Bar Reservoir, February 1996*. ATSDR concluded that PCBs detected in fish from lower Watts Bar Reservoir pose a public health concern. Frequent and long-term ingestion of fish from the reservoir poses a moderately increased risk of cancer and may increase the possibility of developmental effects in infants whose mothers consume fish regularly during gestation and while nursing. ATSDR also found that current levels of contaminants in the reservoir surface water and sediment were not a public health hazard, and that the reservoir was safe for swimming, skiing, boating, and other recreational purposes. Additionally, water from the municipal water systems was safe to drink. ATSDR also reported that DOE's selected remedial actions would protect public health. These actions include maintaining the fish consumption advisories; continuing environmental monitoring; implementing institutional controls to prevent disturbance, resuspension, removal, or disposal of contaminated sediment; and providing community and health professional education about the PCB contamination.

- *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, the National Center for Environmental Health (NCEH), the National Institute for Occupational Safety and Health (NIOSH), and DOE. This effort led to the establishment of the Public Health Working Group in 1999, which led to the establishment of the Oak Ridge Reservation Health Effects Subcommittee (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.

- *Oak Ridge Reservation Health Effects Subcommittee*. ORRHES was created 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 was established in 1999 by ATSDR and Centers for Disease Control and Prevention (CDC) under the authority of the Federal Advisory Committee Act (FACA) as a subcommittee of the U.S. Department of Health and Human Services' Citizens Advisory Committee on Public Health Service Activities and Research at DOE Sites. The Subcommittee consists of individuals who represent diverse interests, expertise, backgrounds, and communities, as well as liaison members from state and federal agencies. To help ensure citizen participation, meetings of the Subcommittee's work groups are open to the public and anyone may attend and present ideas and opinions. The Subcommittee performs the following functions:

  - Serves as a citizen advisory group to CDC and ATSDR and provides recommendations on matters related to public health activities and research at the ORR.

- Provides an opportunity for citizens to collaborate with agency staff members and to learn more about the public health assessment process and other public health activities.

- Helps to prioritize the public health issues and community concerns to be evaluated by ATSDR.

Figure 4 shows the organizational structure of the ORRHES and Figure 5 graphically demonstrates ways for the public to provide input into the ATSDR public health assessment process. For more information on the ORRHES, visit the ORRHES Web site at http://www.atsdr.cdc.gov/HAC/oakridge/index.html.

- *ORRHES Work Groups*. The ORRHES may create various work groups to conduct in-depth exploration of specific issues and present findings to the Subcommittee for deliberation. Work group meetings are open to all who wish to attend and participate. The following ORRHES work groups were established:

  - Agenda Work Group
  - Communications and Outreach Work Group
  - Health Education Needs Assessment Work Group
  - Public Health Assessment Work Group
  - Guidelines and Procedures Work Group

- *ATSDR Field Office*. In 2001, ATSDR opened a field office in Oak Ridge. The office was opened to promote collaboration between ATSDR and communities surrounding the ORR by providing community members with opportunities to become involved in ATSDR's public health activities at the ORR. The ATSDR field office is located at 1975 Tulane Avenue, Oak Ridge, Tennessee. ATSDR field office staff can be contacted by calling 865-220-0295.

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

ATSDR has conducted several additional analyses that are not documented here or in Appendix B, as have other agencies that have been involved with this site. Community members can find more information on ATSDR's past activities by the following three ways:

1. *Visit one of the records repositories.* Copies of ATSDR's publications for the ORR, along with publications from other agencies, can be viewed in records repositories at the Oak Ridge Public Library, the DOE Information Center in Oak Ridge, and the TDOH. For directions to these repositories, please contact the ATSDR Oak Ridge field office at 865-220-0295.

2. *Visit the ATSDR or ORRHES Web sites.* These Web sites include our past publications, schedules of future events, and other information materials. ATSDR's Web site is at www.atsdr.cdc.gov and the ORRHES site is at www.atsdr.cdc.gov/HAC/oakridge. The most comprehensive summary of past activities can be found at http://www.atsdr.cdc.gov/HAC/oakridge/phact/c_toc.html.

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

Figure 4. Organizational Structure for the Oak Ridge Reservation Health Effects Subcommittee

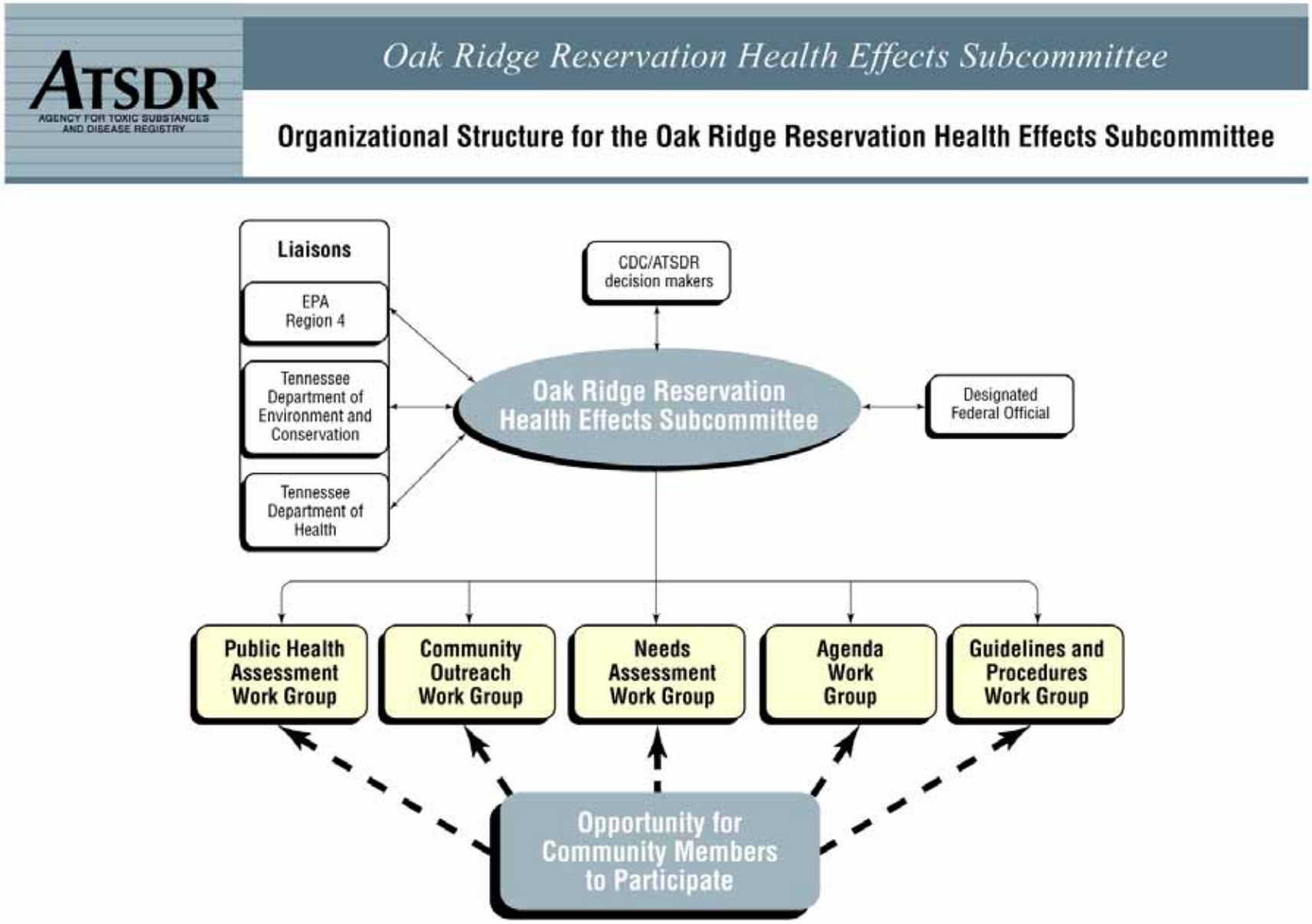
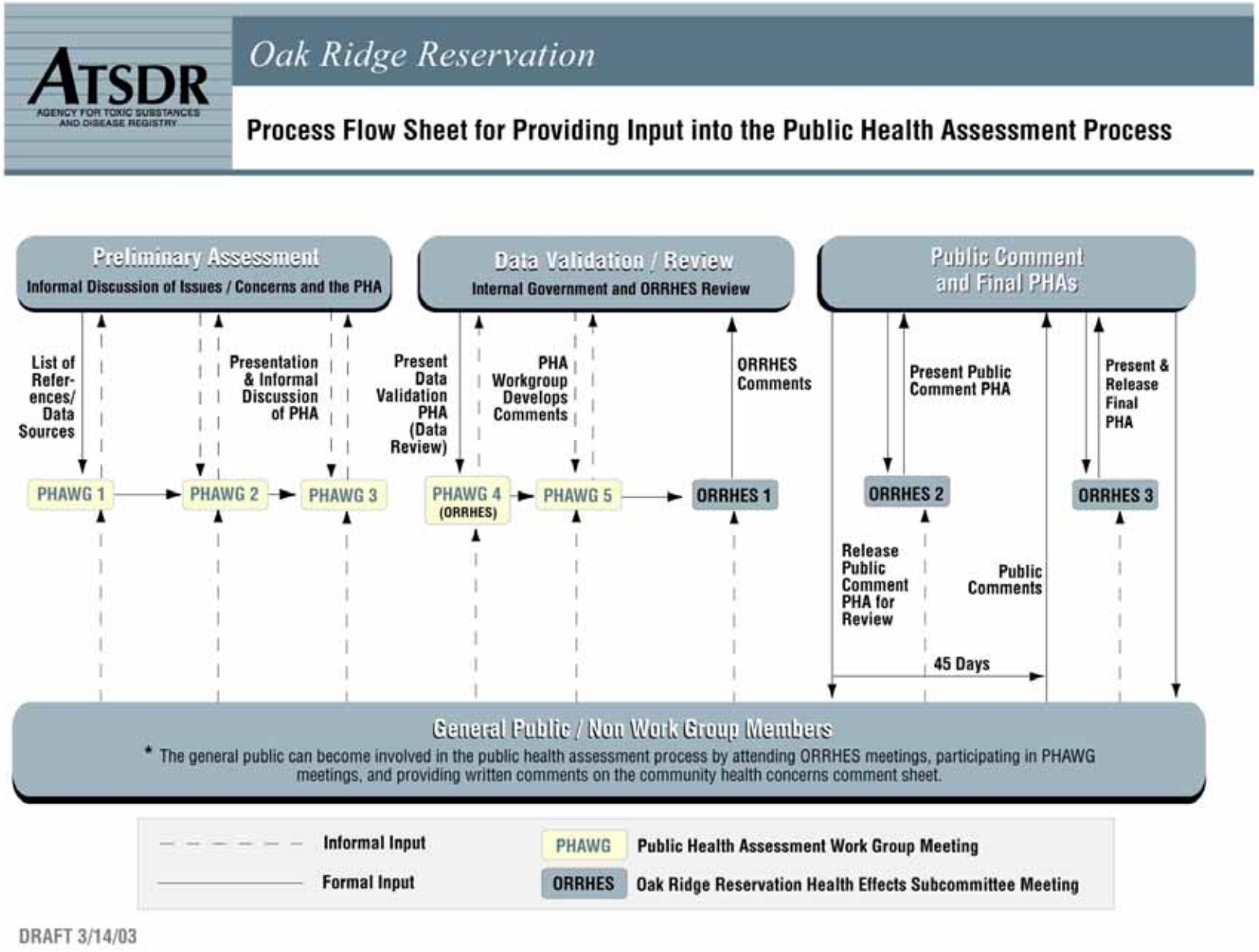


Figure 5. Process Flow Sheet for Providing Input into the Public Health Assessment



II.F.2. TDOH

Oak Ridge Health Studies. In 1991, DOE and the state of Tennessee entered into the Tennessee Oversight Agreement, which allowed the TDOH to undertake a two-phase independent state research project to determine whether past environmental releases from ORR operations harmed people who lived nearby (ORHASP 1999).

- *Phase I.* Phase I of the Oak Ridge Health Study is a Dose Reconstruction Feasibility Study. This feasibility study evaluated all past releases of hazardous substances and operations at the ORR. The objective of the study was to determine the quantity, quality, and potential usefulness of the available information and data on these past releases and subsequent exposure pathways. Phase I of the health studies began in May 1992 and was completed in September 1993. A brief summarizing the Phase I Feasibility Study is provided in Appendix I.

  The findings of the Phase I Dose Reconstruction Feasibility Study indicated that a significant amount of information was available to reconstruct the past releases and potential off-site exposure doses for four hazardous substances that may have been responsible for adverse health effects. These four substances include (1) radioactive iodine releases associated with radioactive lanthanum processing at X-10 from 1944 through 1956; (2) mercury releases associated with lithium separation and enrichment operations at the Y-12 plant from 1955 through 1963; (3) PCBs in fish from EFPC, the Clinch River, and the Watts Bar Reservoir; and (4) radionuclides from White Oak Creek associated with various chemical separation activities at X-10 from 1943 through the 1960s.

- *Phase II (also referred to as the Oak Ridge Dose Reconstruction).* Phase II of the health studies conducted at Oak Ridge began in mid-1994 and was completed in early 1999. Phase II primarily consisted of a dose reconstruction study focusing on past releases of radioactive iodine, radionuclides from White Oak Creek, mercury, and PCBs. In addition to the full dose reconstruction analyses, the Phase II effort also included additional detailed screening analyses for releases of uranium and several other toxic substances that had not been fully characterized in Phase I (a brief in Appendix I summarizes the Screening-Level Evaluation of Additional Potential Materials of Concern, Task 7). The significant findings for each of the substances evaluated are presented in the following paragraphs.

  - Radioactive iodine releases were associated with radioactive lanthanum processing at X-10 from 1944 through 1956. Results indicate that children who were born in the area in the early 1950s and who drank milk produced by cows or goats living in their yards, had an increased risk of developing thyroid cancer. The report stated that children living within a 25-mile radius of Oak Ridge were likely to have had an increased risk of more than 1 in 10,000 of developing thyroid cancer.

- The study evaluated mercury releases associated with lithium separation and enrichment operations at the Y-12 plant from 1955 through 1963. Results indicate that depending on their activities, individuals living in the area during the years that mercury releases were highest (mid-1950s to early 1960s) may have received annual average doses of mercury exceeding the EPA reference dose.

EPA's reference dose is an estimate of the largest amount of a substance that a person can take in on a daily basis over their lifetime without experiencing adverse health effects.

- Additional studies were conducted on PCBs in fish from EFPC, the Clinch River, and the Watts Bar Reservoir. Preliminary results indicated that individuals who consumed a large amount of fish from these waters might have received doses that exceeded the EPA reference dose for PCBs.

- Radionuclides associated with various chemical separation activities at the X-10 site from 1943 through the 1960s were released into White Oak Creek. Eight radionuclides (cesium 137, ruthenium 106, strontium 90, cobalt 60, cerium 144, zirconium 95, niobium 95, and iodine 131) deemed more likely to carry significant risks were studied. The results indicate that the releases caused small increases in the radiation dose of individuals who consumed fish from the Clinch River near the mouth of White Oak Creek. The dose reconstruction scientists estimated that a man who ate up to 130 meals of fish from the mouth of White Oak Creek every year for 50 years (worst-case scenario) would face an excess cancer risk ranging from 4 to 350 in 100,000. The risk from eating fish goes down proportionately for people who eat fewer fish and for people who eat fish caught farther downstream.

- Uranium was released from various large-scale uranium operations, primarily uranium processing and machining operations at the Y-12 plant and uranium enrichment operations at the K-25 and S-50 plants. Because uranium was not initially given high priority as a contaminant of concern, a Level II screening assessment for all uranium releases was performed. Preliminary screening indices were slightly below the decision guide of one chance in 10,000, which indicated that more work may be needed to better characterize uranium releases and possible heath risk. A brief summarizing the Task 6 report is provided in Appendix I.

- *The Oak Ridge Health Agreement Steering Panel (ORHASP)*—a panel of experts and local citizens—was appointed to direct and oversee the Oak Ridge Health Studies and provide liaison with the community. Based on the findings of the Oak Ridge Health Studies and what is generally known about the health risks posed by exposures to various toxic chemicals and radioactive substances, ORHASP concluded that past releases from ORR were likely to have affected the health of some people. Two groups most likely to have been harmed were (1) local children who drank milk produced by a "backyard" cow or goat in the early 1950s and (2) fetuses of women who routinely ate fish from

contaminated creeks and rivers downstream of ORR in the 1950s and early 1960s. The Panel made eight recommendations in their project summary report:

1. Three specific initiatives directed to public health intervention should be undertaken:

    a) In partnership with a local college or university, a series of workshops should be periodically conducted for local physicians and other health professionals who need to be educated on ORR environmental and occupational health issues arising from the Oak Ridge Health Agreement Studies and other related health studies, as results become available.

    b) In partnership with a local community college or community outreach program, a public information colloquium should be conducted to provide continuing dialogue and education on environmental and occupational health issues relevant to past, current, and future ORR operations.

    c) A partnership working group of local, state, and federal public health officials, health care professionals and representatives of the greater Oak Ridge community should be established to evaluate the need for a formal clinical evaluation process. If such a process is determined to be feasible, the group should formulate recommendations for the development of (1) a goal for a formal community clinical evaluation process; (2) the types of and qualifications for health care professionals who would be involved in the clinical evaluations of concerned members of the community; and (3) protocol guidelines for individual clinical evaluations and referral for follow-up examinations. The group suggested that the results contained in this report and the other reports published as part of the Oak Ridge Health Agreement Studies serve as a basis for the development of such protocol guidelines.

2. Formal epidemiologic studies of populations exposed to iodine 131, mercury, PCBs, and radionuclides from White Oak Creek are unlikely to be successful and should not be performed at this time.

3. DOE, EPA, the state (and perhaps other agencies) should undertake a coordinated program to obtain needed information and satisfy stakeholder concerns. A soil sampling program is vital to gain information relevant to the historic contamination levels in residential areas closest to the ORR plants. Detailed sampling is recommended in all of the most closely situated neighborhoods and also in a few residential areas at greater distances. Any decision about additional dose reconstruction studies should be deferred until the results of the recommended soil sampling program have been obtained and carefully interpreted.

4. DOE should undertake a program to measure the atmospheric dispersion of controlled tracer releases from representative stacks and vents at Y-12. The primary goal of these measurements would be to define the transport of a nondepositing tracer such as SF6 from the Y-12 plant to populated areas of Oak Ridge, including the Scarboro and Woodland communities, which are both relatively close to the plant.

5. More definitive information is needed to better understand the potential toxic effects of exposures to mixtures of contaminants—mercury and PCBs, for example—on the same organ systems. Studies relating to this topic should be undertaken by one or more appropriate government-sponsored public health research agencies.

6. DOE should take action to assure that copies of the important documents used in the health effects studies are properly indexed and retained at a secure location, irrespective of future shifts of contractor responsibility at the ORR facilities.

7. DOE should assure the long-term continuation of the ORR environmental monitoring program. The program should include routine measurements in critical media for those materials found to be most important in the health agreement studies, if the material in question could still be present in the local environment. Specifically, the ORR program should (a) continue to monitor the remaining environmental burden of mercury in EFPC within the Y-12 plant, in the lower EFPC floodplain, and in sediment in the downstream watercourses, tracking the resulting methyl mercury risk to consumers of fish taken from downstream fisheries; and (b) assure that the program continues to monitor uranium contamination originating from Y-12, with due consideration of isotopic form.

8. In the area of statewide health effects registries, (a) the state should continue efforts to improve the accuracy and completeness of the cancer incidence registry, and (b) the state should continue to seek funding for a statewide birth defects registry.

- *Feasibility of Epidemiologic Studies*. A study was conducted to explore the feasibility of initiating analytical epidemiological studies (for example, case-control or cohort) to address potential health concerns in the off-site populations surrounding the ORR. TDOH and the ORHASP contracted with a physician from Vanderbilt University's Department of Preventive Medicine to conduct the study. The study was released in July 1996. The study concluded that the feasibility and desirability of initiating future analytical epidemiologic studies would be significantly influenced by the findings of the dose reconstruction studies which will clarify the extent and magnitude of releases and possible human exposure from past releases of radioactive iodine, mercury, PCBs, uranium, and other radionuclides, including cesium 137.

- *Public Meetings*. Between January 1992 and December 1999, TDOH and ORHASP held open meetings in Oak Ridge (more than 40 meetings), Nashville (5 meetings), Harriman

(2 meetings), and Knoxville (3 meetings). In addition, the ORHASP held two meetings in the Scarboro area to update the residents on Phase II of the Oak Ridge Health Studies. The first meeting was held at the Oak Valley Baptist Church in November 1995, and the second meeting was held at the Scarboro Community Center in September 1997.

II.F.3. Other Agencies

Aerial Radiological Surveys and ORR Off-site Background. DOE and its predecessors on the ORR site and its immediate surroundings have performed aerial radiological surveys since 1959 and through to 1997, with increasing sophistication, as the methodology and detection capabilities have improved. Briefly, the present methodology is to calibrate during flight the aircraft-mounted instruments against a known radiation source, then survey the intended target area. The surveys are carried out at a constant airspeed and altitude. Any detected radiation sources are then investigated on the ground by standard survey techniques.

Around the ORR, including the Scarboro community, most of the "new" radiation sources are single-contour anomalies that show no elevated ground level readings. A single contour is defined as radiation that is limited in its area; that is, only a spot of radiation with no additional radiation detected at decreasing levels radiating from the central spot. If elevated readings within this single contour are found, the source of the radiation is determined. By this method, an inventory of known "off-site" radiation sources is established and maintained. They are included as "regions of interest" on the published radiation contour maps of the Oak Ridge area. They include such locations as the Atomic City Auto Parts, the CXS Railroad bed, and others related to past or current nuclear operations, as well as the Bull Run Steam plant where flyash from operations is stored (Maurer 1989).

The Chattanooga shale outcroppings containing elevated concentrations of uranium and its decay products occurring on East Fork Ridge and a few small cesium 137 deposits along the Clinch River during low water levels are both found by aerial survey. The Clinch River deposits have been studied by TDEC/Oak Ridge Operations (ORO) and deemed to be a non-hazard (Storms and Rector 1997).

Furthermore, the aerial surveys are sufficiently sensitive to detect sources that do not constitute a hazard. By implication, the aerial surveys will readily detect sources that do constitute a hazard. Except for a known few locations due to past or present operations, the off-site areas of Bear Creek and Union valleys, including residential areas of Oak Ridge, do not show any elevations of radiation above background. Thus, there is direct empirical evidence that the Union valley and Oak Ridge neighborhoods have not been contaminated.

Scarboro Community Health Investigation. In November 1997, a Nashville newspaper published an article about illnesses among children living near the nuclear weapons facility at the ORR in eastern Tennessee. The article described a high rate of respiratory illness among residents of the nearby community of Scarboro; it told of 16 children who had repeated episodes of "severe ear, nose, throat, stomach, and respiratory illnesses." Among those respiratory illnesses were asthma, bronchitis, sinusitis, allergic rhinitis, and otitis media. The article implied that exposure to the ORR caused these illnesses especially given the proximity of these children's residences to ORR

facilities. In response to this article, the Commissioner of the TDOH asked the CDC to work with the department to investigate the situation in Scarboro. The Scarboro Community Health Investigation, which included a community health survey and a follow-up medical evaluation of children under 18 years of age, was coordinated by TDOH to investigate a reported excess of respiratory illness among children in the Scarboro community. This investigation, both the survey and the examination components, was mainly designed to measure the rates of common respiratory illnesses among children who reside in Scarboro, compare these rates with national rates, and to determine if there were any unusual characteristics of these illnesses. The investigation was not designed to find what caused the illnesses.

In 1998, a study protocol was developed and a community health survey was administered to the members of each household in the community. The purpose of the survey was to determine whether the rates of certain diseases were higher in Scarboro than elsewhere in the United States and to determine whether exposure to various factors increased residents' risk for health problems. In addition, information regarding occupations, occupational exposures, and general health concerns was collected for adults. The participation/response rate of the health investigation survey was 83% (220/264 households) and included 119 questionnaires about children living in these households and 358 questionnaires about adults. In September 1998, CDC released the preliminary results of the survey. The asthma rate was 13% among children in Scarboro, compared to national estimates of 7% among all children aged 0–18 years and 9% among African-American children aged 0–18 years. The Scarboro rate was, however, within the range of rates from 6% to 16% reported in similar studies throughout the United States. The wheezing rate among children in Scarboro was 35%, compared to international estimates that range from 1.6% to 36.8%. With the exception of unvented gas stoves, no statistically significant association was found between exposure to common environmental triggers of asthma (that is, pests, environmental tobacco smoke, and the presence of dogs or cats in the home) or potential occupational exposures (such as living with an adult who works at the ORR or living with an adult who works with dust and fumes and brings exposed clothes home for laundering), and asthma or wheezing illness.

Based on the information obtained in the health investigation survey, 36 children, including those identified in the media report, were invited to receive a physical examination. These examinations were conducted in November and December 1998 to confirm the results of the community survey, to determine whether children with respiratory illnesses were getting the medical care they needed, and to determine whether the children reported in the newspaper to have respiratory medical problems really had these problems. Children who were invited to participate met one or more conditions: (1) severe asthma, defined as more than 3 episodes of wheezing or visiting an emergency room because of these symptoms; (2) severe undiagnosed respiratory illness, defined as more than 3 episodes of wheezing and visiting an emergency room because of these symptoms; (3) respiratory illness and no regular source of medical care; or (4) identified as having respiratory illness in newspaper reports. Of the 36 children invited, 23 participated in the physical examination. Some of the eligible 36 children had moved out of Scarboro; others either were not available or decided not to participate.

During the physical examination, nurses asked children who participated and their parents a series of questions about the health of the child; volunteer pediatricians reviewed the results of

the nurse interview and examined the children. In addition to direct physical examinations, children also underwent a blood test and a special breathing test. If the examining doctor thought the child needed an x-ray to complete the assessment, this was done. All examinations, tests, and transportation to and from Knoxville were provided free of charge.

Immediately after the examinations, the results were reviewed and none of the children had findings that needed immediate intervention. A number of laboratory tests were found to be either above or below the normal range, such as blood calcium level, blood hemoglobin level, or breathing test abnormality. Following the initial review of results, laboratory results were communicated by letter or telephone to the parents of the children and their doctors. If the parents did not want the results sent to a doctor, the results were given to the parents by telephone. The parents of children with any health concern identified as a result of the examination were sent a personal letter from Paul Erwin, M.D., of the East Tennessee Regional Office of the TDOH, informing them of the need for follow-up with their medical provider. If they did not have a medical provider, they were to contact Brenda Vowell, RNC, Public Health Nurse, East Tennessee Regional Office of the TDOH, for help in finding a provider and possible TennCare or Children's Special Service.

In January 1999, a team of physicians representing CDC, TDOH, the Oak Ridge medical community, and the Morehouse School of Medicine, thoroughly reviewed the findings of the physical examinations and the community survey. Of the 23 children who were examined, 22 had evidence of some form of respiratory illness (reported during the nurse interview or discovered during the doctor’s examination). Overall, the children appeared healthy and no problems that needed urgent management were identified. Several children had mild respiratory illnesses at the time of the examination; only one child had findings of an abnormality of the lungs at the time of the examination. None of the children had wheezing. The examinations did not indicate any unusual pattern of illness among children in Scarboro. The illnesses that were detected were not more severe than would be expected and were typical of those that might be found in any community. The findings of examinations essentially confirmed the results of the community health survey. The results of the review were presented on January 7, 1999, at a community meeting in Scarboro. The final report was released in July 2000. A brief summarizing this report is provided in Appendix I.

Three months after the letters went to the parents and physicians about the findings, attempts were made to telephone the parents of children who participated. Eight parents were successfully contacted. Because some of the parents had more than one child who was examined, questions addressed the health of 14 children. Parents of nine children could not be contacted despite attempts on several days to contact them by telephone.

Of the 14 children whose parents had been contacted, 7 had seen a doctor since the examinations. In most cases, the health of the child was the about the same, although one child had been hospitalized because of asthma, and another child’s asthma medication had been increased to treat worsening asthma. Several children had nasal allergies, and several parents mentioned difficulties in obtaining medicines because of cost and lack of coverage by TennCare for the particular medicines. Health department nurses subsequently have assisted these parents in getting the needed medicines.

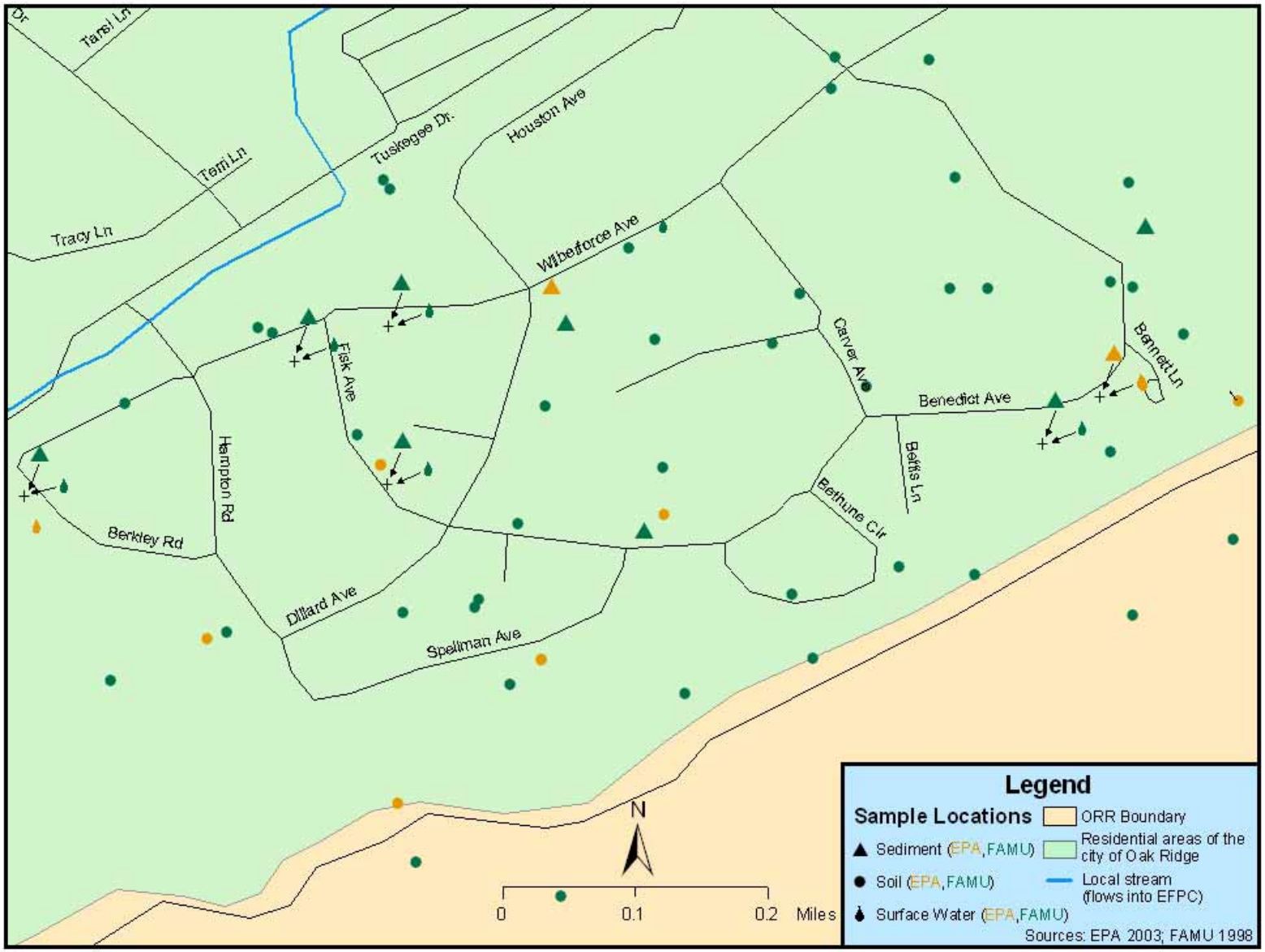
Scarboro Community Environmental Study. In 1998, soil, sediment, and surface water were sampled in the Scarboro community to address community concerns about environmental monitoring in the Scarboro neighborhood (see Figure 6 for sample locations). The analytical component of the study was conducted by the Environmental Sciences Institute at Florida Agricultural and Mechanical University (FAMU) and its contractual partners at the Environmental Radioactivity Measurement Facility at Florida State University and the Bureau of Laboratories of the Florida Department of Environmental Protection, and by DOE subcontractors in the Neutron Activation Analysis Group at the Oak Ridge National Laboratory. All samples were analyzed for mercury, gross alpha/beta content, uranium, and gamma emitting radionuclides. About 10% of the samples were also analyzed for target compound list organics, target analyte list inorganics, strontium 90, uranium, thorium, and plutonium.

Organic compounds were only detected in one of the samples tested. This same sample also contained lead and zinc at concentrations twice as high as that found in the *Background Soil Characterization Project* (DOE 1993). Mercury was found within the range given in the Background Soil Characterization Project, and about 10% of the soil samples showed evidence of enrichment in uranium 235. The final Scarboro Community Environmental Study was released in September 22, 1998, during a Scarboro community meeting (FAMU 1998). A brief summarizing this report is provided in Appendix I.

Scarboro Community Environmental Sampling Validation Study. In 2001, EPA's Science and Ecosystem Division Enforcement Investigation Branch collected soil, sediment, and surface water samples from the Scarboro community to respond to community concerns, identify data gaps, and validate the sampling performed by FAMU in 1998 (FAMU 1998) (see Figure 6 for sample locations). All samples were subjected to a full analytical scan, including inorganic metals, volatile organic compounds, semi-volatile organic compounds, radiochemicals, organochlorine pesticides, and PCBs. In addition, EPA collected uranium core samples from two locations in Scarboro and conducted a radiation walkover of the areas selected for sampling to determine whether radiation existed above background levels.

The level of radiation was below background levels and the radionuclide analytical values did not indicate a level of health concern. Uranium levels in the core soil samples were also below background levels. EPA concluded that the results support the sampling performed by FAMU in 1998, and that there is not an elevation of chemical, metal, or radionuclides above a regulatory health level of concern. The residents of Scarboro are not currently being exposed to harmful levels of substances from the Y-12 plant. The report stated that "based on EPA's results, the Scarboro community is safe. Therefore, additional sampling to determine current exposure is not warranted." A final report was released in April 2003 (EPA 2003). A brief summarizing this report is provided in Appendix I.

Figure 6. FAMU and EPA Sample Locations in Scarboro



III. EVALUATION OF ENVIRONMENTAL CONTAMINATION AND POTENTIAL EXPOSURE PATHWAYS

III.A. Introduction

In 2001, ATSDR scientists conducted a review and analysis of the Phase I and Phase II screening evaluation of TDOH's Oak Ridge Health Studies to identify contaminants that require further public health evaluation. In the Phase I and Phase II screening evaluation, the TDOH conducted extensive reviews of available information and conducted qualitative and quantitative analyses of past (1944–1990) releases and off-site exposures to hazardous substances from the entire ORR. On the basis of ATSDR's review and analysis of Phase I and Phase II screening evaluations, ATSDR scientists determined that past releases of uranium, mercury, iodine 131, fluorides, radionuclides from White Oak Creek, and PCBs require further public health evaluations. The public health assessment is the primary public health process ATSDR is using to further evaluate these contaminants. The public health assessment process will:

1. Identify populations off the site who may have been exposed to hazardous substances at levels of health concern.

2. Determine the public health implications of the exposure.

3. Address the health concerns of people in the community.

4. Recommend follow-up public health actions or studies to address the exposure.

ATSDR scientists are conducting public health assessments on the following releases: Y-12 releases of uranium, Y-12 releases of mercury, X-10 release of iodine 131, X-10 release of radionuclides from White Oak Creek, K-25 releases of uranium and fluoride, and PCBs released from all three facilities. Public health assessments will also be conducted on other issues of concern, such as the Toxic Substances Control Act (TSCA) incinerator and off-site groundwater. ATSDR is also screening current (1990 to 2003) environmental data to determine whether additional chemicals will require further evaluation.

This public health assessment on the Y-12 uranium releases evaluates and analyzes the information, data, and findings of previous studies and investigations of releases of uranium from the Y-12 plant and assesses the health implications of past and current uranium exposures to residents living near the ORR, specifically the residents of the reference community (that is, Scarboro).

III.A.1. Exposure Evaluation

What is meant by exposure?

ATSDR's public health assessments are driven by exposure or contact. Contaminants (chemicals or radioactive materials) released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to

a chemical contaminant if they come into contact with that contaminant. If no one comes into contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come into contact with the contaminants. In the case of radiological contamination, however, exposure can occur without direct contact because of the emission of radiation, which is a form of energy.

An exposure pathway has five elements: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. The source is the place where the chemical or radioactive material was released. The environmental media (such as, groundwater, soil, surface water, or air) transport the contaminants. The point of exposure is the place where persons come into contact with the contaminated media. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed are the receptor population.

The route of a contaminant's movement is the pathway. ATSDR identifies and evaluates exposure pathways by considering how people might come into contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical contaminant. Exposure to radiation can occur by being near the radioactive material.

How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate specific conditions of the site to determine whether people are being exposed to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, water, air, waste, or biota) is occurring through ingestion, dermal (skin) contact, or inhalation.

If exposure is possible, ATSDR scientists then consider whether environmental contamination is present at levels that might affect public health. ATSDR evaluates environmental contamination using available environmental sampling data and, in some cases, modeling studies. ATSDR selects contaminants for further evaluation by comparing environmental contaminant concentrations against **health-based comparison values.** Comparison values are developed by ATSDR from available scientific literature concerning exposure and health effects. Comparison values are derived for each of the media and reflect an estimated contaminant concentration that is not expected to cause harmful health effects for a given contaminant, assuming a standard daily contact rate (for example, the amount of water or soil consumed or the amount of air breathed) and representative body weight.

A comparison value is used by ATSDR to screen chemicals that require additional evaluation.

Comparison values are not thresholds for harmful health effects. ATSDR comparison values represent contaminant concentrations that are many times lower than levels at which no effects were observed in studies on experimental animals or in human epidemiologic studies. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (such as site-specific exposure, duration, and frequency) for health effects, including

the toxicology of the contaminant, other epidemiology studies, and the weight of evidence. Figure 7 illustrates ATSDR's chemical screening process.

More information about the ATSDR evaluation process can be found in ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/HAGM/ or by contacting ATSDR at 1-888-42-ATSDR. An interactive program that provides an overview of the public health assessment process ATSDR uses to evaluate whether people will be harmed by hazardous materials is available at: http://www.atsdr.cdc.gov/training/public-health-assessment-overview/html/index.html.

If someone is exposed, will they get sick?

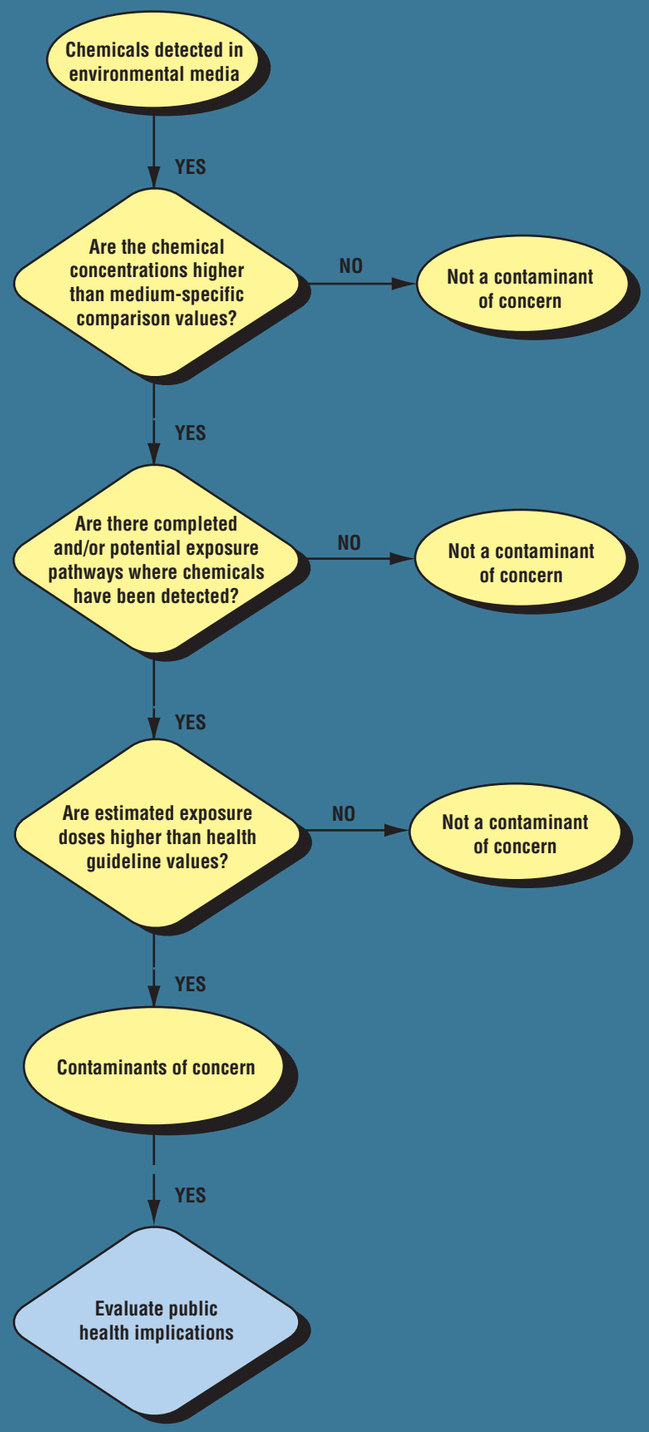
Exposure does not always result in harmful health effects. The type and severity of health effects that occur in an individual as the result of contact with a contaminant depend on the exposure concentration (how much), the frequency (how often) and duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how that individual absorbs, distributes, metabolizes, and excretes the contaminant. Taken together, these factors and characteristics determine the health effects that can occur as a result of exposure to a contaminant in the environment.

5/19/03

Figure 7. ATSDR Chemical Screening Process for Scarboro

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Decision Diagram



Results

Chemicals Detected in Soil, Sediment, and/or Surface Water

Acetic acid	cis-Chlordane	Manganese
Acetone	Cobalt	Mercury
alpha-Pinene	Copper	Nickel
Aluminum	Cyclotetrasiloxane	Potassium
Antimony	DDE p,p'-	Pyrene
Arsenic	DDT p,p'-	Selenium
Barium	Di-n-butyl phthalate	Silver
Benzene ethanamine	Dodacane	Sodium
Benzoic acid	Fluoranthene	Thallium
Beryllium	gamma-Chlordane	Toluene
Bromoform	Heptachlor	Uranium-235
Butyl benzyl phthalate	Heptachlor epoxide	Uranium-238
Cadmium	Iron	Vanadium
Calcium	Lead	Zinc
Chromium	Magnesium	

Chemicals Higher Than Comparison Values

Soil	Sediment	Surface Water
Arsenic	Arsenic	Arsenic
gamma-Chlordane	Iron	Lead
Heptachlor epoxide		
Iron		

Chemicals With Completed and/or Potential Exposure Pathways

Soil	Sediment	Surface Water
Arsenic	Arsenic	Arsenic
gamma-Chlordane	Iron	Lead
Heptachlor epoxide		
Iron		

Chemicals Higher Than Health Guidelines

Soil	Sediment	Surface Water
Arsenic		
Heptachlor epoxide		
Iron		

Public Health Implications Evaluation—
Weight of Evidence

Criteria

- Based on the results of environmental investigations
- Based on maximum exposure conditions
  - maximum concentration detected
  - maximum exposure duration
  - maximum exposure frequency
  - maximum exposure bioavailability

- Can or are exposures occurring
- Identify potential or completed exposure pathways

- Estimate doses based on site-specific exposure conditions
- Use more realistic exposure assumptions
  - realistic concentrations
  - realistic exposure duration
  - realistic exposure frequency
  - realistic exposure bioavailability
  - site-specific receptor population

- Evaluate the public health implications of contaminants of concern in greater detail

- Review toxicologic, medical, epidemiologic, and other scientific data on the contaminants of concern
- Evaluate whether contaminants of concern can affect public health in the vicinity of the site

III.A.2. Evaluating Exposures

To evaluate exposures to the reference population, Scarboro, ATSDR evaluated available past and current data to determine whether uranium concentrations were above natural background levels and/or ATSDR's comparison values. In the case of radiation doses, ATSDR calculated the doses based on site-specific data obtained from various environmental investigations and exposure factor sources. ATSDR also reviewed relevant toxicologic and epidemiologic data to obtain information about the toxicity of uranium (discussed in Appendix C). Both the chemical and radioactive properties of uranium can be harmful, and therefore they are evaluated separately.

It is important to remember that exposure to a certain contaminant does not always result in harmful health effects. The type and severity of health effects expected to occur depend on the exposure concentration, the toxicity of the contaminant, the frequency and duration of exposure, and the multiplicity of exposures.

III.A.2.a. Comparing Environmental Data to ATSDR's Comparison Values

ATSDR uses the term "conservative" to refer to values that are protective of public health in essentially all situations. Values that are overestimated are considered to be conservative.

Comparison values are derived using conservative exposure assumptions and health-based doses. Comparison values reflect concentrations that are much lower than those that have been observed to cause adverse health effects. Thus, comparison values are protective of public health in essentially all exposure situations. As a result, **concentrations detected at or below ATSDR's comparison values are not considered to warrant health concern**. While concentrations at or below the relevant comparison value can reasonably be considered safe, it does not automatically follow that any environmental concentration exceeding a comparison value would be expected to produce adverse health effects. **It cannot be emphasized strongly enough that comparison values are not thresholds of toxicity.** The likelihood that adverse health outcomes will actually occur depends on site-specific conditions, individual lifestyle, and genetic factors that affect the route, magnitude, and duration of actual exposure; an environmental concentration alone will not cause an adverse health outcome.

When evaluating chemical effects of uranium exposure, ATSDR scientists used comparison values that are specific to each environmental media. The comparison values used are shown in Table 2.

Table 2. Comparison Values for Uranium

Media	Comparison Value	Source
Air	0.3 µg/m^3	Chronic EMEG for highly soluble uranium salts
Surface water	20 µg/L	Intermediate child EMEG for highly soluble uranium salts
Soil	100 mg/kg	Intermediate child EMEG for highly soluble uranium salts
Fish	4.1 mg/kg	RBC for soluble uranium salts

µg/m^3: microgram per cubic meter
µg/L: microgram per liter
mg/kg: milligram per kilogram

ATSDR's environmental media evaluation guides (EMEGs) are nonenforceable, health-based comparison values developed for screening environmental contamination for further evaluation. EPA's risk-based concentration (RBC) is a health-based comparison value developed to screen sites not yet on the NPL, respond rapidly to citizens' inquiries, and spot-check formal baseline risk assessments.

III.A.2.b. Comparing Estimated Doses to ATSDR's Minimal Risk Level and Other Comparison Values

Deriving exposure doses

Exposure doses are expressed in milligrams per kilogram per day (mg/kg/day). When estimating exposure doses, health assessors evaluate chemical concentrations to which people could have been exposed, together with the length of time and the frequency of exposure. Collectively, these factors influence an individual's physiological response to chemical exposure and potential outcomes. Where possible, ATSDR used site-specific information regarding the frequency and duration of exposures. When site-specific information was not available, ATSDR employed several conservative exposure assumptions to estimate exposures.

A toxicologic dose is the amount of chemical a person is exposed to over time. The radiation dose is the amount of energy from radiation that is actually absorbed by the body.

The following general equation was used to calculate chemical exposure doses:

$$\text{Estimated exposure dose} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

where:

- C: Concentration of uranium
- IR: Intake Rate
- EF: Exposure Frequency, or number of exposure events per year of exposure
- ED: Exposure Duration, or the duration over which exposure occurs
- BW: Body Weight
- AT: Averaging Time, or the period over which cumulative exposures are averaged

The following general equation was used for estimating the committed effective dose or the committed equivalent dose (organ) resulting from internal radiation exposure:

$$\text{Estimated dose} = C \times IR \times EF \times DCF$$

where:

- C: Concentration of uranium (expressed as picocuries per unit mass)
- IR: Intake Rate (mass per time period)
- EF: Exposure Frequency, or number of exposure events per year of exposure

DCF: Dose Conversion Factor, dose coefficient as published by the International Commission on Radiological Protection (ICRP). The DCF takes into account a standard body weight of 70 kg.

Minimal Risk Level

Using the general equations given above, ATSDR derived toxicologic doses that residents living near the site may have received. As a first step, ATSDR compared these estimated site-specific doses against ATSDR's minimal risk levels (MRLs). MRLs are based on noncancer health effects only and are not based on a consideration of cancer effects. MRLs are derived when reliable and sufficient data exist to identify the target organs of effect or the most sensitive health effects for a specific duration for a given route of exposure. Proposed MRLs undergo a rigorous review process: Health Effects/MRL workgroup reviews within ATSDR's Division of Toxicology; expert panel of external peer reviews; and agency-wide MRL workgroup reviews, with participation from other federal agencies, including EPA; and are then submitted for public comment.

An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse *noncancer* health effects over a specified duration of exposure. These substance-specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors to identify contaminants and potential health effects that are not expected to cause adverse health effects. It is important to note that MRLs are not intended to define cleanup or action levels. MRLs are intended only to serve as a screening tool to help public health professionals decide where to look more closely.

MRLs are derived for hazardous substances using the no-observed-adverse-effect level (NOAEL)/uncertainty factor approach. They are below levels that might cause adverse health effects in the people most sensitive to such effects. Most MRLs contain a degree of uncertainty because of the lack of precise toxicologic information on the people who might be most sensitive (for example, infants, the elderly, or persons who are nutritionally or immunologically compromised) to the effects of hazardous substances. Consistent with the public health principle of prevention, ATSDR uses a conservative (that is, protective) approach to address this uncertainty.

MRLs are generally based on the most sensitive end point considered to be of relevance to humans. Serious health effects (such as birth defects or irreparable damage to the liver or kidneys) are not used as a basis for establishing MRLs. **Estimated doses that are less than these values are not considered to be of health concern.** However, exposure to levels above the MRL does not automatically mean that adverse health effects will occur. To maximize human health protection, MRLs have built-in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. The result is that even if a dose is higher than the MRL, it does not necessarily follow that harmful health effects will occur. Rather, it is an indication that ATSDR should further examine the harmful effect levels reported in the scientific literature and more fully review exposure potential.

Table 3 shows the MRLs developed for uranium. Figures 8 and 9 compare the chemical doses and concentrations, respectively, for ingestion and inhalation of uranium. Figure 10 shows ATSDR's process of determining radiological doses. More detailed information is available in two ATSDR publications: the *Toxicological Profile for Uranium* (ATSDR 1999a) and the *Toxicological Profile for Ionizing Radiation* (ATSDR 1999b). Additional information about the toxicologic implications of uranium exposure is provided in Appendix C.

Other Comparison Values

When evaluating the carcinogenic effects of radiation from uranium exposure, ATSDR scientists use the dose of 5,000 millirem (mrem) over 70 years as the radiogenic cancer comparison value. This value is a committed effective dose equivalent (CEDE) calculated from the intake of uranium, with the assumption that the entire dose (a 70-year dose, in this case)[3] is received in the first year following the intake. Doses below this value are not expected to result in adverse health effects. ATSDR derived this value 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 committed effective dose equivalent (CEDE) is the radiation dose accumulated over a 70-year exposure and assuming the entire 70-year dose is received in the first year following intake of a radioactive substance. By definition, the CEDE is 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 CEDE is used in radiation safety because it implicitly includes the relative carcinogenic sensitivity of the various tissues.

III.A.2.c. Comparing Estimated Doses to Health Effects Levels

If the MRLs or radiogenic cancer comparison value are exceeded, ATSDR examines the health effects levels discussed in the scientific literature and more fully reviews exposure potential. ATSDR reviews available human studies as well as experimental animal studies. This information is used to describe the disease-causing potential of a particular chemical and to compare site-specific dose estimates with doses shown in applicable studies to result in illness (known as the margin of exposure). This process enables ATSDR to weight the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

[3] 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 to be protective of public health.

Table 3. ATSDR's Minimal Risk Levels (MRLs) for Uranium

Route	Duration	Form	MRL Value	Dose Endpoint	Source
Inhalation	Intermediate	Soluble	0.0004 mg/m^3	LOAEL; Minimal microscopic lesions in the renal tubules in half the dogs examined were observed at doses of 0.15 mg/m^3.	Rothstein 1949a
Inhalation	Intermediate	Insoluble	0.008 mg/m^3	NOAEL; No adverse health effects were observed in dogs exposed to doses of 1.1 mg/m^3.	Rothstein 1949b
Inhalation	Chronic	Soluble	0.0003 mg/m^3	NOAEL; No adverse health effects were observed in dogs exposed to doses of 0.05 mg/m^3.	Stokinger et al. 1953
Oral	Intermediate		0.002 mg/kg/day	LOAEL; Renal toxicity was observed in rabbits exposed to doses of 0.05 mg/kg/day.	Gilman et al. 1998b
External Radiation	Acute	Ionizing Radiation	400 mrem	NOAEL; The difference of 0.3 IQ point in intelligence test scores between separated and unseparated identical twins is considered the NOAEL.	Burt 1966
External Radiation	Chronic	Ionizing Radiation	100 mrem/year	NOAEL; The annual dose of 360 mrem/year has not been associated with adverse health effects in humans or animals.	BEIR V 1990

Sources: ATSDR 1999a, 1999b

Acute duration is defined as less than or equal to 14 days.
Intermediate duration is defined as 15 to 364 days.
Chronic duration is defined as exposures exceeding 365 days.
The no-observed-adverse-effect level (NOAEL) is the highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.
The lowest-observed-adverse-effect level (LOAEL) is the lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.
The MRL level 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.
The rabbit is the mammalian species most sensitive to uranium toxicity and is likely to be even more sensitive than humans.
mg/m^3: milligram per cubic meter
mg/kg/day: milligram per kilogram per day
mrem: millirem
mrem/year: millirem per year

Figure 8. Comparison of Uranium Chemical Doses (Ingestion)

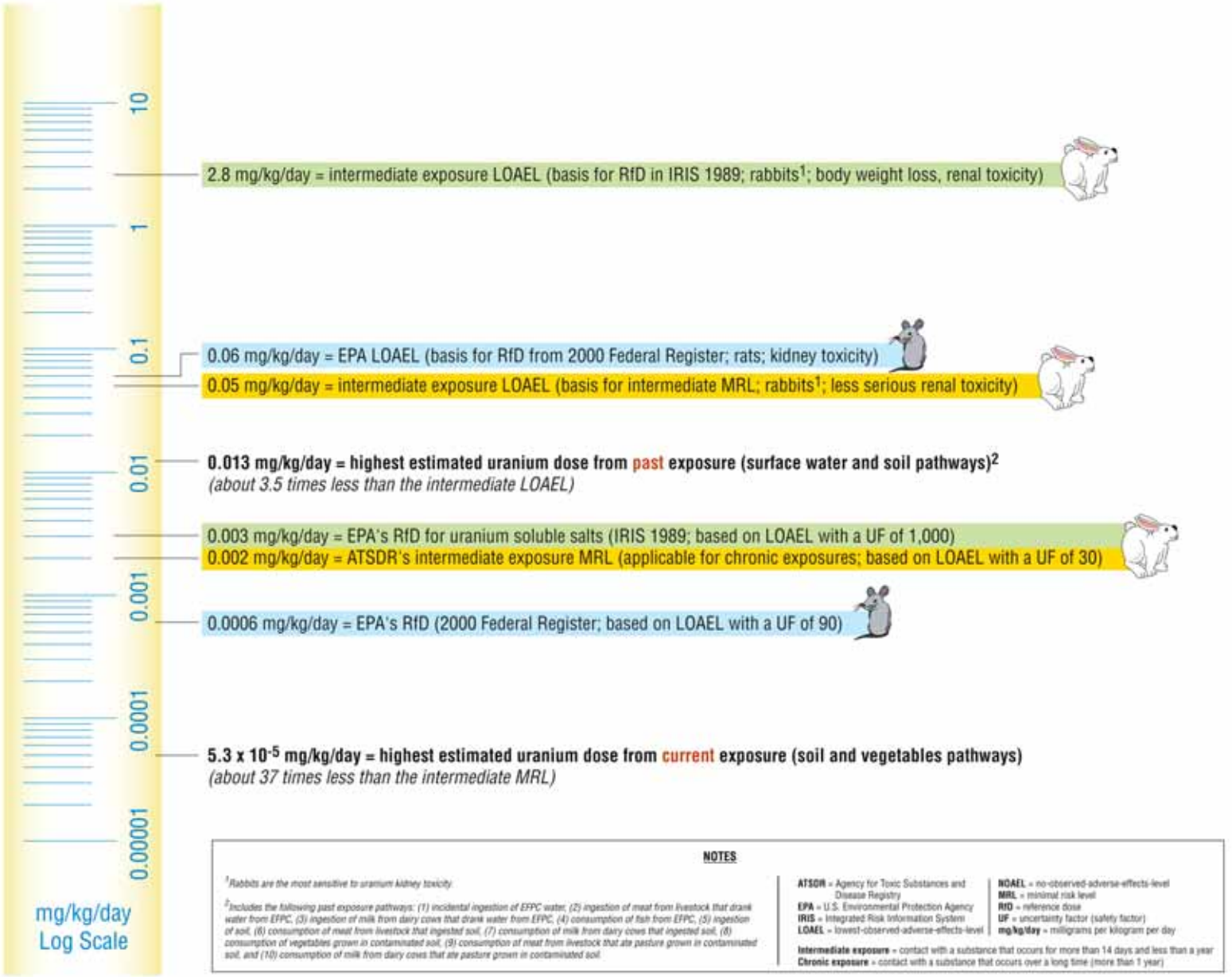


Figure 9. Comparison of Uranium Chemical Doses (Inhalation)

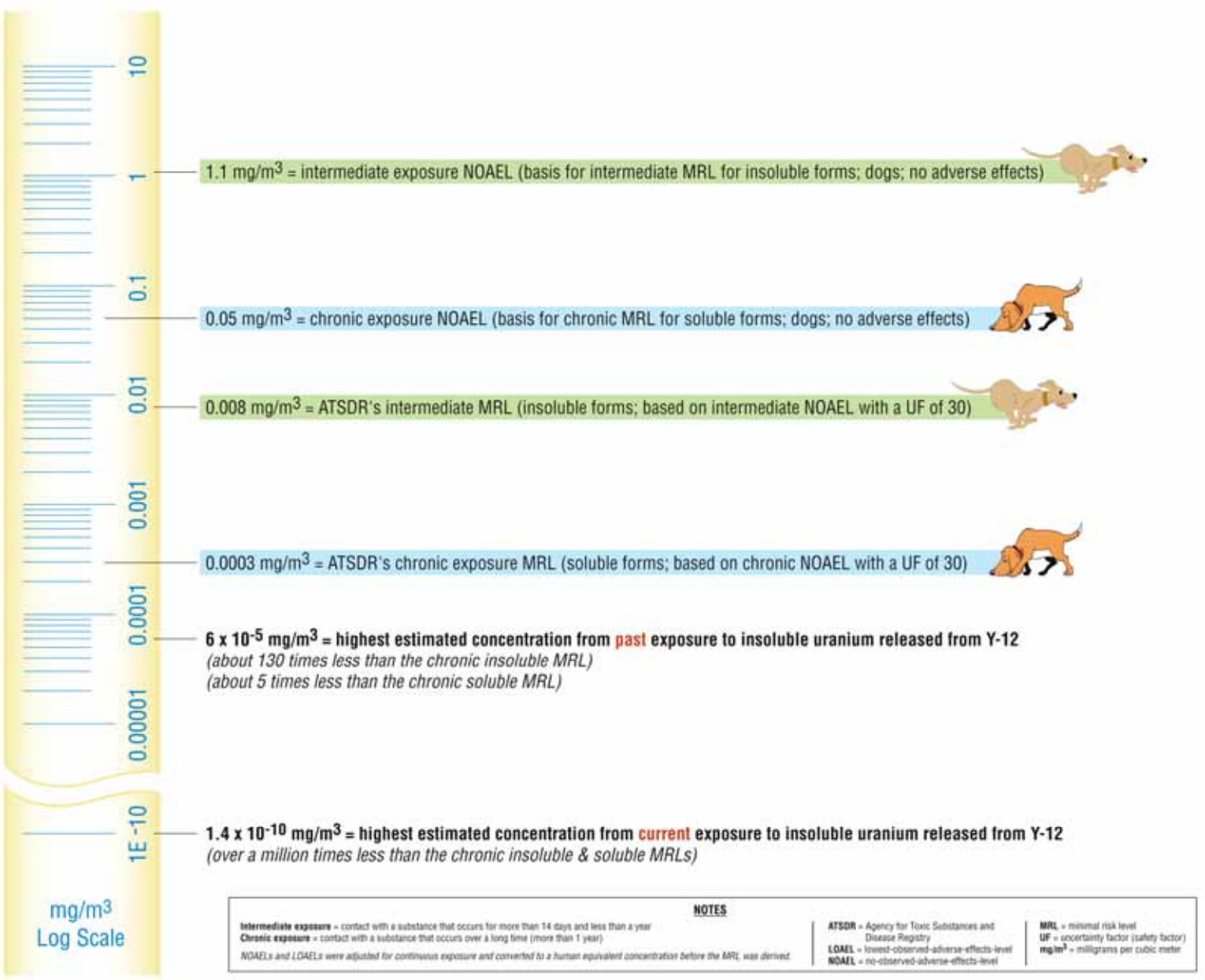
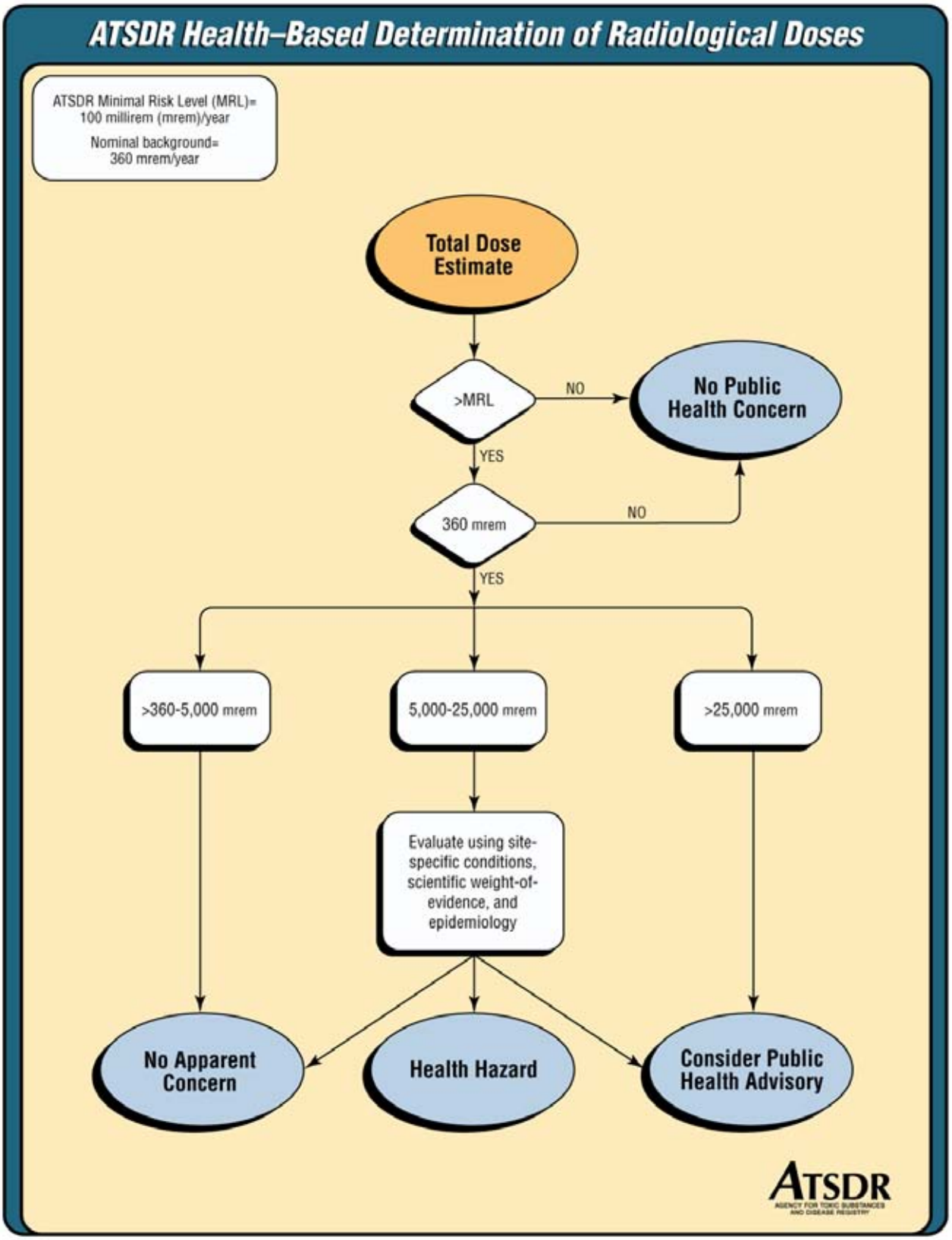


Figure 10. ATSDR Health-Based Determination of Radiological Doses



III.B. Public Health Evaluation

ATSDR evaluated past and current exposure to uranium released from the Y-12 plant and found that the levels of uranium to which people were exposed were too low to be a health hazard for both radiation and chemical health effects.

III.B.1. Past Exposure (1944–1995)

The meteorological data indicates that the predominate wind directions at the Y-12 plant are southwest and northeast, generally up and down Bear Creek valley, between Pine Ridge and Chestnut Ridge with limited winds crossing over the ridges. Most of the uranium would deposit up and down the Bear Creek valley and Union valley. However, no one lives in these valleys. The city of Oak Ridge is the only established community where residents resided during the years of uranium releases that could have been impacted by Y-12 uranium releases. The Scarboro community located within the city of Oak Ridge was selected as a reference location to estimate concentrations of uranium in the air, surface water, and soil in an off-site area where residents resided during years of past Y-12 plant uranium releases.

Furthermore, the Task 6 team identified Scarboro as the reference location using air dispersion modeling, specifically EPA's Industrial Source Complex Short Term (ISCST3) dispersion model, Version 96113 (USEPA 1995 as cited in ChemRisk 1999). Ground-level uranium air concentrations were estimated for a 40 by 47 kilometer grid to quantitatively relate past Y-12 plant uranium release rates to resulting average airborne uranium concentrations at locations surrounding the reservation. Using this method, the Task 6 team was able to identify off-site locations with the highest estimated uranium air concentrations. 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). Scarboro represents an established community adjacent to the Y-12 plant with the highest estimated uranium air concentrations.

Therefore, in this evaluation, conclusions regarding exposure of Scarboro residents to uranium are also applicable to residents living in the city of Oak Ridge.

ATSDR evaluated both the radiation and chemical aspects of past uranium exposure. Neither the total radiation dose,[4] nor the chemical ingestion and inhalation doses from exposure to uranium released from the Y-12 plant in the past would cause harmful health effects for people living near ORR, including those in the Scarboro community.

[4] The total radiation dose for past exposures is the sum of both internal and external exposures to the air, surface water, and soil pathways.

III.B.1.a. Past Radiation Effects

ATSDR evaluated whether off-site exposure to past levels of uranium released from the Y-12 plant would cause harmful radiation effects in communities near the Y-12 plant, especially the reference location (the Scarboro community), which is considered the area that would have received the highest off-site exposures. The total past radiation dose (155 mrem, discussed in the next paragraph) the reference population received from Y-12 uranium is well below levels of health concern and is not expected to have caused any adverse health effects in the past. Therefore, the past releases of uranium from the Y-12 plant are not a health hazard for people living near the Y-12 plant.

ATSDR used the screening results from the Task 6 report to evaluate past uranium releases to the environment from the Y-12 plant and past uranium exposures to residents living near the Y-12 plant. During the development of the Task 6 report, uranium radiation doses from the air, surface water, and soil pathways were estimated for the reference location, Scarboro, using a 52-year exposure scenario (Figure 11 shows the exposure pathways evaluated).

To evaluate potential radiation health effects to the population in Scarboro, ATSDR adjusted the Task 6 committed effective dose equivalents (CEDEs) to be equivalent to a 70-year exposure (see Table 4).[5] The total past uranium radiation dose received by the reference population, the Scarboro community, from multiple routes of internal and external exposure pathways is a CEDE of 155 millirem (mrem) over 70 years. This total past radiation dose is well below (32 times less than) the ATSDR radiogenic cancer comparison value of a CEDE of 5,000 mrem over 70 years (see Figure 12). ATSDR derived this radiogenic cancer comparison value after reviewing the peer-reviewed literature and other documents developed to review the health effects of ionizing radiation (Appendix D provides more information about ATSDR's derivation of the radiogenic cancer comparison value of 5,000 mrem over 70 years). This radiogenic cancer comparison value assumes that from the intake of uranium, the entire radiation dose (a 70-year dose, in this case) is received in the first year following the intake. Doses below this value are not expected to result in adverse health effects. Therefore, ATSDR does not expect carcinogenic health effects (cancer) to have occurred from past radiation doses received from past Y-12 uranium releases.

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 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 in the first year which is well below (45 times less than) the 100 mrem/year ATSDR chronic exposure MRL for ionizing radiation (see Figure 12). The ATSDR MRLs are based on noncancer health effects only and are not based on a consideration of cancer

[5] The committed effective dose equivalents (CEDEs) from the Task 6 Level II screening evaluation were converted from Sievert (Sv) to mrem by multiplying by 10^5. These CEDE values were then multiplied by 1.35 (70 years/52 years) for comparison with the ATSDR radiogenic cancer comparison value, which is based on a 70-year exposure.

effects. The ATSDR MRL of 100 mrem/year for chronic ionizing radiation exposure is derived by dividing the average annual effective dose to the U.S. population (360 mrem/year) by a safety factor of 3 to account for human variability (ATSDR 199b). The average U.S. annual effective dose of 360 mrem/year is obtained mainly from naturally occurring radioactive material, medical uses of radiation, and radiation from consumer products (see Figure 12) (BEIR V 1990 as cited in ATSDR 1999b). This average annual background effective dose of 360 mrem/year has not been associated with adverse health effects in humans or animals (ATSDR 1999b). ATSDR believes the chronic ionizing radiation MRL of 100 mrem/year is below levels that might cause adverse health effects in persons most sensitive to such effects; therefore, ATSDR does not expect noncancer health effects to have occurred from radiation doses received from past Y-12 uranium releases.

Table 4. Total Past Uranium Radiation Dose to the Scarboro Community

Exposure Pathway	Isotope	Committed Effective Dose Equivalents (CEDE) in mrem over 70 years	Total CEDE for Each Exposure Pathway in mrem over 70 years
Sum of doses from the air pathway	U 234/235	34	40
	U 238	6	
Sum of doses from the surface water (EFPC) pathway	U 234/235	27	49
	U 238	22	
Sum of doses from the soil pathway	U 234/235	38	66
	U 238	28	
Total across all media	U 234/235	99	**155**
	U 238	56	

Source: ChemRisk 1999

The Task 6 level II CEDEs were converted from Sievert (Sv) to mrem by multiplying by 10^5. In addition, the values were multiplied by 1.35 (i.e., 70 years/52 years) for comparison with the ATSDR radiogenic cancer comparison value, which is based on a 70-year exposure.

Figure 11. Exposure Pathways Evaluated

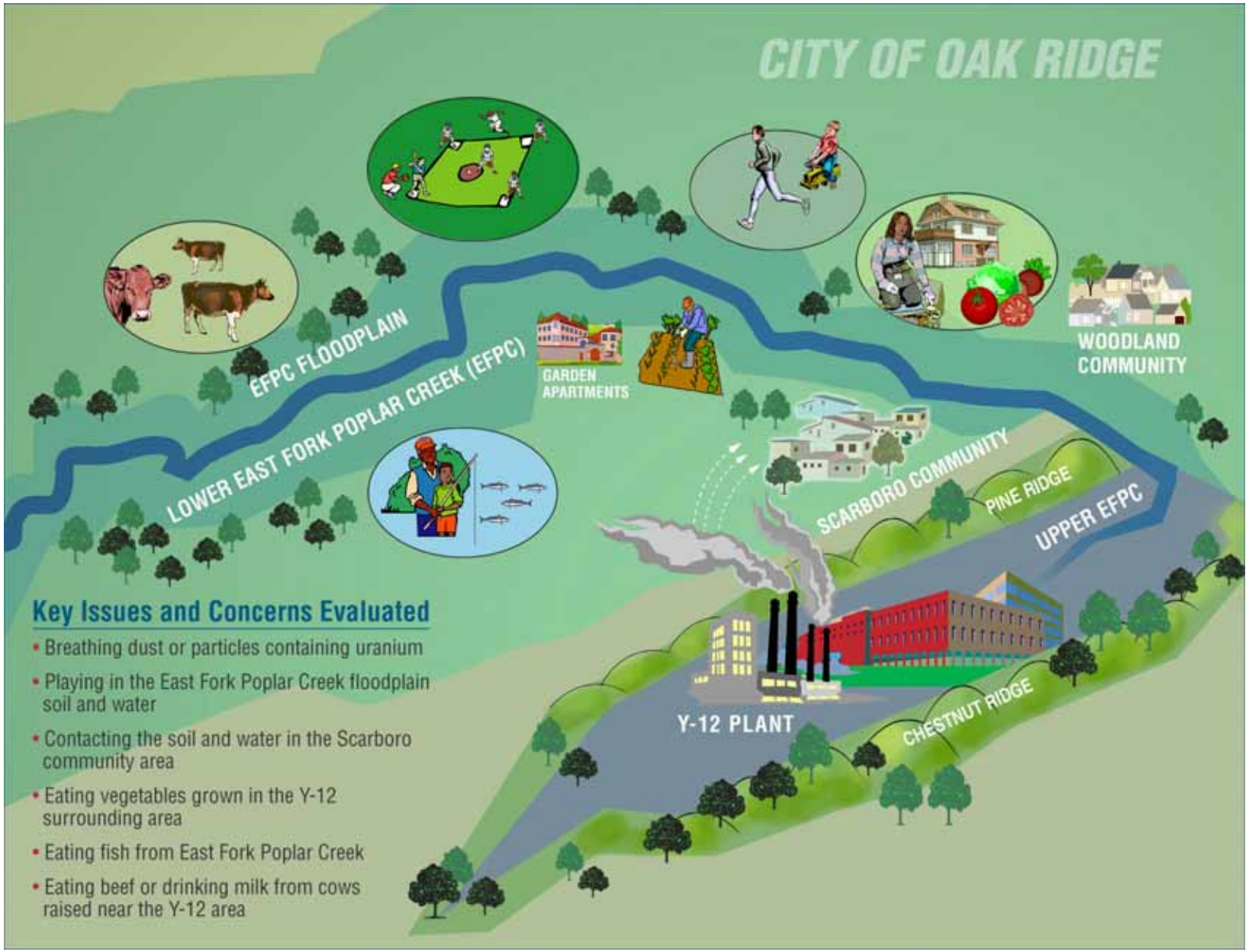
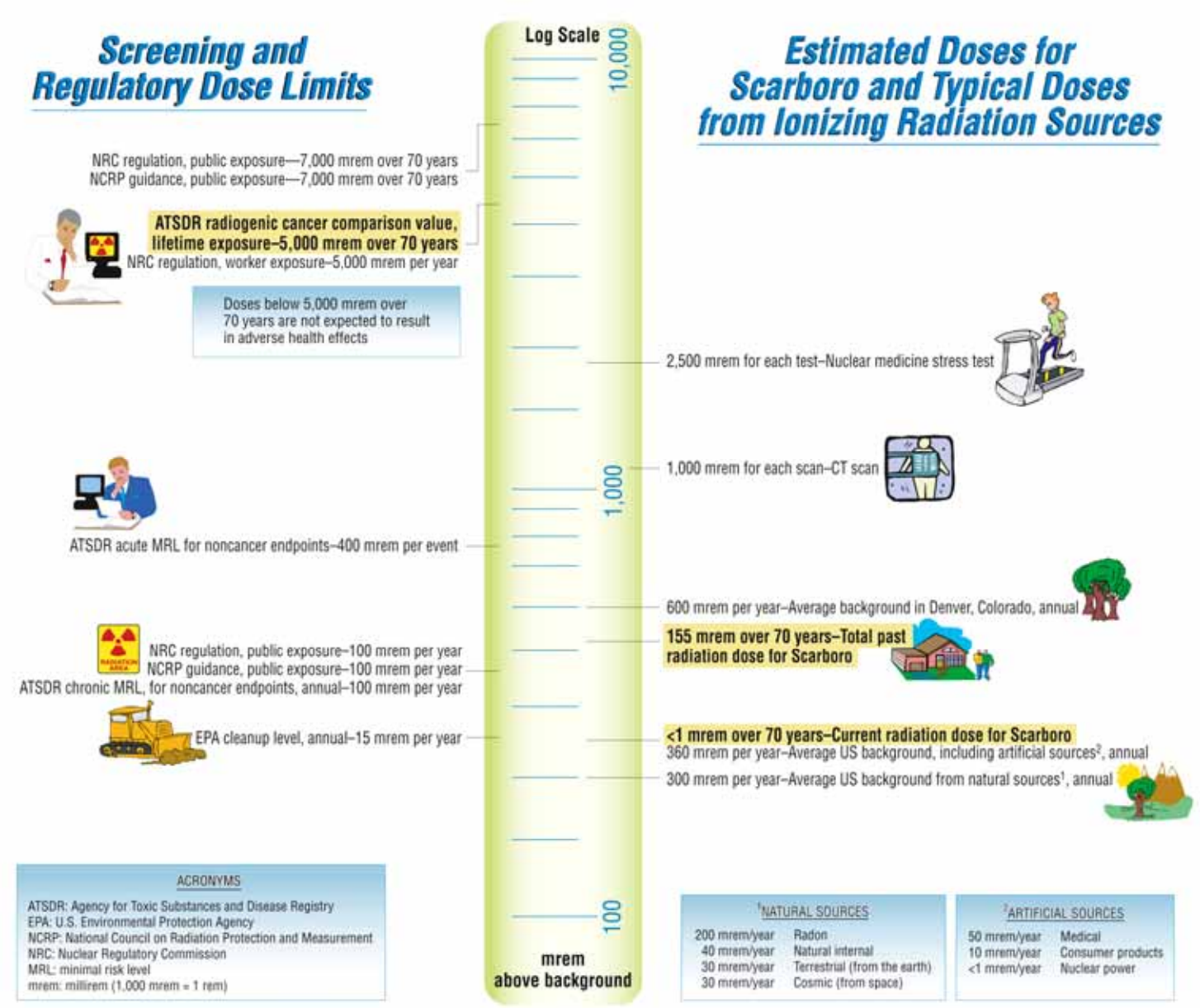


Figure 12. Comparison of Radiation Doses



Additionally, it should be noted that several levels of conservatism were built into the Task 6 evaluation of past exposures. The Task 6 values that ATSDR relied on to evaluate past exposures came from a screening evaluation that routinely and appropriately used conservative and protective assumptions and approaches, which led to an overestimation of concentrations and doses. Even using these overestimated concentrations and doses, persons in the reference community, Scarboro, were exposed to levels of uranium that are not expected to cause health effects. Following is a list of conservative aspects in this evaluation.

1. The majority of the total uranium radiation 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. 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 (χ is chi) 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. A detailed discussion of linear regression evaluation by ATSDR is provided in Appendix E.

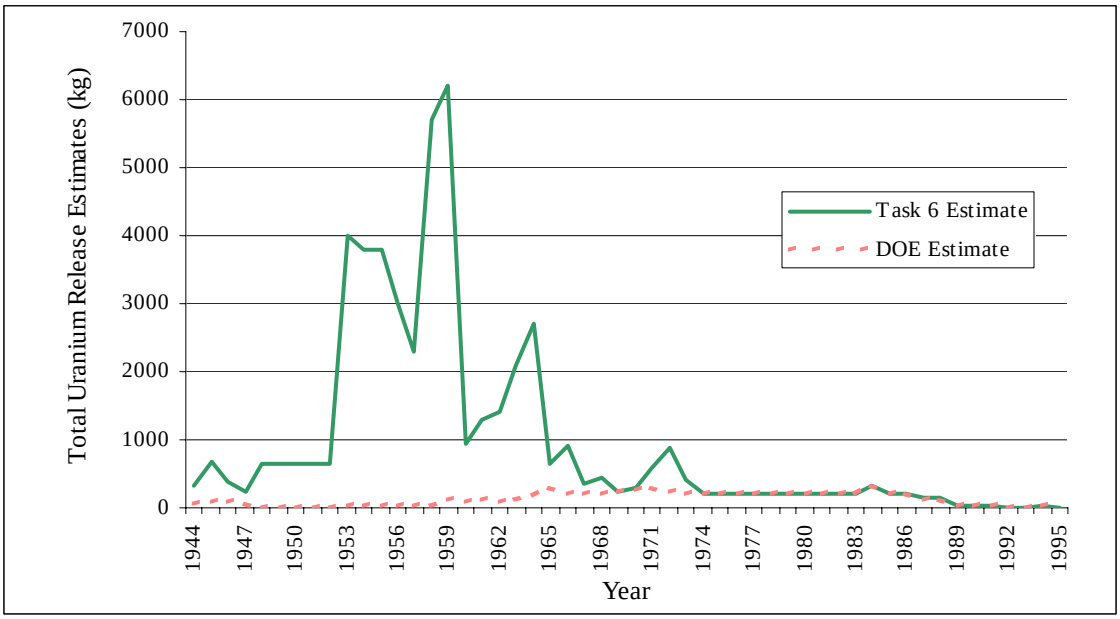
4. In evaluating the soil exposure pathway, the Task 6 team used EFPC floodplain soil data to calculate doses. Actual measured uranium concentrations in Scarboro soil are much lower than the uranium concentrations in the floodplain soil. Consequently, the uranium doses that were estimated for the residents 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.

This conservatism and overestimation, used in the Task 6 evaluation, resulted in overestimation of radiation doses from uranium that the reference population, Scarboro, was exposed to in the past; however, even those overestimated doses were below levels of health concern. Therefore, residents living near the Y-12 plant would not be expected to have any adverse health effects from past exposure to uranium. Each past exposure pathway is evaluated separately in the following sections.

Past Air Exposure Pathway

The Task 6 team independently evaluated past Y-12 airborne uranium releases and generated release estimates much higher than those previously reported by DOE (see Figure 13 and Table 5). They attributed the difference to DOE's use of incomplete sets of effluent monitoring data and release documents, along with their use of release estimates based on effluent monitoring data not adequately corrected to account for sampling biases (ChemRisk 1999). It is ATSDR's understanding that DOE and the community have not disputed the release estimates generated by the Task 6 team. Please see Section 2.0 in the Task 6 report for more details about how the airborne uranium release estimates were determined.

Figure 13. Annual Airborne Uranium Release Estimates for the Y-12 Plant



Source: ChemRisk 1999

Table 5. Annual Airborne Uranium Release Estimates for the Y-12 Plant (1944–1995)

Year	Task 6 Estimate (kg)	DOE Estimate (kg)	Year	Task 6 Estimate (kg)	DOE Estimate (kg)
1944	310	55	1970	300	259
1945	670	102	1971	580	290
1946	390	102	1972	870	222
1947	250	55	1973	410	206
1948	650	0	1974	210	207
1949	650	0	1975	210	209
1950	650	0	1976	210	207
1951	650	0	1977	210	206
1952	650	0	1978	210	205
1953	4,000	30	1979	210	206
1954	3,800	32	1980	220	218
1955	3,800	32	1981	210	207
1956	3,000	43	1982	210	207
1957	2,300	41	1983	210	208
1958	5,700	41	1984	330	329
1959	6,200	120	1985	210	210
1960	930	99	1986	210	211
1961	1,300	109	1987	150	116
1962	1,400	100	1988	150	116
1963	2,100	103	1989	44*	44
1964	2,700	170	1990	21*	21
1965	640	281	1991	21*	21
1966	920	212	1992	7*	7
1967	340	212	1993	3*	3
1968	440	211	1994	24*	24
1969	250	223	1995	2*	2
			Total	**50,000**	**6,535**

Source: ChemRisk 1999

* Values for 1989 to 1995 were based on releases reported by DOE. Release estimates for these years were not independently reconstructed during the dose reconstruction.

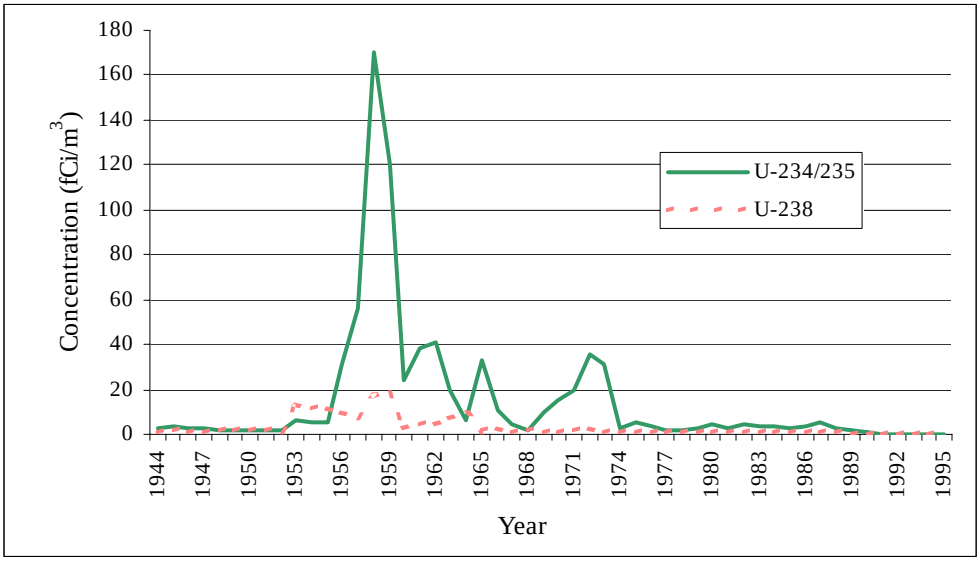
Using Task 6's newly generated annual airborne uranium release estimates for the Y-12 plant from 1944 to 1995 and the measured air radioactivity concentrations from DOE air monitoring station 46, located in the reference location of Scarboro, from 1986–1995 (DOE began monitoring station 46 in 1986), the Task 6 team used an empirical χ/Q (χ is chi) approach to estimate average annual air radioactivity concentrations in Scarboro from the 1944 to 1995 Y-12 plant uranium releases (see Figure 14 and Table 6). The empirical χ/Q is the ratio of measured air radioactivity concentration (air monitoring station 46 data) to release rate (Task 6 annual airborne uranium release estimates). Please see Section 3.0 in the Task 6 report for more details about how the uranium air concentrations were estimated.

The Task 6 team used these average annual U 234/235 and U 238 air radioactivity concentrations based on the empirical χ/Q method to calculated past uranium CEDEs to the Scarboro community via the air exposure pathways. These past uranium CEDEs for each air exposure pathway in Scarboro were summed to calculate the past U 234/235 CEDE of 34 mrem and the

past U 238 CEDE of 6 mrem from the air pathway (see Table 4). The total uranium CEDE from the air exposure pathway in Scarboro, after being adjusted to reflect a 70-year exposure, is 40 mrem.

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 (ChemRisk 1999). This would cause the empirical χ/Q values to also be overestimated and in turn would cause the estimated average air radioactivity concentrations in Scarboro to be overestimated (ChemRisk 1999).

Figure 14. Task 6 Estimated Average Annual Air Radioactivity Concentrations in Scarboro from Y-12 Uranium Releases



Source: ChemRisk 1999

Table 6. Task 6 Estimated Average Annual Air Radioactivity Concentrations in Scarboro from Y-12 Uranium Releases (1944–1995)

Year	U 234/235 (fCi/m^3)	U 238 (fCi/m^3)	Year	U 234/235 (fCi/m^3)	U 238 (fCi/m^3)
1944	2.4	1.1	1970	15	0.91
1945	4.0	2.2	1971	20	1.8
1946	3.0	1.3	1972	36	2.7
1947	2.5	0.81	1973	31	1.2
1948	1.6	2.1	1974	2.7	0.67
1949	1.6	2.1	1975	5.0	0.67
1950	1.6	2.1	1976	3.2	0.67
1951	1.6	2.1	1977	1.6	0.67
1952	1.6	2.1	1978	1.7	0.67
1953	6.5	13	1979	2.3	0.67
1954	5.6	12	1980	4.6	0.71
1955	5.7	12	1981	2.8	0.67
1956	31	10	1982	4.7	0.66
1957	56	7.8	1983	4.0	0.67
1958	170	17	1984	3.4	1.1
1959	120	19	1985	2.7	0.68
1960	24	3.0	1986	3.4	0.69
1961	38	4.2	1987	5.7	0.48
1962	41	4.5	1988	2.9	0.47
1963	20	6.8	1989	1.4	0.024
1964	6.5	8.8	1990	0.77	0.014
1965	33	2.0	1991	0.38	0.063
1966	11	3.0	1992	0.36	0.022
1967	1.9	1.1	1993	0.29	0.0093
1968	2.2	1.4	1994	0.31	0.078
1969	9.4	0.77	1995	0.17	0.0055

Source: ChemRisk 1999

fCi/m^3 is femtocuries per cubic meter. 1 femtocurie equals 1×10^{-15} curies.
Concentrations were estimated using the empirical χ/Q approach.
All values are rounded to two significant figures.

ATSDR evaluated the Task 6 methodology for estimating annual average air radioactivity concentrations in Scarboro from Y-12 uranium releases relative to measured uranium air radioactivity concentrations at the DOE air monitoring station 46 in Scarboro from 1986 to 1995. According to ATSDR's evaluation, the Task 6 empirical χ/Q estimation of the average U 234/235 air radioactivity concentrations consistently overestimated the concentrations in Scarboro from 1986 to 1995 (see Figure 15). In addition, estimated average U 238 air radioactivity concentrations using the Task 6 empirical χ/Q method overestimated or slightly underestimated measured U 238 air radioactivity concentrations (see Figure 16). A detailed discussion of linear regression evaluation by ATSDR is provided in Appendix E.

Consequently, the estimated average U 234/235 and U 238 air radioactivity concentrations at Scarboro from 1945 to 1995 Y-12 uranium releases (see Table 6) are most likely overestimated because these concentrations are based on the Task 6 empirical χ/Q value. In addition, the Task 6 team used these likely overestimated average U 234/235 and U 238 air radioactivity

concentrations based on the empirical χ/Q method to calculated past uranium CEDEs to the Scarboro community via the air exposure pathways (see Table 7 for a list of air exposure pathways considered by the Task 6 team). As shown in Table 7, the majority of the estimated total radiation dose via the air pathway in Scarboro from Y-12 uranium releases is attributed to inhalation of airborne particles.

Figure 15. Comparison of Average U 234/235 Air Radioactivity Concentrations in Scarboro Measured vs. Estimated

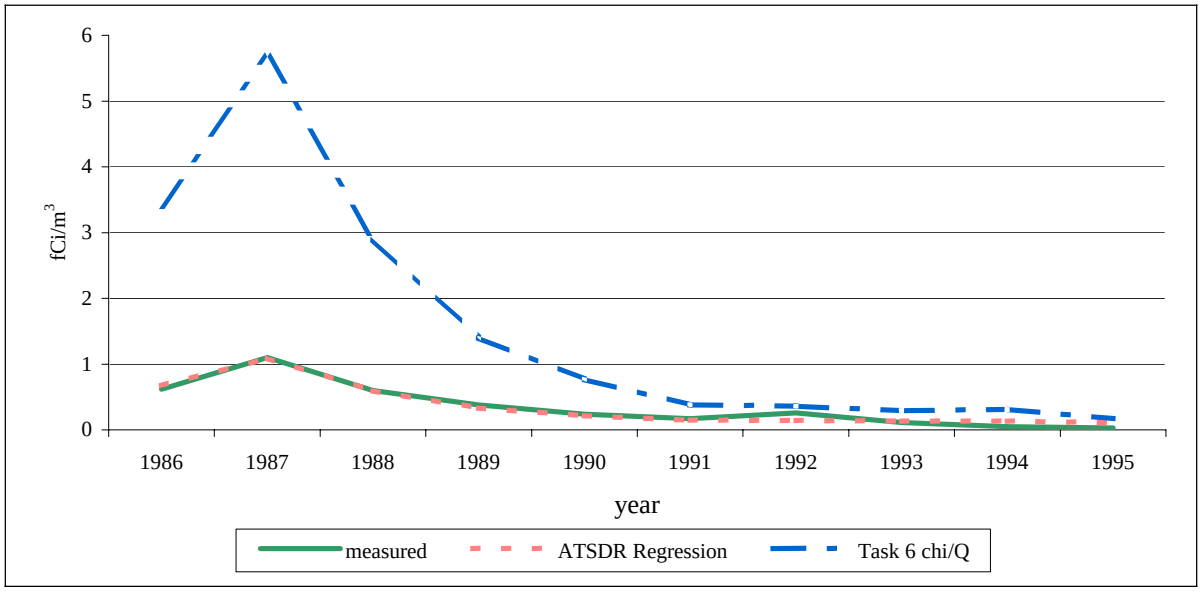


Figure 16. Comparison of Average U 238 Air Radioactivity Concentrations In Scarboro Measured vs. Estimated

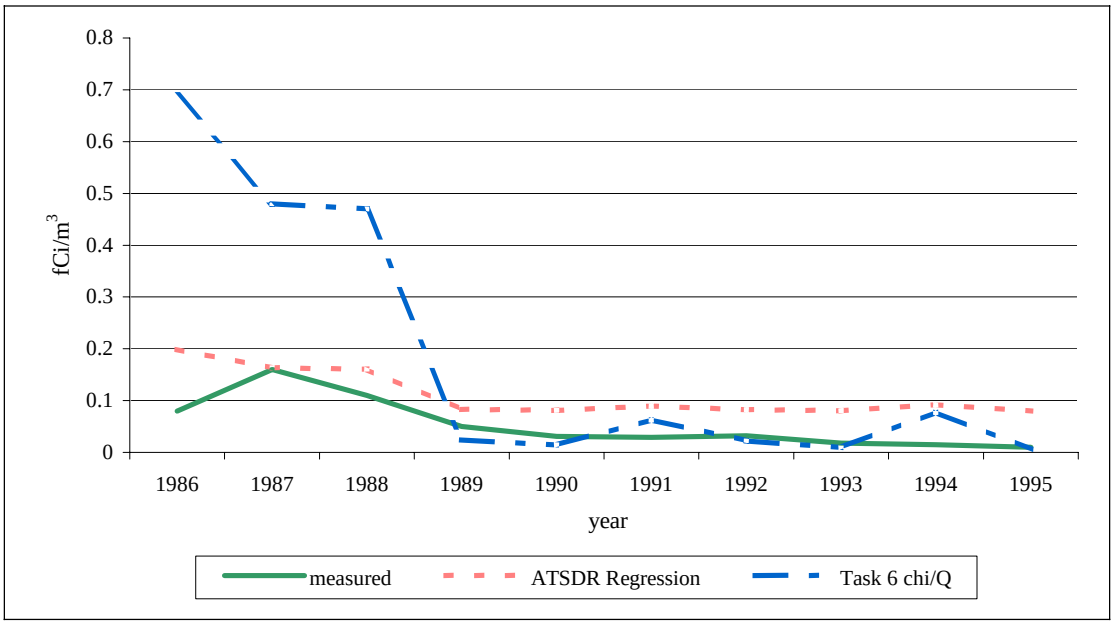


Table 7. Air Pathways Considered by the Task 6 Team

Exposure Pathway to Humans	% Pathway Contributes to Total Radiation Dose	
	U 234/235	U 238
Inhalation of airborne particles	30%	10%
Direct contact with air containing uranium particulates	<1%	<1%
Ingestion of meat from livestock that inhaled airborne particles	<1%	<1%
Ingestion of milk from dairy cows that inhaled airborne particles	<1%	<1%
Consumption of vegetables contaminated with deposited particles	4%	<1%
Consumption of meat from livestock that ate pasture contaminated with deposited particles	<1%	<1%
Consumption of milk from dairy cows that ate pasture contaminated with deposited particles	<1%	<1%

Source: ChemRisk 1999

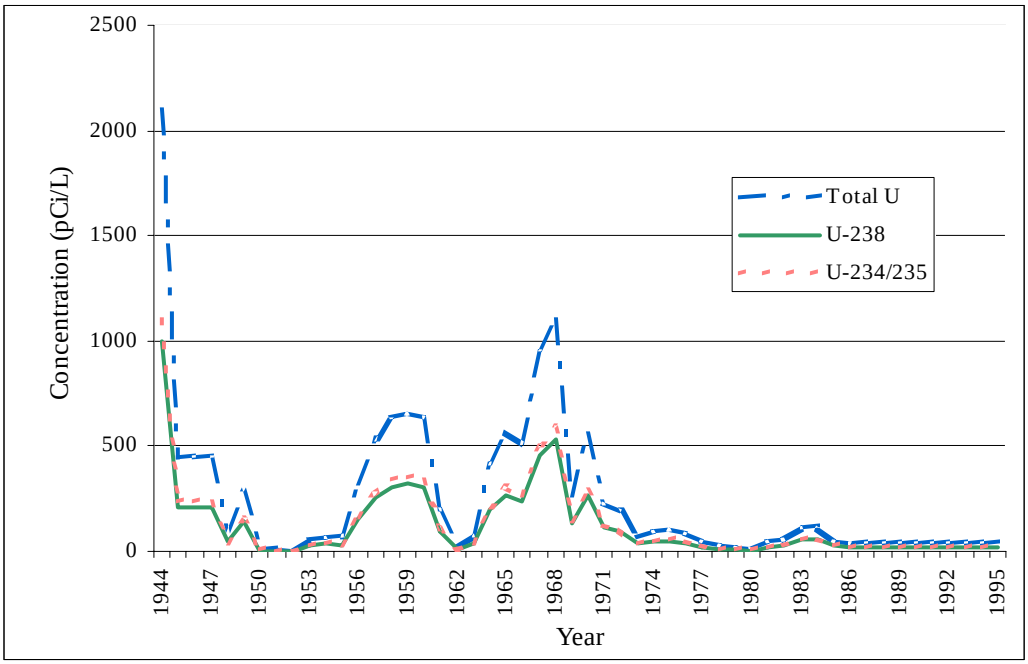
To calculate an estimated uranium radiation dose, the Task 6 team used the latest dose coefficients recommended by the ICRP (ChemRisk 1999). Dose coefficients are a combination of factors that may contain uncertainty with respect to physiological parameters. In the case of uranium, the physiological parameters related to dose assessment are well known. Therefore, the uncertainties in the assessment of uranium doses are more precise than other radionuclides. Please see Appendix F for additional information about the ICRP's dose coefficients (for examples, see Harrison et al. 2001; Leggett 2001).

Past Surface Water Exposure Pathway

The closest surface water body to the reference location, Scarboro, is EFPC, which originates from within the Y-12 plant boundary, flows through the city of Oak Ridge, and confluences with Poplar Creek (ChemRisk 1999). EFPC passes about 0.4 miles to the northeast of the populated area of Scarboro at its closest point (ChemRisk 1999). EFPC represents the most credible source of surface water exposure for Scarboro residents (ChemRisk 1999). Public access to the creek exists after it leaves the reservation. However, the creek appears to be too shallow for swimming, although some areas are suitable for wading and fishing.

To calculate annual average uranium radioactivity concentrations in EFPC from 1944 to 1995, the Task 6 team divided the annual waterborne uranium release estimates from the Y-12 plant by the EFPC annual flow rate (see Figure 17 and Table 8). Please see Section 3.3 in the Task 6 report for more details about how the uranium surface water concentrations were determined.

Figure 17. Average Annual Uranium Concentrations in EFPC Surface Water



Source: ChemRisk 1999

The Task 6 team then calculated estimated CEDEs via the EFPC surface water exposure pathways. The total past uranium CEDE from EFPC surface water exposure pathways, after being adjusted to reflect a 70-year exposure[6], is 49 mrem (see Table 4). As shown in Table 9, the majority of the exposure to uranium is attributed to frequently eating fish from EFPC (24% of the total U 234/235 dose and 35% of the total U 238 dose). It is ATSDR's understanding that EFPC is not a very productive fishing location and very few people actually eat fish from the creek. If a person did not frequently eat EFPC fish over a prolonged period of time, the person's uranium radioactivity dose from the surface water pathway would be expected to be substantially lower than the estimated radioactivity doses reported in this public health assessment.

As with the air pathway, to calculate an estimated uranium radiation dose for the surface water pathway, the Task 6 team used the dose coefficients recommended by the ICRP (ChemRisk 1999). Please see Appendix F for additional information about the ICRP's dose coefficients (for examples, see Harrison et al. 2001; Leggett 2001).

[6] The total past uranium CEDEs for the EFPC surface water pathway from the Task 6 report were multiplied by 1.35 (70 years/52 years) for comparison with ATSDR's comparison values.

Table 8. Average Annual Uranium Concentrations in East Fork Poplar Creek Surface Water (1944–1995)

Year	Total Uranium (pCi/L)	U 238 (pCi/L)	U 234/235 (pCi/L)	Uranium (mg/L)	Year	Total Uranium (pCi/L)	U 238 (pCi/L)	U 234/235 (pCi/L)	Uranium (mg/L)
1944	2,100	1,000	1,100	3.0	1970	560	270	290	0.79
1945	450	210	240	0.63	1971	230	110	120	0.32
1946	450	210	240	0.63	1972	190	92	100	0.27
1947	450	210	240	0.63	1973	71	34	37	0.099
1948	99	47	52	0.14	1974	99	47	52	0.14
1949	290	140	150	0.41	1975	104	50	55	0.15
1950	9.1	4.3	4.8	0.013	1976	87	42	46	0.12
1951	6.2	2.9	3.3	0.0088	1977	48	23	25	0.067
1952	0.0070	0.0033	0.0037	0.000010	1978	26	12	14	0.036
1953	61	29	32	0.085	1979	23	11	12	0.033
1954	71	34	37	0.099	1980	9.9	4.7	5.2	0.014
1955	68	32	36	0.095	1981	44	21	23	0.062
1956	320	150	170	0.45	1982	54	25	28	0.075
1957	540	260	280	0.76	1983	110	54	60	0.16
1958	640	300	340	0.89	1984	110	54	60	0.16
1959	660	320	350	0.93	1985	50	24	26	0.070
1960	640	300	340	0.90	1986	42	20	22	0.058
1961	200	93	100	0.27	1987	42	20	22	0.058
1962	14.8	7.0	7.8	0.021	1988	42	20	22	0.058
1963	80	38	42	0.11	1989	42	20	22	0.058
1964	420	200	220	0.59	1990	42	20	22	0.058
1965	570	270	300	0.79	1991	42	20	22	0.058
1966	510	240	270	0.71	1992	42*	20*	22*	0.058*
1967	970	460	510	1.4	1993	42*	20*	22*	0.058*
1968	1,100	530	590	1.6	1994	42*	20*	22*	0.058*
1969	270	130	140	0.38	1995	42*	20*	22*	0.058*
EFPC Average Concentrations (1944–1995)							**121**	**134**	**0.36**

Source: ChemRisk 1999

*Assumed same concentration as 1991.
All values are rounded to two significant figures.

Table 9. Surface Water Pathways Considered by the Task 6 Team

Exposure Pathway to Humans	% Pathway Contributes to Total Radiation Dose	
	U 234/235	U 238
Incidental ingestion of EFPC water	<1%	<1%
Ingestion of meat from livestock that drank water from EFPC	<1%	<1%
Ingestion of milk from dairy cows that drank water from EFPC	2%	3%
Consumption of fish from EFPC	24%	35%
Immersion in EFPC water	<1%	<1%

Source: ChemRisk 1999

Past Soil Exposure Pathway

At the beginning of the Task 6 dose reconstruction, uranium soil data from the reference location, Scarboro, were not available. In its place, uranium soil data from the EFPC floodplain were used as a surrogate for past uranium radioactivity concentrations in Scarboro soil (ChemRisk 1999). The Task 6 team used the average soil concentrations of U 234/235 and U 238 collected from EFPC floodplain between the Y-12 boundary and EFPC MILE 8.8 to estimate past uranium radioactivity doses via the soil pathways in Scarboro. Please see Section 3.4 in the Task 6 report for more details about how uranium concentrations in soil were determined.

The Task 6 report noted that the use of uranium concentrations in EFPC floodplain soil to represent uranium concentrations in Scarboro soil, which is outside of the floodplain, probably introduced conservatism (ChemRisk 1999). The Task 6 report also noted that the uranium concentrations in EFPC floodplain soil, which were available at that time, were not sufficient to support a defensible analysis of average or typical exposure to members of the Scarboro community during the years from the community's inception to the present (ChemRisk 1999).

The Task 6 team estimated past uranium radiation doses by using uranium radioactivity concentrations in EFPC floodplain soil to calculate estimated CEDEs via the soil exposure pathways to residents of Scarboro. The total past uranium CEDE from the soil pathway, after being adjusted to reflect a 70-year exposure[7], is 66 mrem (see Table 4). As shown in Table 10, the majority of the past uranium radiation dose (30% of the total U 234/235 dose and 43% of the total U 238 dose) for the soil pathways is attributed to frequently eating vegetables grown in contaminated floodplain soil over a prolonged period of time. If a person did not frequently eat homegrown vegetables over a prolonged period of time, the person's uranium dose from the soil pathway would have been substantially lower than the estimated doses reported in this public health assessment.

Table 10. Soil Pathways Considered by the Task 6 Team

Exposure Pathway to Humans	% Pathway Contributes to Total Radiation Dose	
	U 234/235	U 238
Inhalation of resuspended dust	2%	3%
Ingestion of soil	<1%	1%
Consumption of meat from livestock that ingested soil	<1%	<1%
Consumption of milk from dairy cows that ingested soil	<1%	1%
Consumption of vegetables grown in contaminated soil	30%	43%
Consumption of meat from livestock that ate pasture grown in contaminated soil	<1%	<1%
Consumption of milk from dairy cows that ate pasture grown in contaminated soil	<1%	1%
External exposure to contaminated soil	3%	<1%

Source: ChemRisk 1999

[7] The total past uranium CEDEs for the EFPC floodplain soil pathway from the Task 6 report were multiplied by 1.35 (70 years/52 years) for comparison with ATSDR's comparison values.

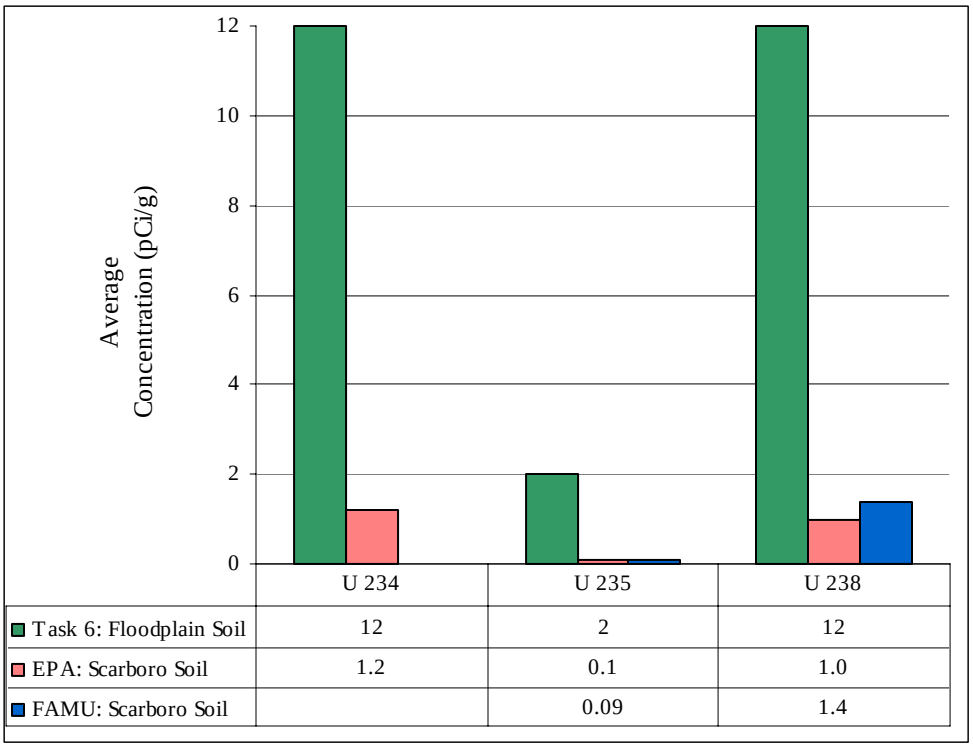
Toward the end of the Task 6 project (in May 1998), 40 soil samples from the Scarboro community were collected by the Environmental Sciences Institute at FAMU (FAMU 1998). In 2001, EPA collected six additional soil samples from the Scarboro community to validate the 1998 FAMU results (EPA 2003). An independent review by Auxier & Associates (Prichard 1998) of the Task 6 report and the report generated by FAMU noted that aerial deposition of uranium was the primary source of uranium contamination in Scarboro soil, rather than the transportation of EFPC floodplain soils for use as fill. It was concluded that the radioactivity concentrations of uranium within the Task 6 report (based on EFPC floodplain soil samples) are inconsistent with the radioactivity concentrations of uranium observed in Scarboro soils and that the Task 6 assumptions are unlikely to accurately represent past uranium radioactivity concentrations in Scarboro soil (Prichard 1998). Additionally, technical reviews of the Auxier report, the Task 6 report, and the report generated by FAMU noted that the use of actual Scarboro soil data is preferable to the reliance on floodplain soil data. However, the reviewers cautioned using the FAMU data to estimate past exposure without additional research into the environmental distribution of uranium in the area[8]. Appendix G contains a summary of the technical reviewers' comments.

Based on the FAMU and EPA uranium soil data, the actual uranium radioactivity concentrations in Scarboro soil were much lower than the uranium radioactivity concentrations from the EFPC floodplain soil that the Task 6 team used as a surrogate. As shown in Figure 18 and Table 11, the actual uranium radioactivity concentrations in Scarboro soil are approximately 8 to 22 times less than the EFPC floodplain soil concentrations. Consequently, if the uranium radioactivity concentrations from Scarboro soil were used to estimate the past uranium radioactivity doses instead of the EFPC floodplain soil, the total past uranium CEDE of 66 mrem for the soil exposure pathway (see Table 4) would have been significantly lower.

As with the air and surface water pathways, to calculate an estimated uranium radiation dose for the soil exposure pathway, the Task 6 team used the dose coefficients recommended by the ICRP (ChemRisk 1999). Please see Appendix F for additional information about the ICRP's dose coefficients.

[8] The mobility of uranium in soil and its vertical transport (leaching) to groundwater depend on the form of uranium and the properties of the soil, as well as the amount of water available (ATSDR 1999a). The sorption of uranium in most soils is such that it may not leach readily from soil to groundwater; the migration is typically quite local (ATSDR 1999a). In addition, the predominant chemical form of uranium released into the air from the Y-12 plant was highly insoluble uranium oxide (ChemRisk 1999). Leaching is not expected to be a major loss mechanism for insoluble materials, which bind tightly to soil particles (Prichard 1998).

Figure 18. Comparison of the Average Uranium Radioactivity Concentrations EFPC Floodplain Soil vs. Scarboro Soil



Sources: ChemRisk 1999, EPA 2003, FAMU 1998

FAMU did not analyze for U 234.

Table 11. Comparison of Average Uranium Radioactivity Concentrations EFPC Floodplain Soil vs. Scarboro Soil

		Average U 234 Concentration (pCi/g)	Average U 235 Concentration (pCi/g)	Average U 238 Concentration (pCi/g)
Task 6: Floodplain Soil		12	2	12
EPA: Scarboro Soil		1.2	0.1	1.0
FAMU: Scarboro Soil		not available	0.09	1.4
How much lower are the soil radioactivity concentrations in Scarboro than the EFPC floodplain?	Task 6 vs. EPA	10 times	20 times	12 times
	Task 6 vs. FAMU	not available	22 times	8.6 times

Sources: ChemRisk 1999, EPA 2003, FAMU 1998

III.B.1.b. Past Chemical Effects

ATSDR evaluated whether exposure to past levels of uranium released from the Y-12 plant would cause harmful chemical effects in communities near the Y-12 plant, especially the reference location (the Scarboro community), which is considered the area that would have received the highest exposures. Based upon the chemical toxicity of uranium, residents living near the ORR were not exposed through inhalation of air or ingestion of surface water and soil to harmful levels of uranium in the past. Therefore, the past Y-12 uranium releases are not a health hazard to people living near the Y-12 plant.

Past Exposure via Inhalation

Using the average air concentrations generated by the Task 6 team (converted from radioactivity values to mass units[9]), ATSDR calculated the average air concentrations of total uranium in Scarboro for each year from 1944 to 1995 and compared them to the ATSDR MRL for inhalation of insoluble uranium (see Table 12, Figure 19, and Figure 9). All the average air concentrations of uranium in Scarboro are less than 1% of the ATSDR MRL. As shown in Figure 19, the average annual air concentrations of total uranium are well below the inhalation MRL of 0.008 mg/m^3 for every year. MRLs have built-in uncertainty or safety factors, making them considerably lower than levels at which health effects have been observed. Values below the MRL are not considered to be of health concern. Therefore, no further evaluation is required. Additionally, as noted previously in the past radiation effects section, the uranium air concentrations are most likely overestimated. Therefore, ATSDR concludes that residents living near Oak Ridge were not exposed to airborne uranium at levels that would cause harmful chemical effects.

[9] Each individual isotope (U 234, U 235, and U 238) has a separate and distinct half life and mass. Therefore, one can convert the activity of each individual isotope using its specific activity expressed as curies of radioactivity per gram of pure radionuclide (0.331 pCi/µg for U 238, 0.34 pCi/µg for U 234, 0.0154 pCi/µg for U 235). To convert the radioactive measurement of the isotope to grams, one divides the radioactive measurement by its specific activity while ensuring the units of measurement are consistent.

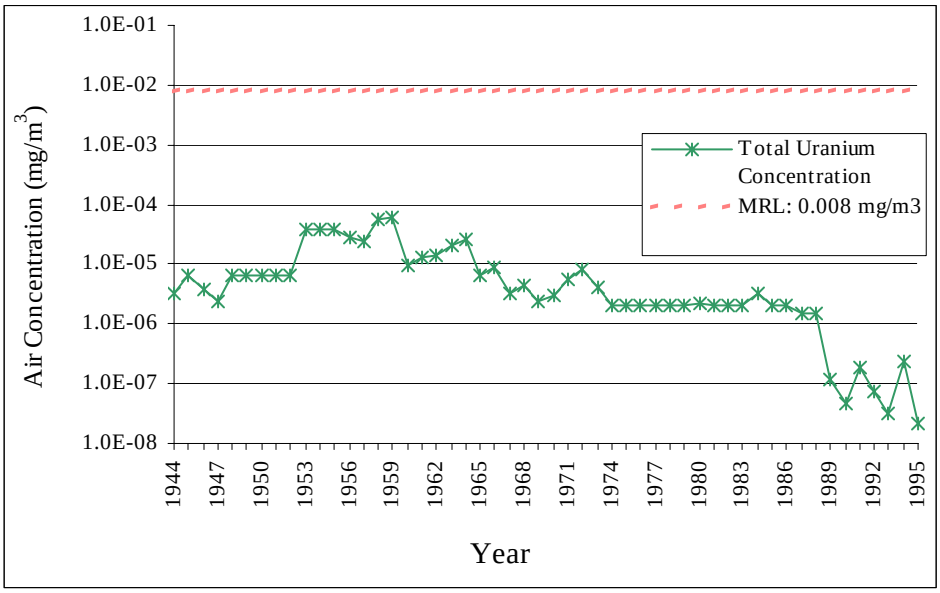
Table 12. Estimated Average Annual Air Concentrations of Uranium in Scarboro

Year	Total Uranium Concentration (mg/m^3)	Is the concentration above the MRL?	Percent of MRL	Year	Total Uranium Concentration (mg/m^3)	Is the concentration above the MRL?	Percent of MRL
1944	3.2×10^{-6}	no	0.04%	1970	2.9×10^{-6}	no	0.04%
1945	6.6×10^{-6}	no	0.08%	1971	5.7×10^{-6}	no	0.07%
1946	3.8×10^{-6}	no	0.05%	1972	8.2×10^{-6}	no	0.10%
1947	2.5×10^{-6}	no	0.03%	1973	4.0×10^{-6}	no	0.05%
1948	6.4×10^{-6}	no	0.08%	1974	2.1×10^{-6}	no	0.03%
1949	6.4×10^{-6}	no	0.08%	1975	2.1×10^{-6}	no	0.03%
1950	6.4×10^{-6}	no	0.08%	1976	2.1×10^{-6}	no	0.03%
1951	6.4×10^{-6}	no	0.08%	1977	2.0×10^{-6}	no	0.03%
1952	6.4×10^{-6}	no	0.08%	1978	2.1×10^{-6}	no	0.03%
1953	4.0×10^{-5}	no	0.50%	1979	2.1×10^{-6}	no	0.03%
1954	3.7×10^{-5}	no	0.47%	1980	2.2×10^{-6}	no	0.03%
1955	3.7×10^{-5}	no	0.47%	1981	2.0×10^{-6}	no	0.03%
1956	2.9×10^{-5}	no	0.36%	1982	2.0×10^{-6}	no	0.03%
1957	2.4×10^{-5}	no	0.30%	1983	2.1×10^{-6}	no	0.03%
1958	5.4×10^{-5}	no	0.68%	1984	3.3×10^{-6}	no	0.04%
1959	6.0×10^{-5}	no	0.75%	1985	2.1×10^{-6}	no	0.03%
1960	9.3×10^{-6}	no	0.12%	1986	2.1×10^{-6}	no	0.03%
1961	1.3×10^{-5}	no	0.16%	1987	1.5×10^{-6}	no	0.02%
1962	1.4×10^{-5}	no	0.17%	1988	1.4×10^{-6}	no	0.02%
1963	2.1×10^{-5}	no	0.26%	1989	1.2×10^{-7}	no	<0.01%
1964	2.6×10^{-5}	no	0.33%	1990	4.7×10^{-8}	no	<0.01%
1965	6.3×10^{-6}	no	0.08%	1991	1.9×10^{-7}	no	<0.01%
1966	9.1×10^{-6}	no	0.11%	1992	7.1×10^{-8}	no	<0.01%
1967	3.3×10^{-6}	no	0.04%	1993	3.2×10^{-8}	no	<0.01%
1968	4.4×10^{-6}	no	0.05%	1994	2.4×10^{-7}	no	<0.01%
1969	2.5×10^{-6}	no	0.03%	1995	2.1×10^{-8}	no	<0.01%

Source: ChemRisk 1999

None of the concentrations exceeded the ATSDR inhalation MRL of 0.008 mg/m^3 (i.e., 8.0×10^{-3}) for insoluble uranium.

Figure 19. Estimated Average Annual Air Concentrations of Total Uranium in Scarboro



The air concentration values can be written different ways, for example 1.0E-01 mg/m^3 is the same as 1.0×10^{-1} mg/m^3 and 0.1 mg/m^3.

Past Exposure via Ingestion

The Task 6 team calculated an annual average intake of uranium from 1944 to 1995 through both surface water and soil exposure pathways to residents of Scarboro. They considered (1) incidental ingestion of EFPC water, (2) ingestion of meat from livestock that drank water from EFPC, (3) ingestion of milk from dairy cows that drank water from EFPC, (4) consumption of fish from EFPC, (5) ingestion of soil, (6) consumption of meat from livestock that ingested soil, (7) consumption of milk from dairy cows that ingested soil, (8) consumption of vegetables grown in contaminated soil, (9) consumption of meat from livestock that ate pasture grown in contaminated soil, and (10) consumption of milk from dairy cows that ate pasture grown in contaminated soil (Figure 11 shows the exposure pathways evaluated).

ATSDR used the Task 6 annual average intakes of uranium to calculate past uranium doses for an adult male, adult female, 12-year-old child, and 6-year-old child for each year from 1944 to 1995 (see Table 13). Please see the Evaluating Exposures section (Section III.A.2.) for an explanation of how ATSDR calculated doses. As shown in Figure 20, the doses for several of the individual years exceeded ATSDR's intermediate-duration oral MRL for chemical toxicity of uranium (0.002 milligrams per kilogram per day; mg/kg/day). Remember that the MRL is a screening value. Calculated exposure doses higher than the MRL do not automatically mean harmful health effects will occur. Rather, they are an indication that ATSDR should further examine the harmful effect levels reported in the scientific literature and more fully review exposure potential. Therefore, because some of the estimated doses exceeded the MRL, ATSDR further investigated the toxicologic literature to find doses associated with known health effects.

The lowest oral (ingestion) dose of uranium that has caused the most sensitive harmful health effect (renal/kidney toxicity in rabbits) considered to be of relevance to humans was 0.05 mg/kg/day (ATSDR 1999a). The rabbit is the mammalian species most sensitive to uranium kidney toxicity and is likely to be even more sensitive than humans (ATSDR 1999a). Therefore, ATSDR is comfortable with extrapolating the results from this animal toxicity study to humans. This oral uranium dose of 0.05 mg/kg/day is the minimum lowest-observed-adverse-effect level (LOAEL) that is used by ATSDR to derive the MRL for intermediate-duration oral exposure to uranium. This intermediate-duration oral MRL is also protective for chronic-duration oral exposure because renal effects of uranium exposure are more dependent on the dose than on the duration of exposure (ATSDR 1999a). All the estimated past uranium doses from ingestion of uranium via the soil and surface water pathways in Table 13 and Figure 20 are well below the LOAEL of 0.05 mg/kg/day at which renal effects have been observed in rabbits (ATSDR 1999a) (see Figure 8). Therefore, ATSDR concludes that residents living near Oak Ridge were not exposed to uranium at levels that would cause harmful chemical effects.

Table 13. Estimated Average Annual Doses from Ingestion of Uranium via the Soil and Surface Water Pathways (1944–1995)[*]

Year	Annual Average Intake (mg/d)	Dose (mg/kg/day)				Is the dose above the MRL?			
		Adult Male	Adult Female	12-yr Child	6-yr Child	Adult Male	Adult Female	12-yr Child	6-yr Child
1944	0.273	3.5×10^{-3}	3.9×10^{-3}	6.1×10^{-3}	1.2×10^{-2}	Yes	Yes	yes	yes
1945	0.069	8.9×10^{-4}	9.7×10^{-4}	1.5×10^{-3}	3.0×10^{-3}	No	No	no	yes
1946	0.061	7.8×10^{-4}	8.6×10^{-4}	1.4×10^{-3}	2.7×10^{-3}	No	No	no	yes
1947	0.066	8.5×10^{-4}	9.4×10^{-4}	1.5×10^{-3}	2.9×10^{-3}	No	No	no	yes
1948	0.026	3.4×10^{-4}	3.7×10^{-4}	5.9×10^{-4}	1.1×10^{-3}	No	No	no	no
1949	0.050	6.5×10^{-4}	7.1×10^{-4}	1.1×10^{-3}	2.2×10^{-3}	No	No	no	yes
1950	0.015	2.0×10^{-4}	2.2×10^{-4}	3.4×10^{-4}	6.7×10^{-4}	No	No	no	no
1951	0.016	2.1×10^{-4}	2.3×10^{-4}	3.6×10^{-4}	7.1×10^{-4}	No	No	no	no
1952	0.016	2.1×10^{-4}	2.3×10^{-4}	3.6×10^{-4}	7.1×10^{-4}	No	No	no	no
1953	0.075	9.6×10^{-4}	1.1×10^{-3}	1.7×10^{-3}	3.3×10^{-3}	No	No	no	yes
1954	0.075	9.6×10^{-4}	1.1×10^{-3}	1.7×10^{-3}	3.3×10^{-3}	No	No	no	yes
1955	0.139	1.8×10^{-3}	2.0×10^{-3}	3.1×10^{-3}	6.1×10^{-3}	No	No	yes	yes
1956	0.170	2.2×10^{-3}	2.4×10^{-3}	3.8×10^{-3}	7.4×10^{-3}	Yes	Yes	yes	yes
1957	0.308	4.0×10^{-3}	4.3×10^{-3}	6.8×10^{-3}	1.3×10^{-2}	Yes	Yes	yes	yes
1958	0.198	2.5×10^{-3}	2.8×10^{-3}	4.4×10^{-3}	8.6×10^{-3}	Yes	Yes	yes	yes
1959	0.125	1.6×10^{-3}	1.8×10^{-3}	2.8×10^{-3}	5.4×10^{-3}	No	No	yes	yes
1960	0.138	1.8×10^{-3}	1.9×10^{-3}	3.1×10^{-3}	6.0×10^{-3}	No	No	yes	yes
1961	0.104	1.3×10^{-3}	1.5×10^{-3}	2.3×10^{-3}	4.5×10^{-3}	No	No	yes	yes
1962	0.084	1.1×10^{-3}	1.2×10^{-3}	1.9×10^{-3}	3.7×10^{-3}	No	No	no	yes
1963	0.103	1.3×10^{-3}	1.4×10^{-3}	2.3×10^{-3}	4.5×10^{-3}	No	No	yes	yes
1964	0.201	2.6×10^{-3}	2.8×10^{-3}	4.5×10^{-3}	8.7×10^{-3}	Yes	Yes	yes	yes
1965	0.104	1.3×10^{-3}	1.5×10^{-3}	2.3×10^{-3}	4.5×10^{-3}	No	No	yes	yes
1966	0.108	1.4×10^{-3}	1.5×10^{-3}	2.4×10^{-3}	4.7×10^{-3}	No	No	yes	yes
1967	0.138	1.8×10^{-3}	1.9×10^{-3}	3.1×10^{-3}	6.0×10^{-3}	No	No	yes	yes
1968	0.154	2.0×10^{-3}	2.2×10^{-3}	3.4×10^{-3}	6.7×10^{-3}	No	Yes	yes	yes

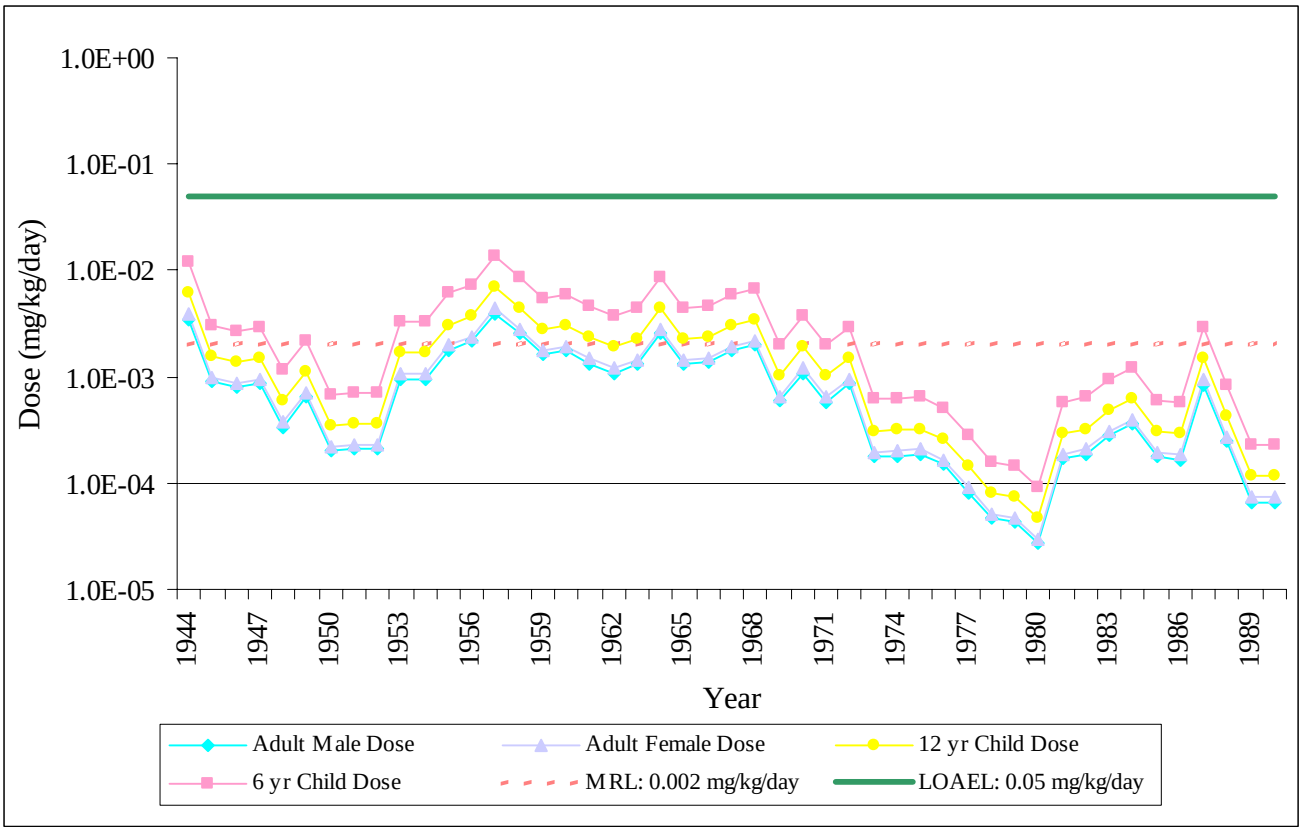
[*] This table is continued on the following page.

Year	Annual Average Intake (mg/d)	Dose (mg/kg/day)				Is the dose above the MRL?			
		Adult Male	Adult Female	12-yr Child	6-yr Child	Adult Male	Adult Female	12-yr Child	6-yr Child
1969	0.046	5.9×10^{-4}	6.5×10^{-4}	1.0×10^{-3}	2.0×10^{-3}	No	No	no	no
1970	0.085	1.1×10^{-3}	1.2×10^{-3}	1.9×10^{-3}	3.7×10^{-3}	No	No	no	yes
1971	0.045	5.8×10^{-4}	6.4×10^{-4}	1.0×10^{-3}	2.0×10^{-3}	No	No	no	no
1972	0.068	8.7×10^{-4}	9.5×10^{-4}	1.5×10^{-3}	2.9×10^{-3}	No	No	no	yes
1973	0.014	1.8×10^{-4}	2.0×10^{-4}	3.1×10^{-4}	6.1×10^{-4}	No	No	no	no
1974	0.014	1.8×10^{-4}	2.0×10^{-4}	3.1×10^{-4}	6.1×10^{-4}	No	No	no	no
1975	0.015	1.9×10^{-4}	2.1×10^{-4}	3.3×10^{-4}	6.4×10^{-4}	No	No	no	no
1976	0.012	1.5×10^{-4}	1.6×10^{-4}	2.6×10^{-4}	5.1×10^{-4}	No	No	no	no
1977	0.006	8.2×10^{-5}	9.0×10^{-5}	1.4×10^{-4}	2.8×10^{-4}	No	No	no	no
1978	0.004	4.6×10^{-5}	5.1×10^{-5}	8.0×10^{-5}	1.6×10^{-4}	No	No	no	no
1979	0.003	4.3×10^{-5}	4.8×10^{-5}	7.5×10^{-5}	1.5×10^{-4}	No	No	no	no
1980	0.002	2.7×10^{-5}	3.0×10^{-5}	4.7×10^{-5}	9.1×10^{-5}	No	No	no	no
1981	0.013	1.7×10^{-4}	1.8×10^{-4}	2.9×10^{-4}	5.7×10^{-4}	No	No	no	no
1982	0.015	1.9×10^{-4}	2.1×10^{-4}	3.2×10^{-4}	6.4×10^{-4}	No	No	no	no
1983	0.022	2.8×10^{-4}	3.1×10^{-4}	4.9×10^{-4}	9.6×10^{-4}	No	No	no	no
1984	0.028	3.6×10^{-4}	4.0×10^{-4}	6.2×10^{-4}	1.2×10^{-3}	No	No	no	no
1985	0.014	1.8×10^{-4}	2.0×10^{-4}	3.1×10^{-4}	6.1×10^{-4}	No	No	no	no
1986	0.013	1.7×10^{-4}	1.8×10^{-4}	2.9×10^{-4}	5.7×10^{-4}	No	No	no	no
1987	0.066	8.5×10^{-4}	9.3×10^{-4}	1.5×10^{-3}	2.9×10^{-3}	No	No	no	yes
1988	0.019	2.5×10^{-4}	2.7×10^{-4}	4.3×10^{-4}	8.4×10^{-4}	No	No	no	no
1989	0.005	6.7×10^{-5}	7.3×10^{-5}	1.2×10^{-4}	2.3×10^{-4}	No	No	no	no
1990	0.005	6.7×10^{-5}	7.3×10^{-5}	1.2×10^{-4}	2.3×10^{-4}	No	No	no	no
Number of years the dose is above the MRL (0.002 mg/kg/day)						**5**	**6**	**14**	**24**
Number of years the dose is above the LOAEL (0.05 mg/kg/day)						**0**	**0**	**0**	**0**

Source: ChemRisk 1999

Doses were calculated using the following formula: Dose = Intake / Body Weight assuming an adult male weighed 78 kg; an adult female, 71 kg; a 12-year-old child, 45 kg; and a 6-year-old child, 23 kg.
The LOAEL is the lowest-observed-adverse-effect level.
The dose of 0.05 mg/kg/day is the minimal LOAEL from a study in which an increased incidence of renal toxicity (specifically, anisokaryosis and nuclear vesiculation) was observed in New Zealand rabbits. The rabbit is the mammalian species most sensitive to uranium toxicity and is likely to be even more sensitive than humans.

Figure 20. Estimated Average Annual Doses of Uranium via the Soil and Surface Water Pathways

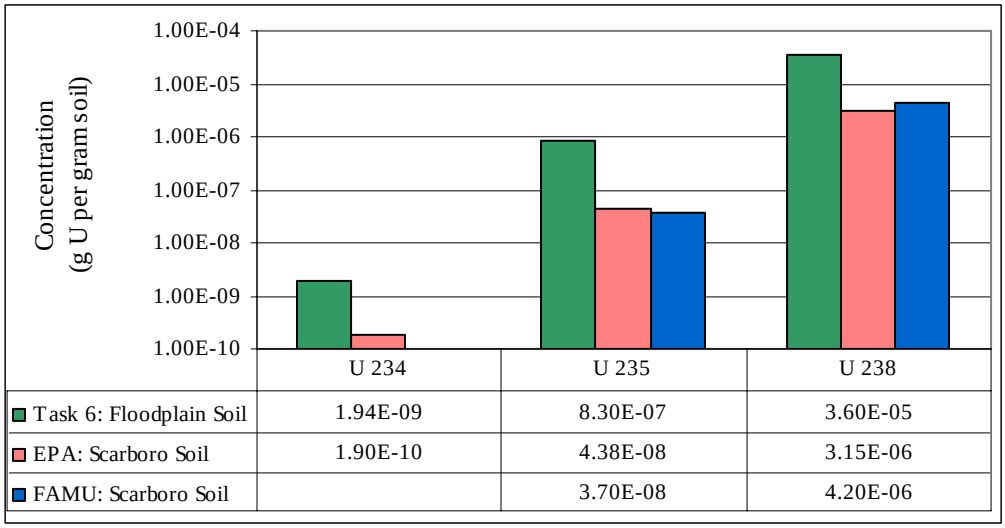


The dose values can be written different ways, for example 1.0E-01 mg/kg/day is the same as 1.0×10^{-1} mg/kg/day and 0.1 mg/kg/day.

For some of the same reasons described previously in the Past Radiation Effects section (Section III.B.1.a.), the past ingestion doses of uranium (as shown in Table 13 and Figure 20) are overestimated. The annual intakes were calculated using the same overestimated EFPC floodplain soil concentrations in place of actual Scarboro soil concentrations (converted from radioactivity values to mass units[10]). The uranium concentrations in the Scarboro soil are at least 8.6 times less than the EFPC floodplain soil (see Figure 21). Also, the calculated ingestion doses are based on potential exposures from recreating in EFPC, eating fish from EFPC, eating livestock raised in the EFPC floodplain, drinking milk from dairy cows raised in the EFPC floodplain, and eating homegrown vegetables grown in the EFPC floodplain. Livestock are only allowed within the city limits in limited zoning areas and EFPC is not a very productive fishing location. Very few people frequently ate livestock raised in the floodplain, fish from the creek, or vegetables grown in the floodplain over a prolonged period of time. A person's exposure is actually much lower if the person did not frequently engage in these activities over a prolonged period of time.

[10] Each individual isotope (U 234, U 235, and U 238) has a separate and distinct half life and mass. Therefore, one can convert the activity of each individual isotope using its specific activity (0.331 pCi/µg for U 238, 0.34 pCi/µg for U 234, 0.0154 pCi/µg for U 235). To convert the radioactive measurement of the isotope to grams, one divides the radioactive measurement by its specific activity while ensuring the units of measurement are consistent.

Figure 21. Comparison of Uranium Concentrations
EFPC Floodplain Soil vs. Scarboro Soil



	U 234	U 235	U 238
Task 6: Floodplain Soil	1.94E-09	8.30E-07	3.60E-05
EPA: Scarboro Soil	1.90E-10	4.38E-08	3.15E-06
FAMU: Scarboro Soil		3.70E-08	4.20E-06

Sources: ChemRisk 1999, EPA 2003, FAMU 1998

FAMU did not analyze for U 234.
The concentration values can be written different ways, for example 1.00E-04 g U per gram soil is the same as 1.00×10^{-4} g U per gram soil and 0.0001 g U per gram soil.

Given that the past average annual doses of uranium (shown in Table 13) are overestimated and that they are below levels at which health effects have been observed in the mammalian species most sensitive to uranium toxicity, ATSDR does not expect that people living in communities near the Y-12 plant, including in the reference community (i.e., the residents of Scarboro), have ingested levels of uranium via the soil and surface water exposure pathways that would have resulted in harmful chemical effects.

III.B.2. Current Exposure (1995 to 2002)

This section discusses the current uranium exposures from 1995 to 2002 to residents living near ORR. This evaluation primarily relies on data supplied by the Oak Ridge Environmental Information System (OREIS), a centralized, standardized, quality-assured, and configuration-controlled environmental data management system that is publicly available. Data from FAMU (1998) and EPA (2003) were also used to supplement the evaluation.

Meteorological data indicates that the predominate winds at the Y-12 plant are generally up and down Bear Creek valley, between Pine Ridge and Chestnut Ridge with limited winds crossing over the ridge. This would result in most of the uranium released from Y-12 to deposit in Bear Creek valley and Union valley. However, no one lives in these two valleys. The city of Oak Ridge is the community that could have been impacted by Y-12 uranium releases. In this evaluation of current exposures, the Scarboro community is used as a reference location that represents the city of Oak Ridge. Additionally, 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). 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). Therefore, in this evaluation, conclusions regarding exposures to Scarboro residents are also applicable to other residents living in the city of Oak Ridge.

ATSDR determined that current exposures to uranium can include the following pathways: (1) ingestion of soils, (2) ingestion of foods, (3) ingestion of water from nearby creeks, (4) inhalation of air, and (5) external exposure from uranium in soils.

Based on our review of data collected in and around the reference location (Scarboro), ATSDR has determined that the presence of uranium is not a public health hazard to people living near the Y-12 plant.

III.B.2.a. Current Radiation Effects

ATSDR evaluated whether exposure to the levels of uranium currently being released from the Y-12 plant would cause harmful radiation effects in the reference population, the Scarboro community. The current uranium radiation dose received by the Scarboro community from the air and soil exposure pathways (0.216 mrem, discussed in the next paragraph) is well below levels of health concern and is not expected to cause adverse health effects. Therefore, the current levels of uranium in off-site areas near the Y-12 plant are not a health hazard.

The current radiation CEDE[11] received by the reference population, the Scarboro community, from exposure to uranium through ingestion of soil and vegetables and inhalation of air is 0.216 mrem over 70 years (see Table 14). This current radiation dose (0.216 mrem) to the residents of Scarboro is well below (23,000 times less than) the radiogenic cancer comparison value of 5,000 mrem over 70 years (see Figure 12). ATSDR derived this CEDE after reviewing the peer-reviewed literature and other documents developed to review the health effects of ionizing radiation (Appendix D contains 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 radiation dose (a 70-year dose, in this case) is received in the first year following the intake. Doses below this value are not expected to result in adverse health effects. Therefore, ATSDR does not expect carcinogenic health effects to have occurred from radiation doses received from current uranium exposures in Scarboro.

To evaluate noncancer health effects from the current uranium radiation dose (CEDE of 0.216 mrem over 70 years) estimated to be received by the Scarboro community, an approximation can be made to compare the CEDE of 0.216 mrem, which is based on 70 years of exposure, to the ATSDR chronic exposure MRL for ionizing radiation (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 Figure 12). ATSDR MRLs are based on noncancer health effects only and are not

[11] For current exposure, ATSDR evaluated the radiation dose resulting from internally deposited radionuclides only.

based on a consideration of cancer effects. The ATSDR MRL for chronic ionizing radiation exposure is derived by dividing the average annual effective dose to the U.S. population (360 mrem/year) by a safety factor of 3 to account for human variability (ATSDR 199b). The average U.S. annual effective dose of 360 mrem/year is obtained mainly from naturally occurring radioactive material, medical uses of radiation, and radiation from consumer products (see Figure 12) (BEIR V 1990 as cited in ATSDR 1999b). This annual effective dose of 360 mrem/year has not been associated with adverse health effects in humans or animals (ATSDR 1999b). ATSDR believes the chronic ionizing radiation MRL 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 radiation doses received from current uranium exposure for communities near the Y-12 plant.

Table 14. Current Uranium Radiation Dose to the Scarboro Community

Exposure Pathway	Committed Effective Dose Equivalents (mrem)
Inhalation of air in Scarboro	3.95×10^{-2}
Soil ingestion by a 1-year old Scarboro resident	3.97×10^{-2}
Ingestion of vegetables from a private garden	1.37×10^{-1}
Summed Radiation Dose	**2.16×10^{-1}**

The radiation doses calculated by ATSDR as resulting from the internal deposition of uranium include the background contribution of uranium typically in the body from other natural sources.

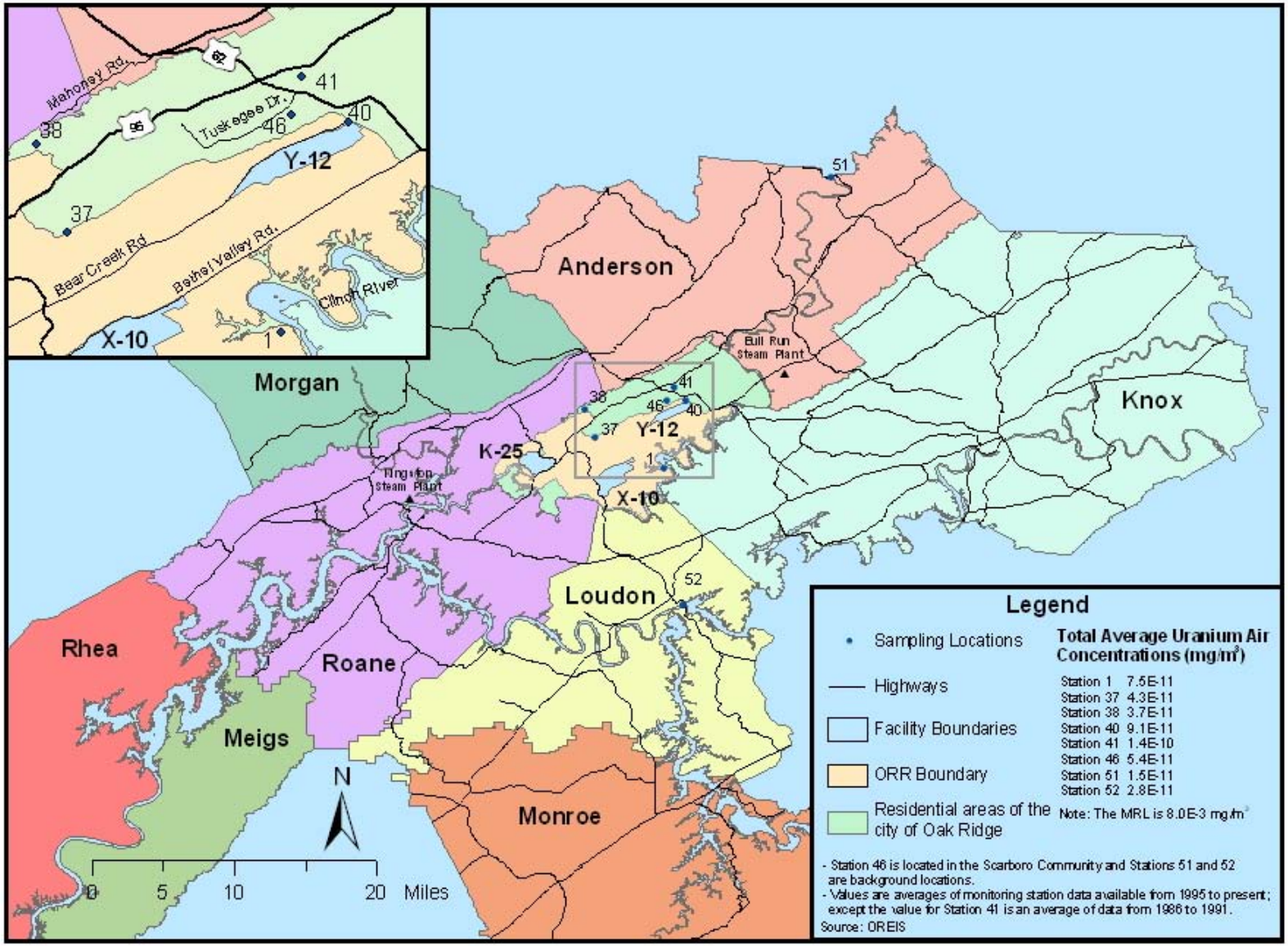
Current Air Exposure Pathway

Operations at the Y-12 plant continue to release materials to the atmosphere. In addition to monitoring the release of uranium from exhaust ventilation systems at the source, DOE has established a series of perimeter air monitoring stations around the reservation, including air monitoring station 46 located in Scarboro west of the Scarboro Community Center. ATSDR reviewed air data accumulated since 1995[12] from four on-site perimeter air monitoring stations, two off-site remote air monitoring stations, and two off-site perimeter air monitoring stations located in Scarboro and the city of Oak Ridge. ATSDR used these values to assess the current radiation impact of inhaling air containing uranium[13] (see Figure 22 for the locations of the air monitoring stations and Figure 27 for a comparison of the air concentrations).

[12] ATSDR evaluated data from 1986 to 1991 for Station 41.

[13] Fossil fuel plants, such as coal burning plants, release naturally occurring radioactive materials through their stacks. Because the Bull Run and Kingston Steam Plants are in the vicinity of Oak Ridge, these facilities could be impacting the uranium analyses performed in Oak Ridge. ATSDR could not locate specific information about these plants from the Tennessee Valley Authority. The agency did, however, locate information from a peer-reviewed publication that reported the typical concentrations of uranium in coal ash and fly ash. These values were 4 picocuries per gram (pCi/g) and 5.4 pCi/g, respectively (Stranden 1985).

Figure 22. Locations of Air Monitoring Stations



To estimate the radiation dose, the isotopic activity was evaluated using the appropriate ICRP dose coefficient and a protective inhalation rate. The EPA Exposure Factors Handbook recommends an inhalation rate of 8.7 cubic meters per day (m^3/day) for a child 1 to 12 years of age and an average inhalation rate of 13.25 m^3/day for adults (EPA 1997). For the assessment, ATSDR used a slightly more conservative inhalation rate of 15.25 m^3/day (i.e., 5.5 million liters/year) for adults. Radiation doses resulting from the inhalation pathway are presented in Table 15. As shown in Table 15, people living in the reference location, Scarboro, are expected to inhale sufficient uranium to impart a CEDE of 3.95×10^{-2} mrem. The table also indicates other monitoring stations as reference points. For example, Stations 51 and 52 are considered background stations not impacted by Y-12 releases. The on-site stations indicate air concentrations of uranium at the perimeter of the facility.

Furthermore, as the uranium inhaled is considered insoluble, the organ receiving the greatest radiation dose would be the lung. Therefore, ATSDR also calculated radiation doses to the lung. These doses to the lung are not at levels known to cause any adverse health outcomes.

Table 15. Estimated Current Total Radiation Doses from Inhalation of Uranium

Station	Whole Body Dose (mrem)	Lung Dose (mrem)
1 (on-site perimeter monitor)	4.18×10^{-2}	3.47×10^{-1}
37 (on-site perimeter monitor)	2.40×10^{-2}	1.99×10^{-1}
38 (on-site perimeter monitor)	2.13×10^{-2}	1.77×10^{-1}
40 (on-site perimeter monitor)	7.94×10^{-2}	6.59×10^{-1}
41 (city of Oak Ridge)	4.79×10^{-2}	3.98×10^{-1}
46 (Scarboro)	3.95×10^{-2}	3.28×10^{-1}
51 (Norris Dam)	9.31×10^{-3}	7.73×10^{-2}
52 (Fort Loudoun Dam)	1.68×10^{-2}	1.40×10^{-1}

Values are expressed as committed effective dose equivalents (CEDE).
Total uranium doses were calculated using the average concentrations for the data available since 1995, except the doses for Station 41 were calculated using the average concentration for data from 1986 to 1991.

Current Surface Water Exposure Pathway

To evaluate current exposures to uranium through the surface water pathway, ATSDR analyzed available surface water data taken from 1995 to 2002 at off-site locations (Scarboro drainage ditches and Lower EFPC) and for comparison, three on-site locations (Upper EFPC, Bear Creek, and the on-site portion of Lower EFPC after it joins with Bear Creek) (see Figure 23). As shown on Figure 23, the Upper EFPC, located entirely on the reservation, originates and flows through the Y-12 plant to the eastern site boundary and into Lower EFPC. Lower EFPC flows north from the Y-12 plant off site through the business and residential sections of city of Oak Ridge, but does not flow through Scarboro. After flowing through Oak Ridge for about 12 miles, Lower EFPC enters the ORR site again on the western end of the city and joins Poplar Creek, which flows to the Clinch River near the K-25 site. Bear Creek, also located entirely on the site, originates on the western end of the Y-12 plant and flows southwest to join Lower EFPC near the K-25 site. While access to the three on-site locations is restricted, the public has access to the portion of Lower EFPC that flows through the city. However, the creek appears to be too shallow

for swimming, and the state has issued a fishing advisory for EFPC that warns the public to avoid eating fish from the creek and to avoid contact with the water. The Scarboro surface water samples analyzed by FAMU and EPA in 1998 and 2001, were collected from drainage ditches in Scarboro. Also, Scarboro is located at a higher elevation along Pine Ridge than the EFPC floodplain, thus, surface water in Scarboro flows into EFPC.

Table 16 shows the mean total uranium concentrations for surface water samples collected from 1995 to 2002 at the two off-site locations and the three on-site locations. The mean uranium concentrations (0.197 µg/L) in surface water from Scarboro ditches are well below (100 times less than) the ATSDR EMEG of 20 µg/L for highly soluble uranium salts (see Table 2). The ATSDR EMEG is a nonenforceable, health-based comparison value developed for screening environmental contaminants for further evaluation. The EMEG reflects a concentration that is much lower than those that have been observed to cause adverse health effects. As a result, exposure to concentrations at or below ATSDR's comparison values are not considered to warrant health concern. Even though the mean uranium concentrations are above ATSDR's EMEG of 20 µg/L in Upper EFPC and Bear Creek (on-site locations with access restricted), the mean uranium concentrations decrease to below the EMEG in the off-site portions of Lower EFPC. The total uranium mean concentration in Bear Creek decreases dramatically after joining with Lower EFPC. The total uranium mean concentrations in Scarboro and in the off-site areas of Lower EFPC are below ATSDR's EMEG; therefore, the concentrations of uranium that people might be exposed to are not of health concern.

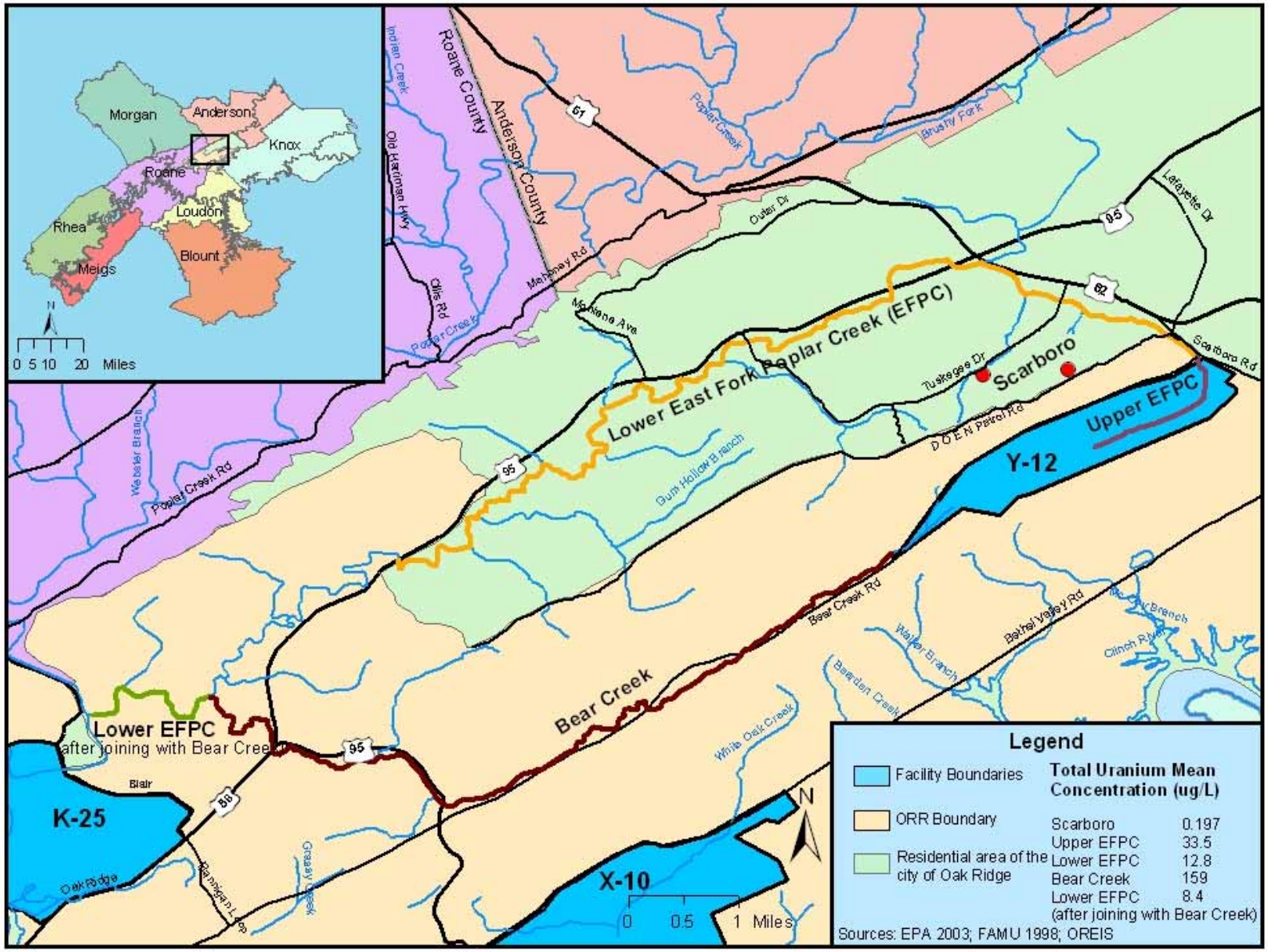
Table 16. Total Uranium Concentrations in EFPC and Bear Creek

Location	Mean Concentration (µg/L)	Is the mean above the EMEG of 20 µg/L?
Scarboro drainage ditches (off site)	0.197	no
Upper EFPC (on site)	33.5	yes
Lower EFPC (off site)	12.8	no
Bear Creek (on site)	159	yes
Lower EFPC (on site after joining with Bear Creek)	8.4	no

Source: EPA 2003; FAMU 1998; OREIS

In addition, the mean total uranium concentrations in Scarboro and Lower EFPC are below EPA's maximum contaminant level (MCL) for uranium (30 µg/L). The MCL is the level of a contaminant that is allowed in drinking water. EFPC, however, is not used as a drinking water source. The city of Oak Ridge, including the community of Scarboro, is served by municipal water obtained from the Clinch River (Melton Hill Lake), upstream from the reservation.

Figure 23. Locations of Surface Water Samples



Current Soil Exposure Pathway

In 1997, residents of Scarboro and the local chapter of the National Association for the Advancement of Colored People (NAACP) raised concerns that activities at the Y-12 plant could have produced enriched uranium in Scarboro soils. Enriched uranium contains higher than normal amounts of U 235 as compared to natural uranium and is more radioactive than naturally occurring uranium. Therefore, enrichment is a measure of the mass percentage of U 235 in the final product; that is, the percentage of U 235 is elevated above that commonly found in nature relative to the other naturally occurring uranium isotopes. The degree of enrichment is determined by the use, not necessarily by the radioactivity of the sample. The detection and identification of enriched uranium, however, can be difficult in environmental samples, especially because the typical levels of U 235 are low in natural soils. In response to the concerns expressed by the residents and the NAACP, FAMU collected soil and water samples for the analysis of uranium and other radionuclides (FAMU 1998).

The results of the FAMU study were released in 1998. In 1999, EPA proposed a study to validate the FAMU results and released their findings in 2003 (EPA 2003). Each of these studies only collected samples in the Scarboro community, thus no comparison to other areas of Oak Ridge were made[14]. To address exposure to the soil pathway, ATSDR evaluated soil data recently collected in the reference location, Scarboro. ATSDR compared these Scarboro soil data to national background values, as well as to soil samples collected by DOE for the Background Soil Characterization Project in the Oak Ridge area (DOE 1993). During this background characterization project, DOE collected soil samples from uncontaminated areas on ORR, as well as from areas off site.

Prior to the nuclear age, background concentration and natural background were identical. After the advent of nuclear weapons, the natural background concentration has been impacted by atmospheric testing. This change of background and natural concentrations now means that there are two separate values, a naturally occurring concentration that is indicated as a pre-nuclear age concentration and a background concentration, which has been impacted by atmospheric testing. To evaluate the presence or absence of enriched uranium, the data are best evaluated on a percent basis. For the purposes of evaluating the radiation dose, however, activity in the form of picocuries (pCi) is necessary.

To evaluate the results of EPA's and FAMU's sampling for public health implications, ATSDR compared the isotopic composition of the uranium in Scarboro soil to the isotopic composition found in naturally occurring uranium. ATSDR also compared the isotope ratio to see if these could indicate elevated uranium, even if the concentrations appeared typical. The EPA isotopic analyses of Scarboro soil indicated that the average radioactivity concentrations were 1.2 picocuries per gram (pCi/g) for U 234, 0.1 pCi/g for U 235, and 1.0 pCi/g for U 238. The isotopic ratio of U 235/U 238 suggested that the radioactivity concentration of U 235 in Scarboro soil was elevated greater than typical concentrations found in nature (see Table 17). Based on an initial observation, the U 235 detected in Scarboro soil appears to be representative of

[14] ATSDR attempted to locate background soil sampling data within other residential areas of the city of Oak Ridge, but as of this writing was unsuccessful. Areas that ATSDR attempted to obtain data from included background samples collected for the Atomic City Auto Parts (ACAP) remediation. ACAP is a privately owned company contaminated with materials derived and purchased from Oak Ridge Operations. Under consent orders from the state of Tennessee, DOE assumed responsibility for the cleanup of the contaminated areas. In the case of ACAP, environmental media were sampled for U 234, U 235, and U 238. ATSDR was informed by DOE that only one monitoring well and soil boring were collected around ACAP. Therefore, ATSDR does not consider any data derived from this site as representative soil background samples. ATSDR is also trying to locate information related to the CSX Railroad remediation and sampling data collected in the Woodland area of Oak Ridge.

enriched uranium as the isotopic ratio of U 235/U 238 is larger (0.096) than the expected isotopic ratio (0.047) in nature. However, the ratio of the activities can be misleading because the activity of U 235 detected was close to the detection limit and the associated uncertainty of the measurement was large, in some cases 75% of the measured value.

Table 17. Comparison of the Ratio of Isotopic Activities for Uranium in Scarboro Soil to Naturally Occurring Uranium

	U 234	U 235	U 238
Scarboro soil concentration	1.2 pCi/g	0.1 pCi/g	1.0 pCi/g
Isotopic ratio in Scarboro soil	1.16 (U 234/U 238)	0.096 (U 235/U 238)	
Isotopic ratio in nature	0.972 (U 234/U 238)	0.047 (U 235/U 238)	

Source: EPA 2003

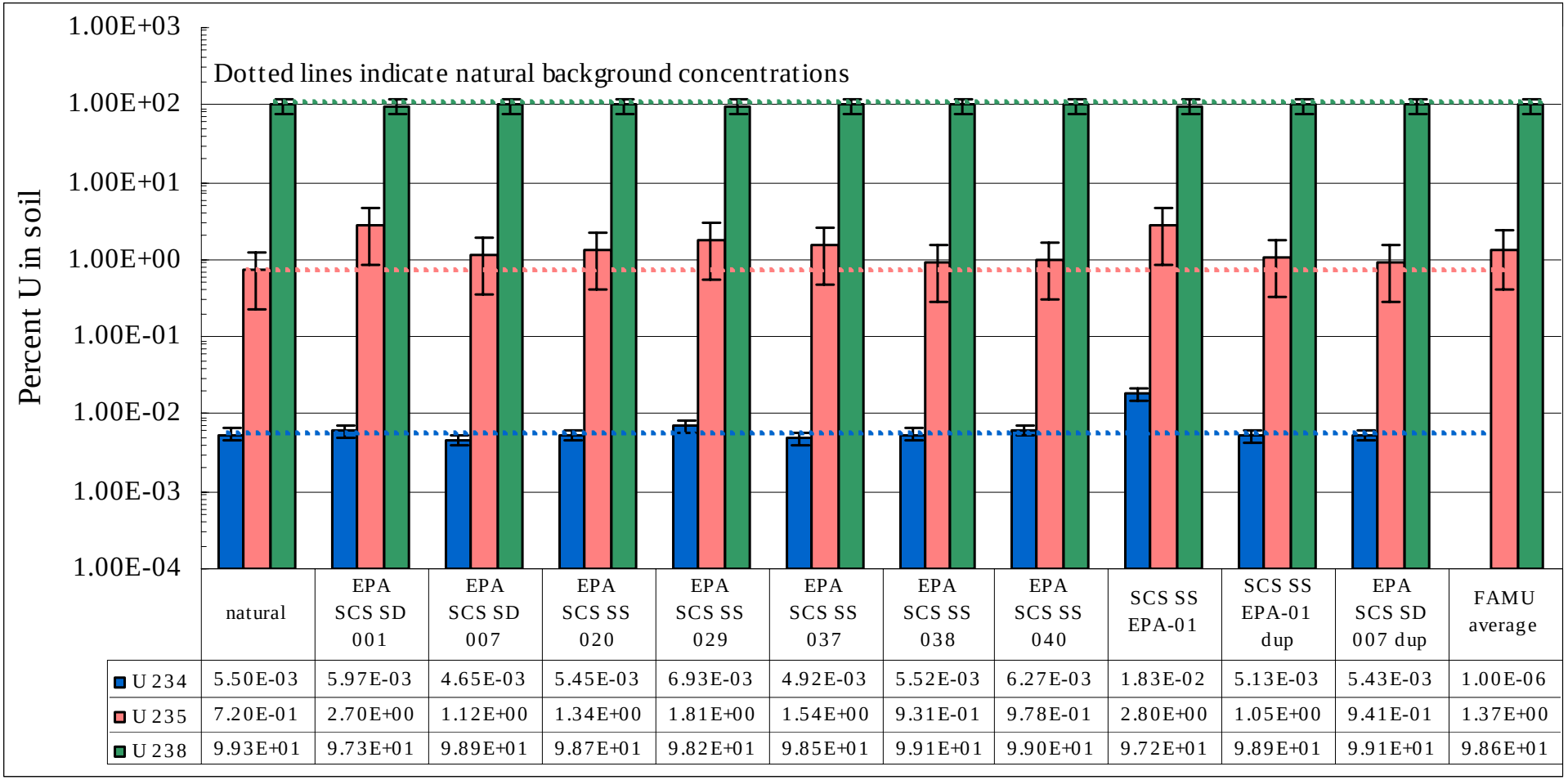
Not shown in the table is the considerable uncertainty in the U 235 measurement. This uncertainty is a function of the amount of U 235 found in nature and the method of analysis.

Therefore, the next step was to determine if the U 235, as a percentage of total uranium, was significantly elevated, which would indicate the presence of enriched uranium. ATSDR converted the measured uranium activity levels obtained from the FAMU and EPA studies to mass units[15]. ATSDR then compared the results of both EPA's (EPA 2003) and FAMU's (FAMU 1998) sampling efforts to measured soil background concentrations reported by DOE (DOE 1993). ATSDR also compared the results to the established isotopic abundance of the three uranium isotopes. The results of this evaluation are shown in Figure 24. This figure shows the isotopic concentrations of uranium, expressed as a percent of uranium isotopes in soil, in naturally occurring uranium, 10 Scarboro soil and sediment samples from the EPA study, and the average uranium concentrations in Scarboro soil samples from the FAMU study. The dotted lines at 0.005% (U 234), 0.72% (U 235), and 99.2% (U 238) represent the percent abundance of the uranium isotopes in nature. The error bars represent the uncertainties associated with the analyses of the uranium measurements. The data show that two of the EPA samples (sd 007 and ss EPA 1) including the uncertainty, appear to be above the U 235 concentrations found in nature. However, closer evaluation of EPA samples SS EPA 1 and SS EPA 1 dup (a duplicate sample) shows that the uncertainty of these samples is within the range of naturally occurring U 235. Therefore, ATSDR considers only one EPA sample (sd 001) slightly in excess of the naturally occurring concentrations of U 235. Figure 25 compares the uranium isotopic concentrations in naturally occurring uranium to the average uranium isotopic concentrations in soil samples from Scarboro (EPA and FAMU studies) and in background soil samples from uncontaminated areas on and off the ORR (DOE study).

The overall results indicate that the concentrations of uranium detected in the Scarboro community by EPA and FAMU are indistinguishable from the background concentrations of uranium in the area around Oak Ridge. Furthermore, the percentages of total uranium in the Scarboro community are essentially identical to the percentages of total uranium found in nature. However, the Oak Ridge area appears to contain more U 235 than typically found in nature.

[15] To convert the radioactive measurement of the isotope to grams, one divides the radioactive measurement by its specific activity.

Figure 24. Comparison of Uranium Isotopic Concentrations in Natural Uranium, 10 EPA Scarboro Soil Samples, and Average FAMU Scarboro Soil Samples

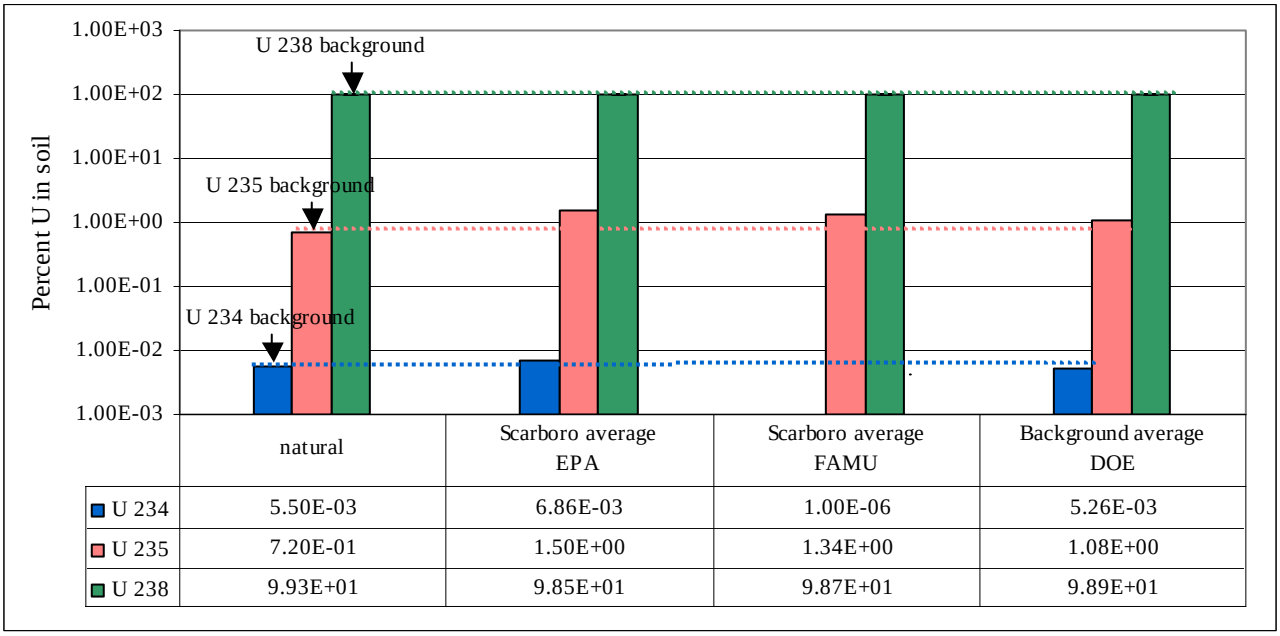


	natural	EPA SCS SD 001	EPA SCS SD 007	EPA SCS SS 020	EPA SCS SS 029	EPA SCS SS 037	EPA SCS SS 038	EPA SCS SS 040	SCS SS EPA-01	SCS SS EPA-01 dup	EPA SCS SD 007 dup	FAMU average
U 234	5.50E-03	5.97E-03	4.65E-03	5.45E-03	6.93E-03	4.92E-03	5.52E-03	6.27E-03	1.83E-02	5.13E-03	5.43E-03	1.00E-06
U 235	7.20E-01	2.70E+00	1.12E+00	1.34E+00	1.81E+00	1.54E+00	9.31E-01	9.78E-01	2.80E+00	1.05E+00	9.41E-01	1.37E+00
U 238	9.93E+01	9.73E+01	9.89E+01	9.87E+01	9.82E+01	9.85E+01	9.91E+01	9.90E+01	9.72E+01	9.89E+01	9.91E+01	9.86E+01

Sources: EPA 2003; FAMU 1998

The isotopic concentration values can be written different ways, for example 1.00E-03 percent U in soil is the same as 1.00×10^{-3} percent U in soil and 0.001 percent U in soil.

Figure 25. Comparison of the Average Uranium Isotopic Concentrations in Natural Uranium, EPA and FAMU Scarboro Soil Samples, and Background Soil Samples



	natural	Scarboro average EPA	Scarboro average FAMU	Background average DOE
U 234	5.50E-03	6.86E-03	1.00E-06	5.26E-03
U 235	7.20E-01	1.50E+00	1.34E+00	1.08E+00
U 238	9.93E+01	9.85E+01	9.87E+01	9.89E+01

Sources: DOE 1993; EPA 2003; FAMU 1998

The background average is from the DOE Background Soil Characterization Project, for which soil samples were taken from uncontaminated areas on and off the ORR.
The isotopic concentration values can be written different ways, for example 1.00E-03 percent U in soil is the same as 1.00×10^{-3} percent U in soil and 0.001 percent U in soil.

Concern has also been expressed that the Scarboro community has been impacted by uranium releases to EFPC. To evaluate this concern, ATSDR evaluated the location and surface elevation of Scarboro and EFPC. Lower EFPC flows north from the Y-12 plant off site through the business and residential sections of city of Oak Ridge, but does not flow through Scarboro. At its closest point, the EFPC passes about 0.4 miles to the northeast of the populated areas of Scarboro (ChemRisk 1999b). Also, Scarboro is located at a higher elevation along Pine Ridge than the EFPC floodplain, and Scarboro does not receive surface water from the EFPC. In addition, ATSDR compared the average uranium isotopic ratios (U 234/U 238; U 235/U 238) of Scarboro soil and EFPC floodplain soil from off-site areas to that of natural occurring uranium. The isotopic ratios are shown in Table 18.

Table 18. Comparison of the Average Uranium Isotopic Ratios in Scarboro Soil, EFPC Floodplain Soil, and Natural Uranium

Location	U 234/U 238	U 235/U 238
Scarboro	4.79×10^{-5}	0.01
EFPC	2.84×10^{-5}	0.004
Natural	5.54×10^{-5}	0.0072

Sources: ChemRisk 1999; DOE 1993; EPA 2003; FAMU 1998; OREIS
The ratios are based on the percentages of the specific isotopes found in nature, not their radioactivity.

These data suggest that the ratio of U 234/U 238 in Scarboro soil is elevated over the ratio found in EFPC floodplain soils; however, the ratios for both locations are less than the ratio typically found in nature. The percentages of uranium in the Scarboro community are essentially identical to the amount of uranium found in nature; nonetheless, the Oak Ridge area may contain more U 235 than typically found in nature. However, the ratio of U 235/U 238 in Scarboro soil is not elevated over those found in the EFPC floodplain or in nature. The uranium content in soils within the Scarboro community is representative of uranium found in areas not impacted by Y-12 operations; that is, the soils in Scarboro are not contaminated by atmospheric releases related to ORR operations.

Additionally, in 1993, ATSDR scientists released a public health consultation that evaluated the environmental sampling data from EFPC to determine the public health implications of past and current Y-12 plant releases into the creek. ATSDR concluded that the concentrations of uranium and other radionuclides detected in soil, sediment, surface water, and fish from EFPC were not present at levels of public health concern (ATSDR 1993b).

Soil ingestion pathway

Typically, the proportion of a population exposed to contaminated soils is identified by estimating the area of contaminant dispersion and then determining the population within the contaminated area. Furthermore, the population can be characterized by identifying individuals who are more likely to ingest soil (i.e., children). However, the entire population in the contaminated area may ingest some soil. People incidentally (accidentally) ingest soil when they use their hands to handle food that they eat, smoke cigarettes, or put their fingers in their mouths because soil or dust particles can adhere to food, cigarettes, and hands. Children are particularly sensitive because they are likely to ingest more soil than adults. Displaying hand-to-mouth behavior is a normal phase of childhood and therefore children have more opportunities to ingest soil than adults do.

For the purposes of this assessment, ATSDR evaluated soil ingestion for Scarboro children (assuming they incidentally ingest 100 mg/day) and their resulting uranium CEDEs over a period of 70 years. For this scenario, ATSDR chose dose coefficients for an infant as these would result in the highest dose to a child who might ingest soils at various ingestion rates. Furthermore, as the uranium ingested is considered insoluble, the organ receiving the greatest radiation dose would be the bone (see Table 19). Therefore, ATSDR calculated uranium CEDEs to both the bone and the whole body. These radiation doses to the bone and whole body are well below the ATSDR radiogenic cancer comparison value of 5,000 mrem over 70 years and are not at levels known to cause any adverse health outcomes.

Table 19. Uranium Radiation Doses Following Soil Ingestion by a 1-year old Scarboro Resident at Each Sample Location

Sample Location	Bone (mrem)	Whole body (mrem)
S. Benedict 1	4.37×10^{-1}	3.05×10^{-2}
S. Dillard	6.02×10^{-1}	4.17×10^{-2}
S. Fisk	5.96×10^{-1}	4.15×10^{-2}
Parcel	6.27×10^{-1}	4.38×10^{-2}
S. Benedict 2	6.12×10^{-1}	4.25×10^{-2}
Spellman	7.34×10^{-1}	5.11×10^{-2}
Hampton	5.56×10^{-1}	3.88×10^{-2}
Bennett Lane	3.85×10^{-1}	2.73×10^{-2}
Average	$\mathbf{5.69 \times 10^{-1}}$	$\mathbf{3.97 \times 10^{-2}}$

The dose is the CEDEs expected to be received over a period of 70 years following an intake. It is based on the ingestion of 100 milligrams of soil daily for the course of one year.

Ingestion of vegetables grown near the Y-12 plant

When uptake into plants is possible, the identification of populations that are exposed or potentially exposed through consumption of contaminated plants is evaluated. Because of the chemical nature and solubility in water, uranium oxides, the form of uranium released from the Y-12 plant (ChemRisk 1999), are not readily taken up by plants (Dreesen et al. 1982; Moffett and Tellier 1977 as cited in ATSDR 1999a). The uptake, called the concentration ratio (CR), is expressed as a ratio of uranium in soil to the amount of uranium in plants. The concentration ratio is dependent on the soil and type of plant, with recommended values ranging from 0.002 to 0.017 (LANL 2000; NCRP 1999). For example, if a kilogram of soil contains a microgram of uranium, a kilogram of plant material may contain 0.002 to 0.017 micrograms of uranium.

From 1998 to 2000, DOE collected homegrown vegetables from a Scarboro resident and analyzed these foods for radionuclides, including the uranium isotopes. ATSDR analyzed the private garden vegetable data to evaluate the uranium radiation dose a person might receive from the ingestion of these vegetables. The rate of consumption of contaminated plants may differ considerably from the national average for certain populations living near hazardous waste sites. EPA has published a handbook, the Exposure Factors Handbook (EPA 1997), in which regional rates for foods are listed. ATSDR used the food intake parameters specific to the South (see Table 20).

Table 20. Food Ingestion Rates for the Southern United States

Food	Per Capita Intake (g/kg/day)	Standard Error
Total fruit	3.017	0.105
Total vegetable	4.268	0.047
Total meat	2.249	0.025
Homegrown fruits	2.97	0.3
Homegrown vegetables	2.27	0.122
Home-produced meat	2.24	0.194

Source: EPA 1997

g/kg/day: grams per kilogram per day

ATSDR estimates that a person who frequently eats vegetables from a private garden in Scarboro is expected to receive about 0.137 mrem of uranium per year. The summary of this analysis from the ingestion of foods collected from a private garden in Scarboro is provided in Table 21.

Table 21. Radiation Doses from Uranium Following Ingestion of Private Garden Vegetables Grown in Scarboro

Vegetable type	Concentration (total mg U)	Total Radiation Dose (mrem per gram food)
Leafy	1.14E-02	1.87×10^{-3}
Tomatoes	3.92E-04	4.34×10^{-5}
Turnips	1.22E-03	1.54×10^{-4}
Total per kg food	1.31E-02	2.06×10^{-6}
	Total following ingestion	1.37×10^{-1} mrem per year

Source: OREIS

Ingestion is based on an 80-kilogram adult eating 2.27 grams of produce per kilogram of body weight per day for 365 days a year (EPA 1997).

In addition, DOE collects and analyzes vegetables grown in plots near on-site and off-site air monitoring stations and in private gardens (Figure 26 gives sample locations). The vegetables included lettuce, turnips, turnip greens, and tomatoes. These vegetables are analyzed for radionuclides, including the uranium isotopes. ATSDR estimated the annual dose a resident might receive from ingesting equal amounts of these vegetables using the same default values estimated for a Scarboro resident. That is, the typical resident would ingest 2.27 grams of produce per day for each kilogram of their body weight. For these calculations, we used a body weight of 80 kilograms (approximately 176 pounds) and 365 days per year. The estimated average radiation doses from uranium are summarized in Table 22. These results indicate that the produce grown and consumed in the Scarboro community contains essentially the same amount of uranium as produce grown in the outlying areas.

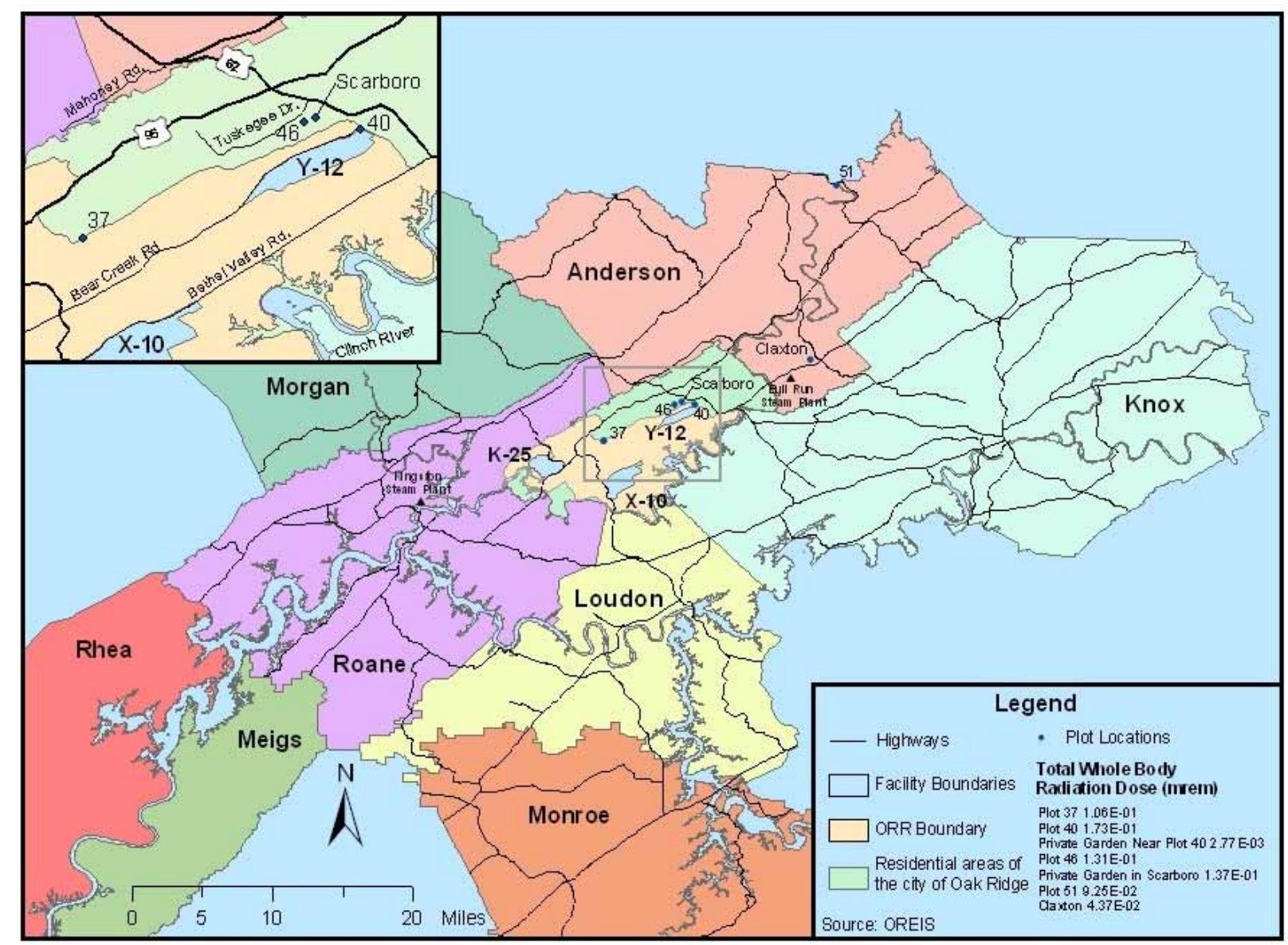
Table 22. Radiation Doses from Uranium Following Ingestion of Garden Vegetables Grown On and Off the Oak Ridge Reservation

Plot Identification Number	Location	Concentration*	Total Whole Body Radiation Dose (mrem)
Plot 37	Monitoring station 37 On site west of Y-12 in the ORR	9.26×10^{-9}	1.06×10^{-1}
Plot 40	Monitoring station 40 On site near Bear Creek Road and Scarboro Road Intersection	1.28×10^{-8}	1.73×10^{-1}
Private Garden	Off site near station 40	3.35×10^{-10}	2.77×10^{-3}
Plot 46	Monitoring station 46 Off site in Scarboro	1.25×10^{-8}	1.31×10^{-1}
Private Garden	Off site in Scarboro	4.35×10^{-9}	1.37×10^{-1}
Plot 51	Monitoring Station 51 Off site in Anderson County	6.8×10^{-9}	9.25×10^{-2}
Claxton	Off site in Claxton	5.08×10^{-9}	4.37×10^{-2}
		Average ± SD	$9.8 \times 10^{-2} \pm 5.8 \times 10^{-2}$
		Average excluding Plot 46 and Scarboro private garden	8.36×10^{-2}

Source: OREIS

* Average concentration of uranium in all vegetables sampled (grams U per gram of food)

Figure 26. Locations Where Vegetable Samples Were Grown On and Off the Oak Ridge Reservation



External exposure from uranium in soils

Just being near uranium is not dangerous to your health because uranium gives off very little of the penetrating gamma radiation (ATSDR 1999a). 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). Thus, uranium is a very weak emitter of radiation and is considered a health problem if internalized within the body. A comparison of dose factors using federal guidance documents (EPA 1988, 1993) indicates that uranium in the soil pathway can be removed from any additional evaluation.

III.B.2.b. Current Chemical Effects

ATSDR evaluated whether exposure to the levels of uranium currently being released from the Y-12 plant would cause harmful chemical effects in people living near the Y-12 plant, including the reference population (the Scarboro community). On the basis of the chemical toxicity of uranium, it can be stated that residents living near the ORR are not currently being exposed to harmful levels of uranium through inhalation of air or ingestion of soils, homegrown vegetables, and surface water.

Current Inhalation Exposure Pathway

ATSDR reviewed the air monitoring data accumulated since 1995 in the Scarboro community (Station 46) and air monitoring data accumulated from 1986 to 1991 in the city of Oak Ridge (Station 41). ATSDR used these data to assess the chemical impact of inhaling air containing uranium[16]. These data were compared to data from perimeter air monitoring stations (Stations 1, 37, 38, and 40) on the reservation as well as to background data at remote air monitoring stations (Stations 51 and 52) (Figure 22 shows the locations of the air monitoring stations). For the comparisons, ATSDR converted the isotopic uranium values to mass[17], expressing the activity in units of milligrams of uranium per cubic meter of air (mg/m^3). The air concentrations of uranium in Scarboro averaged 5.4×10^{-11} mg/m^3 and in the city of Oak Ridge averaged 1.4×10^{-10} mg/m^3 (see Figure 27). All of the air concentrations are within an order of magnitude of each other, including the background locations. The average uranium air concentrations from perimeter monitoring stations on the reservation to the west of Scarboro are about 20% lower than the

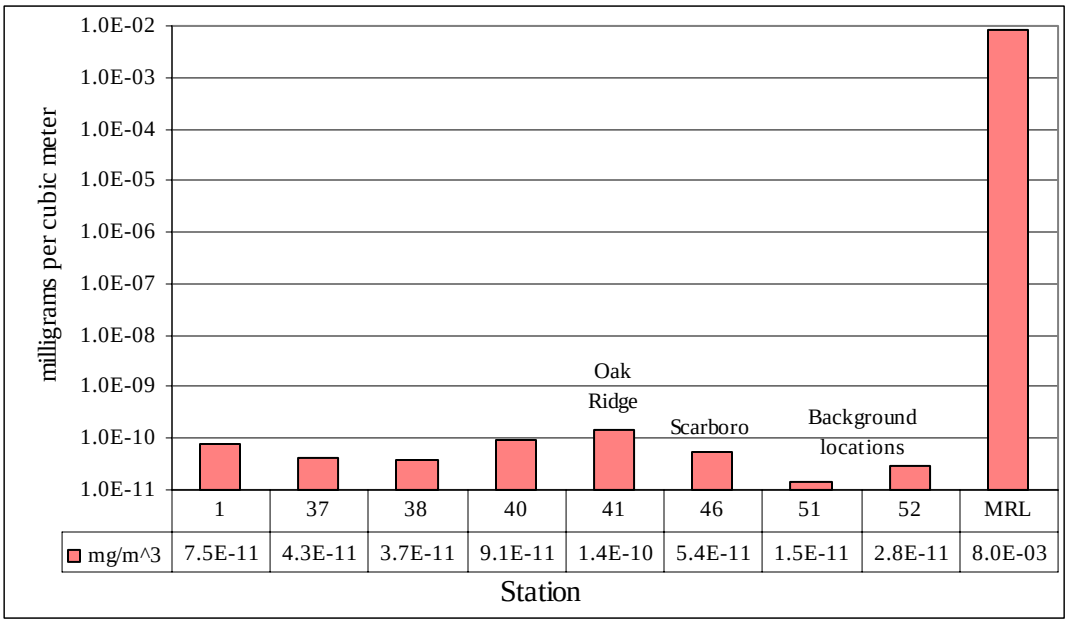
[16] Fossil fuel plants, such as coal burning plants, release naturally occurring radioactive materials through their stacks. Because the Bull Run and Kingston Steam Plants are in the vicinity of Oak Ridge, these facilities could be impacting the uranium analyses performed in Oak Ridge. ATSDR could not locate specific information about these plants from the Tennessee Valley Authority. The agency did, however, locate information from a peer-reviewed publication that reported the typical concentrations of uranium in coal ash and fly ash. These values were 4 picocuries per gram (pCi/g) and 5.4 pCi/g, respectively (Stranden 1985).

[17] Each individual isotope (U 234, U 235, and U 238) has a separate and distinct half life and mass. Therefore, one can convert the activity of each individual isotope using its specific activity expressed as curies of radioactivity per gram of pure radionuclide (0.333 pCi/µg for U 238, 6,187 pCi/µg for U 234, 2.14 pCi/µg for U 235). To convert the radioactive measurement of the isotope to milligrams, one divides the radioactive measurement by its specific activity while ensuring the units of measurement are consistent.

average concentrations measured in the Scarboro location. The average background uranium air concentrations from the remote air monitoring stations are about 60% lower than that of Scarboro; however, the average concentration from Station 1, located on site near X-10, is about 40% higher than Scarboro. Station 41, located in Oak Ridge near the intersection of South Illinois Avenue and the Oak Ridge Turnpike, has an average concentration about 60% higher than Scarboro. Therefore, ATSDR believes this indicates that a portion of the uranium detected in the air around Scarboro is from the Y-12 plant.

The current air concentrations were compared to ATSDR's intermediate-duration inhalation MRL of 8×10^{-3} mg/m^3 for insoluble uranium. As shown in Figures 9 and 27, air concentrations from all stations, including Scarboro, are more than a million times less than the MRL and therefore well below levels that would be expected to cause harmful chemical effects.

Figure 27. Average Uranium Air Concentrations Compared to the MRL



Source: OREIS

The air concentration values can be written different ways, for example 1.0E-02 milligrams per cubic meter is the same as 1.0×10^{-2} milligrams per cubic meter and 0.01 milligrams per cubic meter.
Values are averages of monitoring station data available from 1995 to present; except the value for Station 41 is an average of data from 1986 to 1991.
Station 46 is in the Scarboro community, and Stations 51 and 52 (located at the Norris and Fort Loudoun Dams, respectively) are monitoring locations that have not been impacted by releases from the ORR. The remaining stations are on the reservation.
ATSDR's MRL is also shown.

Current Ingestion Exposure Pathway

Ingestion of soils

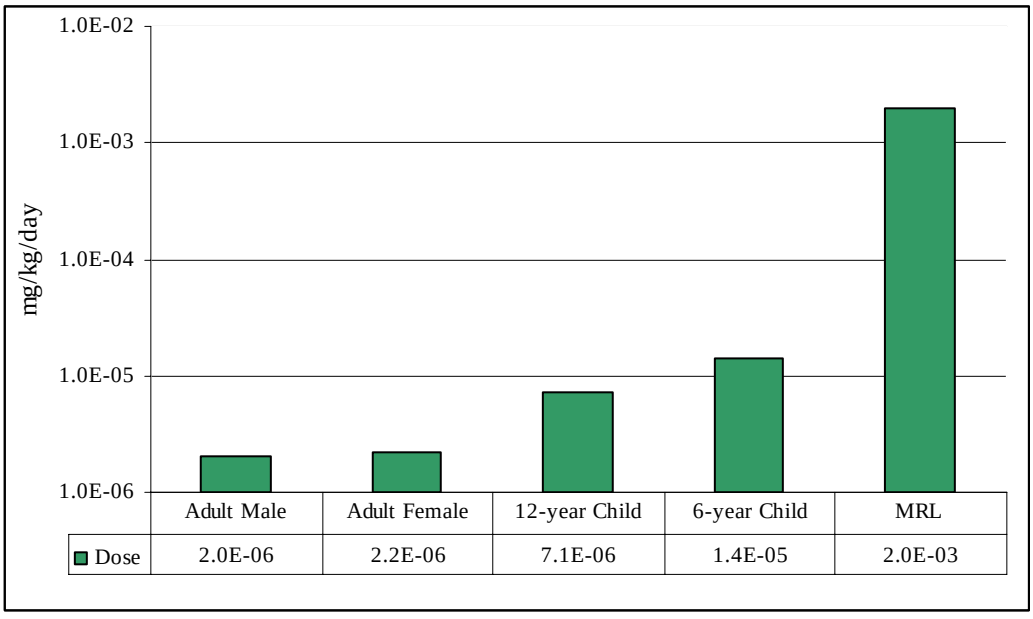
As with the evaluation of radiation effects, ATSDR considered that the entire population of Scarboro incidentally ingests soil. Adults were assumed to incidentally ingest 50 mg of soil/day, whereas children were assumed to incidentally ingest 100 mg/day. For the purposes of the assessment, ATSDR evaluated current doses for an adult male, an adult female, a 12-year-old child, and a 6-year-old child. The results are summarized in Table 23 and Figure 28. The Evaluating Exposures section (Section III.A.2.) explains ATSDR's method of calculating doses.

Table 23. Uranium Doses from Ingestion of Scarboro Soil

Population	Body Weight (kg)	Intake Rate (mg/day)	Dose (mg/kg/day)
Adult Male	78	50	2.0×10^{-6}
Adult Female	71	50	2.2×10^{-6}
12-year Child	45	100	7.1×10^{-6}
6-year Child	23	100	1.4×10^{-5}
		Ingestion MRL	2.0×10^{-3}

The average soil uranium concentration of 3.19 mg U/kg soil (EPA 2003) was used in the formula Dose = (Conc. × IR) / BW to calculate the uranium dose from incidental ingestion of soil.

Figure 28. Uranium Dose Following Ingestion of Soil



The dose values can be written different ways, for example 1.0E-02 mg/kg/day is the same as 1.0×10^{-2} mg/kg/day and 0.01 mg/kg/day.

The estimated uranium doses from ingestion of Scarboro soil by all receptor populations are well below the ATSDR MRL for intermediate-duration oral exposure to uranium (0.002 mg/kg/day) (shown in Table 23). The maximum uranium dose to the receptor population (6-year-old child) is

approximately 140 times less that the ATSDR MRL. Remember that the MRL is a screening level for which values below are not of health concern. This intermediate-duration oral MRL is also protective for chronic-duration oral exposure because the renal effects of uranium exposure are more dependent on the dose than on the duration of exposure (ATSDR 1999a). Therefore, residents of Scarboro are not currently being exposed to harmful levels of uranium through incidentally ingesting soil.

Ingestion of vegetables grown near the Y-12 plant

Because of its chemical nature and solubility in water, uranium oxide is transported poorly from soils to plants (Dreesen et al. 1982; Moffett and Tellier 1977 as cited in ATSDR 1999a). The uptake varies widely (i.e., concentration ratios range from 0.002 to 0.017; LANL 2000; NCRP 1999) and is dependent on the nature of the soil, the pH, and the concentration of uranium in the soil.

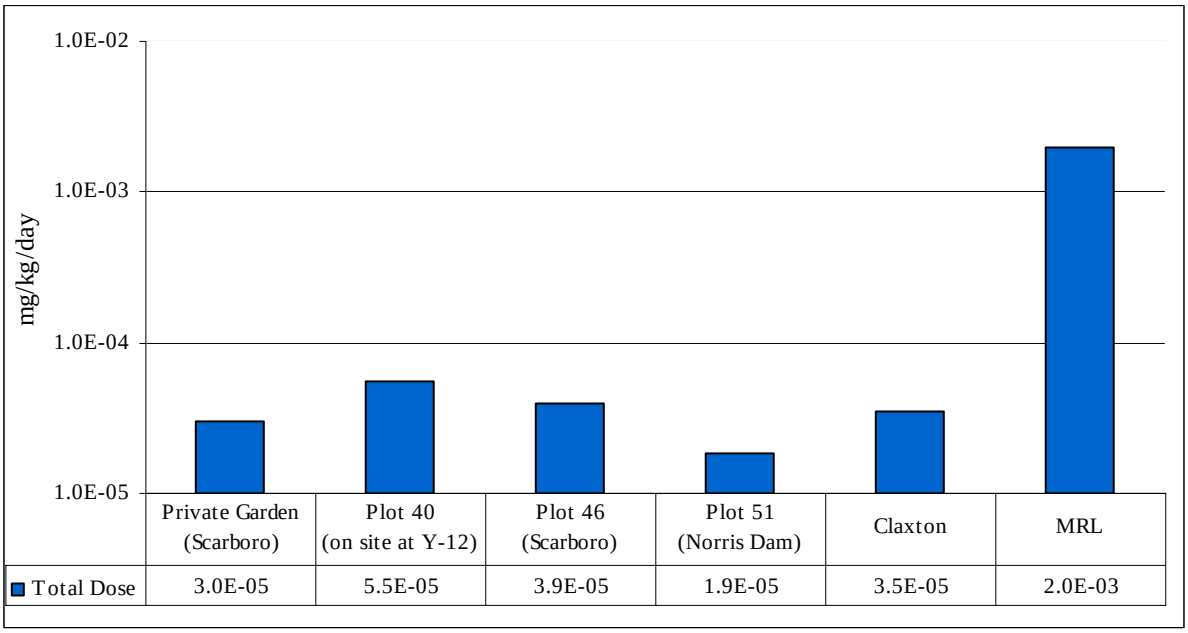
As noted previously in the radiation effects section, DOE collected homegrown vegetables from plots near on-site and off-site air monitoring stations and in private gardens in Scarboro and Claxton and analyzed these foods for the uranium isotopes. ATSDR used food ingestion rates (listed in Table 20) to evaluate the mass intake one might receive from the ingestion of these vegetables. The estimated doses of uranium from ingestion of vegetables from several locations on and around the ORR, including a private garden in Scarboro and a garden grown at air monitoring station 46 (also located in Scarboro), are given in Table 24 and Figure 29.

Table 24. Total Uranium Dose Following Ingestion of Vegetables Grown On and Off the Oak Ridge Reservation

Location	Total Intake (mg/g)	Total Dose (mg/kg/day)
Private Garden (Scarboro)	1.3×10^{-5}	3.0×10^{-5}
Plot 40 (on site at Y-12)	2.4×10^{-5}	5.5×10^{-5}
Plot 46 (Scarboro)	1.7×10^{-5}	3.9×10^{-5}
Plot 51 (Norris Dam)	8.2×10^{-6}	1.9×10^{-5}
Claxton	1.5×10^{-5}	3.5×10^{-5}
MRL		2.0×10^{-3}

The total uranium doses were calculated by multiplying the total intakes by 2.27 g/kg/day, which is the mean intake of homegrown vegetables for people who live in the South and garden (EPA 1997).

Figure 29. Total Uranium Dose Following Ingestion of Vegetables Grown On and Off the Oak Ridge Reservation



	Private Garden (Scarboro)	Plot 40 (on site at Y-12)	Plot 46 (Scarboro)	Plot 51 (Norris Dam)	Claxton	MRL
Total Dose	3.0E-05	5.5E-05	3.9E-05	1.9E-05	3.5E-05	2.0E-03

The dose values can be written different ways, for example 1.0E-02 mg/kg/day is the same as 1.0×10^{-2} mg/kg/day and 0.01 mg/kg/day.

ATSDR has established an MRL of 0.002 mg/kg/day for the ingestion of uranium. As shown in Table 24, the total uranium doses from ingestion of vegetables grown in all on-site and off-site locations, including the Scarboro community, are well below the ATSDR MRL for intermediate-duration oral exposure to uranium (0.002 mg/kg/day). The estimated total uranium doses from ingestion of vegetables grown in private gardens in Scarboro are more than 50 times less than the MRL, and therefore ingestion of these vegetables is not of health concern.

The uranium doses following ingestion of soils and vegetables from a private garden in Scarboro are so low that even if the exposures from the two pathways are combined, the resulting dose is still lower than the MRL. As discussed in the Evaluating Exposures section (Section III.A.2.), estimated doses that are less than the MRL are not considered to be of health concern and do not require further evaluation. For example, if the highest dose following ingestion of soil (1.4×10^{-5} mg/kg/day for a 6-year-old child, see Table 23) is added to the total intake from ingestion of vegetables grown in Scarboro (3.9×10^{-5} mg/kg/day from Plot 46, see Table 24), the total ingestion dose is 5.3×10^{-5} mg/kg/day, which is about two orders of magnitude below the MRL of 2.0×10^{-3} mg/kg/day (see Figure 8). Therefore, the combined exposure from both ingestion pathways would not result in harmful health effects.

Ingestion of water from nearby creeks

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. Under the authorization of the Safe Drinking Water Act, EPA has set national health-based

standards to protect drinking water and its sources. More information concerning the Safe Drinking Water Act can be found on EPA's website at http://www.epa.gov/safewater or by calling EPA's Safe Drinking Water Hotline at 1-800-426-4791. The total uranium mean concentrations in surface water from Scarboro ditches and Lower EFPC are below EPA's MCL for uranium (30 µg/L). In addition, Table 16 shows that the mean total uranium concentrations for surface water samples collected from Scarboro ditches and Lower EFPC are below ATSDR's EMEG of 20 µg/L, which is a nonenforceable, health-based comparison value developed for screening environmental contaminants for further evaluation. The EMEG reflects a concentration that is much lower than those that have been observed to cause adverse health effects. As a result, exposure to concentrations at or below ATSDR's EMEG are not considered to warrant health concern. Therefore, the concentrations of uranium that people might be exposed to are not of health concern.

The MCL is the level of a contaminant that is allowed in drinking water.

IV. PUBLIC HEALTH IMPLICATIONS

IV.A. 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 city of Oak Ridge is the established community where people lived during the years of uranium releases that could have been impacted by the Y-12 uranium releases. The Scarboro community, within the city of Oak Ridge, was selected as a reference location that represents the whole city. The Scarboro location was used to estimate concentrations of uranium in the air, surface water, and soil in an off-site area where residents resided during years of past Y-12 plant 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). Therefore this evaluation's conclusions regarding exposures of Scarboro residents to uranium are also applicable to residents living in the city of Oak Ridge.

As Table 25 shows, 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 a health hazard. Therefore, the residents of 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. **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 the Public Health Evaluation section (Section III.B.).

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

Exposure	Effects	Pathway	Are People Being Exposed?	Estimated Dose	Screening Comparison Value	Is the Dose Above or Below the Screening Value (Magnitude)?	Conclusion Category
Past	Radiation	Total	Yes	155 mrem over 70 years	5,000 mrem over 70 years	Below (32 times less)	**No apparent public health hazard:** exposures are not at levels expected to cause adverse health effects.
				2.2 mrem/year	100 mrem/year	Below (45 times less)	
	Chemical	Inhalation	Yes	2.1×10^{-8} to 6.0×10^{-5} mg/m^3	8×10^{-3} mg/m^3	Below (130 times less)	
		Ingestion	Yes	2.7×10^{-5} to 1.3×10^{-2} mg/kg/day	2×10^{-3} mg/kg/day	Above. However, all doses are less than the dose (5×10^{-2} mg/kg/day) at which renal health effects have been observed in the most sensitive mammalian species.	
Current	Radiation	Ingestion and Inhalation	Yes	0.216 mrem over 70 years	5,000 mrem over 70 years	Below (23,000 times less)	**No apparent public health hazard:** exposures are not at levels expected to cause adverse health effects.
				0.003 mrem/year	100 mrem/year	Below (33,000 times less)	
	Chemical	Inhalation	Yes	5.4×10^{-11} and 1.4×10^{-10} mg/m^3	8×10^{-3} mg/m^3	Below (more than a million times less)	
		Ingestion	Yes	5.3×10^{-5} mg/kg/day	2×10^{-3} mg/kg/day	Below (37 times less)	

IV.B. Past Exposure Evaluation

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

IV.B.1.Past Radiation Exposure

To evaluate the 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 for the reference community—the Scarboro population—was 155 mrem over 70 years (see Table 4), and accounts for multiple routes of exposure (see Figure 11). This radiation dose of 155 mrem is 32 times less than the radiogenic cancer comparison value of 5,000 mrem (see Figure 12). Doses below this comparison value are not expected to result in adverse health effects. 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. ATSDR derived this committed effective dose equivalent (CEDE) value of 5,000 mrem over 70 years 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 received by the Scarboro community (a CEDE of 155 mrem over 70 years), 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 1 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 10 and 12).

The ATSDR MRLs are based on noncancer health effects only, not 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 are safe and not considered to be of health concern; exposure to estimated doses above the MRL does not necessarily mean that adverse health effects will occur. Rather, it is an indication that ATSDR should further examine the harmful effect levels reported in the scientific literature and more fully review exposure potential.

[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.

- 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 3 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 MRL 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.

IV.B.2 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 Figures 9 and 19, 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 (see Figure 9).

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 hazard (see Figures 8 and 20, 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 (see Figure 8) (ATSDR 1999a).

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 protective assumptions and approaches. This 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 this evaluation's conservative aspects:

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, which 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 U 234/235 concentrations by as much as a factor of 5. Consequently, airborne U 234/235 doses based on this method were most likely overestimated (see Figure 15 and Appendix E).

4. 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. The estimated doses would be much lower if they were based on actual measured concentrations in Scarboro.

IV.C. Current Exposure Evaluation

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

IV.C.1.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 inhalation of air, ingestion of soils, and 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 12).

ATSDR derived the CEDE of 5,000 mrem over 70 years 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. Doses below this value are not expected to result in adverse health effects. Therefore, ATSDR does not expect that harmful radiation effects from exposure to uranium are now occurring.

As noted previously, to evaluate noncancer health effects from the current radiation dose (a CEDE of 0.216 mrem over 70 years), an approximation can be made 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 1 year of exposure. The CEDE of 0.216 mrem over 70 years can be divided by 70 years, yielding an approximate value of 0.003 mrem as the radiation dose for the first year. This is well below (33,000 times less than) the 100 mrem/year ATSDR chronic exposure MRL for ionizing radiation (see Figures 10 and 12). ATSDR MRLs are based on noncancer adverse health effects only, not 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 be occurring 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. Therefore, ATSDR does not expect harmful heath effects to occur (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 and 18 and Figures 21, 24, and 25). 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 in air, surface water, and soil (including ingestion of soil and vegetables) would not cause harmful health effects.

IV.C.2.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 27). The average uranium air concentrations, therefore, are well below levels that would be expected to cause harmful chemical effects (see Figure 9).

- 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 (see Figure 9).

ATSDR also compared the doses from ingestion of uranium through the soil pathway (see Table 23 and Figure 28)—including ingestion of soil and vegetables from the reference location, Scarboro (see Table 24 and Figure 29)—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 (1.4×10^{-5} mg/kg/day for a 6-year-old child, see Table 23) is approximately 140 times less than the MRL, and the uranium dose from ingestion of vegetables grown in the private gardens in Scarboro (3.9×10^{-5} mg/kg/day from Plot 46, see Table 24) is more than 50 times less than the MRL. Therefore, the uranium doses are well below the MRL and not a health hazard.

Further, the uranium doses following ingestion of soils and vegetables from a private garden in Scarboro are so low that even if the exposures from the two pathways are combined, the resulting dose is still lower than the MRL. For example, if the highest dose following ingestion of soil is added to the total intake from ingestion of vegetables grown in Scarboro, the total ingestion dose is 5.3×10^{-5} mg/kg/day, which is about two orders of magnitude below the MRL (see Figure 8). Therefore, even the combined exposure from both ingestion pathways would not result in harmful health effects.

- 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 (see Figure 8).

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 mean concentrations of uranium 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 a health hazard.

V. Health Outcome Data Evaluation

Health outcome data are measures of disease occurrence in a population. Common sources of health outcome data are existing databases (cancer registries, birth defects registries, death certificates) that measure morbidity or mortality—that is, disease or death. Health outcome data can provide information on the general health status of a community: where, when, and what types of disease occurs and to whom it occurs. Public health officials use health outcome data to look for unusual patterns or trends in disease occurrence by comparing disease occurrences in different populations over periods of years. These health outcome data evaluations are descriptive epidemiologic analyses that are exploratory in that they may provide additional information about human health effects and can help identify the need for public health intervention activities such as community health education. Health outcome data cannot—and are not meant to—establish cause and effect between environmental exposures to hazardous materials and adverse health effects in a community.

ATSDR scientists generally consider health outcome data evaluation for one of two reasons: (1) to evaluate the possible health effects in a population that is known to have been exposed to enough environmental contamination to experience health effects or (2) to help address community concerns about a particular illness in a community. In this public health assessment on Y-12 uranium releases, ATSDR scientists determined that people living near the Y-12 plant were exposed to uranium released from the Y-12 plant from the 1940s through the 1990s. In addition, community members have expressed much concern about a perceived increase in respiration illness in Scarboro community children and an increase in cancer in the areas surrounding the ORR.

Criteria for Conducting a Health Outcome Data Evaluation

To determine how to use or analyze health outcome data in the public health assessment process, or even whether to use it at all, ATSDR scientists receive input from epidemiologists, toxicologists, environmental scientists, and community involvement specialists. These scientists consider the following criteria, based on site-specific exposure considerations only, to determine whether or not a health outcome evaluation should be included in the public health assessment.

1. Are there one or more current (or past) potential or completed exposure pathways at the site?

2. Can the time period of exposure be determined?

3. Can the population that was or is being exposed be quantified?

4. Are the estimated exposure doses(s) and the duration of exposure sufficient for a plausible, reasonable expectation of health effects?

5. Are health outcome data available at a geographic level or with enough specificity to be correlated to the exposed population?

6. Do the validated data sources or databases have information on the specific health outcome(s) or disease(s) of interest—i.e., the outcome(s) or disease(s) likely to occur from exposure to the site contaminants—and are those data accessible?

Based on the finding of the exposure evaluation in this public health assessment, ATSDR sufficiently documented completed exposure pathways to uranium released from the Y-12 plant via the air, surface water, and soil pathways from the mid-1940s to the late 1990s for residents in the city of Oak Ridge, specifically in the Scarboro community. The estimated exposures of Scarboro residents to Y-12 uranium, though, are not sufficient for a plausible, reasonable expectation of health effects. The documented evidence of off-site exposure to uranium indicates that estimates of past and current uranium doses are too low to be a public health hazard for both radiation and chemical health effects (see Section IV. Public Health Implications).

Although natural and depleted uranium are weakly radioactive, 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. The National Academy of Sciences reported that eating food or water that has normal amounts of uranium is not likely to cause cancer or other health problems in most people. They also stated that people ingesting large quantities of uranium could possibly get a kind of bone cancer called a sarcoma.

The estimated radiation dose to Scarboro residents from Y-12 uranium is less than the average U.S. background radiation dose and well below (32 to 23,000 times less than) the ATSDR radiogenic cancer comparison value (see Figure 9). Doses below these values are not expected to result in adverse health effects. 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 exposures from the Y-12 plant—was not exposed to hazardous levels of uranium, then other residents living near the Y-12 plant, including those within the city of Oak Ridge, are also not being exposed to levels of uranium expected to cause harmful health effects. Since the estimated uranium doses are not expected to cause health effects, no further analysis of health outcome data is appropriate. Analysis of site-related health outcome data is not scientifically reasonable unless the level of estimated exposure is likely to result in health effects. Since such an estimate of exposure cannot be made, the requirement to consider analysis of site-related health outcome data on the basis of exposure is complete.

In addition, health outcome databases are not available for the known specific health effect or disease associated with exposure to uranium. Uranium is a chemical substance that is also radioactive. Scientists have never detected harmful radiation effects from low levels of natural uranium, although some may be possible. Scientists have, however, seen chemical effects in the kidneys (nephrotoxicity in the renal proximal tubules or kidney disease) of a few people and animals after ingestion of large amounts of uranium. Currently there are not validated data sources or databases with information on nephrotoxicity in the renal proximal tubules, renal damage, or kidney disease for people living in the Oak Ridge area. Also, renal damage or kidney disease is not unique to high-level exposure to uranium. Many other non-radioactive heavy

metals (cadmium, lead, mercury) are more potent classical nephrotoxic metals that produce very severe, perhaps fatal, injury at the level of exposures reported for uranium in the literature.

Responding to Community Health Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. The concerns of all community members are important and must be addressed during the public health assessment process. The individual concerns addressed in the Community Health Concerns section (Section VI.) of 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.

Also, in 1997, residents of the Scarboro community expressed concerns about the rate of respiratory illness among children in Scarboro. In response to this community concern, the CDC and TDOH conducted the Scarboro Community Health Investigation, which included a community health survey and a follow-up medical evaluation of children. This investigation is summarized in Section II.F.3. and in Appendix I.

Area residents have also voiced concern about cancer. Citizens living in the communities surrounding the ORR have expressed many concerns to the ORRHES about a perceived increase in cancer in areas surrounding the ORR. Furthermore, a 1993 TDOH survey of eight counties surrounding the ORR indicated that cancer was mentioned as a health problem more than twice as much as any other health problem. (The survey also showed that 83% of the surveyed population in the surrounding counties believes it is very important to examine the actual occurrence of disease among residents in the Oak Ridge area.)

In order to address these concerns, ORRHES requested that the ATSDR conduct an assessment of health outcome data (cancer incidence) in the eight counties surrounding the ORR. Therefore, ATSDR is currently conducting a cancer incidence review using data that are already collected by the Tennessee Cancer Registry. This cancer incidence review is a descriptive epidemiologic analysis that will provide a general picture of the occurrence of cancer in a community. The purpose of conducting this evaluation is to provide citizens living in the ORR area with information regarding cancer rates in their area compared to the state of Tennessee. This evaluation will only examine cancer rates at the population level, not at the individual level. It is not designed to evaluate specific associations between adverse health outcomes and documented human exposures, and it will not and cannot establish cause and effect.

"Cancer incidence" refers to newly diagnosed cases of cancer that are reported to the Tennessee Cancer Registry.

In addition, over the last 20 years, local, state, and federal health agencies have conducted public health activities to address and evaluate public health issues and concerns related to chemical and radioactive substances released from the ORR. See Appendix B for a summary of previous public health activities.

VI. 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 concerns and issues along with ATSDR's responses. The concerns and responses are sorted by category (health concerns/general, cancer health effects, noncancer health effects, and health concerns/procedural issues).

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

	Summarized Concern/Issue	ATSDR's Response
Health Concerns/General		
1	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 hazard for both radiation and chemical health effects (please see Figures 8, 9, and 12 and Table 25). 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 (FAMU 1998) and EPA (EPA 2003) 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 the Current Soil Exposure Pathway discussion under the Current Radiation Effects section (Section III.B.2.a.) and Figures 21, 24, and 25 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 the Current Inhalation Exposure Pathway discussion under the Current Chemical Effects section (Section III.B.2.b.) and Figure 27 for additional details.
2	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/info_cntr/index.html or by calling 865-241-4780.

	Summarized Concern/Issue	ATSDR's Response
3	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 (FAMU 1998) and EPA (EPA 2003) 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 the Current Soil Exposure Pathway discussion under Current Radiation Effects section (Section III.B.2.a.) and Figures 21, 24, and 25 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 the Current Inhalation Exposure Pathway discussion under the Current Chemical Effects section (Section III.B.2.b.) and Figure 27 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 exposure to the mercury concentrations in Scarboro.

	Summarized Concern/Issue	ATSDR's Response
4	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 city of Oak Ridge is the established community where residents resided during the years of uranium releases that could have been impacted by Y-12 uranium releases. In this public health assessment, the Scarboro community was used as a reference location that represents the city of Oak Ridge. 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 2003) 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 the Current Soil Exposure Pathway discussion under Current Radiation Effects section (Section III.B.2.a.) and Figures 21, 24, and 25 for more details about this evaluation.
5	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	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 Concern/Issue	ATSDR's Response
7	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.
8	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 Concern/Issue	ATSDR's Response
9	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, to help reduce or prevent further exposure, and to expand the knowledge base about health effects related to exposure to hazardous substances. Under this purview, ATSDR is determining whether hazardous levels of uranium from the Y-12 plant represent a public health hazard for people living near the ORR. 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 Concern/Issue	ATSDR's Response
10	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 2003; 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/info_cntr/index.html 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 2003) 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 the Current Soil Exposure Pathway discussion under Current Radiation Effects section (Section III.B.2.a.) and Figures 21, 24, and 25 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 Concern/Issue	ATSDR's Response
11	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). This investigation is summarized in Section II.F.3. and in Appendix I.
12	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.

	Summarized Concern/Issue	ATSDR's Response
13	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	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.
15	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 the Past Surface Water Exposure Pathway and the Past Soil Exposure Pathway discussions under the Past Radiation Effects section (Section III.B.1.a.) and the Past Exposure via Ingestion discussion under the Past Chemical Effects section (Section III.B.1.b) for more details about this evaluation. In 1998 and 2001, FAMU and EPA, respectively, sampled surface water and sediment from Scarboro ditches (EPA 2003; 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 the Current Surface Water Exposure Pathway and Current Soil Exposure Pathway discussions under the Current Radiation Effects section (Section III.B.2.a.) and in the Current Ingestion Exposure Pathway discussion under the Current Chemical Effects section (Section III.B.2.b.). 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 21, 24, and 25). The uranium content of soils/sediment in Scarboro is indistinguishable from natural background levels and is not at a level of health concern.

	Summarized Concern/Issue	ATSDR's Response
16	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 the Ingestion of Vegetables Grown Near the Y-12 Plants discussions in the Current Radiation Effects (Section III.B.2.a.) and Current Chemical Effects (Section III.B.2.b.) sections for more details about ATSDR's evaluation. ATSDR compared the levels of uranium detected in Scarboro soil (EPA 2003; 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 in Scarboro soil were indistinguishable from background and are not a health hazard. Please see the Current Soil Exposure Pathway discussion under Current Radiation Effects section (Section III.B.2.a.) and Figures 21, 24, and 25 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). This investigation is summarized in Section II.F.1. and in Appendix I.
17	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). The level of radiation received by Scarboro residents is not a health hazard.

	Summarized Concern/Issue	ATSDR's Response
18	If strontium 90 (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 2002c). 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 hazard.
19	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.	Based on ATSDR's review and analysis of past exposures in the Phase I and Phase II screening evaluations in the State of Tennessee's Oak Ridge Health Studies, ATSDR concluded that past release of beryllium from the Y-12 plant is not a public health hazard to people living near the Y-12 plant. 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 and fluoride from the K-25 facility, iodine 131, mercury, White Oak Creek releases in the 1950s, PCBs, 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. Also, 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 2003) 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 2003; 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 Concern/Issue	ATSDR's Response
20	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	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 to the community is included in this report. ATSDR will evaluate uranium from the K-25 facility and the groundwater pathway in the future.
22	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 and the presence of relatively small amounts of contaminants (i.e., several Clinch River Cs 137 hot spots and natural uranium at the Chattanooga shale outcrop on East Fork Ridge), ATSDR does not find the surveys extremely useful in estimating doses or in making health decisions.

	Summarized Concern/Issue	ATSDR's Response
23	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 the Summary of Public Health Activities section (specifically, Section II.F.1.) 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.
24	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	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.

	Summarized Concern/Issue	ATSDR's Response
Cancer Health Effects		
26	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. 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).
Noncancer Health Effects		
27	A lot of deformed and retarded babies were born in Oak Ridge.	Uranium is not known to cause these kinds of health effects. The level of exposure to uranium from the Y-12 plant is not expected to cause these problems in pregnant women. 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 Concern/Issue	ATSDR's Response
28	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). This investigation is summarized in Section II.F.3. and in Appendix I.

	Summarized Concern/Issue	ATSDR's Response
Health Concerns/Procedural		
29	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 ORR 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 summarizing all radiological flyovers, *Aerial Radiological Surveys of the Scarboro Community*, are available from the Information Center by visiting the following Web site http://www.oakridge.doe.gov/info_cntr/index.html 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.
30	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 2003; FAMU 1998), the Background Soil Characterization Project (DOE 1993), and natural background levels. As shown in Figures 21, 24, and 25, there was no significant difference between them. Please see the Current Soil Exposure Pathway discussion under Current Radiation Effects section (Section III.B.2.a.) 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	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 Concern/Issue	ATSDR's Response
32	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	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.
34	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 2004.

VII. 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.

Studies of developmental effects in the offspring of uranium miners and millers have not reported any chemical or radiological effects on the development of humans. Very high doses of uranium in drinking water (far above any plausible human exposure) 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). Therefore, based on the estimated uranium exposure to people living near the Y-12 plant, ATSDR does not expect adverse health effects to a fetus from Y-12 uranium releases.

VIII. CONCLUSIONS

Having thoroughly evaluated past public health activities and available current environmental information, ATSDR has reached the following conclusions:

- ATSDR concludes that **off-site exposures to uranium released from the Y-12 plant is not a health hazard.** Past and current off-site exposures to uranium are not at levels expected to cause adverse 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 the Y-12 uranium releases as posing *no apparent public health hazard* from exposure to uranium. That categorization means that people could be or were exposed, but the level of exposure is not expected to 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 the fact that the evaluation had several conservative aspects, its conclusion was that exposure to uranium through both the inhalation and ingestion pathways would result in doses below levels expected to cause adverse 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 approximate radiation dose of 2.2 mrem for the first year dose is well below (45 times less than) the ATSDR MRL of 100 mrem/year for ionizing radiation (see Figure 12).

    - 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 (see Figure 9).

    - 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. Those 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 (see Figure 8).

- 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 well below levels known to cause 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 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 (see Figure 12).

- 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 (see Figure 9).

- The estimated uranium doses from ingestion of Scarboro soil (1.4×10^{-5} mg/kg/day for a 6-year-old child) and vegetables grown in Scarboro (3.9×10^{-5} mg/kg/day from Plot 46), as well as both doses combined (5.3×10^{-5} mg/kg/day), are well below (more than 37 times less than) the intermediate-duration oral MRL of 2.0×10^{-3} mg/kg/day (see Figure 8).

- The total uranium mean concentrations in surface water from Scarboro ditches (0.197 µg/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 EMEG, of 20 µg/L.

IX. RECOMMENDATIONS

Having evaluated past public health activities and the available environmental information, 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 apparent 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.

X. 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*). Phase II was completed in January 2000.

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

- In 1996, ATSDR evaluated the current public health issues related to the past and present releases into the Lower Watts Bar Reservoir from the ORR in a *Health Consultation on the Lower Watts Bar Reservoir* (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 2003).

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 and fluorides from the K-25 facility, iodine 131, mercury, White Oak Creek releases in the 1950s, PCBs, 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 being 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 2004, ATSDR will conduct additional 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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